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EUROPEAN SCIENTIFIC NOTES. VOLUME 33, NUMBER 11,(U)
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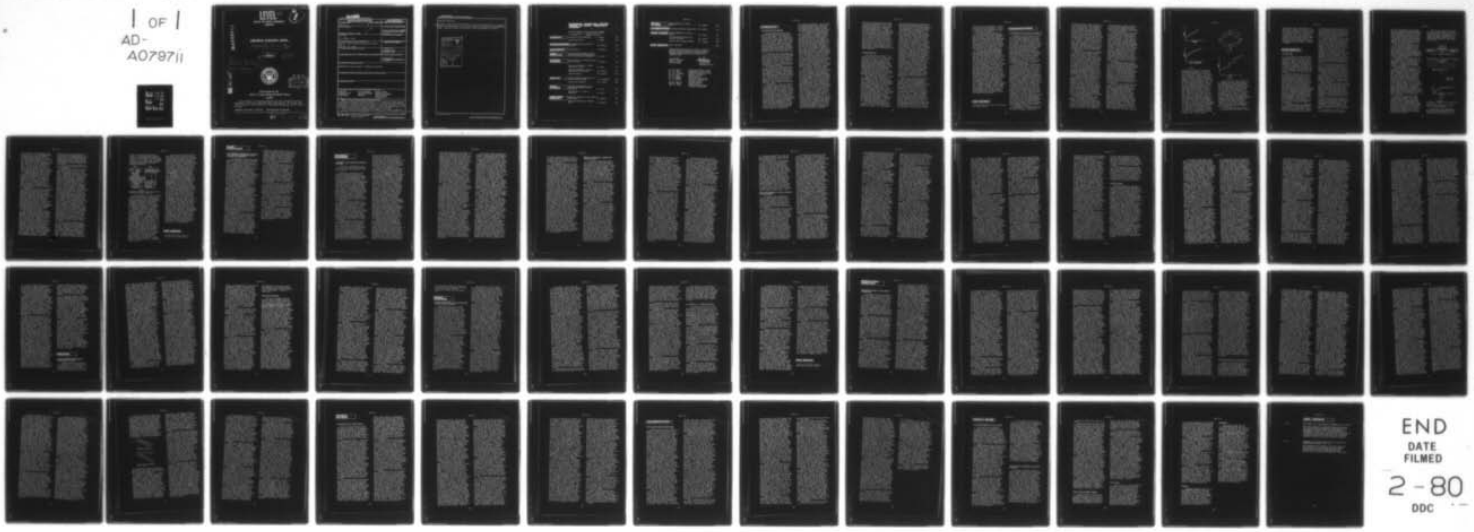

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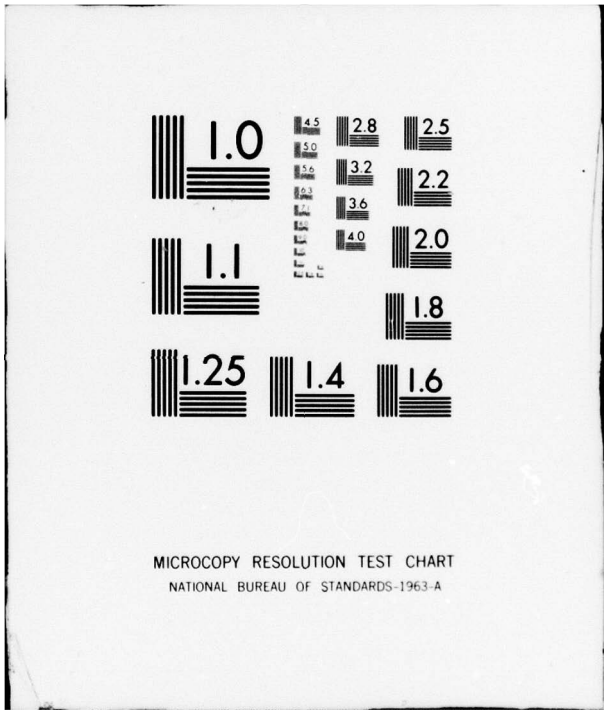

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LONDON

EUROPEAN SCIENTIFIC NOTES

Volume 33, Number 11,

ESN-33-11
30 NOV 1979
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Robert E. Machol
Dodie Thomas

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ESN 33-11	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES AD78795		5. TYPE OF REPORT & PERIOD COVERED Montly Publication, NOVEMBER 6. PERFORMING ORG. REPORT NUMBER ESN 33-11
7. AUTHOR(s) R.E. MACHOL, editor		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research Branch Office London Box 39 FPO New York 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 30 November 1979 13. NUMBER OF PAGES 47
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

CHEMISTRY	FLUID MECHANICS	OCEAN SCIENCES
COMMUNICATIONS	MATERIAL SCIENCES	OPERATIONS RESEARCH
ELECTRONICS	MEDICINE	OPTICAL PHYSICS
		TRANSPORTATION

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

This a a monthly publication presenting brief articles concerning recent developments in European Scientifc 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 → CONT

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CONT

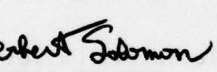
scientific staff of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

edited by Robert E. Machol and Dodie Thomas

30 November 1979 Volume 33, No. 11

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



HERBERT SOLOMON
Chief Scientist

P.F. GIBBER
Captain, USN
Commanding Officer

CHEMISTRY

THE BUNSEN SOCIETY MEETING

The 78th Annual Meeting of the German Bunsen Society was held this year on the campus of the new University of Dusseldorf. This University, established a little over a decade ago, occupies a spacious campus about four miles south of the center of this city. It is not really a campus in the American sense because the student body consists almost entirely of commuters. The buildings are all modern concrete and glass structures with little architectural style, efficiently planned though offering little aesthetic pleasure.

Following a long-established tradition of the Society, the meeting had a main theme, which this year centered about the separation and enrichment of materials. About a half dozen one-hour lectures and 30 poster presentations dealt with this topic. One of the posters, by Dr. D. Schiöberg (Univ. of Marburg), concerned the mechanism of desalinizing membranes.

In addition to the presentations related to the main theme there were sessions dealing with homogeneous and heterogeneous catalysis, spectroscopy, the structure of liquids, interfaces, thermodynamics, macromolecular chemistry, electrochemistry, and photochemistry. These sessions consisted of 15 minute presentations in parallel sessions, much as we find at our ACS meetings. The schedule was tight and there was little in-depth discussion after the papers.

In one of the contributed papers, F. Strohbusch and R. Suetter (Univ. of Freiburg) reported on some collaborative work with Eyring (Utah) on the mechanism of proton transfer in polar organic solvents. By studying the relaxation kinetics of acid-base systems in non-aqueous solvents, they found that the rates were very strongly affected by small traces of water and/or other impurities. They also found that in acetonitrile the proton transfer between acids containing OH and NH groups and bases took place at rates well below the diffusion-controlled rate. The rates of proton-transfer processes were also the subject of another paper by J. Hemmig and H.H. Linbach (Freiburg). They studied the intramolecular proton transfer in tetraphenylporphyrin and found that the proton transfer showed an anomalous temperature dependence which they explained through a tunnelling model.

Dr. Bernard Nickel [Max-Planck-Institute (MPI) for Biophysical Chemistry, Göttingen] presented evidence for energy transfer between an upper excited singlet state of N-methylcarbazol and toluene. The upper singlet state of the former compound was reached through T-T annihilation, and they observed delayed fluorescence of the S_n state to provide conclusive evidence for the energy transfer process. The solvatochromy of coumarin derivatives was studied by psec laser-flash spectroscopy by J. Schulz-Hennig and A. Müeller from the same institute. In dimethylsulfoxide (DMSO) and benzene they could observe strong red shifts in the fluorescence spectra and blue-shifts in the absorption of the excited molecules that could be explained as being caused by the orientation of the solvate dipoles under these conditions. By extending further the model originally proposed by E. Lippert (Technical Univ. of Berlin), they were able to calculate the dipole moment of such molecules in the S_1 state.

The session on the structure of liquids contained several presentations on liquid crystals, including one by Prof. H. Stegemeyer and K. Bergmann. In the field of electrochemistry there were three papers presented by different staff members from the Fritz Haber Institute in Berlin. In the area of photochemistry a contribution by Prof. G. von Bünau (now at the University of Siegen) dealt with a study of the photocyclization of N-methyldiphenylamine in micelle systems. He finds that under these conditions the course of the reaction is very similar to what is known about it in hydrocarbon solvents and that it involves a zwitterionic intermediate dihydrocarbazol that is formed from the triplet state of the starting materials. Dr. H. Goerner (MPI for Coal Research, Institute for Radiation Chemistry) reported on their latest results on the photoisomerization of halogen-substituted stilbenes that appears to take place via an upper triplet state. A very talented young physical chemist, Dr. S. Schneider (Technical University, Munich) described his ingenious

apparatus for obtaining pulsed Raman spectra by coupling a dye laser with a pulsed-nitrogen laser. As a first example they have been studying the photodissociation of a tetrachloro keto-dihydronaphthalene. A paper of possibly unusual interest dealing with the spectroscopy of adsorbed dye molecules was unfortunately cancelled because of the illness of its author, Dr. H. Killesreiter (Marburg). All in all there were about 120 presentations and close to 900 registrants. The caliber of the papers that I heard was very good, and there is little doubt that physical chemistry in Germany is now in a very healthy and vigorous state. [George Wyman, United States Army Research and Standarization Group (Europe)]

SOLUTION REACTIONS

Two meetings on reactions in solution were held back to back at the University of Kent just outside Canterbury 9-15 July 1979. The first of these was the Second International Conference on the Mechanisms of Reactions in Solution (organized by the Chemical Society); the second was the Annual Meeting of the Chemical Society Discussion Group on Fast Reactions in Solution. The first meeting attracted some 400 participants and took up three and one-half days; the second meeting was essentially a one-day affair with about 125 participants.

The mechanisms conference consisted of 7 plenary (1-hour) lectures, 8 section plenary lectures (40 minutes), and approximately 180 contributed papers. Except for the plenary lectures, the meeting consisted of 4 simultaneous sessions, dealing with reactions that were organic, inorganic, physical, and biological respectively. (Of course there was considerable overlap in terms of subject matter between them.) An unusual aspect of the meeting was that about half of the contributed papers were presented both as oral presentations (20 minutes) and as posters; many participants complained that this was inadequate. A volume of rather detailed abstracts was also distributed to each participant.

Since the volume of abstracts did not contain the abstracts of the plenary lectures, a few comments on these are in order. To this observer the outstanding lecture of the entire meeting was by Bulgarian-born Prof. Kebarle (University of Alberta, Canada) on "Contributions of Ionic Gas-Phase Thermochemistry to Solution Reactions Involving Ionic Intermediates." In this paper Kebarle reviewed recent work in his laboratory that involved the trapping of ions in the gas phase under relatively high pressure, generally 3-10 torr (to minimize their collisions with the walls) and low charge density (to minimize their destruction by recombination). Analysis of the reaction mixture was by mass spectrometry. Using this technique they have been able to study a variety of equilibria, such as those involving proton transfer, and from the results they have calculated thermodynamic quantities. Thus they have found that under these conditions the well known anomaly, observed when the basicity of amines is determined as a function of methyl-substitution on ammonia, disappears; in the gas phase they find that there is a regular increase in basicities in going from ammonia to trimethylamine. Much the same can be found when hyperconjugation in the conjugate cations of aromatic hydrocarbons is studied as a function of methyl substitution; there is a monotonic increase in hyperconjugation as the number of methyl groups is increased in the side chain. These results also explain how work in the vapor phase can help elucidate the mechanism of effects observed in solutions.

The plenary lecture by Prof. Sir G. Porter, (The Royal Institution, London) dealt with the mechanism of energy transfer and concentration quenching in the photosynthetic process Prof. R.H. Abeles' (Brandeis Univ., MA) lecture expounded his theory on the mechanism of the action of B_{12}-coenzymes, an area of research that is, by his own admission, subject to considerable controversy at the present time. Prof. H. Taube (Stanford Univ., CA) gave an elegant introductory lecture providing a review of electron-transfer processes observed in the chemistry of coordination complexes. He discussed how, in his laboratories, they have been successful in determining some rate constants for electron-transfer reactions of Ru and Os complexes. (These ions are particularly suitable for this type of work,

because of the large number of valence states that they can exhibit.) They find that the rate constants for organic complexes containing both +2 and +3 Ru is usually 10^7-10^8.

The Fast Reactions meeting consisted entirely of contributed papers that were presented orally (5 minutes!) and as posters. There were approximately 40 presentations and mimeographed copies of all the abstracts of all papers were distributed to all participants. In contrast with the Reaction Mechanisms meeting, there was a reasonable amount of time available for viewing the posters (4 hours), but there was obviously very little time for discussion of the oral presentations.

It is obvious from the program that the meeting gained considerable international flavor from the "spill-over" of participants who stayed for the extra day after the large Mechanisms meeting. This resulted in roughly twice as many papers as one might have expected from such a meeting of a Chemical Society Discussion Group, and a corresponding increase in the variety of topics discussed. Regrettably, there were no contributions at all dealing with fast photochemical reactions, an important area of research that has so greatly benefited from the development of pulsed lasers. (Even Porter, who presented a plenary lecture at the Mechanisms meeting and has a home ten miles from Canterbury, and who received a Nobel Prize a decade ago for his work in this area, did not participate in the second meeting!) Thus the above mentioned variety related primarily to the types of reactions studied, as the techniques used were largely stopped-flow, temperature-jump, pressure-jump, and, in a few instances, pulse radiolysis methods. In addition, there were several papers dealing with micelles and microemulsions. [George Wyman, United States Army Research and Standardization Group (Europe)]

ONRL REPORTS

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

COMMUNICATIONS

TELECOMMUNICATIONS RESEARCH IN DARMSTADT

Germany has a long history of public ownership of public utilities so it is not surprising that, as in many other countries in Europe (but unlike the US), the telephone system is publicly owned. It is in fact part of the post office, as it is in England. The Post Office Department has two research institutes, both in Darmstadt, one for postal matters and one for communication. The Forschungsinstitut des Fernmeldetechnischen Zentralamt der Deutschen Bundespost (the Telecommunication Research Institute of the German Post Office) has existed for a long time—its predecessor was in Berlin before WW II. It does research on telephone, TV, and other types of telecommunication. (The TV in Germany is also publicly owned, although it does have commercials.)

A group under Günther Wengenroth, including J. Ost and H. Wendt, is working on "conference TV," a type of TV presentation that requires less channel capacity than ordinary TV. Ordinary TV requires several megahertz of bandwidth, and when this is encoded for digital transmission about 16 bits/sec are required for each Hz of bandwidth (according to the sampling theorem, the signal must be sampled twice per cycle, and 8 bits per sample are used to give adequate dynamic range.) Wengenroth and his colleagues are trying to develop a system which could be utilized at convenient points, that is they want an individual to be able to dial such a conference from his office without going to some conference center. This means that one cannot count on having coaxial cable or other high-bandwidth channels, but can count only on a twisted pair which can handle only about 2 Mbits/sec. It should be noted that such twisted pairs are conventionally used to carry 30 multiplexed channels of 64 kbits each. In accordance with the above 16:1 ratio, each of these 64 kbit/sec channels carries a telephone voice communication of approximately 4kHz (actually 3.8 kHz).

European TV is normally 625 lines (see *ESN* 32-8:262). In conference TV one uses an ordinary camera, but

transmits only half (313) of the lines. This requires both a down-converter and an up-converter. In the down-converter adjacent lines are combined, using a weighted averaging procedure involving 3/4 of one line and 1/4 of the other; this type of averaging minimizes storage requirements. The up-converter, which is more important for picture quality than the down-converter, interpolates by weighting one line by 1/2 and lines on either side of it by 1/4. Actually, it is more complicated than this; for example the fly-back time, which amounts to 15-20%, is utilized for transmitting some of the information, and this means that storage is required so that this information can be fitted in and synchronized in the proper way.

Most of the reduction in bandwidth is obtained by not sending those portions of the picture which do not change from frame to frame, and updating the receiver with changes only. In static situations this is of course easy, but even in dynamic situations it is remarkable that the great bulk of the picture does not change from one frame to the next. The circuitry for prediction and comparing of the predicted picture with the actual is, of course, very sophisticated. Most of it was designed by Wengenroth, although he acknowledges a debt to Bell Telephone Laboratories in Homdel, NJ, who worked on similar concepts in the early 70s, but stopped around 1975.

A demonstration system had a woman's picture on a pendulum which was swung back and forth to simulate a dynamic picture. One could see the picture as it was picked up with the original 625-line camera; what it looked like after it had been reduced to 313 lines before and after digitizing and transmission; and finally the fully reconstituted 625-line picture. This was, of course, only black and white, but the quality is remarkably high, considering the enormous reduction in bandwidth compared to the usual coaxial-cable transmission.

The above described techniques require that there be a delay of 2 frames. Since the Germans use 50 frames/sec (compared to 60 frames/sec in the US—this appears to have historical if not logical connections to our respective AC frequencies) this delay amounts to 40 msec. If the delay exceeds some critical time, dialogue becomes impossible. However 40 msec is still small compared with the delay of about 250 msec involved in transatlantic telephone conversations which go via satellite.

With repeaters every 3 km, this type of digitized transmission can be sent arbitrary distances along twisted pairs from a subscriber to a central station. To go from one central station to another requires digital transmission, and there is very little such transmission available now between stations in Germany, which makes near-term implementation unlikely. However, all new links starting in the 1980s will be digital, so in the long term this should be routine. Wengenroth and his group feel that their research will be completed in about 3 years. After that, development, if any, will be contracted to industry. It seems possible therefore that this service might be offered to subscribers as early as the mid-1980s—or it might be much later.

The Operations Research Group at the Telecommunications Research Institute is headed by Eckart Wollner; his group includes Raymond Garcia and Klaus-Dieter Hackbarth. These men have been trained in mathematics, physics, and engineering respectively, and all now consider themselves OR analysts. In my opinion [and that opinion is shared by Prof. Mueller-Merbach (Univ. of Darmstadt) who accompanied me on this visit] their approach to operations research is more like that of one whose training was in mathematics rather than in engineering.

The basic task in which they are engaged is the investigation of analytic and heuristic methods for planning telecommunication networks for telephone, data, and cable TV, both for medium and long terms. Their principal effort has been on the long-term planning of a transmission network (as distinguished from a switching network). They modeled this as a capacitated graph with nodes which are centers in various cities and edges which are the transmission lines. The cost of a transmission line is a concave function of its capacity and a linear function of its length, with a fixed cost in each case (Fig. 1). The entire network of the Federal Republic

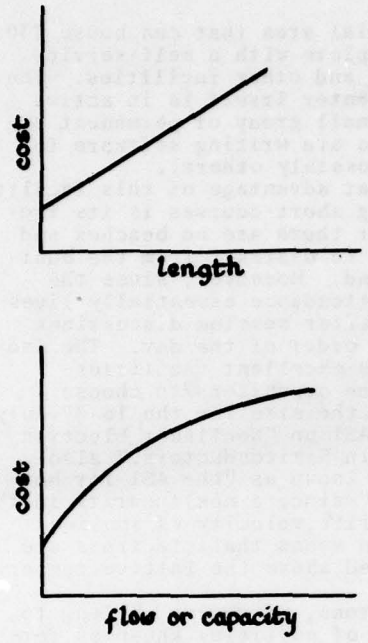


Figure 1

of Germany would have 400 nodes and 10,000 possible edges. To simplify it they have considered only the primary and secondary nodes. Thus Darmstadt, which is a tertiary city, would not be included in their simulation, though its nearby neighbor, Frankfurt, would be. There are then 64 such nodes and 1,000 possible edges of which 80-100 are actually present. The problem is to design an optimal network of edges (transmission lines). There are constraints on minimal traffic capacities and constraints owing to lines that already exist. The objective function is to minimize cost. Cost minimization would mean that in Fig. 2 path A or path B but not both would exist between nodes 1 and 3. Other criteria, especially reliability and redundancy, would be extremely valuable in practice, but the computer time goes as the cube of the number of nodes if cost is the objective function, and as the 4th power of the number of nodes if multipath and realiability are included, so they have decided to leave out this refinement. As it is, they must do a heuristic optimization because of the magnitude of the problem. They obtain a local optimal and then add or remove edges.

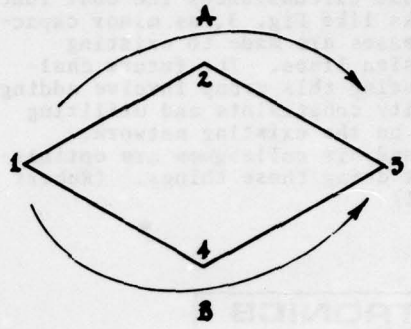


Figure 2

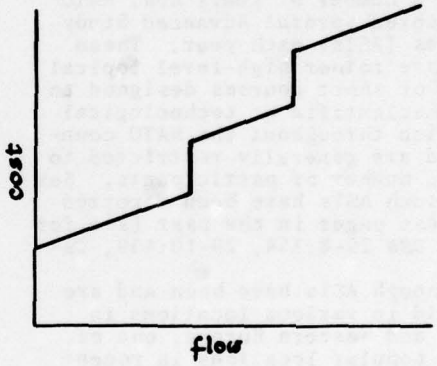


Figure 3

While they have done a great deal of computer analysis—optimization and appropriate sensitivity analyses—there has been no implementation of their recommendations to date because none of the optimizations are based on real data. They explained to me that the appropriate data for the existing system is not easy to obtain. Research is done in this Institute, but development is done at a different institute called the Engineering Center; these people only make planning proposals, decisions being made at the Engineering Center and by the Ministry. They have been able to compute some very small examples with real data just to test the methods, but thus far they have been unable to go beyond this.

To convert the long-term model to a medium-term model implies building

very few new lines, but primarily increasing the capacity of existing lines. Under these circumstances the cost function looks like Fig. 3, as minor capacity increases are made to existing transmission lines. The future challenges facing this group involve adding reliability constraints and utilizing the data on the existing network. Wollner and his colleagues are optimistic about doing these things. (Robert E. Machol)

ELECTRONICS

HOT ELECTRONS

For a number of years now, NATO has sponsored several Advanced Study Institutes (ASIs) each year. These usually are rather high-level topical meetings or short courses designed to transfer scientific or technological information throughout the NATO countries and are generally restricted to a limited number of participants. Several of such ASIs have been reported on in these pages in the past (see for example, *ESN* 29-8:354, 29-10:439, 29-11:474).

Although ASIs have been and are being held in various locations in Northern and Western Europe, one of the more popular locations in recent years has been the Sogesta center, a modern functional and educational research center located about 4 km from the Italian hill town of Urbino—a name familar to many readers as the birth place of the painter Raphael. The name Sogesta, an acronym for Società per Gestire Tecnologia Avanzata (Corporation for Managing Advanced Technology), was indeed chosen appropriately: Sogesta, a company belonging to the ENI group (the Italian National Hydrocarbon Authority) organizes, manages, and accommodates study courses, schools, seminars, and research activities for and in collaboration with ENI and other Italian and foreign organizations.

The center itself is a group of very modern contiguous buildings that house a number of classrooms with capacities of 10 to 300 persons, with excellent audio/visual aid, a computer center and associated libraries, and a residential area that can house 230 and is complete with a self-service restaurant and other facilities. The computer center itself is in active use by a small group of permanent employees who are writing software for ENI (and possibly others).

A great advantage of this facility for holding short-courses is its isolation; for there are no beaches and no casinos to distract from the business at hand. Moreover, since the group in attendance essentially lives together, after-session discussions become the order of the day. The isolation plus excellent facilities prompted the organizers to choose Sogesta as the site for the 16-27 July 1979 NATO ASI on "Nonlinear Electron Transport in Semiconductors," also informally known as "the ASI for hot electrons," since a nonlinearity in the curve of drift velocity vs applied field often means that electrons are being heated above the lattice temperature.

Electrons, of course, belong to that class of particles known as fermions. I found it therefore to be an interesting coincidence that Sogesta overlooks the buildings of Fermignano (pronounced fermine-yano), a town located in the valley about a mile away.

True to the spirit of NATO, the organizers and directors came from several countries: Dr. D.K. Ferry from Colorado State Univ. (US); Dr. J.R. Barker, from the Univ. of Warwick (UK) and Dr. Carlo Jacoboni, from the Univ. of Modena (Italy).

The lecturers of the ASI came from the US, UK, Italy, FRG, Austria, France, and Belgium. There were 69 participants, including the lecturers, with representation not only from these countries but also from other NATO countries. Possibly because of prior connections with institutions in NATO countries, there was also one representative each from Saudi Arabia and Hungary.

That this was indeed a Study Institute was emphasized by the very full schedule. The lectures of the first week started on Monday at 9 a.m. and concluded at noon on Saturday. The advertised last day for the ASI was Friday July 27th, and indeed, the last speaker finished at 6:35 p.m. on that day.

The purpose of the ASI was to provide a deep basic total picture

of the various aspects of nonlinear electron transport in semiconductors. The list of topics addressed included: Phenomenological aspects of hot carriers, electronic structure, electron-phonon interactions, transport, carrier-carrier interaction, nonequilibrium phonons, semiconductors in high magnetic fields, noise and diffusion, optical excitation, and devices involving all such phenomena.

But why have such a Study Institute at this time? After all, did not most of the researchers in the US stop work on the subject of nonlinear transport during the 60's? What could be the possible application that could merit such a NATO-supported effort "to provide young researchers with the foundations of the principles of nonlinear transport?"

According to the organizers, the chief reason is the progress that is being made toward the ultramicroscopic geometries required for very high speed, very large-scale integrated circuits, or toward higher-frequency microwave amplifiers.

As an example of the need to look at nonlinear transport phenomena, we consider a field effect transistor whose channel is only 1000 Å in length. With 1 V applied across its channel, the longitudinal electric field is 10^7 V/m. In 1951 Ryder and Shockley had already demonstrated carrier velocity saturation in germanium for fields in excess of 10^5 V/m; so that the concept of linear transport with drift velocity given by $v_d = \mu F$, where μ is the mobility and F is the electric field, ceased to hold. More drastic even is the phenomenon of negative differential mobility in gallium arsenide, predicted by Hilsum and discovered experimentally and exploited by Gunn, which occurs with F of around 3×10^5 V/m and is the basis of the well known Gunn oscillator.

But why not reduce the channel voltage in the example given above and therefore remain in the linear transport region? Because the theoretical limit to feasible electrode voltages is that corresponding to thermal energy, kT (0.026 V at room temperature), and in practice, one requires electrode voltages of several times this amount. But even 0.1 V, or four times the room-temperature thermal voltage still leaves us in the domain of nonlinear transport.

Besides the saturation of drift velocity or the transfer of electrons from one subband to another, as in gallium arsenide, other effects occur. Ferry, for example, reported on a simulation study carried out for the field effect transistor (FET) shown in Fig. 1(a).

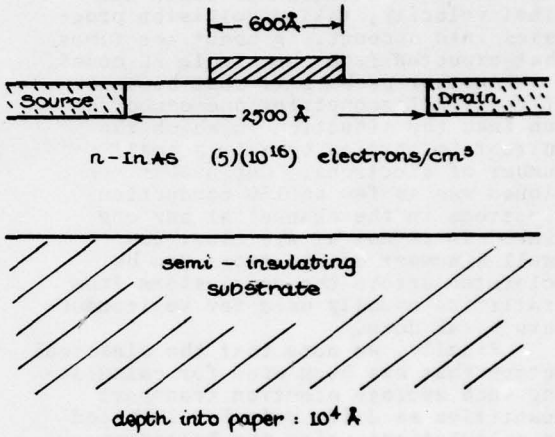


Figure 1
a) Geometry of MESFET for Ferry's simulation study.
b) Drift velocity vs time after source drain voltage is switched on.

Here, based on the geometry of the structure, he had calculated an RC time constant of 10^{-13} sec. Assuming, as is usually done in the

linear domain, an instantaneous relation of $v_d = \mu F$, this would mean that on application of a step function source/drain voltage of, say, 0.1 V, the drain current should rise to nearly its final value in about 2×10^{-13} sec. According to the simulation study the actual v_d vs t curve expected for this device (at 77K) is that of Fig. 1(b). In other words, the time required for an electron to reach its final velocity, taking collision processes into account, is about ten times that expected from the simple RC model.

Another problem is that because of the small geometries one can often run into the situation in which the current is carried by only a small number of electrons. One number mentioned was as few as 130 conduction electrons in the channel at any one time. It is not at all clear how small a number of electrons can be tolerated before the conclusions from statistics usually used for semiconductors break down.

Finally, we note that the classical method that has been used for calculating such average electron transport quantities as drift velocity is based on calculations using the Boltzmann transport equation. According to Barker, the use of the Boltzmann equation, with its simple local relative processes implied, fails for electron transport in the high fields associated with ultra-small devices. Instead, calculations should be performed using quantum transport theory. As an example, he mentioned that for devices 1000 Å long the Boltzmann equation method can give errors of up to 50%.

The reasons given above for justifying the renewed look and the introduction of young scientists to problems dealing with nonlinear transport are related to the construction of devices now on the horizon. These are actually not the whole story, however, for there are many other effects that were discussed, both electrical and optical in nature, that are related to the behavior of electrons in the nonlinear transport situation encountered in both high electric and high magnetic fields, even though most of these may not have relevance to practical devices at this time. Some, on the other hand, have turned out to be useful during measurement procedures. An example is the Shubnikov-de Haas effect, by which the electron temperature in a semiconductor is found by measuring the ratios of the amplitudes of oscillation peaks in the fluctuations of magneto-resistance, seen as the magnetic field is swept through values corresponding to several Landau level resonances.

It is for this reason that the ASI covered the broad spectrum of nonlinear transport.

During the last few years there have been several centers or institutes that have been active in the field of nonlinear transport of electrons. Among these are several groups in Austria; North Texas State Univ., Denton, Texas; the Univ. of Warwick, UK; the Université des Sciences et Techniques du Languedoc, Montpellier, France; Colorado State Univ., Fort Collins, Colorado; Cornell Univ., Ithaca, New York; and, for about the last ten years, the Univ. of Modena, Italy. It was therefore, quite appropriate that Jacoboni, from Modena, present the introductory lecture. Here he briefly discussed the process of electron heating, i.e., the various scattering mechanisms for both polar and covalent semiconductors that lead to electrons being heated above lattice temperature by an applied electric field. He also cautioned against the practice of assigning a specific electron temperature to these hot electrons, since for a number of high-field situations the electron distribution ceases to be Maxwellian. Finally, he discussed the general framework of electron transport investigations with the aid of Fig. 2, pointing out that the aim of both theory and experiment is to arrive at the distribution function, i.e., the relative distribution of electrons as a function of energy, momentum, etc., and from this to arrive at such quantities as average electron energy or drift velocity.

A list of the succeeding lecturers, their subjects, and the amount of time alloted to their presentations follows. Each lecture was nominally one hour in length 1) K. Hess (Univ. of Illinois, Urbana, Illinois) in six lectures discussed phenomenological physics of hot carriers in semiconductors. 2) The topic of C. Calandra (Univ. of Modena, Modena, Italy) for three hours was the highly theoretical

subject of electronic structure of solids. 3) Electron-phonon interactions were the subject of a three-hour review by P. Vogl (Univ. of Graz, Graz, Austria). 4) G. Bauer (Univ. of Leoben, Leoben, Austria) during five lectures discussed experimental studies of nonlinear transport.

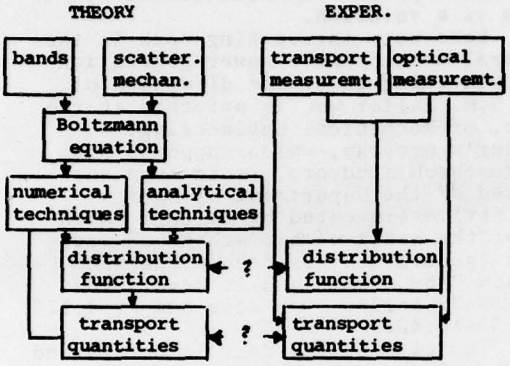


Figure 2
Techniques for obtaining electron distribution functions and transport quantities

The following topics were discussed in two lectures each: 1) Optical excitation of hot carriers in semiconductors (R. Ulbrich, Institute of Physics, Universität Dortmund, Dortmund, FRG); 2) Magnetic transport (R. Nicholas, Clarendon Laboratory, Oxford, UK); 3) Noise and diffusion (J.P. Nougier, Université des Sciences et Techniques du Languedoc, Montpellier, France.)

One hour each were devoted to the following topics: 1) Theoretical concepts of photo-excited hot carriers (C.J. Hearn, Marine Sciences Laboratory, Gwynedd, UK). 2) Semi-classical transport (Ferry). 3) Quantum transport (Barker). 4) Quantum optics and semiconductors (A. Smirl, Physics Department, North Texas State Univ., Denton, Texas). 5) Theory of hot electrons in high magnetic fields (D. Calecki, Solid State Physics, L'Ecole Normale Supérieure, Paris, France). 6) Devices (H. Grubin, United Technologies Research Center, East Hartford, Conn.). 7) Multiphonon Scattering (P. Kocevar, Physics Institute, Univ. of Graz, Graz, Austria). 8) Carrier-carrier Interactions and Screening (C.J. Hearn). 9) Nonequilibrium Phonon Processes (P. Kocevar). 10) Time of Flight Techniques (L. Reggiani, Institute of Physics, Univ. of Modena, Modena, Italy).

Brief abstracts of the material presented in these lectures as well as a listing of a number of additional seminars will be found in a more extensive ONRL report describing this Study Institute entitled "Physics of Nonlinear Transport in Semiconductors," to be issued by this office in the near future. Moreover, as has been the practice with other ASIs, the written text associated with the lectures (though not the seminars) is to be published by Plenum Press as Proceedings of this ASI, in 1980.

In summary, it can be stated that the organizers put together a most comprehensive package that covered the field quite thoroughly, so that anyone who was in attendance or those who will ultimately read the Proceedings are or will be well informed of the many aspects of this subject. This does not mean that the persons who attended the ASI and were exposed to this subject for the first time could become experts within the brief two-week period or, for that matter, follow the lectures dealing with theoretical topics to any great degree, for the material really came at us at a fast and furious pace. This ASI, indeed, was an advanced study institute. In fact, it was easy to observe that nearly all the questions during the lectures were asked by individuals who had been working in the field for some time, i.e., by other lecturers. Despite strong encouragment by the directors, there were very few questions asked by the "students." Nevertheless, I believe this ASI should be deemed worthwhile, for even though I, as an observer and on par with many of the "students" cannot claim a great depth of knowledge in this field, I believe that we were exposed to an excellent introduction that can become the basis of important work in the future. (Irving Kaufman)

ONRL REPORTS

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

FLUID MECHANICS

FLUID MECHANICS RESEARCH IN THE MECHANICAL ENGINEERING DEPARTMENT OF THE UNIVERSITY OF EDINBURGH

The Department of Mechanical Engineering at the University of Edinburgh, under the direction of Professor J.L. King, is small by European standards and is comprised of 12 faculty. About twenty undergraduate students are awarded their bachelor's degrees each year in Mechanical Engineering; the research program is carried on with postdoctoral and research fellows. Departmental activities are grouped in sections on thermodynamics and fluids, solid mechanics and materials, and dynamics and control. King's interests lie mainly with the solid mechanics and materials section; he has worked in the area of composite materials and is currently engaged in the application of variational principles to various problems in mechanics.

King introduced me to Dr. W.D. McComb who is currently working on a number of problems in fluid mechanics and turbulence. McComb described and illustrated to me an interesting experiment involving the addition of polymer particles in concentration from 1 to 5 ppm either to the center or to the wall of a turbulent pipe flow. In the case of addition at the center of the pipe, drag reduction manifested itself only far downstream, because the particles diffused out slowly toward the walls where they were effective. It is clear that for such polymer particles to reduce drag the nature of the turbulent bursting has to be modified; hence they must be present in the bursting areas that seem to be close to the walls.

McComb has also examined the addition of asbestos fibers to pipe-flow and the effect of scale of asbestos fibers on drag reduction. He found that the mechanism of drag reduction changed as the fiber size was reduced to the magnitude of polymer particles. McComb has also investigated the effect of drag-reducing polymers on pulsation noise from small air bubbles introduced into the flow. All additives seem to reduce the sound intensity radiated by the bubbles. Some additives were more effective at lower concentration than at higher; and one, Separan 8273, exhibited an effectiveness that oscillated with concentration in a surprising manner. McComb has also recently developed a theory of time-dependent isotropic turbulence which is a perturbation method for solving the Navier-Stokes equations. It is significant that his theory along with that of Kraichnan yields the Kolmogoroff spectrum as a solution.

Some very interesting work in the general area of wave power generation is proceeding under the direction of Dr. S.H. Salter who is attached to the Dept. of Mechanical Engineering. Salter's program, which supports some 20 research students, is in turn supported by the Department of Energy. The device (invented by Salter) which is at the heart of his scheme of wave power generation has been nicknamed by him "the duck," and is described in *ESN* 32-4:124. See also *ESN* 32-4:128 and 33-10:406.

The size of the duck is determined by the size of the waves at a particular location of ocean; thus ducks suitable for extracting energy from waves in the Atlantic Ocean would be of the order of 10-15 m in scale, whereas ducks suitable for extracting energy for North Sea locations would be on the order of 5 m in scale.

Salter has been given funding to produce wave generators which can synthesize almost any type of wave profile. A special pool with wave generators along the various edges can generate standing waves as well as arbitrary two-dimensional traveling wave patterns. This testing program is proceeding admirably.

Estimates of wave energy incident on the shores of Great Britain have indicated that a considerable proportion of the energy used in Britain can be supplied by wave power. With America's extensive shoreline, it would be worthwhile investigating the possibilities of wave power for ourselves. (Martin Lessen)

MATERIAL SCIENCES

METALLURGY AT THE TECHNICAL UNIVERSITY OF WARSAW

(Keywords: undirectional solidification, grain boundaries, dislocations, strengthening mechanisms, amorphous metals)

Research in metallurgy at the Technical University of Warsaw is carried on in the Institute of Materials Science and Engineering, headed by Prof. Stefan Wojciechowski. This Institute also has full status as a teaching "faculty" (read "department") just like those in electrical engineering, chemistry, etc. The Institute comprises some 200 people, including 120 with a university degree of some kind. There are 60 persons with doctoral degrees, including about 8 full professors and 10 associate professors. Most of these 18 have, during the five years of the Institute's existence, built research groups, typically 10 to 12 researchers and one professor. This report will discuss three of these research areas which I found especially interesting.

The main research interest of Wojciechowski is unidirectional solidification of eutectic alloys. Unidirectional solidification is a process that leads to a microstructure in which one of the two phases of the eutectic mixture develops in the form of parallel fibers or platelets uniformly distributed in the second phase matrix. Material with such a microstructure is characterized by anisotropic physical and mechanical properties that are advantageous in certain applications.

Recent work has been carried out on the 72% Ag-28% Cu eutectic; the inherently useful electrical properties of this alloy can be further enhanced by creating an aligned structure. Resistivity of the contact material is the main contribution to the total resistance of a contact system, which determines the system's current-carrying capability, and it has been found that alloys with the aligned microstructures possess better properties in this regard than equiaxed grain structures of the same alloy. The exact properties are directly affected by the lamellar spacing and so indirectly controlled by the solidification rate. Wojciechowski's work on these materials has a decidedly applied flavor, with concern shown for such features as the welding characteristics of the materials, thermal stability of the structures, etc.

Prof. Maciej Grabski heads a group that is interested in strengthening and dislocation interactions in metals. This includes primarily precipitation strengthening and the effect of grain boundaries on the mechanical properties of metals. The group comprises about 12 persons including graduate students. They are looking at classical physical metallurgy topics such as the interaction of dislocations with grain boundaries and precipitate particles, including the effect of ultrafine grain structure (1 to 5 μm in diameter) on mechanical properties. Until recently the work has been at room temperature, but is now being extended to higher temperatures. For example, at about half the melting temperature, ultrafine grains may lead to superplasticity owing to grain boundary sliding. The work is related to both basic physical metallurgy questions and engineering properties, but the emphasis is on pure scientific research strongly connected to dislocation theory. Until a few years ago, the work was conducted without developing direct microstructure-properties correlations, but there is now an emphasis on TEM (transmission electron microscope) observations to confirm predictions of theoretical models. Often, very pure metals are studied (e.g., Al of 99.9999% purity), as well as pure alloys (e.g., stainless steel-type compositions such as Fe-23Cr-19 Ni).

Grabski recruits students for his group when they have completed 3 years of their 5-year program and gives them a special indoctrination in dislocation theory. This is necessary because the theme of the research in the group is the development of accurate theoretical models such as for grain boundary structure and bonding, with TEM used both to suggest and support the appropriate models. During my visit, I had the opportunity to observe some of the dramatic, dynamic experiments that are being conducted. In one experiment, deformed

pure metal foils were being heated from below room temperature in the cold stage of the TEM, and dislocations that migrate to grain boundaries were being observed and timed as they spread in the boundaries. These studies are in direct pursuit of laws for the strengthening effect of alloying impurities. It has been shown, for example, that the temperature at which the dislocations spread in the grain boundary is related to the purity of the material, with very pure metals exhibiting much lower spreading temperatures than technical purity metals. This is consistent with the familiar concept of pure metals being weaker; the observation is that the dislocations in the pure metal require less thermal activation in order to be mobilized, so at any given temperature, the purer material will be less resistent to deformation, i.e., weaker (more ductile).

The work of Grabski's group on the subject goes much further than simply confirming this point qualitatively, however. The group includes researchers with backgrounds in physics who are concerned with building models for grain-boundary bonding, then relating predicted grain-boundary energies to measured values. Others are working on models for dislocation generation in grain boundaries, a mechanism which Grabski calculates may often account for 80% of the dislocations generated, but for which the exact details are unknown. Grabski reports that the classical "Frank-Read source" mechanism for dislocation generation is found mostly in textbooks and only infrequently in real metal samples.

While the work of his group emphasizes the development of accurate theoretical models, Grabski is not impressed by recent work in other laboratories on computer simulation of grain boundaries. He maintains that the models generated by these means are usually inaccurate because the interatomic potentials on which they are based are not the same in the grain boundary as in the grain interior. The work of his group began with a Schrödinger-wave-equation approach to bonding, working on the basic presumption that electrons are the "glue" that keeps atoms together in metals; most of the results of this work are too complex to report here (which means that this writer doesn't understand it) but are being published regularly in the Western metallurgical literature.

The largest group at Warsaw is headed by Prof. Henryk Matyja on the subject of amorphous metals produced by very rapid quenching of certain alloys from the molten state. (For a complete review of this subject area see *ESN* 32-10:326.) To produce metallic glasses it is necessary to cool liquid metals at rates exceeding one million degrees per second. This is achieved by allowing a thin layer of molten metal to come rapidly in contact with a substrate of high thermal conductivity. Nowadays, most research laboratories (and manufacturers) achieve this by the technique of "melt-spinning": a continuous stream of molten metal is squirted against a rapidly rotating metal wheel; the molten metal solidifies and is thrown off the wheel as a continuous ribbon some 50 μm thick. Though in principle this technique is simple, the production of high-quality material is dependent on a large number of operating parameters such as wheel speed, surface condition, nozzle size, etc.

Amorphous metallic materials have interesting and unique physical properties, and stability of the amorphous state is of great importance in order to maintain these properties.

Matyja and co-workers are concentrating their efforts on the question of stability. Factors affecting the transition from the glassy to the crystalline state are being examined in various alloys. Also, the effect of various technological parameters of amorphous metal formation, such as cooling rate, atmosphere, and the material of the quenching surface (heat sink), are being gauged in an effort to rationalize divergent results in various laboratories. Techniques being applied to the study of crystallization phenomena include TEM, calorimetry, and x-ray diffraction. The "structure" (or lack thereof) of amorphous materials can be evaluated by sophisticated x-ray techniques, but Matyja relies mostly on examination of electron diffraction patterns. The techniques used may not be the ultimate in sophistication, but are expedient and serve the aims of the research, which are first and foremost to assess the correlations between process variables and properties that are of major importance relative to technological control. There is, for example, very little published work

on rapidly quenched alloys in which the basic process variables (e.g., the cooling rate) are well-characterized, and Matyja and co-workers are trying to bridge this gap.

I concluded during my visit that there are two main obstacles to performing world-class metallurgy research in Poland. First, there is some shortage of grade A equipment, as much of this is made in the West and therefore relatively difficult to acquire. The facilities at Warsaw are all the more impressive given this situation. The second problem is to recruit and retain highly qualified research people at the universities. Places for graduate students and postdoctoral researchers are limited, and the financial remuneration is less than for industrial positions. Even a full professor will receive only about 15,000 Zl (about $600.00 per month), while the average researcher is getting only about 4500 Zl (about $180.00 per month). There is heavy government pressure to do applied research, and so Polish metallurgical research therefore could not and does not attempt to cover the whole range of materials problems but rather emphasizes selected "main problem" areas that have been suggested to a national board by a group leader (e.g., Wojciechowski) and accepted for support. There are relatively few centers for metallurgy research in Poland, but the groups at these few tend to be quite large. This seems sensible as it keeps the talent from being spread too thin. There are only three "Metallurgy" departments in Poland, at Krakow, Czestochowa, and Katowice; these departments have their historical bases in mining and extractive metallurgy, but now do research on physical metallurgy, and do it very well indeed. There are also several "Materials Science and Engineering" groups in Poland, such as the one at Warsaw, described here. These latter groups have been created more recently, often by combining several appropriate institutes at a given university, and tend to be more attuned to modern metallurgy than the metallurgy departments per se. (Jeff Perkins)

MEETING IN STOCKHOLM: SURFACE AND COLLOID SCIENCE

The Third International Conference on Surface and Colloid Science, 20-25 August 1979, was very well attended and truly international. About 450 scientists from 34 countries came together in Stockholm, Sweden. In addition to the expected Scandinavian contingents and large groups from other western European countries, there were sizable numbers from eastern Europe (17 from the USSR), and even a representative from the People's Republic of China. The official language of the Conference was English, but there were obviously many different accents.

The meeting was hosted by the Swedish Institute of Surface Chemistry (Director, P. Stenius) and took place in a large convention center at Massan, just outside of Stockholm. This caused some complaints among the attendees, who were dispersed in many hotels in Stockholm and had to commute to the meeting. There were also many comments on the high registration fee of $200-235, which didn't even cover the cost of coffee during the breaks. Needless to say, prices are high in Stockholm, and punitive for smokers and drinkers.

Although the meeting was listed as the third in a series, it is the successor to the many earlier meetings of the Comité International de Détergence (CID). The frequency of conferences has increased in the last decade largely because interest in surface science has increased tremendously during this time. Most of the recent developments have been in the area of the solid/gas interface, where new instrumental methods [e.g., electron spectroscopy for chemical analysis (ESCA), low energy electron diffraction (LEED)] have provided a wealth of information about the fine structure of solid surfaces. There have also been well publicized advances in our understanding of biological surfaces and membranes (e.g., immunology). This meeting touched on some of these aspects, but focused mainly on liquid systems (e.g., micellar systems, polymer colloids, solid dispersions in liquids, thin liquid films). The theoretical and technical advances in liquid systems have not been great in the last few years, and the

interesting new material was in the area of applied surface chemistry (e.g., techniques in enhanced oil recovery, adhesion, wetting, and medically related developments).

The four plenary lectures were: J.Th. Overbeek (Utrecht, The Netherlands), "The Rule of Schulze and Hardy;" K. Shinoda (Yokohama, Japan), "Conceptual Progress in Surfactant Solutions;" E. Matijevic (Potsdam, NY), "Colloid Chemical Aspects of Corrosion of Metals;" and B.V. Derjaguin (Moscow, USSR), "Structural and Thermodynamic Peculiarities of the Boundary Layers of Liquids." The presentations were largely reviews except for that of Matijevic, who projected colloid and surface chemistry into the area of corrosion, the domain of electrochemists and material scientists. He has found that while the initiation of corrosion is electrochemical in nature, the mechanisms and the particular products can best be studied by the methods of colloid chemistry.

Except for the four plenary lectures, there were three parallel sessions for the entire meeting and it was necessary to make choices. This was especially difficult in the case of the 12 invited lectures, many of which were scheduled to conflict with one another. However, two reporters were present, and we were able to achieve a reasonable coverage of the papers in the various symposia. The present article deals with micellar systems, polymer colloids, and thin liquid films and bimolecular layers. The following article deals with oil recovery, wetting, and adhesion.

The symposium on micellar systems ran for three days and covered all aspects of the subject: formation, effects of additives, counter ion binding, size and shape of micelles, inverted micelles, microemulsions, and reactions in micelles. The papers tended to be largely review, with the exception of those devoted to applications. A particularly good example of an applied study was a paper given by N.A. Mazer (MIT) on micelle formation in bile and physical aspects of the formation of gallstones. From light-scattering studies it was possible to draw some conclusions about the conditions leading to the precipitation of stones, and also the location of bile salts in lipid bilayer structures.

The papers on polymer colloids were better balanced between the old and new, i.e., reviews of basic studies and recent applications. The invited lecturers described the characterization of latex particle surfaces (J.W. Vanderhoff, Lehigh Univ., PA) as well as the biomedical applications of polymeric microspheres (A. Rembaum, JPL, Cal Tech). It appears that microspheres of about 0.01-8 μm can be tagged with antibodies and used as markers for specific receptors (antigens) on cell membranes. Labeling with magnetic microspheres has led to the separation of cells using magnetic fields. Drugs can also be incorporated in carriers of colloidal size, and used for drug delivery (P. Speiser, Zurich, and R.M. Fitch, Univ. of Conn.).

During the last two days the symposium on thin liquid films and biomolecular lipid layers covered developments in both theory and applications. Among the theoretical papers on thin films were the invited lecture by I.B. Ivanov (Sofia, Bulgaria) on dynamic behavior, and papers by H.T. Davis (Univ. of Minnesota) on stress, and J. Lucassen (Unilever, Port Sunlight, UK) on disjoining pressure, contact angle, and line tension. A paper presented by W. Fox (Oakland Research Assoc., NY) reviewed some of the older work on thin-film stability, emphasizing the conservation of edge forces as a principle in determining the contacts between liquid phases.

A motion picture by M. Dupeyrat, E. Nakache, and Michel (Université de Paris VI), added at the last minute to fill a vacancy in the program, demonstrated systems in which one can observe oscillations of interfaces. Followers of the literature on dissipative structures, who have referred to Benard cells and the Zhabotinsky-Belousov reactions as the two known examples, can now mention the oscillations that occur at an interface (e.g., water/nitrobenzene) when concentration gradients of surfactants and salts are allowed to equilibrate by diffusion across the interface.

In the section on biomolecular films, S. Nir (Roswell Park, Buffalo, NY) discussed the aggregation and fusion of vesicles, and M. Blank (Columbia Univ., NY) addressed the problem of the thickness of an interface. It appears that several physical properties of films show discontinuities

at a thickness comparable to that of the natural membrane. Could the membrane thickness be the result of an optimization process?

One of the solid accomplishments of this conference was the decision (taken at a well attended special meeting) to form an international association of colloid and interface scientists that would continue these meetings in a formal way. For further information about the proposed society, contact Dr. G.D. Parfitt, Tioxide International Ltd., Stockton-on-Tees, TS18 2NQ, UK. Ratification of the proposed structure is scheduled for the next meeting, which will be held in Jerusalem, Israel, the summer of 1981. Details about the meeting can be obtained from Prof. A.S. Kertes, Chemistry Department, Hebrew University, Jerusalem. Kertes has indicated his interest in giving equal emphasis to applied and to basic aspects, and welcomes suggestions about the program. (Martin Blank, Columbia Univ., NY)

MORE FROM STOCKHOLM: WETTING, ADHESION AND OIL RECOVERY

We continue our description of the 3rd International Conference on Surface and Colloid Science in Stockholm, Sweden, with a review of the symposia on adhesion and wetting and on surface phenomena in enhanced oil recovery which ran concurrent with the symposia described in the preceeding article.

The meeting on adhesion and wetting was rather disappointing. The subject matter of the papers was too diverse for the sessions to command audience continuity. Also, the quality of many of the papers left much to be desired, although (mercifully) there were some gems. One of the better papers was the invited lecture given by Prof. D.H. Everett (Univ. of Bristol, UK) in which he presented a very lucid derivation of the Young and Laplace equations, starting (as had Willard Gibbs) with the Gauss equation first presented in 1829. Everett suggested that Gibbs had said it all and that everything since has been embroidery (or misinterpretation of Gibbs). As he went through the analysis, Everett showed where surface roughness, surface tension gradients, liquid/liquid displacements, and spontaneous jumps through pores could be introduced.

The adsorption of water on clean quartz, a topic that never fails to produce controversy, was the subject of a number of papers. Dr. D.M. Pashley (with retired Prof. J.A. Kitchener, Royal School of Mines, Imperial College of Science and Technology, Univ. of London) described work in which they used ellipsometry to monitor film thickness. Although electric double-layer theory will allow a film thickness in equilibrium with the near-saturated vapor of a few 10s of angstroms, Pashley reported much thicker films: 100s of angstroms. The quartz must be meticulously cleaned of organic contamination, otherwise a much thinner equilibrium film is formed. At saturation, Pashley reported that droplets of water stood on the adsorbed film, which implies that there is a difference between the molecular organization of water in the continuous film and that in the droplets, the latter presumably having the structure of ordinary bulk water. Pashley was thoroughly quizzed on his procedures, but he defended himself admirably. Dr. B.V. Derjaguin (Inst. of Physical Chemistry, USSR Acad. of Sci., Moscow), who has claimed for many years that the adsorbed water on quartz and on amorphous silica is "peculiar," spoke in high praise of the work by Pashley and Kitchener. Later in the week, Derjaguin presented work that he had done 30 years earlier on the thermosmosis of water and polar organic molecules through porous silica membranes. He claims that when the pores are very narrow, the diffusion rate indicates thick boundary layers with molecular organization different from the bulk liquids.

Two other excellent papers were presented in the wetting and adhesion sessions, by Dr. J.A. Tallmadge (Drexel Univ., Philadelphia, PA) and Dr. L.T. Drzal (USAF Materials Laboratory, Dayton, OH). Tallmadge described his work on dynamic menisci in liquid coating operations. He has developed some ingenious devices for observing the coating of liquid films onto continuously and rapidly moving surfaces by dip coating, doctor blade coating, or bead coating (where the liquid is "pulled" from an adjacent reservoir by the moving surface). Tallmadge has been able to model these processes, and has developed analysis to predict coating thickness and the onset of

flow and capillarity instabilities which cause uneven or intermittent coatings.

Drzal described his work on the surface properties of graphite fibers. In addition to reviewing his gas adsorption studies to characterize the chemical construction of the fiber surface, he discussed recent measurements of the interfacial shear strength between matrix resins and single fibers. He is beginning to be able to relate the shear strength to the surface properties of the fibers.

The symposium on surface phenomena in enhanced oil recovery (EOR) commanded a faithful audience including both engineers and scientists involved in oil recovery research and technology. As a result there was much enthusiastic and sometimes heated discussion, especially when the field engineers questioned the relevancy of some of the scientific studies.

In this era of declining oil supply, the intense interest in EOR is not surprising. From a given oil reservoir, natural pressure releases only 20-30% of the total oil in place. Secondary recovery by water flooding is limited to 30-50%, leaving as much as 50% of the original oil trapped in the tortuous pore structure of the sand and clay reservoir. In tertiary oil recovery, another name for EOR, an aqueous surfactant solution is pumped into the reservoir to loosen the trapped oil, which is then pushed out of the well by pumping drive water in after the surfactant solution. As simple as this process may seem, the surface chemical and hydrodynamic complexities of displacing the oil and getting it to the surface are formidable. The displacement process requires several years before there is any production. This long time frame detracts from the economic viability of EOR, as does the high cost of the chemicals, which increase right along with the price of oil. Much of the current research and development is aimed at reducing the recovery time and minimizing the use of expensive chemicals.

In an invited lecture, Dr. J.J. Tabor (Petroleum Recovery Research Center, PRRC, New Mexico Inst. of Mining and Tech., Socorro) reviewed the history of EOR and predicted future research directions. As explained by Tabor, the first step in EOR is the mobilization of the blobs and ganglia of oil by the emulsifying action of the surfactant. The surfactant also adsorbs onto the pore walls to make them preferentially water wet so that the water can displace the oil. Actually, the injected surfactant solution becomes mixed with brine in the reservoir so that the mobilizing solute has a high salinity.

The study of residual oil displacement from porous media has come to be called "blob mechanics." It includes theoretical modeling, as in the paper by Dr. N.R. Morrow (PRRC), and experimental studies that can be as simple as observing oil/water displacement in glass capillaries, as in the work reported by Dr. J. Pinter (Lorand Eotvos Univ., Budapest, Hungary) and Dr. E.L. Neustadter (British Petroleum Research Centre, Sunbury-on-Thames, UK). More often, experiments are with actual reservoir cores or with sand cores, as in the work by Dr. P.K. Shankar and Prof. F.A.L. Dullien (Univ. of Waterloo, Ontario, Canada) who use dye adsorption to monitor changes in the wettability of the core. There was some criticism of studies using glass capillaries as being unrealistic models of porous reservoirs. Neustadter responded that it is necessary to establish first principles in order to understand displacement processes in complex cores.

Bench and field studies have established that oil mobilization is optimum when the surfactant creates extremely low oil-water interfacial tensions (IFT): 0.01 dyne/cm or less. At these ultralow IFTs the emulsification process (oil in water, water in oil, or both, depending on many factors) is very efficient. One of the best papers on ultra-low IFT was given by Dr. D.O. Shah (Univ. of Florida, Gainesville) who reported that in oil-brine systems containing commercial petroleum sulfonate surfactants (ghastly mixtures of alkaline soaps of sulfur-containing petroleum acids with petroleum hydrocarbons), the minimum IFT (0.001 dyne/cm) occurred when the surface charge density at the interface is a maximum. When the aqueous phase is brine, the IFT is even lower. Shah stated that in some cases ultralow IFTs are associated with liquid-crystal formation at the interface.

These ultralow IFTs cannot be determined using conventional methods but are measured by the rotating

drop technique. A narrow glass capillary is filled with the aqueous phase and a drop of oil is suspended at the center of the tube. The capillary is rotated around its long axis causing the drop to elongate; the IFT can be calculated from the extent of elongation at a given speed of rotation. Dr. A. Capelle (Chemische Fabriek Servo B.V., Delden, The Netherlands) was highly critical of the rotating drop method for crude oil-brine systems, because of the long time required to make the test. In the test, the two phases are in equilibrium, or at least there is a steady-state condition at the interface; in actual reservoir displacement, steady-state conditions do not exist. Hence the test IFT may be much lower than the IFT during mobilization. Neustadter made a similar point when he showed (in capillary tube experiments) that flow resistence is affected by dynamic interfacial effects such as surface tension gradients created by dilation of the adsorbed film and interfacial viscosity.

One of the more interesting papers of the symposium was on a light-scattering study of adsorbed films at oil-water interfaces given by Dr. D. Langevin (Laboratoire de Spectroscopie Hertzienne de l'E.N.S., Paris, France). She claims that the technique can be used to measure ultra-low interfacial tensions, perhaps as low as 10^{-6} dynes/cm. Langevin obtains different IFTs depending on whether the measurement is made through the oil phase or the aqueous phase. If this observation is not an artifact, it would indicate that the technique is sensitive to differences in the chemical environments on the oil and water sides of the film.

As the oil is displaced, it is simultaneously solubilized by the surfactant. The surfactant forms micelles, small spherical clusters of soap molecules with the organic part in the interior and the polar groups on the exterior, and the oil molecules "dissolve" in the nonpolar core. The micelles become swollen with solubilized oil and a microemulsion is formed. Since the surfactant is also soluble in the oil, the inverse process can occur; the water is solubilized into the polar core of micelles in the oil. In practice oil-in-water emulsions are preferable since they coalesce more easily.

Prof. F-H. Eicke (Univ. of Basel, Switzerland), in an invited lecture, reviewed the subject of microemulsions and their role in EOR. Langevin, again using laser light scattering, described how, from scatter intensity measurements, the osmotic compressibility and friction force between particles in microemulsions can be measured. Dr. E. Gulari (Univ. of Michigan, Ann Arbor) has used quasielastic light scattering and found a polydispersity of particle size in microemulsions. The range in size is 50-300 Å. X-ray techniques have only been recently applied to microemulsions pertinent to EOR, and Dr. S.S. Marsden (Stanford Univ., CA) reviewed this work.

Once mobilized, the emulsified oil must be reconstituted into a continuous oil phase, called an oil bank, before it can be moved by the drive water. It was pointed out by a number of speakers, beginning with Tabor in his review, that forming the oil bank is the crux of EOR. If the bank does not form, or if it is not large enough, the drive water fingers through the emulsion and free oil, and recovery is nil.

It seems a contradiction in terms that a surfactant solution must readily emulsify the oil and then release it by coalescence into two phases. Nonetheless phase diagrams for surfactant-oil-brine systems show concentration regions for three-phase equilibrium. Besides the oil and water phases there is the "middle" phase comprised of all the constituents. The structure of the middle phase is quite controversial but is probably a complex of pockets of oil and water separated by rigid surfactant-oil-water bilayers. The middle layer can be rigid enough to act as a membrane between the oil and water phases to inhibit fingering and water penetration during the drive process. On the other hand, too viscous a middle layer will inhibit flow throughout the reservoir.

The art of designing a good chemical flood was discussed by Dr. R.C. Nelson (Shell Development Co., Houston, TX). He emphasized the fact that reserviors differ considerably in the salinity of the brine, and different sands and clays have different multivalent cations which precipitate surfactants. So the chemical flood must be designed to compensate for these and other variables. Nelson introduced what he calls "salinity requirement

diagrams," concentration maps showing the salinity, surfactant concentration, and concentration gradient in the reservoir for optimum recovery.

An alternate to using petroleum derived surfactants in the chemical flood is to inject alkaline solutions (pH~11) that react with the organic acids in the oil to generate surfactant *in situ*. Dr. T.P. Castor (Univ. of California, Berkeley) reviewed the use of alkaline chemical floods and noted that, like conventional surfactants, the surfactants formed *in situ* reduce the IFT (but not much below 1.0 cyne/cm) and alter the wetting characteristics of the reservoir walls. He detailed some of the complexities of the mechanisms involved that are no less than for surfactant chemical floods. Dr. T.C. Campbell (PQ Corporation, Lafayette Hill, PA, formerly the Philadelphia Quartz Co.) talked on the liquid alkaline sodium silicates, $Na_2O(SiO_2)_n$, being used for chemical flooding, notably at the Huntington Beach Field, CA. In addition to the emulsifying and wettability effects of the surfactants that they generate, the silicates control water hardness by precipitating divalent cations. Some crudes have insufficient acids or natural surfactants to be amenable to alkaline floods. Campbell described the use of silicates in combination with organic surfactants where it is possible to get much lower IFTs than with either agent alone. Also, the silicate adsorbs on the core walls thereby reducing the amount of surfactant needed in the flood.

In recent years, the concept of following the chemical flood with injections of aqueous solutions of polymers (such as polyacrylamides, polysaccharides, or polyethers) has been tested in both the laboratory and the field. These polymers are sometimes referred to as mobility control agents, since by *in situ* gelling or crosslinking they are supposed to correct for gross heterogenities in the reservoir such as high permeability streaks and underlying water banks. They may also serve to stabilize the chemical flood by reducing its back diffusion. Castor spoke about the degradation of these polymers by mechanical stress, electrochemical action, thermal stress, and biological action. He is developing tests to evaluate the resistance of candidate polymers to these stresses. Dr. M.J. Faber (Koninklijke/Shell, Rijswijk, The Netherlands) has been investigating the effect of the polymers on the surfactant-brine-oil phase behavior. He finds these effects to be quite significant, to the extent tha a fourth axis is needed on the phase diagram.

The symposium left one with the impression that much progress is being made in EOR, but its ultimate success and economic viability is still in the balance. In this writer's opinion, mos of the progress has been on the engineering side, with the scientists struggling painfully to understand the complex processes that take place in the reservoir. (Willard D. Bascom)

POLYMER NETWORKS

The 9th Europhysics Conference on Macromolecules was held in Jablonna, Poland, 23-28 April 1979, and was sponsored by the Networks Group of the European Physical Society, the Polish Academy of Science, and the Polish Physical Society. The meetings were held in the Jablonna Residence, a smal palace built in 1775 by Primate Michal Poniatowski, a brother of the King of Poland. Later it was inherited by the Primate's nephew, Prince Jozef Poniatowski, who distinguished himself as a military figure in the war for independence (from Russia and Austria) Legend has it that Prince Jozef distinguished himself socially as well as militarily (in fact, he is thought to have been something of a "swinger") and that the palace saw some very live times during his residence. The palace was almost destroyed when its art treasures were looted and the interior put to the torch by the retreating Germans in 1944. Happily, the gutted palace became a national property in 1945 and today much of the 18th century decor has been restored.

The Conference was organized into invited lectures and poster presentations. Unfortunately, the lecture hal was too small to accommodate the unexpectedly large attendance. Also, th room in which the posters were displayed was much too small, and the crowd of viewers made it very difficul to study the posters or talk with the authors.

This year's subject was, "Structure and Properties of Polymer Networks". Polymer network theory (PNT) is primarily concerned with polymers in the rubbery state, above the glass transition temperature (T_g). The stress required to extend rubber is determined only by the entropy change (the change in enthalpy is negligible). Consequently, the stress-strain behavior depends on the change in configuration of the molecular chains, and the chain configurations can be treated statistically, as a Gaussian distribution. There is a large amount of literature on the subject dating back to the 1930s.

In PNT the rubber polymer is modeled as a network of random chains which, like a mass of intermingled strings, change their configuration in response to an applied stress in an "affine" way. The term affine means that the vector length of each chain changes in the same way as the corresponding dimensions of the bulk material. A point of contention right from the beginning, still evident at the Jablonna Conference, is the question of entanglements. Given the great length of the polymer chains, there is no question that they will become intertwined with each other. What is not clear is whether these entanglements are of any consequence in determining the elastic stress-strain behavior of the polymer.

Dr. Ole Kramer (Univ. of Copenhagen, Denmark) gave a very instructive review of the role of entanglements in PNT. In the case of uncrosslinked polymers, stress relaxation experiments at relatively short times indicate a nearly constant modulus (a rubber plateau). This modulus is thought by some to be caused by chain entanglement, and assuming a Gaussian distribution of chains, a concentration of entanglements can be calculated. However, the detailed picture of the nature of an entanglement coupling is lacking, and the calculation of an entanglement concentration is held suspect by some.

Upon the introduction of a few chemical crosslinks, it is found that the measured modulus is greater than the theoretical value, and it is often assumed that this difference is caused by entanglements trapped between crosslinks being more effective than in the uncrosslinked rubber. In principle, it should be possible to calculate the entanglement contribution. However, this computation requires controversial assumptions about how these junction points respond to the applied stress. The problem becomes a little easier if the polymer is highly crosslinked since then the entanglements definitely become trapped between crosslink points and must contribute to the model (they cannot be untangled by slippage or molecular fluctuations). The relative contribution of chemical crosslinks and physical entanglements to the rubbery plateau model can be obtained by the "two network" method. An uncrosslinked polymer is crosslinked (usually by irradiation) under an applied strain, and, from a comparison of the initial and postcrosslinked strain, the contribution of crosslinking and entanglements can be distinguished. Kramer cited some results of this type which do indicate that the rubber plateau modulus in the uncrosslinked state is indeed the result of physical entanglements.

Nobel laureate Paul Flory (Stanford Univ.) does not agree with much of the conventional wisdom about polymer networks and the role of entanglements. In his view there are two ideal model networks that represent the extremes of behavior. One is the "phantom" network which is uncrosslinked and in which entanglements play no role at all. The other is the affine network which is so highly crosslinked that trapped entanglements so constrain the crosslink junctions that they must undergo affine displacements. Flory discounts any role for entanglements in determining the rubbery plateau modulus which he believes is caused solely by changes in the conformational entropy of the chains. He states in his abstract, "The suggestion that one or two entanglements incident on a single chain can be singled out as elastically effective is an artifice without foundation...." Flory does concede, however, that entanglements may affect the fluctuation of the chains in a phantom network, i.e., the possible chain configurations, and thereby contribute to the modulus. The real role of entanglements, as Flory sees it, is their restraint on the fluctuations of crosslink points. In highly crosslinked rubber their restraint is so great that the crosslinks undergo affine displacements in the macroscopic sense, i.e., the affine network. However, models of

the phantom and affine networks can only account for two extremes of rubber elasticity. It is the middle ground that Flory has attacked by introducing the notion of domains of constraint on crosslink fluctuations. The domain distribution is taken to be Gaussian, the deformation of their centers is affine, and the domains are deformed by the applied strain. This model is better able to account for certain aspects of rubber elasticity than the phantom or affine models.

The two-network method for investigating rubber elasticity was discussed in detail by Dr. J.D. Ferry (Univ. of Wisconsin), who has been using this technique for many years to determine the role of entanglements. He was careful to be nonspecific about the molecular nature of entanglements, referring to them as topological constraints evident in rheological behavior and various other phenomena. He showed how the assumption in the two-network theory that the properties of the networks are additive can be tested by using it to predict stress-extension behavior, and gave examples of theoretical results giving excellent fit to experimental data.

For deformations sustained over long times, the network is essentially at equilibrium, and the dynamics are dominated by collective motions of large sets of junctions. Dr. G. Ronca (Polytechnic of Milan, Italy) has treated both the phantom and the constrained network cases using a many-body Langevin equation in which junctions are considered as independent particles interacting with one another. The model is exactly solvable for a solvent-swollen network and leads to a nonlinear viscoelastic constitutive equation. For constrained networks, the crosslink points are conceived as heavy interacting particles diffusing at a slower rate than the surrounding fluid. In this case multiple entanglements must be included in the model, making it necessary to assume substantial coupling between deformation and junction fluctuations.

"Applying Occam's Razor to Entanglements" was the title of the lecture by Prof. Manfred Gordon (Univ. of Essex, Colchester, UK). Gordon argues that much of the past development in PNT was unnecessarily complicated, especially in dealing with entanglements. As he sees it, the complicating factor has been the embedding of the model in a continuum. Treating networks as a graph-like state of matter would have greatly simplified the arguments. However, it could not have been obvious that the embedding media could be ignored in the initial PNT development, nor is it obvious that it can be safely ignored in future development which seeks to create more realistic models.

Classical elastomers, such as natural rubber, are chemically crosslinked and also contain minute carbon particles that create additional crosslinks by physical or chemical adsorption of the polymer chains on the particle surface. Another type of rubber has come on the scene in recent years, the thermoplastic elastomers—block copolymers in which the polymer chains have alternate segments of different chemical structure. One of the segments is associated as hard inclusions within a matrix of the other (soft) segment. The hard inclusions act as crosslinks and filler. Dr. R. Bonet (Univ. of Regensburg, FRG) discussed the thermoplastic elastomers in terms of conventional PNT. His essential point was that PNT will have difficulty with these materials largely because the modulus and size of the hard-segment domains are a function of the temperature and strain. It becomes something of a gamble to specify the state of the network even as a function of strain. As the elongation is changed, chain segments can move in and out of the hard inclusions.

The crystallinity of polymers can have profound effects on their behavior. To a first approximation, crystal regions in an otherwise amorphous network will act as crosslink points much as the hard domains in thermoplastic elastomers. Prof. A. Keller (Univ. of Bristol, UK) discussed the role of crystallinity in network formation and began by emphasizing the varied crystal morphology that can develop when the network forms. For example, the composite fiber-platelet morphology that develops when a polymer melts is allowed to flow during cooling (shish kabab structure, *ESN* 32-8:271, 33-3:96). Keller then turned to the recent and rather significant discovery that rapidly cooled solutions of polyolefins form gels, in contrast to the formation of a turbid solution of small lamellar crystals when the cooling is slow.

He suggested that gels develop because of the formation of fringe micelles (local associations of a few chains oriented parallel to one another) which act as gel network crosslink points much like the hard segments in thermoplastic elastomers. The thermoplastic elastomers are, of course, deliberately designed to be chemically inhomogeneous. Keller has postulated that the gel formed by homopolymers during rapid supercooling actually reflect chain inhomogeneity; there are "mistakes" in the chain sequence that can associate into micelles more quickly than chain-folded lamella can develop in a rapidly cooling solution. Keller admits there are some controversial aspects of his explanation, but it would appear that polymers can be crystallized into unusual conformations, possibly with new and commercially useful properties.

A polymer gel consists of a crosslinked network immersed in a fluid medium. The gel can be collapsed, sometimes reversibly and other times not, by a change in temperature or by changing the chemical nature of the immersing fluid. Dr. T. Tanaka (Massachusetts Institute of Technology) described his studies of the collapse of polyacrylamide gels when equilibrated with acetone/water solutions at different temperatures. He has been able to analyse the results as a critical phenomenon quite analogous to critical phenomena in vapor/liquid systems. Indeed, he calculated gel osmotic pressures which, when plotted against gel volume, gave isotherms similar to vapor/liquid PVT curves. From the gel isotherms, Tanaka is able to reproduce the form of the experimental temperature vs gel volume fraction data, including a critical temperature for gel collapse. This work may have applications to physiological phenomena such as vitreous collapse in retinal detachment.

Polymeric gels are not perfect networks, but have a significant fraction of imperfections, notably loops and other ring structures formed by intramolecular reaction, that disturb a simple Gaussian chain distrubution. Loop formation occurs in both bulk and solution polymerization, and most of these defects form during the pre-gelation stage. Usually the extent of imperfection is unknown, but Dr. R.F.T. Stepto (Univ. of Manchester, UK) has been carrying out polymerizations in which the amount of ring formation is known. Most of his work has been done with polyurethanes or polyesters. Pre-gel intramolecular reaction is a function of the concentration of the reactant and the functional groups/unit volume. This quantity can be related to a parameter characterizing the competition between intra- and intermolecular reaction. Measured values of the ring structure fraction and the extent of reaction at gelation can be explained in terms of rate theories or cascade theories. There are, however, as Stepto, pointed out, inconsistencies between the two theories in predicting ring size.

Dr. J. Ball (Cambridge Univ., UK) presented a lecture on the hierarchy of network problems—a hierarchy of increasing mathematical difficulty but also of increasing interest and reality Ball attended in place of Sir Sam Edwards, who has contributed considerably to PNT, especially on the question of excluded volume owing to chain self-repulsion.

The PNT based on chain distribution probabilities is applicable to materials in the rubbery state at temperatures above T_g. The polymerization or the mechanical properties of highly crosslinked polymers like the epoxys or thermosetting polyesters cannot be treated as a system of random chains with limited restraint, especially at temperatures below T_g where they are normally used. The high density of permanent crosslinks in a thermoset severely restrict chain motion. However, the problem is simplified by the fact that there are only a limited number of configurations that can form. For a tetrafunctional monomer, for example, crosslinks with zero to three dangling chains or loops can form along with unreacted monomer and isolated loop structures. In principle, by designating all possible combinations, one can model these thermosets. Dr. A. Ziabicki (Lab. for Polymer Physics, Polish Academy of Sciences, Warsaw) who was the Conference organizer, reviewed the work on this topological approach to crosslinking. He took as an example an assembly of nine junctions (tetrafunctional monomer) and showed that even this small number leads to cumbersome matrix analysis, and that it is necessary to devise statistical distribution functions of the various types of connections. The admissible number

of structural elements can be restricted on the basis of chemical mechanisms and kinetics as done by Edwards, or on the basis of thermodynamic optimization as in Ziabicki's work. However, Ziabicki admitted that the thermodynamic approach has been less useful.

Another way of modeling highly crosslinked polymers is by computer simulation as a self-interacting random walk on a 3-dimensional lattice. This technique was the subject of the talk by Dr. A.M. Elyashevich (Inst. of Macromolecular Compounds, Academy of Sciences, Leningrad, USSR). He discussed the simulation of network formation under the condition that with each crosslink formation there is a complete rearrangement of the network conformation. In addition, it is possible to imitate entanglements, the deformation of the network, and to simulate polymer chain mobility.

The attention being given in the USSR and Eastern European countries to highly crosslinked networks greatly exceeds that in the West. Besides the invited lecture by Elyashevich, there were seven posters presented from the USSR on highly crosslinked systems (none from the West). In a poster by A.A. Askadsky (Inst. of Organo-Element Compounds, Acad. of Sciences, Moscow, USSR), he showed how the chemical structure of epoxy-polyacrylates, polycyanates, and polyphenylquinoxalines can be selected to eliminate creep at high strains. There were three posters that were all authored by B.A. Rosenberg, E.F. Oleinik, V.A. Topolkaraev, and their co-workers (Inst. of Chemical Physics, Academy of Sciences, Moscow, USSR) on the curing process and mechanical properties of epoxys. In one presentation they reported on an epoxy system in which the cross-link density can be varied with only minimal variation in the chain chemical structure. From measurements of relaxation behavior and other mechanical properties, they concluded that the fluctuation in "hole size" increases with increasing crosslinking density. Rosenberg reported that the stress relaxation behavior of an epoxy polymer specimen changes with successive tests; he attributed this to chain rupture and changes in network configuration. The Institute of Chemical Physics group reported that the cure conditions could have a large effect on the mechanical properties depending on where, with respect to the vitrification/gelation map, the cure took place. Topolkaraev used a statistical model of a highly crosslinked polymer to analyse the fracture behavior of an epoxy-amine polymer in the rubbery and glassy states.

J.P. Tsyurupa (Inst. of Organo-Element Compounds, Academy of Sciences, Moscow, USSR) reported on some curious "macronet" polymers formed by solution crosslinking of polystyrene via Friedel-Crafts reaction. When removed from the solvent the network collapses, but the dry powder can be reswollen to increase in volume by factors of 3-4. Yet the swelling agent need not be chemically compatible with polystyrene. Tsyurupa suggests that a cyclic structure is formed which is highly stressed when collapsed and that this internal strain allows swelling even against network/solvent incompatibility.

Overall, the poster contributions covered a wide range of theoretical and experimental topics including interpenetrating networks by Dr. L.H. Sperling (Lehigh Univ., Bethlehem, PA) and Dr. J. Foks (Tech. Univ. of Gdansk, Poland); a study of chain mobility in polyethylene using nuclear magnetic resonance by Dr. F. Plumer (Karl Marx Univ., Leipzig, DDR); and molecular relaxation using thermal-polarization spectroscopy by Yu.V. Zelenev (The Moscow Textile Inst., USSR); and two presentations on the free-radical crosslinking of thermoplastics: polyvinylchloride by K.A. Kumery (Inst. of Fundamental Technological Research, Warsaw, Poland) and polypropylene by I. Chodak (Polymer Inst. of the Slovak Academy of Sciences, Bratislava, Czechoslovakia). (Willard D. Bascom)

MEDICINE

DIFFUSE PULMONARY HEMORRHAGE AND CARBON MONOXIDE UPTAKE

Diffuse pulmonary hemorrhage at the capillary level is caused either by a vasculitis or a deficiency of clotting factors. In the former condition the pathology is the result of several unusual but particularly

troublesome and poorly understood diseases. These diseases, which have been lumped together by some authors into the pulmonary-renal syndrome, have in common a vasculitis with capillary hemorrhage in the kidneys and lungs and a derangement of the immune system. The most common of these is Goodpasture's syndrome, a complex illness named after Ernest Goodpasture, who initially described the syndrome in a patient during the height of the 1918-1919 influenza pandemic. In his case pulmonary hemorrhage and nephritis were found at autopsy. Other diseases that are part of the pulmonary-renal syndrome include polyarteritis nodosa, lupus erythematosis, penicillamine hypersensitivity, and idiopathic hemosiderosis.

A synonym for Goodpasture's Syndrome in immunologic terminology is antiglomerular basement membrane antibody disease (anti-AGM antibody disease). This immune reaction (type II) is characterized by the production of antibodies against the patient's own renal glomerular basement membrane. These antibodies are predominently IgG- and IgM-dependent, cytotoxic tissue-specific, and can be demonstrated by immunofluorescent techniques. The same antibodies can be found in the circulation and it is probable that the damage to the pulmonary alveolar basement membrane is due to cross reactivity with the circulating antibodies. In addition, it has been shown that gamma globulin elutriated from the nephritic glomeruli of patients with Goodpasture's syndrome reacts with normal lung basement membrane. Moreover, gamma globulin elutriated from this lung tissue will then react with normal glomerular basement membrane. The damage can be seen best with an electron microscope. There is diffuse vascular injury with wide endothelial gaps, through which red cells and monocytes can be seen migrating from the capillaries through the basement membrane into the alveolar spaces. The other diseases of the pulmonary renal syndrome are somewhat different immunologically. A type III immune-complex nephritis develops that can also induce sufficient damage to the alveolar basement membrane and capillary endothelium to cause hemorrhage.

Hemoglobin has a strong affinity for carbon monoxide (CO) because of a large number of binding sites for CO on the hemoglobin molecule. Diffusion of a gas from the alveolar spaces across the alveolar-capillary membrane and into the vascular system can be evaluated by measuring the diffusion of CO (D_LCO). The diffusing capacity per unit alveolar volume is termed K_{CO}. Both tests are used clinically in measuring the diffusing capacity across the alveolar-capillary membrane. In patients suffering from any disease leading to thickening and fibrosis of the pulmonary interstitium, the diffusing capacity will be reduced.

The high affinity of hemoglobin for CO was only recently developed in the reverse fashion to its ordinary use, that is, to detect the blood in the lung outside of the vascular system. Other methods for detecting pulmonary hemorrhage are cumbersome and require intravenous injection of red cells labeled with an isotope of cromium (^{51}Cr) or iron (^{59}Fe).

N.B. Bowley, J.M.B. Hughes, W.S. Chin, and R.E. Steiner (Royal Postgraduate Medical School and Hammersmith Hospital, London) have studied a relatively large series of patients with the pulmonary-renal syndrome in conjunction with the CO diffusion test. Because of the development and application of plasma exchange as a therapeutic method of removing circulating antibodies in Goodpasture's syndrome, the Hammersmith Hospital has become a referral center for patients with the disease from all parts of the United Kingdom. Twenty-five patients with Goodpasture's syndrome have been referred to the Hammersmith group. This is an extrordinarily large group of patients with this rare condition to be studied in one institution. All the radiographs of these patients have been evaluated and some analysed in close time proximity with K_{CO} measurements. All except two of the patients had pulmonary hemorrhage at some point in their disease and there were a total of 39 episodes of pulmonary bleeding among the 25 patients. A majority of the patients had symmetrical pulmonary radiographic abnormalities, consistent with hemorrhage, which cleared within 48 hours. However, because of intravenous fluid therapy, pulmonary edema had to be differentiated from pulmonary hemorrhage. Since a number of patients were treated with immunosuppressant drugs, the presence of infection always had to be considered. In ad-

dition, 6 of the patients had unilateral radiographic abnormalities making infection more likely. Of the 39 episodes of pulmonary hemorrhage in the anti-AGM antibody patients, 7 had normal radiographs. Thus, the presence of a normal radiograph does not exclude current pulmonary hemorrhage. In the past iron containing macrophages from the patient's bronchial tree or from the stomach had been considered indicative of one of the diseases of the pulmonary-renal syndrome. Actually, however, iron containing macrophages are not indicative of current pulmonary hemorrhage but of hemorrhage in the recent past.

Thirteen of the 25 patients with Goodpasture's syndrome and 4 with other diseases of the pulmonary-renal syndrome group were analyzed in conjunction with the K_{CO} test.

The 17 cases involved 27 episodes of pulmonary hemorrhage. The K_{CO} rose at some point in each instance. The rise and fall of the K_{CO} was matched in time by the appearance and disappearance of pulmonary radiologic changes in 14 of the 27 bleeding episodes. In 6 the chest radiograph remained normal despite a rise in K_{CO} and in 2 cases the radiologic changes appeared up to 48 hours after the rise in K_{CO}. The chest radiographic abnormalities preceeded the rise in K_{CO} in the remaining 5 cases, but of these, chest infection or fluid overload accounted for 3.

In the diagnosis and management of these complex patients, the onset of new pulmonary signs and symptoms must be carefully evaluated. Pulmonary infection or fluid overload, both of which may be related to the treatment of the pulmonary-renal syndrome, may actually be precipating factors in the exacerbation of pulmonary capillary hemorrhage. Therefore, the chest radiograph is a crucial initial step in their evaluation. If the radiograph is abnormal, hemorrhage, infection, and pulmonary edema must be considered. A rise in the K_{CO} makes the diagnosis of hemorrhage certain but does not exclude the other conditions. On the other hand, a normal K_{CO} rules out pulmonary bleeding with the possible exception of a patient in renal failure whose K_{CO} is expected to be low. Pulmonary hemorrhage in these patients is life threatening but both chest radiography and K_{CO} determinations can be made rapidly. The combination of these two tests allows for an early definitive evaluation of the patient. (Irwin M. Freundlich)

.TOXINS AND TOXINOLOGY

Few areas of biomedicine have enjoyed a more remarkable surge of interest during the past decade than the discipline of toxinology. The 6th International Symposium on Animal, Plant and Microbial Toxins, held in Uppsala, Sweden, 19-24 August 1979, denonstrated the increasing interest in this science. More than 400 members of the International Society on Toxinology and their guests participated in the 5-day program, and as might be expected from an audience comprised of biochemists, pharmacologists, immunologists, biologists, and physicians, the presentations were lively and the discussions thoughtful, although neither appeared to end on schedule (and no one seemed to mind except for a few Uppsalian restaurant owners, who may have felt that the discussions of their patrons should come to an end before 1:00 a.m.).

The science of toxinology became an entity less than 20 years ago. The first international symposium on toxins was held in 1966 at Atlantic City. Since that date the number of published papers on animal and plant poisons has multiplied 6 times. This phenomenal increase in publications can probably be attributed to two factors: 1) the wide use of venoms, or animal or plant poisons (or their fractions), as tools in biology in studying basic biological phenomena, and 2) the use of venom fractions in the treatment of various disease states. The present symposium certainly reflected these two interests. In addition, the more traditional subdisciplines were heeded: what toxins are made of; how they exert their deleterious (or beneficial) effects; their immunological importance; how venom cells produce their secrections; and what the ultrastructure of venom cells looks like, and their possible evolution. Attention along philosophical lines was given to the relationships between structure and function, and the design of venoms in the ani-

mal's armament. Finally, the clinicians were found in their own niche, with a variety of poisonings by snakes, arthropods, and marine animals.

It would be difficult to single out the most interesting of the 82 papers or the 150 poster sessions, since within such a diversified discipline most presentations that the writer was able to attend were interesting and, as a whole, well presented. The synthesis of venom and its secretion in the snake (E. Kochva, Israel) was of particular interest, since Prof. Kochva is one of the foremost authorities on this subject, although as evident from the discussion his views are not universally accepted. The effects of venoms on coagulation was discussed among others, by F. Kornalik (CSSR), and M.C. Boffa (France), with some very pertinent comments by E. Condrea (Israel). Prof. J. Jeljaszewicz (Poland) presented an excellent review on the bacterial activators of prothrombin.

The cytolytic properties of certain toxins were discussed by M. Thelestam (Sweden), J. Freer (Scotland), and R. Seeger (FRG), while interesting posters on the subject included those by S. Shkenderov and colleagues (Bulgaria), D. Lebez (Yugosalvia), and F. Fehrenback (FRG). The effects of various toxins on nerve, muscle, neuromuscular transmission, and ion channels were discussed by M. Olsen (USA), T. Bartfai (Sweden), N. Primor (Israel), D. Eaker (Sweden), J. Harris (England), and A. Grasso (Italy). An extremely interesting poster was that of J. Dolly (England) on specific antibodies against purified actylcholine receptor from denervated muscle differentiate sub- and extra-synaptic forms of the receptor. The structure of the polypeptides having neurotropic effects (the so-called neurotoxins) was discussed by H. Rochat and C. Granier (France) and E. Grishin (USSR), while interesting posters on these polypeptides included those by B. Banks (England), T. Lo (Taiwan), and D. Mebs (FRG).

Toxins and the immune system was the subject of pertinent contributions by G. Pickwell (USA), N. Tamiya (Japan), and D. Matić-Piantanida (Yugoslavia). A special session on "novel toxins" included presentations on tick paralysis (B. Stone, Australia), a marine sponge (L. Cariello, Italy), honeybee venom (M. Owen, Canada), streptolysin (M. Ellessy, Egypt), and various clostridial toxins (T. Wilkins, USA; M. Thelestam, Sweden; and H. Larson, England). In the clinical sessions D. Chapman, A. Reid, and D. Warrell (England), along with W. Wingert, D. Hardy, and F. Russell (USA) and Y. Sawai (Japan), kept therapeutics alive until the late hours of the day. A simple refractometric method for monitoring the course of rattlesnake bites was presented by poster (W. Wingert, USA), and may provide a quantitative method for evaluating the course of a crotalid envenomation.

The sessions on mycotoxins were an added feature of the Symposium. A. Pier (USA) presented a stimulating paper on mycotoxins and immunity, Y. Ueno's (Japan) presentation on trichothecene mycotoxins was most interesting. Lipid A and endotoxins came up for a considerable share of discussion in posters by T. Boiesen (Denmark), H. Raškova (CSSR), R. Urbaschek (FRG), and D. Morrison (USA). The session on enterotoxins indicated that this field alone might require several days of attention at the Society's next international meeting. Papers on the enterotoxins of *E. coli* (D. Robertson, USA: T. Palva, Sweden; and F. Dorner, Switzerland) appeared of particular importance to clinicians.

Discussions on the phospholipids enjoyed the same role as those on the proteases at meetings 20 years ago, or those on the low-molecular-weight peptides 10 years ago. The phospholipids were the "in" session, or at least where the current action is. E. Condrea's (Israel) paper on the hemolytic effect of some snake venoms, as the effect relates to the phospholipases, was an outstanding contribution, as was P. Rosenberg's (USA) paper on prospholipid hydrolysis by phospholipase C in the sarcolema of muscle. F. Gubenšek's (Yugoslavia) poster on the N-terminal sequence of phosphlipase A_2 from *Viper ammodytes* venom and C-C. Yang's (Taiwan) on the histine residue of phospholipase A_2 of *H. haemachatus* venom elicited considerable attention.

To the organizers of this Symposium—Drs. B. Uvnäs, D. Eaker, T. Holme, B. Holmstedt, and T. Wadström—a note of appreciation is in order for providing a most important and stimulating symposium. The organizing committee

left few toxins unturned in making the participants and their guests intellectually and socially satisfied. (Findlay E. Russell, USC, Los Angeles, CA)

OCEAN SCIENCES

PHYSICAL OCEANOGRAPHY AT THE DUNSTAFFNAGE MARINE RESEARCH LABORATORY

Almost 100 years ago, in 1884, the Scottish Meteorological Society set up a marine laboratory on a floating canal barge near Edinburgh. The next year the barge, called The Ark, was beached at Millport on the Isle of Cumbrae off the west coast of Scotland in the mouth of the Firth of Clyde. Research was carried out on the Ark until Millport Marine Biological Station was built in 1897. In 1914 the Scottish Marine Biological Association was formed to take over the management of the Millport laboratory. Between 1967 and 1970 the laboratory was moved to a large beautiful new laboratory located near Dunstaffnage Castle on the west coast of the Scottish mainland near Oban, the vacation center of western Scotland and gateway to the Hebrides. The new complex was renamed after the famous castle nearby.

The Dunstaffnage Marine Research Laboratory has a professional staff of 50, assisted by 38 technical, administrative, and clerical personnel (see *ESN* 27-3:367). There are usually about a dozen graduate students from various universities in residence working on MS or PhD thesis research. Several of the senior staff members lecture at Stirling University with which the Laboratory has close ties. The Director, Professor Ron Currie, holds the chair in oceanography at Herriot-Watt University in Edinburgh.

The Laboratory is largely financed by the Natural Environment Research Council (NERC) as are most of UK's oceanographic research institutions. A substantial proportion of the budget comes from contracts with various industries for carrying out base-line and environmental impact studies. Lesser amounts come from donations by universities and subscriptions of me members.

The Laboratory used to operate the 1400-ton six-year-old research vessel *CHALLENGER*, but she is now part of the NERC fleet, managed by their research vessel center at Barry, Wales. The ship's homeport used to be at the Laboratory's docks, but since has been moved south to Ardrossen near the mouth of the Firth of Clyde. The reason given for the move was that the crew would not tolerate a location two miles from the nearest pub.

Prior to the move to the Oban region, the Laboratory was primarily devoted to classical marine biology. Since then substantial programs in marine environmental impact studies and physical oceanography have been introduced. The latter programs specialize in the western saltwater lochs (fjords) and the ocean in a 600-mile arc north and west of Scotland. Initally the physical oceanographic research was largely carried out in support of programs in fisheries and biological oceanography; more recently it has received funds and impetus in its own right, largely because of the increasing need for various types of environmental data collection on the broad Hebridean continental shelf and the Rockall Plateau further to the west. Both sites have strong potential for petroleum exploration. Experimental equipment for extracting energy from sea waves will also be installed on the shelf. The Rockall Plateau is a shallow (100 m deep) area the size of Ireland, with one promontory, the Rockall Pinnacle, sticking up out of the sea. Great Britain has landed a helicopter on this barren rock, and on this basis claims possession of the entire Plateau which, being hundreds of miles northwest of Ireland, would otherwise be international territory.

The physical oceanography group, called the Marine Physics Department, is headed by R. Bowers, an instrument designer who was with the Institute of Oceanographic Sciences (IOS) at Wormley before joining the Laboratory staff ten years ago. Some of his recent projects include: an automatic Braincon thermograph film reader; a simple, economic, reliable time release for bottom-mounted and bottom-moored anchored instruments; and a modification to the Coulter counter, which converts its measurements of suspended particle sizes to a continous spectrum.

David Ellet is well known for his hydrographic studies over the past 15 years of the areas to the north and west of Scotland. He moved to the Dunstaffnage Laboratory in 1975. He has made a large number of cross sections of temperature and salinity from the Outer Hebrides across the continental shelf to the Rockall Trench and up onto the Rockall Plateau to determine the net transport of water northward through the Rockall Channel. Normally the flow is northwest through the channel with an average value of 3,000,000 m^3/sec, but on occasion the net flow has been southward. He found a strong correlation between the net transport in the top 500 m and the 5-day mean southeast wind component.

In order to determine the flow on the continental shelf he placed a current meter near the edge of the shelf in 1975 and now has over 600 days of meaningful data. The currents were found to be relatively weak here and the shelf water seemed to move independently of the faster flowing waters in the Rockall Channel. During the past year the Department of Environment (DOE) has given Ellet a grant for purchasing several more meters which will enable him to measure currents at different depths and locations on the shelf and in the Channel proper along his Hebrides-Rockall station line. In addition to this hydrographic work, he has also studied the chemistry of the Channel and the detailed topography of the Wyville-Thomson Ridge to the north of the Rockall trench. The latter was part of a project to examine the overflow of deep Norwegian Sea water into the Rockall Channel.

David Meldrum, a physicist who formerly worked at the Scott Polar Research Institute of Cambridge University, was with the team that surveyed the thickness of the Antarctic ice sheet using airborne radar. He is now planning a program of over-the-horizon estimation of sea-surface wave spectra using decametric radar (at ranges up to several thousand miles). The Laboratory is well located for this research as it is in a region with minimal radio interference. Meldrum is currently attempting to implement standardization of biological data at the Laboratory in order to make it more computer-compatible.

David Booth, who recently received his PhD from the Department of Physical Oceanography at the University College of North Wales, is working on a comparative evaluation of production models of current meters to decide which is best-suited for determination of residual currents in continental shelf waters over long time periods. At present he is comparing the Plessey and Aanderaa current meters with VACM's. Booth is also working with Ellet's data from the continental shelf, the Rockall Channel and Plateau, and the Wyville-Thomson Ridge in hopes of extracting valid information on long-term residual currents in the areas. One of his first tasks is to determine the scales that are of interest and the mechanisms to which they are related.

Joe Graham is an electronic engineer who was recently employed to help develop or improve instruments for some of the biologists at the Laboratory. He is working on a tiny instrument to record the heartbeat rate of crabs *in situ* on the ocean floor. A transponder attached to the shell transmits an acoustic signal through the water to a listening hydrophone for each heartbeat. The object is to determine whether the heartbeat rate is a function of environmental factors such as depth, salinity, and water temperature. The transponder is an extension of a fish-tagging device developed at the Univ. of Stirling

Graham's second project is to complete the development of a "fish caller." Captive young fish of commercial varieties are conditioned to respond to sonic signals by swimming toward the sound to be fed. Graham is trying to optimize the form of the intermittent signal, and the conditioning process. An underwater television is used to monitor fish behavior during the tests.

Antone Edwards has collaborated with Ellet in studying the physical oceanography in areas to the north and west of Scotland. However, he spends most of his time in cooperative studies, with D.J. Edelsten and others, of the many long, narrow sea lochs located on the Scottish west coast. The lochs are a definite amenity; their beauty gives much pleasure to the local people and attracts many tourists who represent a major source of income to the area. The lochs are ideal locations for the practice of aquaculture in which sea trout,

salmon, and oysters are grown. Hatchery-grown sea trout, conditioned to respond to sonic signals (v.s.) can be fed on fish food after being turned loose. Other natural fish in the loch will ignore the signals and feed on only the wild natural food while the conditioned sea trout feed almost entirely on the pellets. Thus the productivity of a loch can be materially increased without artificial holding pens.

Unfortunately, the lochs are becoming polluted by industrial wastes from pulp mills and other industries that provide the Highlands with much-needed employment.

Edwards and his associates have studied ways of assessing hydrography for fish farms, the effects of the physical environment on caged fish, factors influencing the renewal of sill bound bottom water in sea lochs, the relationships between hydrographic conditions and primary productivity in sea lochs, and the control of deep water renewal by run-off modification.

One of the world's largest alginate plants is located on Loch Creran close to the Dunstaffnage Laboratory. Its economic importance to the region and the UK as a whole is recognized by the Queen, who has cited the plant three times as a major source of income from European countries. However, it discharges large amounts of waste material into the loch, which has a shallow sill and deep inner basins where the water is flushed out on an average of only once every sixteen months. Staff members at the Laboratory are attempting to develop an economically sound method of biomass conversion (i.e., converting the wastes into methane and fertilizer through bacterial activity). Thus far, a full-scale conversion plant has not been considered economically feasible. Other more recently built waste discharging plants have been located in regions with fast currents and rapid flushing rates so that the wastes are quickly diluted.

There is evidence that the Dunstaffnage Marine Research Laboratory has been rapidly expanding its staff in physical oceanography. Most of the staff are young and enthusiastic, with evident *esprit de corps*. A new, specially designed vessel of about 100 tons is being built for use in the inland waters of the various sea lochs and between the islands.

The Laboratory is located in a beautiful spot overlooking its own small bay, filled with an appealing assortment of private boats. The small penninsula forming one side of the bay is a national monument of resplendent grounds, lovely shade trees, and the relatively well-kept remains of Dunstaffnage Castle which dates all the way back to medieval times. (Wayne V. Burt)

IOS BIDSTON II: SERVICE FUNCTIONS

The Marine Information and Advisory Service (MIAS) is a part of the UK Institute of Oceanographic Sciences (IOS) and is also the UK National Oceanographic Data Centre. Its hybrid functions are similar to the US National Oceanographic Data Center combined with the US University Sea Grant Program. Its responsibility is to obtain oceanographic information and high-quality oceanographic data and to make them available in the most useful format to industry, research workers, and governmental agencies.

In addition to its UK responsibilities, MIAS has been designated by the Intergovernmental Oceanographic Commission as the Responsible Oceanographic Data Centre for instrumentally-measured wave data on a worldwide basis. MIAS is able to provide information from its data bank, from the extensive IOS oceanographic library, or from other oceanographic data centers, libraries, and laboratories. It covers the fields of physical and chemical oceanography, deep ocean biology, and marine geology and geophysics.

Because of the large number of inquiries received for waves, currents, tides, and sea-level information, special advisory services have been set up to cover these fields. The Service is able to offer advice on data, its availability, processing, interpretation, and applicability to particular problems. Emphasis is placed on the oceans and seas around the British Isles, although oceanographic information and data can be obtained from most sea areas.

Although all the scientists at the three IOS laboratories (Wormley, Taunton, and Bidston-Liverpool) are available for consultation, the data bank itself is housed in the Honeywell computer system (level 66 Model 20) at IOS Bidston under the direction of Mr. B. J. Hinde.

Because of the high level of interest in the UK for alternative sources of energy other than fossil fuels, the operation of the many UK oil well drilling platforms in the North Sea, and the likelihood of drilling on the broad continental shelf west of Scotland (the UK claims the tiny Rockall Island pinnacle 450 km west of Scotland which places the vast submerged shallow Rockall Plateau, about half the size of England, in the UK domain), the initial priority for the MIAS data bank has been on wave and current data. However, other oceanographic data are being progressively phased into the system.

Modern commercially generated data-base management systems are used. All data are screened and plotted, but, only those tested are placed in the data bank. All keys concerning or describing each batch of data are stored with the batch. In accordance with the data-base concept, each element is stored only once.

All the company confidential data from the various oil rigs are put in the data bank in such a way that only the furnishers can retrieve them. After five years these data are declassified.

Several processing and presentation programs have been developed to meet customers' standard requirements. These include extreme value predictions, percentage exceedance diagrams, persistence plots, progressive vector diagrams, as well as maps. Data can be selected by geographical area, parameter, date, season, depth, cruise, or project. Output may be provided as tabular print-out, graphical plots, microfiche, or on magnetic tape.

MIAS appears to be an efficient, highly customer-oriented organization that is making a worthwhile contribution to the ocean-oriented UK.

The International Permanent Service for Mean Sea Level (IPSMSL) is based in IOS Bidston. The service, directed by Dr. David Pugh, was set up by the International Association for Physical Science of the Ocean (IAPSO) and is partially funded by the Federation of Astronomical and Geophysical Services, of the UN Intergovernmental Oceanographic Commission. Sea-level records are collected from anyone who will provide them. Mr. N.E. Spencer reduces the data to monthly and annual means. These data are then distributed in publications called "Monthly", and "Annual Mean Heights of Sea Level."

Tidal prediction for the UK and many other countries in the world are made at IOS Bidston. Until 1958 reductions of tidal observations were all done manually, and the predictions were made on two Doodson-Légé mechanical machines with 40 and 42 components, respectively. By 1960 some experimenting with computers was underway, but the bulk of the reduction was still done by hand. Now the whole process from reduction and error analysis to formatting the printout is done with computers.

Dr. J. Graff is currently in charge of all tidal prediction work. As late as 1974 the system used was archaic, but since then it has been completely automated and computerized. Commercial firms print the tide tables from magnetic tapes. Even the formatting is computerized in such a way that the tide tables can be set up in any desired form.

Tides are often very complicated in estuaries and tidal rivers. Twelve months of data are needed and up to 110 constituents are used for all the harmonics that are generated by non-linear reactions with the uneven bottom topography. This is over two and a half times as many constituents as the old tide prediction machines could handle. Graff has one fundamentally difficult problem. Most of the tide gauges in Great Britain are owned and operated by local harbor authorities with no control given to the Bidston laboratory. Bidston has recently started a "tide-gauge inspectorate team" who examine the most important gauges and advise on their maintenance. However, there remain problems that make quality control very difficult. Graff has what he calls his "black box" of procedures to look for and correct anomalies that he estimates contaminate about 20% of the raw data. (Wayne V. Burt)

ONRL REPORTS

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OPERATIONS RESEARCH

OPERATIONS RESEARCH AT SOME GERMAN UNIVERSITIES

The Germans have the reputation of being highly organized and efficient. The "economic miracle" by which they have pulled themselves up from the wreckage of WWII to become one of the world's most prosperous countries is an example of this. I suspect it could not have been done without the application of operations research—whether or not under that name. For a long time operations research was called in German *unternehmensforschung*, literally "undertaking research," but today there is an increasing tendency to use the American phrase "operations research."

There were two very active OR societies in Germany through the 1950s. In 1960 when Hans-Jürgen Zimmermann was president of one and Heiner Müller-Merbach was president of the other (both of these scholars are described later in this article), they combined into a single society, the *Deutschen Gesellschaft für Operations Research*, which has since been a very active group, both domestically and in international OR. Operations research is taught at virtually every German university. I visited four of these in three cities to get a feel for German OR, and I can testify that it is thriving.

Aachen, within a mile or two of both Belgium and Holland, was at one time part of France and bore the name of Aix-la-Chapelle. The local citizens point out the building where Karl der Grosse had his headquarters. This doesn't ring a bell until one realizes that it translates into Charlemagne.

At the Technische Hochschule Aachen ("hochschule," literally high school, means university), operations research is concentrated in the *Lehrstuhl* (chair) *für Unternehmensforschung*, of which the director is Dr. Hans-Jürgen Zimmermann. Zimmermann is one of the great overachievers who manages to do several people's work without ever appearing busy. He is editor of the *International Journal of Fuzzy Sets and Systems*; one of the three editors of the *European Journal of Operational Research*; and editor of a monograph series on operations research. He publishes prodigiously, including ten books, some in English and others in German, two of the several languages that he speaks fluently. He was president of the German OR society 1971-75; of the Association of European OR Societies in IFORS (*ESN* 33-8:337) 1975-78; and is currently a member of the council of the Institute of Management Sciences, a nominally international, but actually largely American, organization. He runs a successful consulting company, teaches undergraduates, supervises doctoral theses, and manages to be an expert oenologist.

In recent years, Zimmermann's primary research interest has been in "fuzzy sets," a concept first proposed by Lotfi Zadeh (Univ. of Calif., Berkeley) more than ten years ago, and now a widely practiced and active research area all over the world. A fuzzy set is one whose boundaries are not well defined; for example, the set of beautiful women. Most of the people in Zimmermann's chair are also doing research in fuzzy sets. H. Hammacher is working on an axiomatic basis for fuzzy set theory; H. Gehrin is working on the information-systems viewpoint of fuzzy sets; H. Lieberling is working on fuzzy sets in multicriteria decision making and the theory of duality as applied to linear programming; and W. Meiritz is working on the application of fuzzy-set theory to pattern recognition with particular application to business and economic systems.

Most of these people are also engaged in other research projects. For example, Lieberling, working mostly in collaboration with Zimmermann has been applying OR to certain types of decision making for international problems, especially in connection with the saving of energy. One interesting study that they have completed shows the difference in the amount of energy consumed in heating apartments if, on the one hand, each tenant's consumption is metered so that he pays for the energy he consumes; or, on the other hand, if each tenant is charged a fraction of the total energy consumed by the building prorated on the area of his own flat. It turns out that when they pay for it they use 15-20% less. Lieberling and Zimmermann are also working on sampling, applied

to certain problems in accounting. In particular, when one takes a year-end inventory, it is normally necessary to census (i.e., count everything). A new law in the Federal Republic of Germany permits sampling (rather than censusing) in determining the amount of various types of inventory on hand. Lieberling and Zimmermann have written a computer program for the calculation of the actual amount of inventory based on certain types of samples, and they are planning to extend these techniques to the field of auditing. While similar theoretical work has been done in the US, these applications may be unique.

Unlike the UK, where many universities give an MSc in Operations Research (*ESN* 32-12:427), there is only one such program in FRG, and this is in Zimmermann's chair. It is a two-year, full-time program for students with a first degree in mathematics, economics, or engineering. The second year includes a "praktikum" which is similar to the projects required of UK MSc candidates, although it is not full-time, and it is not always a real problem. Zimmermann has, through his consulting and other contacts, obtained a number of real problems from industry, including scheduling in a tire factory and product mix in a jam factory, both being local Aachen organizations. The praktikum is normally done by a group of 4 students, and they are required to present their solution and sell it to a Board of Directors, which may be a fictitious board.

This chair also serves engineering undergraduates, computer science students, math students, and both undergraduate business students and candidates for the MBA. The department is also heavily involved in logistics research, including inventory management, optimization of location, and minimization of transportation costs (including scheduling).

Not counting Berlin, which is in the middle of East Germany, the largest cities in W. Germany are Hamburg in the north, Frankfurt in the center, and Munich in the South. Just a few miles from the enormous industrial city of Frankfurt is the charming, small city of Darmstadt.

The Technische Hochschule, Darmstadt, is not so large as the school at Aachen, and the Operations Research Group, which is in the business school, is also smaller than at Aachen. It consists of Prof. Heiner Müller-Merbach, one of the distinguished scholars in the German OR community, an assistant professor named Dietrik Ohse who is about to leave for Frankfurt University where he will get a chair, and four research fellows. OR is also taught in a number of other places in the university, notably by several mathematicians: Prof. H. Schellhaas, who specializes in combinatorics; and Prof. W. Krabs, who is now a vice president, but still teaches optimization theory. There is also an "informatics" chair occupied by Hartmut Wedekind, of whom more below.

The department of OR at Darmstadt was founded by Hasso von Falkenhausen, who left academe a dozen years ago to do applied OR for McKinsey & Co. in Düsseldorf. Müller-Merbach took his doctorate at Darmstadt in applied mathematics and a postdoctoral year at the University of California (Berkeley) in OR, briefly held chairs at the University of Nurenberg and the University of Mainz, and since 1972 has held a chair at Darmstadt. He has been active in professional OR affairs, having been president of the German society and vice president of the International Federation of Operations Research Societies; he is on the organizing committee for the 10th Meeting of the latter organization which will take place in Hamburg in 1981. His early research was associated with mathematical programming, but more recently he has been interested in education for, and methodology of, operations research. In connection with the former he has been co-chairman of the NATO Advanced Research Institute on Education in Systems Science and co-editor of its publications. He has also published the results of an intensive study of education in OR in business administration departments of all universities in Germany, Austria, and German-speaking parts of Switzerland.

In connection with the methodology of operations research, Müller-Merbach explained to me his philosophy. Twenty years ago engineering was taught by example: "Here is a piece of hardware, see how this is built, design it like this." Now it tends to be taught more by principle: "Here are the equations which connect performance to the structural parameters of the device." He feels that OR needs the same kind of thing—we must construct the

principles of model building and of algorithm design so as to raise operations research from an art to a science. He talked to me about the concept of the "morphological box" that he attributed to Zwicky, in which one lists each of the functions in rows and the realizations in columns. It helps to make design choices explicit, and he feels that such explicit choices are also required in the building of models in OR.

Wedekind received his bachelors degree in industrial engineering at Darmstadt in 1960, the MS in OR from Univ. of California at Berkeley in 1962, and returned to Darmstadt for a doctorate in '64. His doctoral thesis was on the optimal assignment of lathes to workers, a queueing problem in which broken-down machines wait for repairman and repairers wait for machines to break down. This is an extension of a problem made famous by Feller in his classic book. Wedekind worked for IBM for the next five years, partly in Germany and partly in California. During this period he received the *habilitation* (a second and more difficult doctorate obtained by most German scholars who wish to be considered for chairs) from Munich. In 1969 he took the chair at Darmstadt in "business administration (information systems and data processing)."

Wedekind's special interest is large data bases (a million or more separate records). He is interested primarily in centralized data bases, feeling that distributed data bases create an insoluble integrity problem. He also believes that distributed data bases have a chance only when the data is static, which means never. He has published several books: *Systems Analysis*, subtitled *Development of Application Systems*, was published in 1967. This, and a second edition published in 1976, were so successful that a third edition is up-coming. He also published a two-volume work on data base systems: Volume 1, *Logical Design*, 1974, and volume 2, *Physical Design*, 1976, the latter being co-authored by Th. Härder, who holds an associate professorship in Wedekind's chair but is leaving for a chair in Frankfurt at the end of this academic year at which time Wedekind himself is leaving to go to Erlangen. Wedekind's other books include a 1969 volume on data organization, and one in 1977 on structured programming with data bases. His research interests at the moment are twofold: universal data base systems—in cooperation with Siemens and sponsored by the FRG—and methodology for the design of data base systems, in cooperation with the IBM laboratories in San Jose, CA.

Ohse did his undergraduate work at Darmstadt in applied math and took his doctorate there in OR, under Müller-Merbach, on the subject of decomposition programming. His principal research interests at this time are in large-scale linear and integer programs, with special emphasis on the development of software for handling the large sparse matrices that are met in such problems. He has also published on transportation models, the bottleneck transshipment problem, relations between graph theory and mathematical programming, and on inventory models. His most important work in the latter area concerns empirical studies of the applications of different heuristics to a wide variety of empirical distributions of stochastic demand. He will be moving to Frankfurt later this year, to a department of quantitative methods in business administration.

At the Univ. of Hamburg, OR is in the Faculty of Economics and Social sciences. The department has four full professors and one associate professor, and the headship rotates. At the present time the chair is held by H. Jakob. Prof. B. Fleischmann trained in mathematics originally, and did research in integer programming. For the past seven years he has been doing OR applications work in industry, especially in logistics and production. He has been back at the University only for a short period of time and is working on physical distribution systems, optimizing the distribution structure of a company that has many factories, warehouses, and customers—a situation where classical depot-location methods do not work. Prof. D.B. Pressmar, who teaches both OR and data processing, works on the interface between the two; that is, computer-aided planning and the application of OR techniques to the optimization of software systems (particularly application systems as distinguished from operating systems). Prof. R. Karrenberg is the other professor in the department, and works in programming. This department does not grant degrees at the diploma level.

They do teach electives throughout the Faculty of Economic and Social Sciences. There are no doctoral courses courses, but there are doctoral students, most of whom must attend a seminar for at least two years, with 5-10 doctorates being awarded each year in the OR area.

Also in Hamburg is one of the two Bundeswehr Hochschules or military universities in the FRG (the other is in Munich, see *ESN* 33-8:314). Each of these schools has about 2000 students and about 250 faculty, most of whom hold the rank of full professor. These 2 schools are completely unlike the military academies in the US, although virtually every military officer goes through one of them. After graduation from this school the officer will then go to weapons school for a year for further military training, but the training here is essentially the same as in any civilian university. The general philosophy seems to be something like the GI Bill in the US; that is, as a reward for spending a certain number of years in the service, the military provides the student with a university education which will enable him to optimize his post-military career.

OR is taught in the School of Economic and Organizational Sciences, especially in the Departments of Business Administration and of Mathematics and Statistics, which are two of the six departments in that faculty. The head of the Department of Business Administration is Prof. Wolfgang Domschke whose research efforts are in network flows, incremental graph theory, and algorithms for location problems. Prof. Harry Hauptmann works on the topology of random search and on differential games. His research is very arcane, and I did not go into details with him.

I spent more time talking to Prof. Klaus Zoller, who has published in a wide variety of the classical fields of OR, including multi-item inventory systems, heuristics for certain types of optimization, and physical distribution systems. In the latter he was particularly interested in how to deal with incomplete information on cost functions. His most recent research interests are in bionics, and in what he calls evolution-theoretic or evolution-strategic approachs to modeling. The basic idea is to emulate biological systems which, through the sexual interchange of genes, yield progress and evolution. So rather than generate random solutions in search of an extreme solution to a variable problem and then reject it altogether if it is not up to standard (this approach is, according to Zoller, rather ineffective), he generates a set of solutions randomly and evaluates these. Then he mutates to to other, possibly better, solutions, either randomly or by crossing pairs of solutions, and observes whatever improvements are found. He finally reduces the thus-increased set of solutions to the original size by deleting the weakest members, and repeats this process until the population stabilizes (in the sense of low variation of values). The idea is that basically sound solutions to multivariable problems can often be destroyed by a very small number of wrong values, just as a good strategy in chess can be ruined by one or two false moves. So rather than throw away the entire solution, he retains it and tries to improve on it—randomly of course, since the program has no way of knowing which are the incorrect values. Zoller is applying these evolution-theoretic methods now to distribution problems.

The Bundeswehr Hochschule in Hamburg was started only five years ago. Its buildings are not only new, but stark modern, all steel and glass, grim and grey on the outside, neat and simple and white on the inside. There is a business-like attitude throughout the school, both students and faculty being embued with a no-nonsense desire to get on with the learning and teaching. However, there is less research being done by the professors whom I contacted here than at other major universities. (Robert E. Machol)

OPERATIONS RESEARCH IN FINLAND, PART I

Operations research came late to Finland. The Finnish Operations Research Society was founded only in 1974, but now has 300 members. It is actively affiliated with The International Federation of Operational Research Societies (IFORS) and EURO (*ESN* 33-8:337). However, "operations research" as such does not seem to be terribly popular in Finland. Many

of these 300 members work only part time in this field, or call themselves by some other name (such as management scientists or, more often, systems analysts or computer specialists).

The principal natural resource of Finland and a contributor to its prosperity is its forests. The management of forests and of the pulp and paper industry have been particularly amenable to optimization through linear programming methods, but many of the OR experts in Finland seem to be stuck at this level in the historical development of the science; and while the scholars at the universities are publishing papers in the more advanced and more recently active fields of operations research, there seems little in the application of more modern techniques or of imaginative developments in the interaction of operations research with government and industry.

For example, the vice president of the Finnish OR Society is Kari Kallio, who works for Nokia Elektronikka, a large Finnish conglomerate with a turnover of some $700 million per year, making it number 412 in the Fortune 500 international companies, and one of the largest Finnish concerns. The electronics division accounts for about $100 million of this. Within the electronics division is the $12 million service bureau, within which is the "remote computing services" at about $5 million and part of this is the "management sciences group" headed by Kallio, with a turnover of some $600,000 per year. This is a highly profitable group and therefore has a rosy future. The service bureau counts all of the major companies in Finland among its customers. It is tied into the "Mark III information service" (originally Honeywell, now General Electric) which has major computing centers in Cleveland, Rockwell (MD), and Amsterdam, with smaller computers in Sydney, Tokyo, Buenos Aires, and numerous other spots, so that when Kallio sits down to his terminal he never knows whether he will be connected to a computer in Helsinki, Amsterdam, or Cleveland.

The Management Science Group was started in 1971 (Kallio became its head in 1975), and in the past 8 years they have made approximately 100 LP applications for customers. This is typical, and Finland is third in the world in LP applications (after the US and Japan—the UK is fourth and France fifth, Kallio told me). Most of these are transportation models, production models, blending models, and financial-planning models; there are many mixed-integer applications, but little nonlinear (other than the integer constraints). I asked him why there was so much LP, and he said because the money was in LP. Most of these applications have been successful. I asked him about the failures. These come when someone has oversold operations research and the computer shouldn't have been used in the first place, or in cases where the professional skills are inadequate. Kallio emphasized that in most of the latter cases the problem was eventually solved, but that the time and/or money was greater than had been originally estimated and so the customer was not satisfied. There were also failures where the company would not give the necessary data to the operational research consultants because it was considered proprietary.

Kallio gave me one example of a successful application. It was a production model for a machine shop with continuous flow (that is, not a job shop) with eight products, three production lines, and ten processes (the processes included cutting, drilling, painting, etc.). The problem was rather conventional except for some special restrictions; for example, certain minimums and maximums for each customer, and the fact that each customer's product had to go through the entire process on a particular production line, with different profit margins depending on the line to which it was assigned. To ensure that the line met with the last-named restriction, dummy 0-1 variables were assigned.

He also gave me one example of a problem that has been solved without linear programming. It was a discrete simulation model of an automated warehouse, the first in Finland. The simulation used Simcript, although Kallio told me that they now prefer Simula which he says "fits human thinking better than Simscript." The model was used to design this warehouse. Kallio now has lots of nice software for designing automated warehouses, but nobody else in Finland seems to want to build one.

Kallio took a Masters degree in statistics at the Univ. of Helsinki in 1965 and his licentiate in 1969 (a licentiate is a degree somewhat less

advanced than our doctorate; many Finns stop there, others go on to take the doctoral degree, which is more advanced than that in the US and generally requires putting together a dissertation consisting of several papers which have already been published). Kallio's office is in the region called "Pasila," a new commercial area six miles from the center of Helsinki. Everything is modern architecture, and the zoning regulations forbid external parking, which gives the region an extraordinarily clean appearance.

The president of the OR Society is Eero Tamminen, who has only just received his doctorate in applied mathematics from the Technical Univ. of Helsinki at the age of 37. His licentiate was in physics. His dissertation was on "Discrete Optimal Control Theory with Application to Dynamic Allocation and Economics." Tamminen tells me that while the concepts of operations research are becoming easier to sell, they are becoming more difficult to sell under that name. People prefer "organization theory" or "budget systems" or "long-range planning" or "system engineering." In fact there is no operations research group in the Technical Research Center (TRC) where Tamminen works, an organization comparable to the National Bureau of Standards in the US or the national Physical Laboratory (*ESN* 32-4:137, 32-10:329; 33-12) in England, but with somewhat larger responsibilities.

TRC has a total of 1600 people, most of whom work in a large building in the Otaniemi district of the Helsinki suburb of Espoo, very close to and associated with the Technical University of Helsinki. The total budget is about $30 million a year, of which half comes directly from the state as subsidy and the other half from "external financing" (which means contracts); about half of the latter comes also from state organizations. TRC is divided into 35 laboratories or departments, one of which is electrical engineering, and this is one of several places in the center in which OR is done. Tamminen works in this department, headed by P. Salminen, who holds the rank of "professor." This has no academic significance but means only that he is head of department in a center closely affiliated with the University. Salminen took his licentiate at the University, specializing in power, but later became interested in control engineering. He told me that the division is now associated with system engineering, not with operations research. The department has 80 people, more than half of whom have academic degrees (in the center as a whole less than one-third of the people have academic degrees, so clearly this is a highly technical department).

TRC was founded in 1942. Its mission is to meet the research and testing needs of the public and private sectors of Finland, and to advance technology and international cooperation. At the present time 64% of the activities are in research and development (although very little in basic research), 27% in "inspection and testing," and 9% in "cooperation." The inspection and testing activities are wholly concentrated in the nuclear power industry, for which TRC (and its electrical engineering department in particular) have heavy responsibility. This department has been working on the reactor since 1968, and designed its control system. The reactor is a highly international development: the condensers came from Westinghouse, the reactors and turbines came from the USSR, other hardware came from Siemens, and the construction was done by the Finns. They are now developing a nuclear training simulator. This was actually started in 1972, but the recent Three Mile Island incident in the US has underlined the necessity for such a simulator. It will be completed late 1979. Nokia (see above) is supplying the simulator, with TRC as a consultant and doing some of the software. The simulator is actually being purchased by the utility which will generate the power.

As an example of their contract work for industry they told me about the microcomputer that is being developed for the control of a paper mill. Since I had been told that Nokia was also selling a microcomputer, I asked whether they were competing with industry by doing this. They pointed out that they were doing this on contract, and in any case they were developing a control system of which computer was merely a component. The paper mill had contracted the prototype to TRC; if the paper mill were to compete with Nokia, that would be something over which TRC had no control.

Salminen and Tamminen are doing a lot of work in Energy. (This was the first country I had seen in which no work was going on in solar energy—doubtless due to their latitude, which varies from 60° at Helsinki in the south to 70° at Lapland in the north.) They have developed a number of energy models. The most important of these is based on linear programming and is very similar to that developed at the Kernforschungsanlage in Jülich (*ESN* 33-10:409). They have also borrowed extensively from IIASA energy models; IIASA is interested primarily in global models, and TRC has adapted them to become models for Finland, especially those involving the competition between peat and oil. Finland has no oil but a great deal of peat, and has been working on gasification and liquefaction of peat since the 1930's. Peat can also be dried and burned for heat, and this is especially economical in northern Finland where the peat is close (because the cost of transportation is critical for such materials).

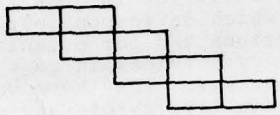
They told me of an optimization study which I would have considered to be operations research. The company produces electricity from hydro, and from burning of peat, coal, and oil; it sells electricity, and it also sells heat, both for process heat and for district heat (that is, heating of houses and buildings). Finally there are interties, so this company also buys electricity from and sells electricity to other power companies. TRC did a study in which they attempted to optimize the interactions of these various factors.

They have also done a study for the Ministry of Trade and Industry planning electrical generating capacity for the next 25 years. The model used was originally developed by the Tennessee Valley Authority in the US and given to the International Energy Agency which gave it free to TRC. TRC computed a number of scenarios for the customer, varying the demand and the capacity generated, for nuclear and for fossil fuels, and also varying the price. Interestingly, the decisions as a result of this study were made about 1974 after a period of high growth and demand. In 1974 there was a recession and demand did not grow in the next few years, and as a result the country now has excess capacity.

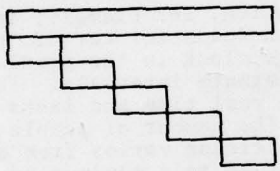
I talked with Jorma Kuutti of Ovako Oy, a company of the Finnish steel industry which had one of the earliest (if not the earliest) applications of OR in Finland (similarly the first civilian OR application in Britain was with the steel industry; see *ESN* 33-3:126). The company is headquartered in Helsinki, but it is strongly decentralized, and there is now no OR group in the company. Kuutti works with a group of about four people in their plant in Imatra about 250 km from Helsinki. A typical problem on which they are now working involves certain products which can be produced in different plants. They must decide which plants produce which products, including the transport of semifinished steel known as billets between plants. As with most of their other problems, this is optimized through linear programming. I asked him why the emphasis on LP; he cited again the historical influence of the pulp and paper industry, but also pointed out that LP is easier to sell (to boards of directors). There is also a good deal of simulation going on in the steel industry.

We turn now to academic OR. The largest university in Finland is the Univ. of Helsinki, while the most prestigious are probably the Helsinki Univ. of Technology (mentioned above in connection with TRC) and the Helsinki Institute of Economics (see below), although people with the universities in Turku (see next month) might quarrel with this. I visited the Helsingin Kauppakorkeakouu (literally the Helsinki School of Economics but actually the business school) and talked with the people in the Department of Administration and Management Systems. "Administration" here mean organization behavior, and one of the three professors in this department specializes in that area; I met the two professors who are in management science, namely Markku Sääksjärvi and Markku Kallio. The latter was visiting briefly at this school although he is, for a two-year period, on assignment at IIASA (see *ESN* 32-2:51). Kallio had his Masters degree in engineering and then took a PhD at the Stanford Business School with a thesis on linear programming methods, and he has been interested in LP ever since. His work at IIASA, in cooperation with

Dr. William Orchard-Hays of the US and Dr. A. Propoi of the Soviet Union, has been on what he calls structured linear programming, specifically the attempt to exploit the structure of the constraint matrix in specialized LP applications. The best-known examples are algorithms which take advantage of the unimodularity of the constraint matrix of the transportation problem, and the Dantzig-Wolfe decomposition algorithm to take advantage of block-angular structure. A modified form of the block-angular structure on which Kallio is working is the staircase structure (see diagram). He is also interested



staircase structure



block-angular structure

in "general hierarchical structures," for example one in which the constraint matrix is block-angular with each block being itself block-angular.

Sääksjärvi's research is primarily in two areas: long-range planning for information systems, and cooperative game theory applied to optimization theory. It frequently turns out that when one optimizes an allocation of resources, as for example by linear programming, some groups or individuals will be allocated less resources than they had been getting historically under a suboptimal allocation. In order to make the optimal allocation acceptable, special compensation such as side payments may be appropriate. These payments would normally be determined by n-person game theory. Sääksjärvi's contribution has been to show how to obtain solutions which are essentially equivalent to the Shapley values by taking account of strengths of coalitions, where the strength of a coalition is measured by the probability that it is formed (if some of the partners are not sure of being in the coalition, then it is weaker). This model has been applied to the Finnish pulp and paper industry. In fact, millions of Finnish marks change hands in accordance with the output of a computer model based on Sääksjärvi's theory.

This school was one of the first business schools in Europe, having been founded in 1911, and has been awarding doctoral degrees since 1931, the earliest of any business school in Scandinavia. Originally a private school, it received increasing state subsidies, and since 1974 has been a state institution. They have recently introduced a combined graduate and undergraduate program leading to the degree of "ekonomi," equivalent to the MBA, requiring nominally four years, but actually in many cases requiring five. As with typical American business students, they all learn a little linear programming and a little statistics, with 10% of the students going on to take more advanced electives in quantitative methods. Most of the texts are in English, although some of the undergraduate texts are in Finnish.

The average professor lectures about five hours per week (associate professor seven hours/wk) for 28 weeks/yr (two 14-wk semesters). The professor gets a salary of about 70 7000 FM/month or about $22,000 p.a. Since prices in Finland are higher than those in the US, this means that the average Finnish professor is a good deal less affluent than his American counterpart, unless he is able to earn a good deal through consulting. Since Finland is a socialist country, education and health care being provided, he may not need as much money as his American counterpart. However, even at 7000 FM/month, the marginal taxes are almost 50%. Prof. Sääksjärvi pointed out to me that if his house needs painting, he paints it himself, since even though he gets a high consulting fee, he does not have enough left after taxes from one day's consulting to pay a painter to paint his house for one day.

Promotion depends on publication (this is somewhat more explicitly acknowledged in Finnish universities than in American). There are Finnish journals, but the pay-off appears to be in the "international" literature, which in practice in this field means English-language publications. Finland is officially a bilingual country, the second language being Swedish, which is the primary language of 7% of the population. Most educated Finns are fluent in Finnish, Swedish, and English. There seems to be less friction between the language groups in Finland than in other bilingual countries such as South Africa and Canada. The Swedish minority here feels itself to be Swedish-speaking Finns, not Swedes resident in Finland.

There are a number of small OR groups scattered around the Finnish government. I talked with the OR group in the Ministry of Finance, four people headed by Mrs. R. Knuuttila and including Jorma Pihlatie (*ESN* 33-8:340) and S. Aaltonen. These three to whom I spoke were all trained in mathematics and have experience in operational research and computers. They work not only for this Ministry, but also as consultants for other government departments. Virtually none of their work involves LP or other optimization models, and this seems to be typical of OR in the Finnish government. Rather they work as planners and in various forms of training and the like.

For example, they have built some taxation models which have been used by the government; thus the government collects about 2 billion Finnish marks per month in taxes, of which about half must be distributed to local governments and churches (Finland does not have separation of church and state!). The exact totals on which the legal allocations depend are not known until the end of the year, and so the government routinely uses a model developed by Pihlatie for this allocation.

Any country with progressive taxation has an increasing percentage of the gross national income going into taxes as a result of inflation. In Finland this percentage is about 40%, and the parliament has decided it should not increase beyond that (in 1973-74 it went to 45%, which was considered unacceptable). The Finance Ministry uses a model based on a statistical sample of taxpayers to determine the exact rate at which the progressive taxation should be decreased to keep the amount of taxes to exactly 40% of the gross national income.

As examples of models outside of the Finance Ministry, Knuuttila and her people have built resource models for the Minister of Education predicting how many students will be in each grade in each year—thus how much space and how many teachers will be required. There have also been recent tendencies to decrease the size of classes, and the model developed by this OR group has been used to determine the effects of such changes.

Finally Aaltonen told me of a model he had built for the Department of Interior which is responsible for rescue operations and for organizing local emergency services in case of catastrophy or war. They have built a game to train fire chiefs and others It simulates a freight train that has overturned, resulting in rupturing of tank cars containing poisonous chlorine gas. The model shows the spread of the gas which, for example, interdicts certain roads for certain periods of time. The clock in the simulation goes at one-minute intervals. The game is played in real time and lasts some 4-5 hours. The number of people who die in the accident varies from a minimum of about 20 to a maximum of about 400, depending on the skill of the players. For example, if they attempt to direct rescue operations through certain roads that are blocked, there may be a great many extra casualties. The game has been used to train many local officials, who feel that they hav learned a great deal from it. Knuuttil is also building a comparable game for the Army.

Knuuttila stressed to me that her group has had considerable success working with lawyers. Their models tend to be written in such a way as to simulate legislation. She finds that the logic of lawyers is very similar to that of management scientists, and she can work much better with lawyers than with social scientists or economists. When lawyers help in the construction of models, she said, they are much more likely to be implemented.

A second article on OR in Finland will appear next month. (Robert E. Machol)

OPTICAL PHYSICS

ELECTRO-OPTICS IN ISRAEL—PART II

Part I of this two-part series presented an overview of EO programs at Ben Gurion University of the Negev, The Hebrew University of Jerusalem, and The Technion--Israel Institute of Technology. Part II concludes with a description of EO programs conducted at Tel Aviv University, Ramat Aviv, and The Weizmann Institute of Science, Rehovot.

Tel Aviv University - One third of the population of Israel lives in Greater Tel Aviv, which is generally accepted as the cultural, industrial, and financial center of the Country. The modern campus of Tel Aviv University (TAU) comprises over 40 buildings on 170 acres in the northern suburb of Ramat Aviv. The University began operation in 1953 as the University College of Sciences under an affiliation with the Hebrew University of Jerusalem. In 1963 it became autonomous and construction of the Ramat Aviv campus began. TAU is growing rapidly, and with its current enrollment of 20,000, is the largest university in Israel. EO Programs are conducted in the Department of Physics and Astronomy (in the Faculty of Exact Sciences) and in the brand-new Department of Electron Devices and Electromagnetic Radiation (in the comparatively new Faculty of Engineering). The former is a relatively small study area, one of seven in the department; the latter is somewhat larger and currently has 22 students working toward graduate degrees.

Prof. Emanuel Marom of the Department of Electron Devices and Electromagnetic Radiation is investigating image subtraction, and has reported on both real-time (optoelectronic) and nonreal-time (photographic/holographic) techniques for displaying the difference between two images. Those who will benefit from the ability to display the difference between two images include investigators in earth resources monitoring, aerial photography, metrology, and automatic inspection. Marom has reported on a novel real-time image subtraction (RTIS) technique that utilized a combination of liquid-crystal light valves, lenses, a quarter-wave plate, and a beam splitter/combiner. [E. Marom, *Opt. Commun.* 26, 169 (1978).] Among the important features of this RTIS technique are its compatibility with incoherent light (thus providing a speckle-free image) and its ability to preserve the sign of the subtracted signals. This development was the result of research conducted at Hughes Research Laboratory, Malibu, California, while Marom was on a two-year leave. Since returning to Tel Aviv in 1978, the emphasis of his RTIS investigations has been on the development of a technique that will utilize a vidicon display.

To better understand the propagation characteristics of electromagnetic waves in fibers is the objective of a new program in Marom's group. Two students have recently commenced research projects in this area. One of the interesting questions to be studied is: Can different modes within a miltimode fiber be addressed separately? Because of current limitations on the product of the data rate and the length in multimode fiber technology, this question is of considerable interest to those requiring very high data rates or moderate data rates transmitted over long distances. Also to be investigated are the anisotropic effects of acoustic pressure upon EM waves in fibers. Areas under investigation by Marom at a lower level than those described above include pattern recognition, integrated optics, and acousto-optical interactions.

Avraham Gover, also of the Department of Electron Devices and Electromagnetic Radiation, is investigating the interaction of electron beams with EM waves with the objective of modeling and developing free-electron lasers. This project is essentially a continuation of his research with Professor Amnon Yariv while at the California Institute of Technology. Since the 1977 report of the first free-electron laser (Stanford University), much interest has developed in electron beam/EM wave interactions. They have co-authored a paper that contains a review of the theoretical and experimental aspects of this field with an emphasis on free-electron lasers of the Cerenkov and Smith-Purcell type. [A. Gover and A. Yariv, *Appl. Phys.* 16, 121 (1978).]. He pointed out that achieving population inversion in

free-electron lasers. This project is essentially a continuation of his research with Professor Amnon Yariv while at the California Institute of Technology. Since the 1977 report of the first free-electron laser (Stanford University), much interest has developed in electron beam/EM wave interactions. They have co-authored a paper that contains a review of the theoretical and experimental aspects of this field with an emphasis on free-electron lasers of the Cerenkov and Smith-Purcell type. [A. Gover and A. Yariv, *Appl. Phys.* 16, 121 (1978).]. He pointed out that achieving population inversion in free-electron lasers requires either that an external force be applied to the electron beam (e.g., Stanford University's magnetic *bremsstrahlung* laser) or that the velocity of the electron beam exceeds the phase velocity of the EM wave. The latter condition can be satisfied by slowing the EM wave either by the presence of a dielectric material (Cerenkov laser) or by the use of a slow-wave structure, such as a metal grating (Smith-Purcell laser). Gover's research in aimed at a demonstration of laser action in a Cerenkov or Smith-Purcell device.

Abraham Katzir (Department of Physics and Astronomy) has been involved since 1974 with the development of GaAs-GaAlAs injection lasers incorporating either distributed feedback (DFB) or distributed Bragg reflectors (DBR). As optical feedback for such lasers is provided by the periodic corrugations of the DFB or DBR, some of the problems associated with the more commonly used Fabry-Perot resonator may be avoided. Since his return to Israel in 1977 after a 3-year research fellowship with Yariv at California Institute of Technology, Katzir has accepted two challenges: To develop an applied physics program at TAU and, as Israel's sole injection laser expert, to develop a research/technology base in this area. One of Katzir's objectives is to improve the already demonstrated DFB $Pb_{1-x}Sn_xTe$ injection laser. (The emission wavelength is a function of x and can be varied from 6 to 30 μm.) He has made lasers of this type (using the liquid-phase epitaxy crystal growth technique) that emit at 9.6 μm. Efficient, single mode operation with decreased wavelength dependence on temperature and current are some of the objectives of this program. Katzir feels that good injection lasers operable between 6 and 30 μm will be used in high-resolution spectroscopy, pollution monitoring, chemical process control, heterodyne detection (as the local oscillator), and optical communication.

The Weizmann Institute of Science The Weizmann Institute of Science (WIS) is located on 75 acres of beautiful lawns and gardens in Rehovot, 14 miles south of Tel Aviv. The WIS, formally dedicated in 1949, developed out of the small Daniel Sieff Research Institute that was founded by the first President of the State of Israel, Dr. Chaim Weizmann. WIS's Feinberg Graduate School offers graduate courses only; the teaching loads are light, and research is emphasized. In addition to the excellent fundamental research carried out at the WIS, an emphasis is placed on "mission-oriented research"—research with the objectives of establishing new industries and accelerating the development of existin ones. The more than 15 science-based companies located in a nearby industrial park provide a visible indication of the success of this endeavor.

Research and teaching are focused on the natural sciences with the staff divided into five faculties: Biology, Biophysics-Biochemistry, Chemistry, Mathematics, and Physics. Currently there are 2200 scientists/engineers, graduate students, and support employee (approximately 1/3 in each category). All of the electro-optics research is conducted in the 50-member Department of Electronics (Physics Faculty) and a report of the investigations carried out by 3 groups within this Department follows.

It has long been known that ethylene (C_2H_4) increases the ripening rates of a variety of fruits, and it has been used in degreening chambers for this purpose. During cooled long-term storage, the concentration of ethylene produced by the fruits themselves can be high enough to increase the ripening rate to unacceptable levels. Because concentrations as low as 100 ppb may lead to deterioration of the fruit, it is important to be able to monitor trac quantities of ethylene present in storage environments. S. Shtrikman has recently used an optoacoustic cell (*ESN* 33-6:246) placed within the resonant cavity of a waveguide CO_2 laser to detect concentrations of ethylene in the sub ppb range. Sub ppb sensitivity for ethylene was achieved with samples containing no other pollutants

and free from foreign gas spectral interference, A "practical" sensitivity of 5 ppb was realized during the monitoring of a continuously flowing gas sample that had passed thru a NaOH scrubber. (The NaOH scrubber eliminated a CO_2 spectral interference problem without changing the ethylene concentration or contributing any foreign interfering gas.) Ethylene produced primarily by internal-combustion engines was detected in air samples collected during rush hour in the main street of Rehovot. Concentrations of 130 ppb were measured with a repeatability of ± 10%. These measurements were made possible by the development by Shtrikman's group of both the resonant optoacoustic cell and wave guide CO_2 laser. [S. Shtrikman and M. Slatkine, *Appl. Phys. Lett.* 31, 830 (1977); E. Kritchman, S. Shtrikman, and M. Slatkine, *J. Opt. Soc. Am.* 68, 1257 (1978).] In addition to the project described above, Shtrikman's group is conducting research in thermoelectric ir detectors, magnetic phenomena (Lifshitz point and other multicritical points), polymer membranes, and synchronous torque couplers.

Since commencing his graduate studies at the University of Michigan in 1963, A.A. Friesem has been investigating the applications of coherent optics. After working for 3 years at the Electro-Optics Laboratory of Radiation Inc. he joined the staff of WIS (1973). Presently his group of 11 is developing application in holography (both real-time and nonreal-time), image processing, and optical fibers. This group has investigated two classes of recording materials, photodielectrics and photoconductor-thermoplastics (PC-TP), for their potential use in real-time holographic nondestructive testing. Holograms are recorded in photodielectric materials by photo-induced variations of their refractive index. Experiments conducted by Friesem's group indicate that the recording mechanism in poly (methyl α-cyanoacrylate) sensitized with parabenzoquinone is due to cross links that draw the chains closer together, increasing the density and hence increasing the refractive index. Holograms produced in this photodielectric exhibited an exposure sensitivity of about 1 J/cm^2, a resolution in excess of 2500 lines/mm, and a diffraction efficiency approaching 100%. The low exposure sensitivity precludes the use of this material in real-time holographic nondestrctive testing (except possibly for small objects); however, its high resolution and diffraction effiency indicate a high potential for use in holographic optical elements. The features of PC-TP devices that make them particularly attractive for use as holographic storage media are high exposure sensitivity; write-read-erase capability; *in situ* recording, development, and readout; and a recording cycle of less than 3 sec, which is close to real-time. PC-TP devices developed at WIS exhibited a very high exposure sensitivity of 50 ergs/cm^2 and a resolution in excess of 1800 lines/mm. The realization of this high exposure sensitivity and the development of improved device fabrication techniques by Friesem's group led to the assembly and evaluation of a modest holographic nondestructive testing system. Other areas in which Friesem's group has been very productive include multicolor holography, holographic interferometry, optical fibers, optical data processing, and laser display techniques.

The author would like to present a few general observations made while visiting the five universities discussed in this series. There is a strong emphasis upon pursuing "meaningful" research projects. Meaningful in this context may be defined as having the potential of benefiting Israel's industry, agriculture, etc. There is also a closeness between the university and industry communities that is strongly encouraged by academic and industrial leaders alike.

Israeli graduate schools have to work hard to attract PhD students because of the length of time involved (typically MS plus four years). Furthermore, it is not easy for the holder of a new PhD to get a good job; industries consider the PhD holder to be overqualified, and a PhD obtained in the US is more highly recognized in most Israeli schools.

Most of the laboratories were adequately equipped and many had the latest in sophisticated electronic/optical instrumentation. The morale of virtually all principal investigators and their students was high and the emphasis on relevancy or meaningfulness of their research did not seem to detract from their enthusiasm. (Richard S. Hughes)

TRANSPORTATION

THOSE BIG RED DOUBLE-DECKER BUSES

London's buses and its "Underground or "Tube" (equivalent to French "Metro" and American "Subway") are familiar to every tourist and resident of that city. In addition to their quaintness and attractiveness they perform an important practical function, carrying 1870 million passengers 5600 million miles in 1978, for which they collected fares of £334,000,000. As a resident of London, I contribute some of those passenger miles, and so when I went to visit the Operational Reseach Group at London Transport it was not only to learn about their OR studies but also to take the opportunity to express my own personal disgruntlement about the bus service.

London Transport, which runs both the buses and the Underground, used to be part of the Ministry of Transport (of the UK Government), but since 1969 has reported to the Greater London Council and obtained its subsidies therefrom. Actually, buses and underground have little in common, and in the future they will probably be separately administered; but at the present time London Transport consists of a bus board, a rail board, and "group functions." The Group Planning Department is in the last named, and the "Planning Research Office" which I visited is part of that Department. It is headed by Derek John Wagon and has about 20 professionals (8 economists and 12 operational researchers) and 8 support people. Wagon, who has an MA in math from Cambridge, has been with London Transport since 1971 and took over the group, then called "economic and operational research group" in 1974 when its then head, David Quarmby, was promoted (see below).

Wagon told me, "Economists do better than OR types; they tend to be policy oriented, while the OR people tend to deal in the nitty-gritty." (I disagree with this conclusion, feeling that the economists may be vaguely floating around in attenuated policy levels while the OR people are doing something demonstrably useful at the nitty-gritty level.) More of his group's effort is spent on economics than OR, and more is spent on bus than on rail. The latter is partly for historical reasons, but also because there is more flexibility in what one can do with buses. Most of the group's effort is devoted to collection and interpretation of data rather than to the more conventional OR concept of quantitative studies leading to specific recommendations for decision makers.

Wagon and his group have developed several Quality Service Indicators (QSIs) for both rail and bus service. From previous research (largely performed by others) they are well aware of people's utility functions. For example, passengers are much more willing to sit on trains and wait than they are to sit on platforms and wait; they apparently value the former at about twice the rate that they value the latter. What customers for short trips value most is short waiting time; for long trips people tend to be more interested in low fare. Wagon does not appear to be interested in the one thing that is my principal frustration; namely, that after waiting an unconscionably long time for, say, a #27 bus, 2 or 3 #27 buses come along bumper to bumper. I suppose it bothers me because it represents a delay which might have been avoided by better management. It doesn't bother Wagon because he believes that customers are interested in the bus they get onto and don't care what comes after it. It is well known that there is a natural tendency for buses to bunch: even if they are started with uniform headways, there will be random fluctuations; and then when two buses do get close to one another, the one in front picks up most of the passengers and therefore goes more slowly while the one in back picks up less and goes more rapidly. As Wagon pointed out to me, the only way to avoid this is by slowing things down; that is, while leap-frogging helps a little, you can't speed up the bus in front, all you can do is hold back the one behind—albeit somewhat delayed from the original schedule. This is practically impossible to do except at the terminals, and could meet with union intervention, a variable hard to quantify in such an analysis.

One of the important QSIs is waiting time. There would be some waiting time even if things ran perfectly, so what Wagon's group measures is the

extra waiting time or EWT; namely, the average waiting time per passenger less what the average waiting time per passenger would be if things were perfect. The difference is made up of two contributions: the number of vehicles running is less than are scheduled (which may be caused either by shortage of vehicles or shortage of staff); and deviations from schedule may be due either to traffic congestion or to the bunching alluded to above. There are well known and not surprising variations of this EWT with time of day, day of week, and time of year. For example, EWT tends to be about three minutes during the summer and four minutes during the winter. About half of the EWT is caused by lack of buses. The EWT tends to be about the same on routes where the buses run every few minutes and on routes where they are much farther apart. These numbers, which have been getting slightly worse each year for the past several years, measure only the time until the next bus comes. It turns out that 10% of the time the next bus is full and the passenger isn't allowed on the bus when it does arrive, so his actual wait is longer than indicated. Again this is much worse (about 11%) in the winter than in the summer (8%).

These figures have improved each year for the last few years; that is, the probability that the bus when it does arrive will be full is smaller in 1979 than it was in 1978, and in turn that was smaller than in 1977. Unfortunately, this does not reflect an improvement—it indicates only that the number of passengers is decreasing and, as indicated below, that is considered particularly bad. It should be noted that this fraction (the 10% noted above), the probability that when a bus arrives it will be full, is measured from the viewpoint of the bus. From the viewpoint of the passenger the probability is considerably bigger, because there are more passengers around when the buses are full than when the buses are empty. Thus, the probability that the first bus (which comes when I am waiting) is full exceeds 10%. This type of paradox is familiar to statisticians.

Wagon and his group have also measured the probability of waiting more than 10 minutes. This would be about 0.05 if EWT were equal to zero. It is actually almost 0.3; of course, this includes periods of low patronage (such as Sunday) when the waiting times are much longer.

They have a great deal of data comparable to the above. Most of such data are collected by retired bus drivers, who are already on pension and require only a small amount of supplemantary income; furthermore, they do not have to have the system explained to them, and they tend to be well accepted by the unionized staff.

Before deciding what to do with the data, one must determine the measure of effectiveness or criterion function. It is clear that the objective is not simply to make a profit; they have in fact a significant loss each year. Fares pay only about 70% of the short-term cost of running the buses and 90% of the short-term cost of running the rail system. The difference, plus any capital investments, must be made up by subsidy from the Greater London Council. On the other hand, cost must be a significant factor. Their charter states that they are to "provide those services which best meet the needs of London for the time be being." They construe that to mean that they should maximize service subject to financial constraints, and they have decided to measure service by the number of passenger miles generated. This leaves something to be desired, but clearly, other things being equal, the better the service the more people will use the facility.

Why passenger miles rather than passengers? Passenger miles tend to emphasize the longer trips, and there is some indication that the longer trips tend to be taken by wealthier people, which would argue against it. On the other hand, shorter trips emphasize downtown, and surely one of the objectives must be to maintain central London rather than having the central city disintegrate (as has happened in other parts of the world). They even know what the elasticities are: at the margin it costs between £0.20 and £0.30 to generate one extra passenger mile. Thus, as they interpret their objective, it means that they will undertake a project which actually drives away a small number of passengers provided it saves them a large amount of money, as well as one which loses them a small amount of money provided it attracts a lot of extra passengers.

Most of us are only barely aware of the buses that don't come into

central London, but in fact these constitute 3/4 of the total. Many of these latter are operated by one man rather than the two-man crew that operate London buses. In the latter, one person drives and the other circulates and collects fares (which depend on both the point of origin and the point of destination). Eliminating the conductor, of course, saves money, but it also slows the bus, and eventually to offset the reduction in service, more buses and more drivers must be provided. In the suburbs (where there are greater distances between stops) this may be worthwhile, but not in the city. Thus at this time about 50% of the fleet has one-man operation. This seems about the limit, although this could change, depending on whether salaries go up more rapidly than the cost of petroleum. The OR group has contributed to this decision the knowledge that it takes from 3.5 to 4 seconds to get a passenger on a one-man bus, but this can be reduced to 2 seconds if there is a flat fare (independent of trip duration). For a two-man bus, it takes about 1.2 seconds to get a passenger on.

Given all this data collection and interpretation and development of QSIs, I was surprised at how little there was in the way of studies utilizing these data to make specific operational recommendations. One example in which the OR group did provide significant input was in the choice of fare policies. Specifically, they have identified the higher marginal benefits from improving off-peak services, and Wagon is convinced that from this alone they have more than earned the £250,000 per year that his group costs. They have a particularly sympathetic ear for their recommendations because Quarmby, their former boss, who was promoted to chief planning officer, subsequently became Head of the Bus Board and a member of the Executive Board. It is surely an unusual situation for an OR Group to have one of their alumni on the principal decision-making board to which they report.

I would have expected a group like this to have major computer simulations. They did build a computer model, and while it models well what happens at the present time, it seems not to do a good job of predicting what would happen when various policy changes were made; and so they have not made extensive use of it.

I was pleased to discover that Wagon is a fellow rider. There is no car park at 55 Broadway, which is the headquarters for London Transport's Administrative Operations, so most of the employees use London Transport. There are exceptions, however: the executives, who perhaps might learn from riding the buses and tube, are generally chauffered to 55 Broadway. At the suburban installations there are large free parking spaces for LTA employees; it has been found that provision of such parking is essential for recruiting.

Based on their criterion function described above, the group has computed that it would be worth about £20 million per year to bring the EWT down from 4 minutes to 3. They have also computed that it would cost a good deal more than that, so they are not planning to do anything about it. Doing operations research for something like London Transport tends to be a discouraging task. Almost anything they would like to do costs money which they can't get, and even when they find something which really doesn't cost very much money, but simply takes a change in the control operation, other factors such as union agreements may militate against it.

In spite of which, public transport in London is a pleasure compared to that in any city in America that I know. (Robert E. Machol)

NEWS & NOTES

APPLIED MATHEMATICS AT IRIA, FRANCE

IRIA (Institut de Recherche d'Informatique et d'Automatique) is located in a rustic setting near Versailles about 30 minutes by car from the Eiffel Tower. It is a government-supported research complex housed in approximately 20 barrack-type buildings vacated when the NATO command left Paris. Most of the activity in applied mathematics is centered in the administrative division called LABORIA under the direction of the eminent mathematician, J.L. Lions.

LABORIA employs about 80 full-time researchers divided among applied projects in physics, chemistry, engineering, biology, and economy. While much of the work at LABORIA is oriented toward direct computer and information-processing applications, there is considerable methodological research in general areas such as numberical methods, stochastic control, and optimization theory. For example, there is a systems theory project headed by Alain Bensoussan and Claude Lemerchal. Specific efforts under the project relate to energy, natural resources and pollution, data handling, and heuristic modeling of complex structures.

Most of the projects, although applied in nature, involve mathematical research at a fundamental level, and the scholastic level of the output is of the same high calibre that is associated with the best French universities.

For a variety of reasons usually having to do with academic responsibilities other than research, many scholars in France regard an IRIA/LABORIA affiliation to be more consistent with their own interests than a university position. Perhaps for this reason it is not unusual that among the LABORIA staff are many individuals with jcint appointments at on one of the Paris universities.

It would not be possible to do justice to the scope and depth of LABORIA's activities without describing over 100 individual research efforts. The only comparable institution in the the US from the point of view of intensity and spectrum of mathematical research is perhaps Bell Labs, although the official missions and end-users are of course quite different.

In a substantial way IRIA also serves as a focal point for communication between mathematical scholars from numerous countries. Many visitors pass through to work for periods varying between several weeks and a year, and conferences are frequently held. For example, in December 1978 there was an International Symposium on Systems Optimization and Analysis organized by Bensoussna and Lions. Several hundred participants from many countries attended sessions on Economic Models; Identification, Estimation, and Filtering; Adaptive Control; Numerical Methods in Optimization;and Distribution Systems.

An example of the multidisciplinary stimulus is provided by another IRIA conference held in February 1979 with the joint sponsorship of the European Institute for Advanced Studies in Management, Brussels, Belgium, organized by Bensoussan and Rofman and titled "Problems Raised by Mathematical Modeling of Social Phenomena." The emphasis here was on methodology and data and the possible contributions of mathematics in social modeling. (J.F. Gould, University of Chicago)

THE 8TH NORDIC CONFERENCE ON BUSINESS ECONOMICS

The Nordic countries—Finland, Sweden, Denmark, and Norway—have many close links, and when they get together their common language is frequently English. Thus I planned my trip to Sweden to coincide with the 8th Nordic Conference on Business Economics held at the Stockholm Business School 22-24 August 1979, and was shocked to discover that some 70% of the papers in this Conference were in Swedish. It turns out that Danish, when written, is very similar to Swedish, although the pronunciation is different; and that while Norwegian has somewhat different works than Swedish, the pronunciation is more like that of Swedish; so people from these two countries can communicate easily with Swedes. Finnis is a completely different language, as incomprehensible to Swedes as it is to Americans, but Finland is a bilingual country and most educated Finns understand Swedish. Unfortunately,

I learned all these facts after my arrival.

These conferences are held approximately every 3 years. The fact that 275 people chose to participate in this one, after a history of more than 20 years of such conferences, tells something about their success. Almost all of the participants were academics, and they represented virtually every college and university in Scandinavia. In the actual session the author was given five minutes to summarize his paper; then a designated discussant gave a critique, following which there was an open discussion. Some 30% of the papers were written and presented in English, these being presumably the ones that were prepared for publication (since there is less prestige in publishing in a Scandinavian language). Even in those cases, however, the discussion of the paper took place in Swedish. For this reason I attended very few of the technical sessions.

The papers of this conference were mostly written by junior people, and are therefore perhaps not typical of the best research being done in Scandinavian countries. There are several reasons for this: all submitted papers were accepted, and so some of the more distinguished scholars felt that they would rather submit their paper through some sort of refereeing process; furthermore there were strict limits on the length of articles; full text of each article had to be submitted many months early; and, as indicated above, the paper was not read at the conference, but rather the author was permitted five minutes to summarize it orally.

The full texts of about 80 papers presented were in the proceedings available to all participants before the conference. Copies of the papers may be obtained by writing to Inglolf Ståhl, Handelshögskolan I Stockholm, Sveavägen 65, Box 6501, S-11383 Stockholm, Sweden. (Robert E. Machol)

PHYSICS AND ASTRONOMY—DUMAND

Sixteen scientists from the US and Japan were guests of the Soviet Academy of Sciences for two weeks of meetings in August concerning the DUMAND project. DUMAND, which stands for Deep Underwater Muon and Neutrino Detection, is an ambitious plan to build a giant (1 km^3) detector 5-km deep in the water off the Hawaiian Islands, for the purpose of studying ultrahigh energy neutrinos which are produced by cosmic rays in the atmosphere and in distant astronomical bodies.

The scientists met with their Soviet colleagues at Khabarovsk, USSR, during the 16th Internation Pacific Science Congress and also on the shore of Lake Baikal in Siberia.

Plans were made for cooperative efforts on feasibility and site studies which will be centered in Hawaii during the next two years. Support for these studies has been obtained from the State of Hawaii, the Department of Energy, and ONR. Soviet and Japanese scientists will join scientists from the University of Hawaii and a number of mainland institutions in investigating the experiment, and detector design. In addition, workshops will be held to discuss the feasibility of making fundamental observations with the detector. In the area of high energy physics, it is hoped that DUMAND can contribute to current developments of a unified theory of the basic forces of nature by the observation of the "quantum" of the weak interaction. In the area of astronomy, DUMAND will search for neutrinos from the centers of active galaxies such as quasars, in order to determine if, as is theorized, there are massive black holes at the centers providing the source of the stupendous energy being emitted. DUMAND would thus open up a whole new branch of astronomy—high energy neutrino astronomy. (V.J. Stenger, University of Hawaii at Manoa)

NOBEL PRIZES

Amid the furor of the government's decision to raise tuition fees for foreigners attending British universities, comes the announcement of several British winners of the 1979 Nobel Prizes. The prize in physics was won by Prof. Abdus Salam, who came to Britain as a student from Pakistan. Salam, of Imperial College of Science and Technology, London, and the International Centre for Theoretical Physics, Trieste, shares the award with two Harvard scientists, Profs. Sheldon Glashow and Steven Weinberg. The three scientists

have worked independently on a problem to which Albert Einstein addressed the greater part of his career—an explanation of the forces that bind the elementary particles that make up atoms of matter. The citation says that the prize is for their contribution to the theory of unified weak and electromagnetic interaction between elementary particles, including the prediction of the weak neutral current.

Another British Nobel Prize winner is Dr. Godfrey Newbold Hounsfield of EMI Ltd., who shares the prize for medicine with Dr. Allan Cormack of Tufts University. Hounsfield invented the world's first scanner capable of clear x-ray picture of the inside of the skull, a development from the work of Cormack who was the first man to specify the requirements for an accurate x-ray picture.

British-born Prof. Herbert Charles Brown, of Purdue University and a member of the Board of Governors of the Hebrew University in Jerusalem, was awarded the Nobel Prize in chemistry. Brown is sharing the honors with Prof. Georg Wittig of the University of Heidelberg for the development of chemical tools for synthesizing organic compounds.

Sir Arthur Lewis, a British citizen born in the West Indies, now a professor at Princeton University, shares the Nobel Prize in economic sciences with Prof. Theodore W. Schultz of the University of Chicago. Both men have been leading exponents of the proposition that education in the developing world has to be seen as an investment, an idea that is perhaps the most important key in the transition of economically primitive societies to a more developed state.

PERSONAL

Alexander Robertus, Chancellor of the University of Strathclyde, and Lord Todd of Trumpington, president of the Royal Society, received the foremost award of the Soviet Academy of Sciences, the Lomonosov Gold Medal, in Moscow, USSR. Prof. Anatoly Alexandrov, presenting the award, referred to Lord Todd's research into the chemical structure and synthesis of nucleic acids which earned him the Nobel Prize for chemistry in 1957.

OBITUARIES

Dr. Steven L. Cook (see *ESN* 32-12:430) who held the Chair in Operational Research at the University of Aston in Birmingham, UK, died of a heart attack on 17 October, age 60.

Sir Frank Fraser Darling, the ecologist and authority on animal genetics, died at the age of 76. In the Reith Lectures broadcast in 1969, he said that we face a future of continuing over-population and that the damage man is causing might endanger earth's life-support system built up over millions of years. Sir Frank wrote many books, had been vice-president of the World Conservation Foundation, was a senior lecturer at Edinburgh University during the 50s and was knighted in 1970.

Prof. Hermann Arthur Jahn, Professor of Mining at the Royal College of Mines, London University, from 1953-63 who held many illustrious positions at institutions and boards throughout the country, died in Beaconsfield at the age of 81.

Dr. Terence Charles Richards, who has died aged 75, was a pioneer in the application of geophysics to oil exploration, specifically offshore projects, where surface geology is confused or non-existent.

Dr. Charles Wynn-Williams, who has died aged 76, was a physicist and computer pioneer who in 1931 built the world's first electronic counter while working with Lord Rutherford at the Cavendish Laboratory, Cambridge. During WWII he built the automatic code-breaking machine called "Heath Robinson", an important precursor of the modern digital computer.

ONRL REPORTS

C-4-79 HOW PLASTICS FAIL—THE CHURCHILL CONFERENCE by W.D. Bascom

This report reviews the presentations and discussion at the 5th International Conference on Deformation, Yield and Fracture of Polymers held at the University of Cambridge on 2-5 April, 1979. The work presented at the Conference gives some insight into the state-of-the-art of research on how polymeric materials fail. No breakthroughs were revealed, but the tone of the Conference suggested a coming to grips with nonlinear processes.

R-4-79 RESEARCH AT THE BIDSTON BRANCH OF THE UK INSTITUTE OF OCEANOGRAPHIC SCIENCES by W.V. Burt

The background of IOS Bidston is presented along with a short history of its predecessors, the Liverpool Observatory, the Liverpool Tidal Institute, and the Institute of Coastal Oceanography and Tides. Ongoing research programs at IOS Bidston are described.