AD-A086 806   OFFICE OF NAVAL RESEARCH LONDON (ENGLAND)   F/G 5/2
EUROPEAN SCIENTIFIC NOTES. VOLUME 34, NUMBER 6.(U)
JUN 80 R S HUGHES, D J PETERS

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LONDON

LEVEL II

EUROPEAN SCIENTIFIC NOTES

ESN 34-6

30 June 1980

Distributed by the
Office of Naval Research Branch Office,
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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 34-6
2. GOVT ACCESSION NO.: AD-A086806
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): (6) EUROPEAN SCIENTIFIC NOTES. Volume 34, Number 6,
5. TYPE OF REPORT & PERIOD COVERED: Monthly Publication, June
6. PERFORMING ORG. REPORT NUMBER: 34-6
7. AUTHOR(s): (10) Richard S. Hughes, Don J. Peters, editors
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Office of Naval Research Branch Office London, Box 39, FPO NY 09510
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS: (11)
12. Report Date: 30 Jun[redacted]80
13. NUMBER OF PAGES: 48
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 54
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): (14) ESN-34-6
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

CHEMISTRY, ENERGY, ENGINEERING, GEOPHYSICS, MATERIALS SCIENCE, MEDICAL PHYSICS, OCEANOGRAPHY, OPERATIONS RESEARCH, PHYSICS, SYSTEMS ANALYSIS

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

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

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

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S/N 0102-LF-014-6601

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

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

edited by Richard S. Hughes and Don J. Peters

30 June 1980 Volume 34, No. 6

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.

CHEMISTRY

AWRE—AN EXCITING VISIT

A 30-minute train ride from central London, followed by a 30-minute car ride, brings one to the Atomic Weapons Research Establishment (AWRE) in Aldermaston. I made this short, 2-stage journey on a cold, clear St. Valentine's Day to visit the research facilities at AWRE. In the open areas surrounding the Aldermaston establishment, the weather felt even colder than in London. I was returning for a visit to AWRE after a previous tour of their mass spectrometry facilities in 1974. At that time, Dr. N. Daly was the head of the mass spectrometry research. Daly, who is a most respected and productive scientist, no longer leads the AWRE Mass Spectrometry Group. Therefore, my visit had two purposes: first, to visit Daly, who now heads a division in the large high-energy laser facility which will be described below; and second, to learn about the chemistry research being conducted at AWRE, which also includes the mass spectrometry research.

The large AWRE laser facility was opened in 1979 by Queen Elizabeth II, who spent 6 hours in a general tour of the Establishment. The large laser facility was designed to study the various high-energy processes that occur when large amounts of energy are focused on a target. Daly heads one of the teams that works in this facility. The other teams deal with the laser optics and with instrumentation. The group under Daly, which is concerned primarily with the target, is subdivided into three sections. One deals with the experimental design of the target; another works with the electronics associated with making measurements of the interaction of the photons with the target; and the third is involved in developing the electronics needed to study the target during irradiation. One of the most notable achievements of Daly's group, responsible for the diagnostics of the plasma once the target has been irradiated by the laser beam, has been the development, modification and improvement of x-ray streak cameras.

Upon entering the facility, one is escorted into a special room and there dons an all-white, lint-free, floor-length garment before one is allowed to proceed. This procedure is somewhat like getting a scrub-up before entering a hospital operating room. However, considering the sensitivity of neodymium YAG lasers to dust and lint particles, one can understand the care that must be undertaken before entering the area. The laser facilities are entered through pressure locks—much like going through watertight hulls on a submarine. Once inside the facility, one is impressed by the amount of equipment and the dedication of the scientists. The laser was not totally operational during my visit—only one of the two "legs" was operating. Nonetheless, the activity in the area was well organized and substantial.

Passage from the laser room into the target area is made via several airtight interlocks. The target chamber also is not complete. At the time of my visit, the problem facing the scientists was a very small vibration in the target chamber. A slight vibration in a massive structure, well over 7 feet in height and 3 feet in width, may not seem important at first, but when one considers that the target size is about one micron and that the British scientists hope to impinge one to 10 terawatts of power onto this target, all vibrations become important.

Considering the overall effort being devoted to the Aldermaston high-energy laser facility, one would have to conclude that the UK high-energy laser facility work is "light and exciting."

On the second part of my AWRE visit, I was hosted by Dr. G. Heath, the head of the Chemistry and Explosives Department. Heath was formerly the Chemistry Division head at the Admiralty Marine Technology Establishment, and in this capacity he became familiar with research at Royal Navy facilities. He explained the organization of AWRE, which previously was led by Mr. D. Cardwell. Cardwell, however, has been replaced by Mr. C. Fielding, the former chief scientist of the Royal Navy.

AWRE is comprised of two major divisions: Production and Nuclear. It is in the nuclear area that a great deal of the research goes on. The nuclear area, in turn, is divided into two subareas: Materials and Explosives, and Design/Engineering/Project Management. Most of the research goes on in the Materials/Explosives subarea. There are four departments in the Materials and Explosives subarea: Chemistry and Explosives, led by Heath; Metallurgy under Mr. G. Ellis;

Chemistry Technology, with Mr. D. Deverell as chief; and a High Energy Materials Division, headed by Mr. N. Thomson. Because my interest was in chemistry, the rest of this article describes the organization of the Chemistry and Explosives Department and some of the work going on there.

There are four divisions in the Chemistry and Explosives Department, each with its own superintendent. The Nuclear Chemistry Division headed by Mr. M. Baker consists of about 50 scientific officers with support personnel. It is in this group that the mass spectrometry organization is located. The Weapons Chemistry Division headed by Mr. M. Dean contains 40 scientific officers; Analytical Chemistry led by Mr. F. Cripps has 40; and Explosive Techniques under Mr. P. Cachia has 70.

Research in the Nuclear Chemistry Division emphasizes the classical radio chemistry techniques. They have a large mass-spectrometry-research trace-analysis group dealing primarily with inorganic materials and medical tracers.

Analytical Chemistry's research features, as one might well imagine, analysis of nuclear materials. However, they also apply neutron-activation techniques for geological surveys made in the UK and, very interesting to me, work to improve the analysis of fingerprints. Using nuclear approaches, they have found methods to enhance the sensitivity of fingerprints and they can analyze fingerprints on materials that have been under water for a long time.

Research in the Weapons Chemistry Division deals with material compatibility studies, trying to marry newer composite and polymeric materials to explosive materials. A lot of their work uses gel precipitation chromatography. They also are studying various explosives, initiation of explosions, stabilization of the explosives, and analysis of the energy output.

The Explosive Techniques Division carries out R&D development in the synthesis of new explosive compounds, new detonators, and new formulization. A great portion of their effort deals with the improvement of safety procedures of explosives used in the UK. They also investigate the thermal and mechanical properties of the explosives as well as their manufacture and development.

Of particular interest to me was a visit to Daly's former mass spectrometry group, which is now part of the Nuclear Chemistry Division. Dr. Andrew McCormick heads this group now. McCormick told me that the Mass Spectrometry Group was established in the 1950s under Dr. H. Wilson, a well-known mass spectroscopist. Wilson built the first large tandem mass spectrometer in the UK for isotope analysis, and the group's major effort was isotopic abundance measurement, primarily of uranium. During the 1960s, Daly succeeded Wilson and the Mass Spectrometry Group at AWRE became the second largest mass spectrometer manufacturer in the UK. Only AEI Ltd. of Manchester built more instruments in the UK during this time. In the late 1960s, the research in the group expanded to include a physical-chemistry measuring group; and McCormick was hired to lead this effort. During the early part of the 1970s, Daly's group grew to about 50 people.

McCormick quickly pointed out that the size of the AWRE Mass Spectrometry Research Group has become smaller. They now have 17 people, only three of whom are university graduates. The ratio of scientists to technicians contrasts with that of Government laboratory research departments in the US where senior scientists greatly outnumber their technicians.

McCormick's research is divided into three efforts. Gas analysis, headed by Dr. A. B. Davis, is concerned primarily with the mass spectrometric measurement of helium and hydrogen diffusion techniques. The second major effort is analysis of solids; this group has three special mass spectrometers available for their work. The first is a three-stage S-shaped tandem instrument used for improved measurement of isotope abundance sensitivity. McCormick reports that they can get 10^{-9} sensitivity on samples consisting of approximately 10^{10} atoms of uranium. The second solid mass spectrometer deals primarily with prototype and quality assurance work, again on uranium; and the third is a two-stage tandem device that acts as a backup for their three-stage instrument. The final effort of the mass spectrometry research is organic analysis. This involves, almost exclusively, gas chromatography-mass spectrometer combination analysis. The instrument used in this effort is a Kratos (AEI MS50) which replaced the group's AEI MS9.

In talking about future research, McCormick expressed interest in laser mass spectrometry similar to the work being done in the Naval Research Laboratory in Washington, DC, and at the Royal Research Unit in Swansea. However, despite Daly's involvement in laser research and his former connection with the mass spectrometry group, the AWRE mass spectrometry team has been so fully occupied with analytical work that they have not started this research yet. According to McCormick, however, it is only a matter of time until this is done.

In conclusion, the benefits of the broad base vertical research integration at AWRE were clearly apparent. Work in most areas involves effort from basic research to manufacturing. This vertical integration is well coupled in most areas; in others, it is less so; but all the work I observed was first-rate, high-quality research. (F.E. Saalfeld)

ENERGY

MUDDLING THROUGH OR MODELING THROUGH

The Conference on Modeling of Large-Scale Energy Systems took place in the new conference hall of IIASA, the International Institute for Applied Systems Analysis, in Laxenburg, a suburb of Vienna, from 25 to 29 February 1980. IIASA, the subject of a separate article in this issue, is situated in Schloss Laxenburg, a castle built a couple of hundred years ago by Maria Theresa and recently refurbished by the Austrian government. The conference center, a wing of the Schloss completed after some last minute changes on the morning of 25 February, has every conceivable modern convenience. I was especially impressed by the wireless microphones given to speakers and questioners.

There were almost 150 attendees from virtually every country in Europe, both east and west, as well as from Latin America, some Arab countries, Pakistan, and Japan. Most of them came from organizations that were actually building models of large-scale energy systems. There were also many participants from IIASA, including the conference chairman, W. Häfele, deputy director of IIASA and leader of its energy systems program, where many such models have been built and manipulated. We were welcomed by Häfele; by R. Levien, director of IIASA; and by T. Vamos, president of IFAC (International Federation of Automatic Control) which sponsored the conference. Häfele spoke briefly about IIASA's work on energy, pointing out that IIASA cannot compete with national bodies, but can deal with global problems which such bodies do not touch. He mentioned some interesting insights which are not normally recognized; for example, that oil is not only a source of energy but also an energy storage medium, and that a supply of water for cooling may be more critical in some cases than a fuel supply. This latter observation is an example of the principle that the energy system must be imbedded in larger national systems. Finally he introduced what was to follow by emphasizing that "comprehensiveness" and "consistency" were the buzzwords for models.

Levien spoke on 4 important "partnerships" for IIASA: one with IFAC, whose secretariat is now permanently headquartered in Laxenburg; one with Austria, which has subsidized Schloss Laxenburg; one with the village of Laxenburg, whose burgermeister was present at the ceremony; and one with Maria Theresa, who died two hundred years ago, but not before having conceived and renovated this lovely Schloss which had space for her 16 children. That space is now being occupied by 96 scientists, and Levien thought that this ratio of 6 to 1 might have some significance.

All sessions of the conference were plenary. The sole language of the conference was English, and there was no translation. In addition to the opening and closing ceremonies and a couple of panel discussions, there were nearly 40 technical papers presented, each 30 to 45 minutes long. More than half of these were basically confined to descriptions of particular models. These papers had titles such as "Energy Models in Mexico"; "A Stochastic Model for Electricity Generation"; "Energy Modeling and Aggregation for Refining"; "Energy Modeling, the Economist's Approach"; "Sectoral Energy Demand for the Belgian Economy: the Case of the Iron and Steel Industry"; "Systems of Models of Assessment of Longterm Development of the Energy Complex in Bulgaria" etc.

The basic subject matters of these papers were large and complex mathematical models which could be manipulated only by simulation on a computer. Typically, these were Leontieff-type input-output models, or linear-programming models sometimes modified to be integer or nonlinear in some aspects. In particular, most such models contained a supply model and a demand model, connected by appropriate economic functions. Most of them had innumerable subsidiary models, connecting the two basic models with such things as research and development effort, the general economy, population growth, import-export restrictions, etc. Most of these models were supported by a technique called scenario writing involving various guesses as to what might happen in the future. Typically, there were several scenarios, including a "low scenario" (pessimistic) and a "high scenario" (optimistic) for the range of some exogenous variable in the future. The majority of the models were deterministic and took uncertainty into acccount only by running the model for several different scenarios, as distinguished from the Monte Carlo method, which generates random numbers and then runs the models for hundreds or thousands of replications; this Monte Carlo method is generally more suitable for simpler models. Finally, most of the models were highly detailed in their analyses of the economy as a whole, or of the energy sector in particular, and involved hundreds or even thousands of variables.

One of these papers describing typical models was entitled "Energy System Management by Computer-Aided Synthesis" by K. Schmitz and H.P. Schwefel, KFA, (Jülich); these energy models were recently described in *ESN* (33-10:409). Since all of these papers were of less interest to me, and, I believe, would be of less interest to the readers of this article, I shall not report on any of them. This report is, therefore, unrepresentative of the conference as a whole, but the papers that follow intrigued me for one reason or another.

The first technical paper was given by Dr. W. Frank of the Austrian Federal Ministry of Trade, Commerce and Industry. He pointed out that modeling with computer simulation was not always the appropriate technique. There were cases when the equations could be handled analytically, and if this were feasible it was clearly a better approach. Frank emphasized that the complexity of a model depends largely on the number of parameters necessary to describe adequately the behavior of the system, and added that modeling the energy of a small country, such as Austria, might be at least as difficult as that of a large country, such as the US or USSR. The Ministry's experience had been that no simple model of Austrian energy would suffice. Finally, he spoke of recent history in Austria. A referendum on nuclear energy in 1979 resulted in the rejection of nuclear fission (and of the use of a just-completed reactor) by 50.4% of the total popular vote. In December of that year, the Austrian parliament passed a law requiring the government to present to the parliament a comprehensive report on energy each year. If only to comply with this law, the use of sophisticated models is going to be required.

Prof. W. Hogan (Kennedy School, Harvard Univ.) made a very impressive "tell it like it is" presentation (In the question period that followed, he admitted that some people—including most politicians—might not agree with his facts; but he insisted that they were facts, nonetheless). Hogan started by recommending an article, "Energy Policy Modeling: A Survey", in *Operations Research* 127, 1-36 (1979). He asserted that he was interested in the state of the question rather than the state of the art. He then presented what he called "the seven realities" of energy policy analysis: (1) The world is not running out of energy; (2) Mideast oil holds great risks, but is so valuable that the world will depend on it for a long time; (3) Higher energy costs cannot be avoided, and prices must be allowed to reflect these costs; (4) Environmental effects of energy usage and the costs of these effects are serious—they are expensive but not prohibitive; (5) Conservation is essential; (6) Serious setbacks and surprises are certain to occur; (7) Sound research and development policy is essential, but there is no simple technical fix (people who feel that something magic like solar energy will solve the problem are doomed to disappointment).

Hogan then made 15 assertions about energy, commenting in each case on the relevance of modeling (in general models become less useful as one goes down the list). (1) As modeling has shown, central management of allocation is always inefficient. (2) Price controls are a divisive issue, and modelers have been helpful in understanding them. (3) Import reduction is "a false hope that misleads American policy." Modeling has been helpful in identifying that the process won't work, but not helpful in showing that it is the wrong question. (4) Environmental constraints can be expensive but need not be prohibitive, and models (especially cost/benefit analyses) have been useful here. (5) Models have shown that worries about investment capacity and employment are a nonproblem. Hogan asserted that there is plenty of capital and manpower. (6) Models have shown that economic growth can be achieved even if energy becomes scarce. (7) Modeling has shown that the potential for conservation is large, and that higher prices could be a major stimulus to conservation. (8) Energy is being depleted, but not exhausted; that is, the world is running out of cheap energy, but not running out of energy. Models have been helpful in clarifying this distinction, but not in understanding how fast depletion will occur. (9) Income distribution is a central policy issue in the US and models have not addressed it. (10) International dimensions: the US has been slow to focus on international interdependence, and models have generally ignored many aspects, such as the less-developed countries (LDCs). (11) Assumptions about future world oil policy have been critical for US policy and "analysis has been wrong and naive" in this respect; for example, most American papers on OPEC assume that that organization behaved like a revenue-maximizing monopolist, which simply is not true. (12) Energy and security: analysts have only recently separated these two issues, and modeling has not been helpful. (13) Inflation and macromanagement: this is "the second most critical policy problem, and confusion reigns" (the most critical policy problem is Mideast oil). At the time of the drastic price rises in 1973-74, and again in 1979, the actions taken by the US to mitigate the effects of shortages actually exacerbated them. (14) The "principle of third-best policies": The US political system prevents us from implementing ideal policies, or, in many cases, even good policies. To avoid confrontations, modelers have frequently looked only at third-best policies. (15) Verification/validation/ventilation: it is necessary to make large-scale models accessible to policy makers. For example, any decision on nuclear-waste disposal must be based on what happens in the next 10,000 years, and this can only be done through a model. But it must be the kind of model that can be clarified to laymen in a court of law.

Häfele, who had given a welcoming paper, also gave a technical paper. He emphasized that energy is conserved, and so, in some sense, no energy is ever "used"; and he introduced the concept of negentropy, a technical term from thermodynamics which can measure the usefulness of energy in some cases. He also made some interesting assertions about the increase of efficiency of various devices over time. The efficiency (e) of prime movers has increased from about 1% in 1700 to about 50% today. Plotting a nonlinear function of efficiency, log e - log(1-e), against time, the data gave an absolutely straight line. A straight line of steeper slope showed an increase in the efficiency of light sources from about 0.2% for a paraffin candle in 1850 to 20% for a fluorescent lamp today. Because of the nonlinear nature of the efficiency axis, there is no reason to believe that these straight lines cannot be extrapolated almost indefinitely into the future.

Häfele presented some remarkable data on energy consumption. For example, energy consumption in urban areas is remarkably constant throughout the world if measured in watts per square meter. This startling observation is explained by the fact that less affluent countries with less energy consumption per capita tend to have higher population densities. Finding such invariants supplies a third approach to assessing energy demand (the first two being the conventional econometric approach and the scenario approach). He also made the distinction between final energy (gasoline at the pump or electricity delivered to the home) and primary energy; and he showed that if energy consumption is measured in watts of final energy per dollar of gross domestic product (GDP), almost the entire world has about the same rate of energy consumption—in the neighborhood of 0.5 to 0.75 watt/dollar—with the exception of North America and the communist countries of eastern Europe and Asia, and that for these countries this number has been decreasing and will fall into the above range in the near future.

A.A. Papin of IIASA presented a paper jointly authored by him and A.A. Makarov (Siberian Power Institute, Irkutsk), in which he contrasted the systems approach with what he called the traditional approach. The traditional approach assumes the existence of objective regularities, the possibility of quantifying these regularities, and the validity of extrapolating on the basis of them. The systems approach examines, rather, external and internal relationships of the system. It assumes visibility of those relationships and their parameters, and the quantitative estimation of the technological parameters characterizing the relationships of interest. He showed how, in certain types of models, relying on the independence of exogenous parameters can actually give outputs whose average accuracy exceeds that of any individual input. He spoke about the modeling of interactions between energy and the economy, and features of the systems approach that are particularly applicable to energy development under conditions of planned economies.

A.F. Beijdorff (Shell International, UK) presented a paper entitled "Energy Price: Pervasive Carrier of Information." He was a clever and witty man. During the question period he was asked to discuss actual prices, as distinguished from such things as optimal prices, which had been in his presentation. He replied that there was no such thing as an actual price, and then pointed out that the British (of whom the questioner was one) were well known for muddling through, and followed with the phrase used as the title of this article. Beijdorff's presentation, which apparently is not to be published in the Proceedings, included some remarkable interpretations of price data. For example, there was an enormous peak in the price of petroleum during WWI, and discounting for inflation, the price of petroleum at that time was as high in "real money" as in January 1980. Also, the price of transport fuels (gasoline) to the consumer, in real money, has not changed significantly in the 1970s except for what he calls a "smokers' dip" in 1975—this is the dip that one notes in cigarette consumption whenever the prices are raised, a dip which is very shortly erased as people go back to the habit. The price of fuel oil in the EEC countries has gone down. The per capita consumption of gasoline has been constant per unit of GDP, while the per capita consumption of fuel oil is way down, but both of these consumptions have held steady if they are measured per household. These data illustrate dramatically the dangers in a superficial analysis of how such things as prices and demand have changed.

He also pointed out that the percentage of GDP which is spent on fuel for heating homes is about the same in Sweden and France. Sweden, of course, is much colder, but in Sweden they spend more for insulation (the cost of which is not counted in such comparisons). In the US, the price of gasoline in real (not inflated) dollars remained constant until 1979, but will doubtless double within the next few years. The US has legislated the efficiency of cars, and they will indeed become more efficient; success will be claimed for the legislation, when in fact the increase in efficiency will be due entirely to the increase in the real price. Actually, the US, Japan, and western Europe have all gradually decreased their usage of energy if it is measured on a per GDP basis. He displayed a chart from the US Department of Energy (DOE) showing how the cost of imported crude oil will increase over time while "coal liquids" (synthetic fuel) will stay constant; these curves, of course, ultimately cross. However, Beijdorff does not believe this. It turns out that people always underestimate the cost of new technological developments such as synthetic fuels. Thus, he displayed a graph of the estimated cost of shale oil between 1973 and the present. When oil cost about $3 per barrel shale oil was estimated to cost $6 per barrel; by the time oil got up to $25 per barrel, people were estimating the cost of shale oil at $28 per barrel. In general, such estimates tend to continue climbing until the first production; then they level off for a while and finally one gets on the "learning curve" from this production and the costs start down.

P. Zweifel presented a paper by him and E. Kofler (Institute for Empirical Research in Economics, Univ. of Zurich) on a new approach which they have developed for decision making under uncertainty. They call it linear-partial-information analysis, and they advance it as a substitute for fuzzy-set theory. The basic idea is that a finite number of different probability functions over states is relevant under conditions of fuzziness. The tool was applied to the evaluation of the relevant health risks of nuclear power, where the information concerning risks is of course very fuzzy indeed.

R.J. Deam (Energy Research Unit, Queen Mary College, UK) presented a paper entitled "Long-Range Pricing of Crude Oil" describing what he called the WEML (World Energy Model Ltd.) model. It is based largely on the analysis of interrelationships between the prices of various energy sources. He illustrated it by showing how, as the price of petroleum goes up, different and more expensive methods of refining will be used, producing more gasoline and kerosene and less heating oil, with coal being substituted for the heating oil. As the price of petroleum goes up to a still higher critical level (and it is almost there now), coal will be substituted 100% for petroleum through liquefaction or other synthetic-fuel forms. In particular, he discussed the conversion of natural gas to methanol, asserting that for exportable natural gas this is a much more efficient way of transporting the energy than by conversion to liquefied natural gas (LNG). He pointed out that the present exportable reserves of natural gas are about the same as those of Mideast crude, and predicted that natural gas might thereby become, in the comparatively near future, the standard against which all other fuels are priced, replacing Saudi Arabian light crude oil which presently constitutes that standard. In the question period, it became apparent that not all of the audience agreed with this prediction.

J.G. Debanné (Univ. of Ottawa) presented a paper entitled "Application of Generalized Trans-Shipment Networks and Integer Programming in Regional Energy Planning Models." The written version was indeed on this topic, but the oral version was quite different. He discussed mission-oriented models, of which the Ford Foundation's energy model and the Club of Rome's limits-to-growth model are examples. He compared them to service-oriented models, of which Data Resources, Incorporated's Energy model is an example. In the former, the mission is accomplished when numerical results are obtained for a number of scenarios and reports are published about the modeling methodology and about results which are intended to guide policy making as well as advance the state of the art. In the latter, service is provided to clients—policy and decision makers—who could be assisted on a recurring and, if possible, interactive basis. Essential attributes of a good model, then, would be that it was specialized for a particular class of problems, timely, relevant, and versatile. Versatility implies that it is adequately interfaced to facilitate communication with the client. He talked about how these models should be iterated between a small model selecting a menu of investment and technology options and a large model evaluating the effect of the above plan on the objective function of the system being modeled. The first would be an integer program, subject to all the real-world constraints, and speed would not be critical; the larger model would be a linear-programming, or a generalized-upper-bound-linear-programming, or transhipment-network, or generalized-network problem, and speed might be critical. (In the generalized network problem, each arc of the network is characterized by an efficiency as well as by an upper bound, a lower bound, a cost, and a flow rate, the latter being the variable to be optimized).

In a panel discussion on "Improvements on Models to Aid Decisions", C.R. Glassey (US DOE) pointed out that models are not suitable for decision makers. They never sit at terminals manipulating the models. They always complain, on the one hand, that the model is too complex, and on the other, that it lacks sufficient detail in some area of common interest. They need an interface; that is, rather than recommending (as most people do) that models be designed which the decision maker can personally utilize, he suggested finding ways of explaining the model to the decision maker and interfacing him with it. Furthermore, he warned that it is necessary to get universal agreement that the model is good; otherwise, after the fact, opponents dig up an expert witness who testifies that the model was no good. Häfele said that he sympathized with decision makers who did not trust models.

The few papers and ideas discussed above I found most interesting, but the bulk of the papers were, as I said, narrowly oriented. What worried me more than this narrowness was that many of them seemed to have no relation to decision making. The speakers presented their models in great detail, but almost none of them gave any evidence that the models had been used or applied. One speaker mentioned that when OPEC had raised its prices, his management had used his model to recompute their budget; but one hardly needs a 2000-variable model predicting energy usage and costs through the year 2000 to do that. Thus, while the conference was doubtless of extraordinary use to the thousands of people around the world who are engaged with energy models, and while many of the participants doubtless learned a great deal from the technical details of one another's model constructions, I found it, on the whole, less rewarding than I had hoped as a guide to future energy policy.

The Proceedings will be edited by Häfele and published by Pergamon Press. (Robert E. Machol)

THREE-MILE ISLAND AND OTHER ENERGY CONCERNS

In addition to the yearly increase in demand for electrical power, any power grid is faced with a demand which oscillates on a daily as well as yearly scale. The total demand is the sum of the two. In the UK the power demand during summer has a minimum of approximately 16,000 MW occurring at 0300, and a maximum of 30,000 MW occurring at 1000. During the winter the demand is increased; the minumum is then 27,000 MW and the maximum of 45,000 MW occurs at 1800. (For perspective the reader should note that one large power station has a capacity of approximately 1,000 MW.) Fulfilling the maximum demand can be accomplished either by increasing the power generating capacity or by using energy stored during the low part of the demand cycle.

Understandably after the Three-Mile Island nuclear accident at Harrisburg, PA, there is much public concern in the UK about nuclear power. On 13 March 1980, Mr. H.T. Dunster presented a lecture to the British Nuclear Energy Society. The speaker, now Deputy Director General, Health and Safety Executive, was formerly with the UK Atomic Energy Authority. The lecture, sponsored by the British Nuclear Society was given at the Royal Institution of Civil Engineers located at 1-7 Great George Street, London.

Dunster spoke on "Some Reactions to the Accident at Three-Mile Island." He began by relating the chronologies of the Three-Mile Island accident and the Crystal River shutdown and identified those features which he thought would encourage changes in UK practices. He continued by discussing emergency measurements, siting considerations, and possible trends in regulatory policy.

Dunster said that the most important design lesson is the necessity of conducting a comprehensive fault study. Emphasis on the maximum creditable accident has forced designers to deal with large accidents rather than with smaller, more common malfunctions. Instrumentation of the Three-Mile Island reactor was adequate but presentation of the data was poor. More information on water level and radiation levels might have been helpful, although the operators did not believe the thermocouple measurements of core temperatures. He emphasized that the need in instrumentation is for data processing so as to present a continually understandable, comprehensive, real-time picture of reactor behavior.

In dealing with emergency procedures, Dunster continued, the plant should be fully automatic for the first one half-hour. The operators should not override the emergency procedures unless they think they can do better. When taken, human actions should be such as to create minimum disadvantage, a different concept from acting on the most likely cause. Dunster proposed having a sealed override switch which would inhibit an operator from taking a casual control action.

The time between the start of an accident and the release of radiation may not be well used in dealing with public safety. In order to correct this deficiency, emergency plans should establish well-defined responsibilities and, ideally, all information should be supplied by a single information center. Dunster stressed that government officials as well as operators need good information in order to make good decisions. He noted that one of the differences between the US and the UK is in the actions likely to be taken by the public. US citizens will evacuate an area if provided with conflicting data, while this may not happen in the UK.

Dunster stated that safety should be provided through proper management and that the safety regulations should not undermine the authority of the operators. Usually an industry prefers the safety regulations to be specific and detailed and Dunster thinks there will be a call for more regulation of this type. He would much prefer appropriate educational measures, and emphasis on the responsibilities of both the operators and the managers in order to achieve a better balance between the operation-production decisions and public safety. According to Dunster, the sites chosen for reactors in the UK will probably not have much influence on the consequences of an accident. However, he pointed out the choice of site is important when making emergency plans.

In conclusion, he stated that the accident at Three-Mile Island took place in a management and regulatory climate different from that in the UK. In addition, the reactor itself was also quite different. And finally, he said that it is necessary to reappraise the balance between designers, inspectors, operators, and management.

During the question period that followed his talk, Dunster pointed out the differences that exist between the US and the UK in regulatory conditions. He said that in the US regulation is accomplished through detailed specifications, rules and guidelines. These persuade management that following the rules is sufficient, and that in such a system it is difficult to encourage performance beyond that of the minimum requirements. The possibility of training the reactor operators on a simulator was also raised. Dunster replied that in his opinion simulation training should be started in the UK, but there is a possibility that it will not be required by government regulation.

Subsequent to Dunster's lecture, the government announced on 15 April that two advanced gas-cooled reactors would be built in the UK. This decision ended several months of discussion between cabinet members and within the nuclear industry. The Energy Secretary, Mr. David Howell, said that there is growing sentiment within the UK government to build the American-type pressurized water reactor. Construction of one nuclear power station per year until 1990 is now planned but it is possible that only the two gas-cooled ones will be built since the pressurized water reactor is favored by many government officials on the basis that there is less potential for damage with this type of reactor.

In addition to nuclear power, several nonconventional power sources have recently been restudied as possible means for increasing the generating capacity in the UK. An investigating committee under the chairmanship of the Department of Energy's chief scientist, Sir Herman Bondi, has reported that tidal power is technically feasible. This scheme would require the construction of a barrier across a large tidal region. The tide would be allowed to enter through sluices into the upper regions at flood and then allowed to fall back through power generating turbines on the ebb. Two prospective barrier sites in the Bristol Channel that have been designated would make use of the exceptionally large tidal range that produces the Severn bore. This would be one of the largest engineering projects ever undertaken. The report suggests that such a plant which would cost between 3 billion and 9 billion pounds sterling to build, could generate electricity at less than 3 pence per kilowatt-hour which is on the verge of being economically feasible. Before this feasibility can be definitely determined, the environmental effect of this project on tides elsewhere on the coast must be established.

The harnessing of wave power has also been revived (see *ESN* 34-3:114 for a detailed report). A small British-built generator was recently delivered to Japan. It is an air turbine, driven up to 1800 rpm by an air bubble which is alternately expanded and compressed by the waves. The effect is somewhat like a whistle buoy. Output of this one generator is between 100 and 170 kW depending on the sea state. Several other devices are in the experimental stage; their backers are hoping for government funds in order to conduct large scale tests.

Storing energy by pumping water from a lower reservoir to an upper one is also being advocated. Raising one acre foot (3.3×10^5 gallons) 100 ft will store 3.7×10^8 Joules. Allowing this water to fall back in about 6 minutes would produce up to 1 Mw depending on the efficiency. In spite of the formidable quantities of water required, the scheme is quite efficient and is being utilized in the US at Grand Coulee Dam in the state of Washington and in the UK at the North Wales Dinorwic power station. The biggest problem with this method is that much of the UK and western Europe is too flat for it to be feasible.

Another energy storage method which has been proposed utilizes large flywheels which could be brought up to speed slowly during the non peak demand hours. A steel flywheel 4 m in diameter and 50 cm thick has a rotational energy of 3×10^9 Joules at 1800 rpm. However, a flywheel rotated at high speed tends to disintegrate as a result of hoop stresses in the rim. This difficulty can be partially overcome by design and by choice of a material with a high tensile strength and low density. The usual criterion for comparison of rotors is the amount of energy stored per unit mass. On this basis steel is about one-third as desirable as carbon fiber and approximately 17 times less desirable than fused silica. Current thinking in the UK is to locate large flywheels in the already existing sites now occupied by obsolete power stations. The flywheels would be linked to motor generators and caged to prevent damage in case of failure.

In a full-length, two-column article in the *Sunday Observer* Sir Martin Ryle, Astronomer Royal, wrote, "Conservation, not the proliferation of nuclear power stations, is a saner solution to our energy problems."

Sir Martin asserted that if the capital cost of a nuclear power station were spent instead on conservation measures, then over the lifetime of the station, three times more energy would be saved than the station would produce. He also called for more research in renewable energy sources: wind; solar heat; waves; solar-electric; tidal and hydroelectric energy; and production of ethanol or methane from waste. He concluded by noting that support of alternative power sources was extremely small. Over the past 25 years the total R&D funding for wind power, one of the most promising sources for the UK, has been £970,000, which is about one day's subsidy by the UK government to the British Leyland Motor Corporation. (John R. Neighbours)

ENGINEERING

ANTENNAS AND PROPAGATION WORK AT FGAN IN GERMANY

The initials of the organization discussed in this article, FGAN, are easier to cope with than its full name, "Forschungsgesellschaft für angewandte Naturwissenschaften e.V." which translates freely as Research Establishment for Applied Sciences. FGAN is a civilian non-profit organization, outside the civil service, concerned with research and development for defense. It has been set up for the explicit purpose of achieving: (1) improvements in the performance of present and future reconnaissance methods and systems; (2) improvements in the development of modern system control; and (3) increases in the efficiency of command and control processes. Its main tasks have been stated in a general way as follows: (1) Provide the national industry with scientific and technical know-how and therefore support innovation in modern system concepts; (2) Function as consultants to, and agents of, the German Ministry of Defense; (3) Observe trends and participate in science development predictions as a basis for threat analysis and formulation of military strategy concepts.

The research tasks of FGAN are defense application oriented and are predominantly experimental. The research work is financed mainly by the Ministry of Defense (MOD) and to a minor extent by the Ministry for Research and Development, although FGAN can also accept commissions from other agencies.

FGAN is divided into six institutes and employs a total of about 460 people of whom nearly one-third are scientists. The yearly budget is about $14 million and there is a supplement of about $3 million for special items. Salaries are paid with funds that do not depend on project approvals. Research programs are negotiated by FGAN with relevant MOD representatives and with scientific advisors from universities.

My visit was to Wachtberg-Werthhoven near Bonn, where four of the institutes are situated, employing about 250 people. I met first with Dr. W.D. Wirth, supervisor of the Electronics Division in the Research Institute for Electronics and Mathematics (FFM). Wirth is responsible for theoretical and experimental research in the field of new radar techniques. FFM has about 100 people and the Electronics Division has 35, including 19 scientists/engineers.

In 1971 Wirth started a phased-array program called Electronic Steerable Radar (ELRA). It is a thinned planar array in which the radiating aperture, instead of being filled with elements regularly spaced by half a wavelength, has only a small number of elements but they are spaced randomly. The random spacing insures that the contributions of all elements (when properly phased) add coherently only in the desired direction. The beamwidth and beam-shape of the antenna are about the same as that of an aperture that is filled. The gain, however, with N elements, will be N times the gain of one element, so that the antenna with a filled aperture has a much higher gain than the one that is sparsely populated. The reduction in gain of the thinned antenna is accounted for by high average radiation levels in all directions.

ELRA operates on S-band and has separate transmitting and receiving antennas. Each of the 200 receiving elements has a solid-state module with low-noise transistors, and mixers that give an intermediate frequency (i.f.) of 30 MHz. Phase shifting (3-bit) to properly steer the beam and filtering are carried out in that module at i.f. Six hundred additional receiving-element units are being built by AEG Telefunken in Ulm and contain improved mixers with image rejection. Improved quartz substrate filters will be used to match to the transmitted waveform of 2 μsec pulses for search, clutter, and tracking modes, or 10 μsec pulses for long-range search. Wirth hopes that the

800-element system will be installed and become operational this year. He plans to sample the signal giving five or more simultaneous, independently steered beams with a broadside beam-width of about 1.8°. Multi-beam clusters will also be studied.

The transmitting aperture is also thinned and contains 300 randomly spaced elements. Each element has its own module containing a 3-bit, pin-diode phase shifter and a triode power amplifier (Raytheon). Peak transmitting power is 500 W. It is hoped that at some future date transistors will replace the present tubes. The transmitter gives a beam-width of about 3° and can transmit sequential pulses in separate directions, as determined by the phase shifters. Both transmitting and receiving antennas are tilted back 30°. Scanning is from the horizon to 90° in elevation and ±60° in azimuth.

Present studies and plans include the formation of subarrays on the received beams to save A/D converters and monopulse operation giving sum and difference patterns for high accuracy angle determination, with both sum and difference patterns optimized for low side lobes.

A most effective method was used to callibrate the system automatically. Nearby and in front of the receiver was a dipole transmitting a signal. The phase of this signal was measured sequentially at all receiving elements and adjusted by comparisons with a standard that included a correction for the near-field phase curvature. This callibration, which is done very rapidly, can be carried out frequently during operations and also takes care of changes due to temperature effects. An equivalent system is used for the transmitter with a nearby receiving dipole.

Many different radar operating and scanning modes were demonstrated. One particularly large target was found to exist in one direction, and the beam pattern, including side lobes, was clearly visible as the beam was scanned past it.

To me, the most interesting antenna was an experimental 3-D thinned array. Thirty-nine radiating loops were randomly distributed in a spherical volume. The loops were horizontal and, to avoid interference, were fed from vertical thin coaxial cables. The array was used as a receiver with phase shifters in each element line. The radiation patterns, including side lobes, were found to be close to those computed.

Several years ago (1973) Wirth had expounded a method of processing radar returns from an aircraft by assuming that the aircraft flies at a constant velocity in a straight line. He is presently extending his work. The method may be regarded as the inverse of the airborne "synthetic aperture radar" in which coherent processing yields a large effective antenna aperture which is the locus traced by the moving actual aperture during the observation time.

Dr. Chr. von Winterfeld is in charge of the Antennas and Scattering Division in the Research Institute for High Frequency Physics (FHP). He also spends some of his time at the University of Aachen where he is associate professor. There are 14 people including 8 scientists in his division. Von Winterfeld's primary interest is in conformal phased arrays. He is attempting to obtain the scattering matrix theoretically, and also experimentally from models in an anechoic chamber. He is investigating different shapes, specifically a sphere with a re-entrant and a cone. He and his team are also calculating the performance of adaptive systems when they are used with conformal arrays. For this, a line array, for example, in the shape of an ellipse, is simulated, and a "null" is inserted to suppress an assumed noise source. The radiation pattern is then computed.

A very large Cassegranian reflector antenna had been purchased for radar research and was described to me by Mr. K.W. Hofmann who is responsible for its operation. It is 34 m in diameter, mounted on a trainable pedestal in an air-conditioned building and was constructed by Siemens A.G. with great precision; the tolerances are given as ±0.2 mm. The antenna can therefore be used to very high frequencies. The limit is about 36 GHz (wavelength 0.86 cm) where the resultant beam-width is about one minute of an arc! At the present time, the antenna is fitted for the 1 GHz band (L-band) where the beam-width is about one half degree. A multi-feed system has been installed with two rows of ten linearly polarized feed horns, giving a total of 2 azimuth × 10 elevation beams. The four central horns are used for monopulse giving sum and difference patterns. The system is used for radar experiments with a 200 kW average, 5 MW peak transmitter.

Ing. Gniss and Ing. Magura described their use of the large antenna in a pattern-recognition project to examine an 8-ft long, tumbling, cylindrical satellite, RADCAT. The antenna system was also used to help track SKYLAB on its last spellbinding journey back to dusty earth. Attempts were made to determine its attitude relative to the position of the solar panels.

Gniss and Magura used a small, 36 GHz radar to examine ground targets (trucks and tanks). They found that they obtained very recognizable pictures when the target extended over 16 beam-widths but thought that 5-10 beam-widths might be adequate. They are studying polarization effects and the effects of camouflage both with actual vehicles and with models in the anechoic chamber. They use US, Swedish (metal), and German (graphite) camouflage nets, and generally they can see through all three types. Broad-band experiments with 1 GHz bandwidth and space diversity are being made and improvements due to the superposition of up to 24 radar images are being studied. Instrumentation is being developed for 1 GHz broad-band measurements in the anechoic chamber at 1, 10, and 18 GHz.

The anechoic chamber used in the above work is estimated at 10 × 5 m in size. The absorber, which was made by Grünzweig and Hardmann in Germany, performed well and was claimed to be much cheaper than competitive products.

An FHP subdivision headed by Dip. Ing. E.P. Baars performs millimeter-wave-propagation measurements. Baars was away during my visit and I talked to his associates, Dr. H. Essen and Mr. R. Makaruschka. They described their ongoing propagation attenuation measurements over a 250 and 500 m path at 47 and 94 GHz (wavelength 6 mm and 3 mm). Meteorological parameters are monitored and rapid-response (10 sec) rain gauges are used. The raindrop size distribution, which is measured electronically, is the most important parameter. Without rain, transmission losses show the greatest fluctuations in daytime, and the smallest ones at night. Ducting phenomena were noted during sunset. Vertical, horizontal, and 45° polarizations were available, but polarization changes did not have much of an effect. Makaruschka had just been on a co-ordination visit to the Rutherford-Appleton Laboratories in the UK; the FGAN measurement setup is similar to that in the UK and allows direct comparisons.

Essen and Makaruschka also studied target signatures with pulsed-radar systems. One of the systems, built by the Hughes Aircraft Company, operates at 94 GHz with 1 W output, 60 nsec pulses, and selectable polarization. The phase noise is only about 15° and allows an examination of the phase fluctuations of the target signal. Another pulsed radar system uses a 300 MHz chirp signal and has dual polarization outputs.

FGAN is a big place for its size. The work described here is but a small sampling of what is going on in their many research projects. (T.C. Cheston)

ELECTRICAL ENGINEERING AT THE UNIVERSITY OF MANCHESTER

Even before I knew the name of any other city in England, I had heard of Manchester. For, while growing up in a small village in Germany, I was the proud possessor of a pair of "Manchester Hosen." (I would later learn to call them corduroy trousers.)

For many years Manchester was "King Cotton" in manufacturing and was the epitome of cities of the Industrial Revolution. In the early 1700s it had been merely a market town of 10,000 people; by 1850 it had become a manufacturing and commercial city of over 300,000; and by 1911 the conurbation of Manchester had a population of over 2½ million. But then the growth stopped dramatically, and the population today remains at just about that figure. The years since WWII have, in fact, seen Manchester beset by increasing industrial problems because of the decline of the textile trades. Nevertheless, the area remains one of the great industrial centers of Britain.

At the present time, Greater Manchester's leading industries are the engineering and electrical sectors, with output ranging from heavy generating equipment to computers and microcircuits, and from machine tools to construction engineering. Although the clothing industry is still in serious decline, clothing factories, especially the rainwear trade, remain the most important employers of female labor. There is also a lot of activity in paper manufacturing and printing as well as in chemicals, food and tobacco products, plastics, surgical dressings, and electrical and aerospace components. Other growing areas are finance and professional and scientific groups. The Univ. of Manchester, which is located very close to the center of the city, therefore has a market for a large percentage of its product: scientifically trained students.

The Faculty of Science, of which the Department of Electrical Engineering (EE) forms a part, is proud of its major role in maintaining the standard of excellence established in the Manchester area by scientific pioneers such as Dalton, Davy and Joule. The work performed at the university by J.J. Thompson and Rutherford is world famous. Even in more recent times several projects in the Faculty of Science have become known internationally. These include the Physics Department's radio telescope at Jodrell Bank, and the work on the Atlas and other computers by EE.

EE, in fact, became famous in the field of computers about 30 years ago because of the Williams tube, the world's first successful cathode-ray tube store for digital computers, invented by the late Prof. Sir Fredrick C. Williams, FRS, who died last year. Williams, who was chairman of EE for about 30 years, developed the computer section so successfully that it evolved into the Department of Computer Science, now one of the largest departments of the university.

Somewhat to my surprise, I found out that EE is not the only department that teaches electrical engineering at the university whose title includes the words "The University of Manchester." Just half a mile away is the Department of Electrical Engineering and Electronics (EEE) of the Univ. of Manchester Institute of Science and Technology (UMIST). The two departments operate completely independently, although there is some collaboration. An example of the latter is a 1-year "taught" MS course, "Instrument Design and Application," which is given jointly by EE and EEE.

A report on a visit to EEE will be found in a companion article.

EE has 3 professorial chairs. One of these was held by Prof. Williams. The remaining two professors are Dr. Ronald Cooper, specializing in power and high voltage, and Dr. J.R. Hoffman, whose field is electronics. EE is presently looking for a person to fill the vacancy left by Williams.

Cooper and Hoffman direct EE jointly at this time, although Cooper, my host during my visit, is actually doing the administrative work. In addition to these 2 individuals, there are about 25 other persons in EE.

The number of students entering the 3-year undergraduate program in EE annually during recent years has been about 80, of whom about 30 come from abroad. There are about 25 students in the graduate research program, principally working toward a PhD. Research topics currently under investigation are summarized below.

(1) Crystal Growth: The growth of epitaxial films of II-VI compounds by chemical-vapor transport, with the aim of producing zinc-sulphoselenide light-emitting diodes; investigations of the growth of larger crystals of II-VI compounds, along with efforts to produce n and p type conductivity in these materials.

(2) Electrolyte Semiconductor Interfaces: Investigations of electrolytes interfacing with gallium arsenide and silicon.

(3) Optical Communications: Research in integrated optics, including active and passive components as well as wave-guiding techniques.

(4) High-Speed Imaging: Development of power supplies for solid-state lasers and circuitry for driving shuttered-image intensifiers.

(5) Alloy Films: Attempts at producing thin alloy films in vacuum by co-deposition of the alloy constituents.

(6) Digitally Controlled Micropattern Generation: A digitally controlled, electron-beam machine built in the department is used for generating micropatterns for semiconductor and magnetic-bubble devices.

(7) Magnetic Bubbles: Investigations of the use of magnetic "bubble domains" for performing logic operations storing and processing information within a magnetic memory plane.

(8) Measurement and Instrumentation: Measurement of magnetic field gradients at low magnetic fields; the development of measuring systems employing noncontacting transducers (such as automatic electrostatic watt meters and optical shaft followers); research on biomedical instrumentation for use in dentistry and for medical applications; applications of fluidic, ultrasonic, microwave, and digital transducers.

(9) Control and Systems Engineering: Analysis and design of digital filters for radar applications; signal processing for radar; system modeling; methods of using microcomputers; simulation and control of a model power generation and distribution system.

(10) Power Transmission: The study of transient movement of alternator rotors; the use of direct digital control in the operation of large turbo alternator-boiler units; the use of digital techniques in the overcurrent protection of feeders and distributors.

(11) High Voltage Engineering: Studies of phenomena that occur in the breakdown of polymeric insulation.

(12) Electrical Machinery: Design of high-efficiency, high-output/volume ratio motors for battery operation; investigation of self-optimizing battery electric-vehicle drives; permanent, magnetic-drive couplings; the development of extremely high-speed induction motors.

Now to some details on the above research topics. Cooper has been investigating high-voltage breakdown in insulators for a number of years and is continuing this effort. He told me that he was the first to show that when breakdown occurs in a solid, the light is always emitted first near the cathode; he said also that he verified Froehlich's theory of breakdown by energetic electrons in the conduction band. Cooper's present work with students involves optical investigations of breakdown between a fine wire in potting compound and a metal sphere, using a streak camera and computer-processed image enhancing. He stated that while no breakdown is generally observed between a very finely pointed wire and the sphere, there is breakdown with a needle of about 10 μm tip radius. Cooper wishes to find out at what curvature breakdown starts and when the phenomenon of "treeing" begins to take place as the gap between needle and sphere is pulsed with 100 kV.

The team of C.J. Hardy and R.S. Quayle performs studies of fine-line patternmaking with an electron-beam machine. Built about 15 years ago, the machine uses an interactive CYBER 72 computer for generating the pattern, then employs a PDP 11 for controlling the beam. Presently the machine makes lines down to 1.5 μm in width, in complex geometries. It is expected that with a new Cambridge-Scientific-Instruments column, 0.5 μm lines can be produced. The working field of the machine in use is 1 mm × 1 mm. While these dimensions are considerably less than those of a production machine (say 4 mm × 4 mm), the fact that such a machine was constructed and is being operated in the department is worth noting.

Two users of the machine are R.M. Pickard and W.W. Clegg, who are engaged in work with magnetic bubbles, those microscopic magnetic domains that can be used for storing binary information and can perform logic operations. I was told that the Pickard-Clegg team is the only university group doing bubble work in the UK. They receive financial support from the Science Research Council and material support from Plessey, one of the large British electronics manufacturers. The group has developed a mathematical simulation of bubble dynamics. Present experimental work is aimed at ascertaining the failure mechanisms at high frequencies by stroboscopic means and at developing methods of improving overlays for reducing failure mechanisms.

In the field of integrated optics, P.L. Jones has been investigating ultrahigh-vacuum methods of epitaxial deposition of II-VI compounds. Materials mentioned to me were zinc sulfide, zinc selenide, and a mixture of the two.

Another staff member, Peter Lilley, has been working with some of the same compounds with the objective of constructing blue-light-emitting diodes. He has obtained yellow-light emission from heavily doped ZnSe and he has made p-type ZnSe. He also told me that workers at the Post Office Research Laboratories developed a technique for determining concentration profiles in gallium arsenide and that a commercial instrument is now available that will accomplish this. By finding the proper electrolyte and the proper bias conditions, Lilley extended this technique to silicon and disclosed this process about a year ago. He mentioned that his technique was not limited by depth or by chemical concentration of the material.

During my visit I got the impression that there was not a great deal of industrially sponsored work in EE at this time. However, such activity can be expected to expand as soon as a professor has been found to replace Prof. Williams. I am told that the new professor will devote his efforts to the field of communication. (Irving Kaufman)

ELECTRICAL ENGINEERING AND ELECTRONICS AT UMIST

During a recent visit to the University of Manchester Institute of Science and Technology (UMIST) I was told that there are three universities in the UK specifically charged to interact with industry: UMIST, Imperial College of the University of London, and the University of Strathclyde. As I found out, the Department of Electrical Engineering and Electronics at UMIST (EEE) certainly carries out this task quite vigorously.

EEE is one of the largest departments of electrical engineering and electronics in the country, with about 350 undergraduates, 250 postgraduate students, and an academic staff of over 50. There are 8 distinct groups engaged in R&D. Of these, the group engaged in power systems engineering has enjoyed a worldwide reputation for a number of years.

There are 3½ professorial chairs. Dr. E.H. Rhoderick, professor of solid state electronics, was chairman of the department for a number of years and is now academic dean. Dr. H.C. Hankins, professor of communication engineering, is the present chairman and was my host during my visit to UMIST. Dr. C.B. Cooper, professor of electrical engineering, is active in the areas of high-voltage engineering and power-systems analysis. Dr. A.C. Rose-Innes, whose earlier work was in superconductivity and who now is very active in problems dealing with static electrification, is professor of physics and electrical engineering.

UMIST recently achieved some publicity because of the fact that the Science Research Council awarded a grant worth £250,000 to a UMIST team for "chips" research involving the interconnection of microcomputers (see *ESN* 33-10:440).

Most of the undergraduate students are British, but about 70% of the postgraduate students are foreigners. Whether the recent government announcement that fees for foreign students are to be increased will effect research at UMIST is problematical at this stage. According to the newspapers, UMIST is presently adopting a policy of hoping and waiting (see *ESN* 34-2:103).

In the remainder of this article I first discuss research being carried on by the various groups, then I talk about conversations I had with some of the staff.

Solid State Electronics

The activities of this group fall into 3 categories: (1) Fundamental studies of physical phenomena which control the performance of existing solid-state devices; (2) Development of novel solid-state devices; and (3) Studies of the causes of failure in industrially produced devices. Among the 9 staff members involved in these efforts are Roderrick, Rose-Innes, and Dr. D.C. Northrop. Their research deals with semiconductor diodes, Auger spectroscopy, metal-insulator-semiconductor (MIS) structures, scanning electron microscopy, deep impurity levels in gallium phosphide, properties of superconductors and contact electrification.

Power Systems

Among the 10 staff members in this area are Cooper and Dr. A. Brameller. Projects include work in probabilistic load flow, reliability evaluation of networks, ferroresonance, interactive computer graphics applied to power network analysis and design, and many others.

Metrology and Instrumentation

The four staff members in this group headed by J. Rawcliffe work on medical instrumentation (e.g., for an artifical kidney system), the automation of tedious classical measurement procedures in the standardization and calibration laboratory, classical metrology, and some work on Galvano magnetic and microcircuit devices.

High-voltage Insulation Engineering

The group of 7 staff members headed by Cooper is predominantly concerned with the problems associated with the insulation of power systems. This includes reliability studies; feasibility studies on new insulators; stress distribution calculations and measurements; studies of impulses and switching-surge breakdown; fundamental studies of dielectrics (gas, liquid and solid); system operation studies; corona detection, and others.

Electrical Machines

Five staff members, headed by B.J. Chalmers, are broadly concerned with the design and performance of electrical machines, transformers, and machine/semiconductor systems and with their application and control.

Digital Processes Group

Headed by M.G. Hartley and E.T. Powner, this group of 6 is concerned with a wide variety of aspects of digital techniques. Some of this work deals with multiple-valued logic systems, computer-aided logic theory and design, road traffic hardware and software traffic simulation, and computer interfacing.

Control

Senior individual in this group of 6 staff members is J.O. Gray. The group is concerned chiefly with electrical drives and servo systems (with emphasis on the application of thyristors, microcircuits, and computers in such systems). Some of the R&D work here deals with control of small machines, computer-aided design of control systems, discrete data systems, automatic control of a nuclear power plant, and multi-input/multi-output sample data systems.

Communication Engineering

This group of 5 staff members is headed by Hankins. Their activities are concentrated in the areas of data transmission, radio frequency measurements and techniques, antenna and UHF amplifier analyses, computer visual communications, and computer networks. A specific example is a project that deals with long-range Hf data transmission.

During my visit to UMIST, Hankins and Dr. A.E. Efthymiads briefed me on the general structure of EEE over the customary morning coffee. My first technical visit was to the Digital and Microprocessor Group, where Hartley and Powner spoke enthusiastically about their work. I heard that UMIST is an approved microprocessor consultant to the government and that the group is the largest microprocessor group outside the US. I also learned that work is being carried out in multiple processors communication systems, instrumentation and control, that the group provides service facilities for industry, and that because of the present great British interest in microprocessors, enthusiasm in this group is very high at this time.

The classical metrology which Rawcliffe discusses does not receive the same enthusiastic support as that given to microprocessors. A recent problem solved by his group for the Royal Observatory was a way of measuring the tilt of the earth to an accuracy of 1 ms of arc (1 ms of arc is equivalent to an arclength of 48 Å in a circle of radius 1 m—that is essentially 35 atomic diameters in extent). The group solved this problem by measuring the differential capacitance of 2 capacitors, of which each had one plate of solid material; the other consisted of a pool of mercury. Since, according to Rawcliffe, there is less interest in such precise measurements these days than there was formerly, the group is now involved in medical instrumentation. A specific problem in progress was the measurement of fluids by electromagnetic means, carried out by Dr. M.L. Snaderson.

Dr. A.R. Peaker, of the Solid State Electronics group, told me of his work on the characterization of deep-level impurities in n-type gallium phosphide. He found that there were two defects; the shallower of these is the dominant recombination center in most epitaxial layers of this material. He has also worked on related problems, especially as they applied to light-emitting diodes.

A most enthusiastic individual in the Control Group is P. Bowler, who characterizes himself as a "design-it, build-it, and make-it-work" type of engineer. His specialty is motor control, ranging from control of motors for tank turrets to those in textile machinery, a large industry in the Manchester area. It was a pleasure to talk with and listen to an individual who felt so enthusiastic about his work and his successes. Bowler gets a large amount of his funding from industry.

Another group that is supported in a similar manner is the Power Systems Group which, according to Brameller, is one of the largest of its kind in the UK. He characterized his work by saying that he analyzes power systems in a mathematical way, first separating the problem into component parts, then examining how the component parts interact with each other. An example of a problem is the design of systems to give the consumer the best value for money, knowing the failure rate. Another problem deals with applying state estimation theory to boiler operation. A third problem deals with natural gas, specifically, minimizing leaks in joints. (Brameller told me that all of England is supplied with natural gas.) His group has calculated that about £4M could be saved annually by controlling gas pressure locally.

In the Communication Engineering Group I talked to Dr. G.F. Gott, who has been working on methods for automatically minimizing the interference on a 2.5 kHz channel for communication in the 3-30 MHz range. According to Hankins, Gott is one of the UK's leaders in 3-30 MHz communications. I am happy to say that, thanks to my meeting Gott at UMIST, he recently visited the US, where he interacted with specialists in his field.

In summary, Electrical Engineering and Electronics at UMIST is presently a very successful enterprise—possibly because of its heavy emphasis on industrial and military support. It is hoped that the proposed change in payments for foreign students does not have the adverse effect on work at UMIST that some people predict.
(Irving Kaufman)

GEOPHYSICS

THE SPANISH NAVAL OBSERVATORY

During a visit to the Oceanographic Division of the Naval Hydrographic Office in Cadiz, Spain, last November, my host, LCDR Francisco Nuche suggested that I also visit the Instituto y Observatorio de Marina (Naval Institute and Observatory) on the outskirts of nearby San Fernando. The result was the most interesting interview I have had during my first year in this office.

The Institute and Observatory dates back to 1753 when it was established as an annex to an ancient naval academy in Cadiz. It was founded to provide navigators with the astronomical data needed for the determination of position at sea.

In 1793 a new building was begun on an island a short distance from San Fernando and in sight of Cadiz. The island is near the center of a 30 mi^2 estuary leading to the Bay of Cadiz. Over the centuries the estuary has been divided into innumerable rectangular salt ponds for the production of salt by evaporating sea water. Only a few of these ponds are currently being used, owing to a slump in world prices for salt. The remainder are being converted into one of the largest aquaculture farms in the world. The principal fish produced is the dorada (*V. Dorada*).

An interesting aside is the fact that Cadiz, with more than three millenia of history as a port, was cut off from the mainland when one of the greatest earthquakes of all time destroyed the sand spit that connected it to the mainland. This was the same earthquake that, with its ensuing *tsunami* (tidal wave), devastated most of Lisbon, Portugal. Cadiz was not reconnected to the mainland for almost a half century.

The Observatory moved into a new building in 1798. Actually the new building was so well constructed and has been kept in such good condition that it still looks almost new, inside and out. The only major change made was the recent addition of a massive concrete pylon extending from bedrock to the roof without touching the building itself. The pylon is used as a foundation for a laser-satellite-tracking station.

The Observatory is very proud of its beautifully housed 30,000-volume library, one of the best scientific libraries in Spain. It has many old and rare scientific volumes, including four *inounabula*.

My host was CDR Manuel Catalán, Assistant Director of the Observatory, who has a doctorate in nuclear engineering from the University of California at Berkeley. Most of the naval officers who were introduced to me spoke excellent English and had also done postgraduate work at Berkeley. The Observatory carries out a large number of programs with a senior staff of only 11 officer-scientists assisted by 35 supporting personnel.

The Observatory publishes an astronomical *ephemeris* for astronomers and geodesists and a nautical almanac for the use of surface and air navigators. The latter has been issued annually since its inception in 1792.

The astronomy section is determining the position of celestial bodies including extragalactic stars, studying the earth's revolution and determining astronomical time. A fully computerized system averages the time from five atomic clocks to furnish the official time base for all of Spain.

In the geophysics section, a local study of the earth's magnetic field has been under way since 1879. The staff recently designed and constructed its own proton fluxgate and optical pumping magnetometers. Catalán and his coworkers have also published a 153-page treatise on magnetometers (in Spanish).

Long- and short-period seismic waves have been recorded on a routine basis in one of the oldest seismological stations in Europe. It dates back to 1897 and now has 6 seismometers in operation. With recent improvements in the sensitivity of their instruments, these scientists have found that electric trains running into Cadiz are now degrading their seismic signals. They plan to move the seismic station 16 miles inland to quieter ground. The division has made a thorough seismic study of southern Spain and the adjoining Alboran Sea using shots as large as 2 tons of TNT.

In support of their astronomical observations, they have maintained a complete weather station since 1851. They have one of the longest unbroken instrumental weather records in Europe.

One of the newest additions to the Observatory is a satellite-tracking station that was established in 1957 in cooperation with the Smithsonian Institute. A Baker-Nunn camera is used for tracking, and precise ranging is carried out with lasers. Catalán stated that in a cooperative program with about a dozen other laser-satellite-tracking stations in Europe they might be able to determine the rate of techtonic-plate movement under individual stations through an inverse process. This seems to me to be a marvelous and incredibly difficult thing to do.

The Observatory holds numerous national and international seminars on geophysics. The notice for the 82nd seminar in the present series was posted on a bulletin board at the time of my visit.

In addition to its research programs and service functions, the Observatory operates a School of Advanced Studies in the Sciences of Mathematics and Geophysics, a 5-year postgraduate school specializing in celestial mechanics and geophysics. Each class has an average of 5 students (Naval Academy graduates and an occasional civilian) with a total of 25 on board at any given time. Each student is encouraged to become highly proficient in the design and construction of new electronic equipment and operates his own well-equipped mini-electronic laboratory. The students were using state-of-the-art, mini-chip electronic components.

The catalogue for the courses has over a hundred pages and describes an incredibly complete advanced curriculum covering many aspects of physics, mathematics, and geophysics.

One of the student officers was constructing a small specialized unique computer for rapid and accurate reduction of star-site data to position at sea. I asked why he was devoting so much time to an outdated technique for navigating when satellite navigation gave many very accurate fixes a day. With a twinkle in his eyes he stated that his system was safer. When I pressed him to find out what he meant, he laughed and said that the US could turn off their satellites but had not found a way yet to turn off the stars! I have noticed on several occasions that European scientists are inordinately proud to report new developments that are totally independent of any influence from the US.

I was deeply impressed by every aspect of the Observatory, not the least of which was its incredible neatness, and I was astounded that so few officer-scientists could do so many difficult tasks so well. The Spanish government must also be impressed, because the level of funding per person appeared to be greater than in any other laboratory that I visited in Spain or Portugal. (Wayne V. Burt)

MATERIALS SCIENCE

A CONFERENCE ON THERMOSETS—THF ECONOMIC OUTLOOK

The "Age of Plastics" began in about 1910 with the introduction of phenolic resins (the bakelites) which were followed, almost a decade later, by the urea-based polymers. Both phenolics and ureas are thermosets, highly cross-linked glassy polymers. In the passing years the thermosets have been eclipsed by the uncross-linked thermoplastics, like polyethylene, polyvinylchloride, polycarbonate, and polystyrene. Today the thermosets claim only 25% of the total plastics market.

The reasons thermoplastics dominate the market are varied. The thermoplastics are 2 to 3 times cheaper than the thermosets. The very properties in which thermosets excel over the thermoplastics, durability and heat resistance, work against them in the marketplace, where they find little use as high volume, throw-away items like packaging or disposable dishes and utensils. Until recently, thermosets required batch processing, whereas the thermoplastics lend themselves readily to continuous production methods. A further problem that besets the thermosets is that they are relatively easy to produce, requiring little investment capital or plant construction time, so there is a chronic oversupply.

All these problems were addressed at Coventry on 5-6 December 1979 in a Plastics and Rubber Institute conference, "Recent Advances in the Properties and Applications of Thermosetting Materials." The attendees were mostly from industry: resin producers, and manufacturers of fiber reinforced plastics, electrical equipment, and plastics processing equipment. Many of the speakers and many in the audience sounded optimistic notes about future growth of thermosets, but some disquieting pessimists were also heard from.

In the absence of the scheduled chairman (Dr. A.J. Kinloch, Propellants Explosives and Rocket Motor Establishment, Waltham Abbey), Dr. A.A.L. Challis (Science Research Council) opened the meeting with the comment that it was about time that thermosets took their rightful share of the plastics market. He pointed to the higher modulus and heat resistance of the thermosets compared to the thermoplastics, and observed that because the thermoset raw materials are usually liquids, they can be mixed with fillers to get very unique properties. Challis also suggested that the chemistry of thermosets can be varied easily to get a range of properties, and that variation in their chemistry has yet to be fully exploited.

The first paper, by Dr. Jan. Eric Vik (Perstorp AB, Sweden), was a review of the history of thermosets, with emphasis on processing methods and advantages over thermoplastics. As already mentioned, the first thermosets were phenolics, whose electrical and heat resistance properties are still unsurpassed among the lower cost plastics. Vik pointed out that the phenolics came along just in time to answer the demands of the electrical and telephone industry for an inexpensive insulating material that could be molded into intricate parts. Then came the urea-based polymers, which could be colored, but had poor resistance to heat, water, acids, and bases. The melamines, launched in the 1930s and having good chemical resistance and scratch resistance, opened up markets for dinnerware and kitchen utensils. Along about 1940 came the polyesters, with their capacity to take high loads of glass-fiber reinforcements and other fillers. These plastics, which could be used for large, load-bearing structures, found ready markets in the building and automobile industries. The polyesters were followed shortly by the epoxies, with their good adhesion to many substrates and their high resistance to chemicals. Most important, the epoxies could be injection molded and thus lent themselves to automatic processing. The epoxies do suffer from their high cost and high toxicity. The newest thermosets are the cross-linked polyurethanes and the polyimides; the latter can be used up to temperatures of 175-370°C. These new materials have not as yet established significant markets.

Until the 1950s, thermosets were processed in batches by various molding techniques, primarily compression molding. Production speed was progressively increased by various preheating methods to hasten resin cure, culminating in rf heating in the 1940s. It was in the 1950s that automatic compression molding and injection molding were introduced. Compression molding tends to introduce more residual stress in the molded part than injection molding, especially for large, flat pieces. This problem can be minimized by combining compression and injection molding; the resin is injected into a slightly open mold which is then closed to give final dimensions to the product. Vik commented that despite this progress, it is not generally recognized that thermosets can be molded as fast and effectively as thermoplastics. He went on to say that the market position of thermosets has probably stabilized in relation to the thermoplastics and will continue to be stable, the thermosets being used in those applications which require their unique properties. Vik does not see the oil shortage as a threat to plastics, since plastics require much less energy than metals to produce and process. Further, he thinks that thermosets are less vulnerable to the oil crisis than thermoplastics, since the former can be more easily extended by filler and reinforcing fibers.

Dr. W.A. Hall (Bakelite UK, Ltd., Birmingham) gave a rousing pep talk for phenolics in which he announced, "Phenolic resins are alive and well." He noted that the industry had been revitalized by direct screw-injection molding of thermosets, which put them in a competitive position with thermoplastics. He then went on to explain how the resin and filler must be tailored for injection molding and cautioned that this tailoring could very much affect the esthetic quality and mechanical properties of the end product. However, it was clear from Hall's talk, and many others during the 2-day meeting, that there was very little data on or understanding of molding parameters on which to base this tailoring.

Dr. A.L. Burns (BP Chemicals Ltd., Penarth) reviewed developments in reinforced polyesters and characterized the past decade as one of consolidating existing knowledge and diversifying into new markets. There have been few major changes in basic polyester chemistry (propylene glycol and styrene with phthalic acid) but polyester matrix glass reinforced plastics (GRP) have found many new uses. In marine applications there are, of course, the GRP hull boats, the largest of these is the Royal Navy's mine sweeper, the HMS *BRECON*, which is 60 m long and has a displacement of 625 tons. Designed to replace the traditional wooden mine sweeper, the *BRECON*, with its GRP hull, has a low magnetic profile, as well as lower maintenance costs and increased corrosion resistance. There is also an increase in the use of polyester GRP in constructing submersibles for seabed exploration. Burns noted that the traditional open-mold layup techniques for fabricating GRP are gradually giving way to closed-mold processing which requires the development of low-viscosity, high-reactivity resins with cure-system controls to give rapid cure after the mold is charged. One important advantage of closed molding is that it reduces the level of styrene vapor in the work area—a problem that GRP fabricators are being forced to face.

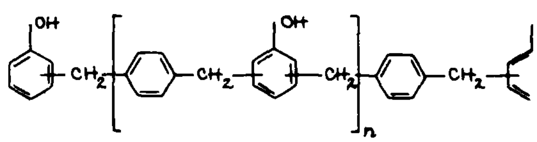
Polyester GRP has captured a new market: freight containers. Traditionally made of metal and wood, refrigerated freight containers now are largely fabricated from polyester GRP panels with polyurethane foam cores. A major hurdle that had to be overcome in this application was to convince health authorities that the chemicals exuding from the plastic would not contaminate foodstuffs. Polyester GRP is also widely used for side and roof panels of vans and trucks. In general, polyester GRP has been expanding into the transportation market, especially that of automobiles. Burns noted however, that the expansion has not been as rapid in the UK as in the US.

The discussion following Burns' talk centered on the failure damage of GRP; when GRP panels are struck, the damage is not localized to the region of impact, but instead, there is a wide area of delamination. Burns had little comment, but Challis stated that an industrial/government consortium was addressing the nature of damage and failure of GRP. A member of the audience remarked that there is a big gap between impact testing and actual component failure, and went on to say that a GRP automobile hood shattered into small pieces in impact testing. Challis responded that impact testing was "in a bit of a mess."

Despite the impressive mechanical and thermal properties of the epoxy resins, their costs keep them from being competitive with the polyesters or phenolics and, indeed, the epoxies have been listed among the "exotic" engineering materials. Recently, new products have been introduced that are more competitive and, in fact, would be the materials of choice when mechanical strength and heat resistance are critical. Mr. D.J. Martin (Ciba-Geigy Plastics Additives Co., Cambridge, UK) described two new general epoxy-molding compounds: T-type and Chopped Pre-Preg (CPC). We were told that T stands for trocher. The T-type is a pellet formulation that can be processed by compression or injection molding and contains short glass fibers or ground filler. The CPC is compression molded, and, having larger glass fibers than the T-type, gives products with better mechanical properties.

Phenolic foam (PF) is a newcomer to the field of insulating foam, which is dominated by polystyrenes and polyurethanes. Dr. K. Hillier (Lankro Chemicals, Ltd., Manchester, UK) spoke on the virtues and the disadvantages of PF. Its virtues are mechanical strength, heat resistance, and low smoke generation in a fire. Hillier presented a series of slides showing that after complete charring, the PF retained its structure and had some residual strength whereas the polystyrene foam had completely disappeared. However, PF is brittle and therefore difficult to cut, and its thermoconductivity is higher than both polystyrene and polyurethane foams.

Two relative newcomers to the thermoset scene are the polyimides (PI) and the phenol-aralkyl (PA) resins. Both are primarily used as matrix resins for high temperature carbon-reinforced composites for aerospace applications. Their main advantage over other thermosets is their ability to retain strength after exposure to elevated temperatures. Dr. G.I. Harris (Advanced Resins, Ltd., Stourbridge, UK), who developed the PAs, discussed their chemistry and properties. Chemically PAs are based on the condensation of phenol with α, α'-dimethoxy-p-xylene to form the prepolymer,



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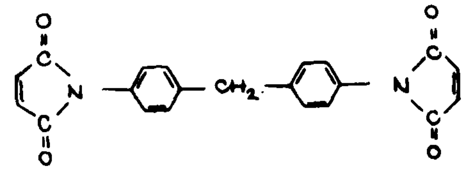
which is cross-linked by polyamines to give polymers that can be used at 250°C with little loss in mechanical strength.

Dr. W.W. Wright (Royal Aircraft Establishment, Farnborough, UK) described the various types of PIs, some having potential use at temperatures of over 500°C. The PIs that were of interest to this conference and that have the greatest commercial potential are based on the condensation of bisimides such as,



These are the least expensive and the most easily processed of the PIs and have about the same thermal resistance as the PAs. Both the PAs and the PIs suffer from processing difficulties; being solids, they must be applied to reinforcing fibers from solvents. These operations are labor intensive and most of the solvents used are toxic. Easier processing techniques may be developed, but for the present the PAs and PIs are limited to very special applications where heat resistance is at a premium.

The rubber-toughened epoxies, although not newcomers to the thermoset scene (*ESN* 33-1:14), are finding use as matrix resins to overcome the usual interlaminar brittleness of glass and carbon-fiber-reinforced composites. Mr. J.A. Bishopp (Ciba-Geigy, Bonded Structures Div., Cambridge, UK) described a proprietary modified-epoxy matrix resin which had the proper flow characteristics for easy lamination and imparted good interlaminar strength. Bishopp indicated that the modifier was not the conventional carboxy-terminated butadiene nitrile rubber, but did not elaborate any further.

Processing thermosets by injection and/or compression molding was the subject of a number of papers. The speakers echoed the comments by Vik that it is not generally recognized that thermosets can be processed as easily as thermoplastics by automated techniques. This may be something of an overstatement, since the high temperatures required to process the thermosets and the abrasive action of filler materials create special problems that do not generally exist in processing the thermoplastics. In a review paper, Mr. R.M. Messenger (Healey Mouldings, Ltd., Warley, UK) discussed these problems and gave an overview of the molding of thermoset materials. The topics given most attention by Messenger and the other speakers on processing were "tool wear" and automation of the processing operation. Because of the abrasiveness of the filler, resin feed stock severly wears the injection-molding tools. The resin formulator is generally ignorant of the effect of materials on tools. For example, minor changes in formulation, i.e., a change in the pigment, may drastically change the wear characteristics of the resin. There are various tests to measure tool wear and the simplest of these is to drill a succession of holes in molded material, with a drill of the same material as the tools. A much more sophisticated way of determining tool wear was described by Mr. G. Unsworth (Sterling Moulding Materials Ltd., London), in a review on advances in materials for thermoset injection molding. A small tab of steel containing a radioactive tracer is inserted in the surface of a test die, and the amount of steel worn off during a molding is determined by measuring the subsequent radioactivity on the molded part. However, neither these tests nor any other technique are available to measure tool wear continuously during production and thereby indicate when the mold should be removed and replaced.

Both Messenger and Unsworth spoke at length about automating the injection molding of thermosets, and it was clear from what they said that in order for thermosets to be competitive with thermoplastics, injection molding must be as fully automated as possible. However, there are some difficult problems in attempting to automate processing. For example, the cure rate, and thus the molding time, is very much dependent on the type of filler that is put into the resin. In addition, the physical nature of the feed stock may be variable, ranging from fine powder to pellets (that sometimes have considerable dust content) to thick pastes. The development of feed mechanisms that can handle this variety of stocks is being given a great deal of attention by the processing equipment manufacturers. Another problem is the variation in the properties of the feed stock, not only from batch to batch, but within batches. This is a matter of quality control and Unsworth maintained that quality control is worse in Europe than in the US. Despite these and other problems, Unsworth indicated that there was at least one thermoset injection molder that runs a full, regular night shift without any labor.

One of the most critical steps in the injection molding of thermosets is the screw mechanism which carries the resin stock from the feed hopper to the mold itself. The screw mechanism advances the resin but, more importantly, through friction heating and/or applied heat, the resin is plasticized to the viscosity that will allow it to flow uniformly into the mold. Mr. K. Guckau (Bucher-Guyer Ltd., Zurich, Switzerland) described the plasticizing action of the screw mechanism and how it is affected by the variation in feed stock. It was apparent from Guckau's talk that this is an area very much in need of detailed study.

If anyone was under the illusion that thermosets are going to overtake the thermoplastics market, this meeting should have convinced them otherwise. The thermosets will be used in those areas where their special properties, high modulus and temperature resistance, are essential. The meeting did serve, however, to demonstrate the lack of communication between the resin suppliers, the processing equipment manufacturers, and the end users of thermoset materials. (Willard D. Bascom)

POLYMERS AND SURFACES AT THE POST OFFICE

Out along the A12 highway, which follows a surprisingly straight course from London into East Anglia, is the Post Office Research Centre (PORC), in the hamlet of Martlesham Heath, about ten miles north of Ipswich. The PORC is a complex of buildings built mostly during the 1970s, and dominated by a tower surmounted by a rectangular structure, set at an angle, which looks as if it still had to be rotated into place. Atop the rectangular structure is a dome which, I was told, had something to do with microwave transmission.

The British Post Office includes telephone communications as well as postal service, as is the case for many other European countries. In the UK there are political efforts to separate the two services and in fact, except for high-level administration, the split has already occurred. The PORC is entirely devoted to research related to telephony and to telecommunications, the latter because the PO is responsible for distributing television signals between studio centers and transmitters.

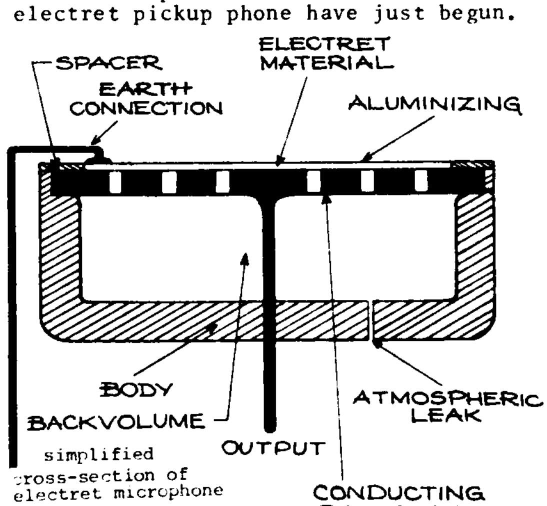
In his forward to the 1978 PORC Review, the director, Mr. C. May, referred to the "century inertia" of telephone equipment. Because the telephone service is so vast (15 million customers), systematic replacement of equipment is slow and expensive, e.g., some equipment is 50 years old. On the other hand, research at PORC is aimed at needs 50 years hence. In retrospect, the point that May was making was brought home to me while waiting in a departure lounge at Heathrow Airport. In the lounge, side by side, were two coin-operated telephones. One was a venerable, circular-dial model for local calls. The other was a touch-dial for international calls which had a digital readout that displayed the 3-min cost of your call after you had punched out the desired number. The call would be put through only after the proper amount of coins was inserted, and, if you finished in less than 3 minutes, the balance was refunded to the nearest 5 pence. Ma Bell would be proud of such a gadget.

Much of the reason for the "century inertia" that May referred to is the prolonged time needed to qualify materials and devices for the treatment they receive at the hands of customers. A lot of the old equipment is still in use because it was well-designed and well-built. Also, many equipment and system designs have been left stranded on the drawing board because they were inadequate to meet the growing volume of telephone traffic and the demand for fast-response equipment.

The heart of the conventional telephone is the microphone pickup, and, since the turn of the century, the pickup has been based on carbon granules. Despite such disadvantages as non-linear response, noise, and poorly defined electrical characteristics, the carbon granule pickup has thwarted all competitors because it has a high electrical output (needs no amplification), ruggedness, and low production costs.

Telephone companies around the world are looking for a replacement for the carbon granule receiver largely because of its considerable non-linear response. The replacement presently favored by the British Post Office is an inexpensive, electret-based microphone. The general principle of these devices is illustrated in the figure (p. 286). A capacitor, formed by placing an aluminized polymer-film electret against a conducting backplate produces a small ac voltage when the film is vibrated by sound. Electret-driven telephone pickups are not new nor is the use of polymer films as electret material. There does, however, seem to be a commitment by BPO for their use in future equipment. The output of the electret microphone

must be amplified, since the output is much below that of a carbon granule pickup. From a materials point of view, the biggest unresolved problem of the electret microphone is the electret material which must be mass-produced, have high dimensional stability (no creep) and have environmental stability.
Dr. D. Murrell explained to me that the most highly developed film material at PORC is aluminum-coated fluorinated ethylene-propylene copolymer (FEP). This is produced in a continuous process that takes FEP film from a roll through an aluminum-metallizing process, and then into contact with a charged knife. The resulting charge on the film is monitored by an electrostatic probe, and the grounded aluminum metallization on the takeup spool leaks off any excess charge from the film surface. Laboratory tests of the aluminized-FEP electret pickup indicate good reliability under normal temperature and operating conditions. The biggest problem is that moisture, especially from human breath, carries unwanted electrical charge to the electret film. This has been solved by placing a film of polyester in front of the aluminum surface to act as a moisture barrier. Murrell's reliability studies (which include corrosion tests) indicate that the electret pickup with moisture barrier should last more than a hundred years. If so, it would outlive many of the other components of the telephone. Field tests of the electret pickup phone have just begun.



simplified cross-section of electret microphone

Another candidate to replace carbon granules is piezoelectric-polymer film. Thin films of polyvinylidene fluoride (PVF_2) that have been properly stretched and polarized generate small voltages when subjected to tensile or bending stresses. As a diaphram in a telephone, such film would convert audio vibration directly into a voltage which, as in the electret-based pickup, must be amplified.

Dr. P. Pantellis is conducting research on piezoelectric PVF_2 at the PORC. His first concern was to obtain raw film of uniform quality in terms of molecular weight, melt index, and fluorine content. Good-quality film from a particular Japanese manufacturer is no longer being supplied, and Pantellis finds that the quality of film from other sources in Japan and Europe is too variable in its piezoelectric properties. He has turned to making his own by a blown-film process, after which the film is biaxially-oriented by drawing to ratios of 4-1 to 7-1. Normally, the next step in forming piezoelectric PVF_2 would be to polarize the film between electrodes at elevated temperatures. This procedure does not lend itself to continuous processing, since the hot film would stretch and develop wrinkles upon cooling. Pantellis, therefore, has developed a room-temperature, corona-discharge technique in which a continuous sheet of biaxially-oriented film is metallized on one side with Al, then passed between a knife-edged electrode and a conducting roller electrode; the roller contacts the metallization. A corona discharge between the two electrodes polarizes the film. Pantellis claims that by making his own film and using corona discharge to pole it, he obtains a better product, in terms of uniform properties and piezoelectric voltage coefficient ($\sim 4.0 \times 10^{-2}$ Vm/N), than he can obtain commercially.

Microelectronics technology has come to depend on the surface spectroscopies and microscopies for research, development, and production; these include Auger, x-ray analysis, photoelectron surface analysis, and transmission and scanning electron microscopy, to mention only a few. This fact has not been lost on the PORC, which has a strong surface analysis group headed by Dr. R. Heckingbottom. They do a certain amount of routine work, but most of the effort involves fundamental research on the surface properties of solids and on the analytical techniques themselves. As Heckingbottom puts it, "analysts must grow." They cannot grow by doing routine work on conventional commercial instruments.

The surface work at PORC is divided into five areas; Auger analysis, x-ray analysis, transmission and scanning electron microscopy, molecular beam epitaxy (MBE), and electrochemical profile plotting. Until now, all of the Auger equipment at PORC has been built by the members of the surface analysis group, but very shortly they will be purchasing a commercial spectrometer, a model with a 1 μm spatial resolution. This instrument will be used primarily for chemical shift research; determining how the chemical environment affects the energy of Auger transitions. They have been using x-ray analysis for surface-topography studies and also have developed a new x-ray method for determining the strain in single crystals. Heckingbottom foresees a surge in the use of MBE for developing semiconductor devices at PORC and elsewhere. Until about a year ago, when the technique began to be used for commercial production in the UK, France, and the US, MBE was essentially a research tool. Its key advantage over other methods of producing semiconductor films is that molecular beams can form spatially well-defined deposits with respect to both layer thickness and edge definition. The purity of the deposit is high, since the growth is done in high vacuum and the beam purity can be monitored by mass spectroscopy. Layer composition and structure can be monitored continuously by Auger and low energy electron diffraction techniques.

Before concluding, let me mention, briefly, other work in surface science, that is being done at PORC in connection with their fiber optics development. Drs. P.L. Dunn and W.J. Duncan are concerned with the adhesion of the glass fibers to the polymer in composites technology, they are investigating the adhesion promoters developed for composites; specifically, the "silane coupling agents" (organo-functional trialkoxysilanes).

Any comparison of the PORC with its US counterpart, the prestigious Bell Laboratories, would be unfair and unrealistic in that PORC contracts much of its research and development to industry and academia. The economic resources put into the UK telephone system are very much less than in the US. However, the British Post Office expects to expand and modernize its telephone service which will very likely mean an increased R&D effort at PORC. (Willard D. Bascom)

MEDICAL PHYSICS

THE ORGANIZATION OF RADIATION PROTECTION IN ISRAEL

In Israel, radiation protection for the public is the responsibility of the Ministry of Health. However the personnel, space, facilities, and equipment to do the job are not part of some government agency as such, but rather are managed by the Research Institute for Environmental Health, an integral part of the School of Medicine in the Tel Aviv University. This cooperative arrangement between a government bureau and an educational institution has the advantage of minimizing bureaucracy and costs while ensuring that the regulatory function goes hand in hand with educational and research missions. It may only be feasible in a small, highly integrated country like Israel. The director of the Research Institute for Environmental Health is Prof. Alexander E. Donagi, who received his doctoral training in the US. In addition to radiation protection the Institute has responsibility for health areas; these include air pollution, noise control, and industrial zoning. This broad mission is carried out by only 35 scientifically trained personnel.

In the field of radiation protection the Institute has complete responsibility for the entire population, excepting only the military and defense establishments. The responsibilities include the safe use of x-ray machines in medical practice, and of radiopharmaceuticals in nuclear medicine. The task of actually monitoring the use of the radiopharmaceuticals is assigned to the Radiation Safety Department of the Soreq Nuclear Research Center at Yavne, an arm of the Israel Atomic Energy Commission. Dr. T. Schlesinger, the director of the department, carries out his responsibilities with the help of 3 physicists who have PhD degrees, 2 engineers, and approximately 15 technicians. In fact, the Soreq Center, a well-equipped establishment with highly trained personnel, acts as a field laboratory for the Institute as well as for the School of Medicine. The specialized and sophisticated instrumentation at the Soreq Center permits it to monitor environmental radiation including fallout (from old or "new" atom-bomb air tests). Two additional major functions carried on by the Sorque Center in cooperation with the Institute are the operation of a secondary standard dosimetry laboratory (neutrons, gamma-beta dose, radioactivity standardization), and a personal dosimetry service covering most of the radiation workers in Israel. The Soreq Center has recently changed over from conventional film to the use of thermoluminescent (TLD) dosimeters. This report discusses some aspects of the services performed by the Institute and by the Center.

National Personal Dosimetry Service

This service monitors the exposure of about 6000 radiation workers in Israel. This represents the nation's entire civilian population of radiation workers except those of one nuclear center which has its own monitoring program. The service covers some 80,000 readings a year and includes exposure to x-rays, gamma-rays, beta-rays and neutrons. The photon exposure is now measured by TLD dosimeters, which can be reused after readout. Thermal neutrons are monitored by means of a badge containing a special film on which a gadolinium sheet is placed. In conjunction with the TLD system, a dose-handling computerized service has been established to accumulate data in a convenient form. The function of this service is to supply information about the doses received by all currently active workers, as well as those who terminate working in a radiation area; this includes the accumulated doses, both annual and lifetime, and doses which exceed 150 milli-Roentgens (mR) per month. (A commonly accepted international standard for maximum-exposure dose to a radiation worker is 5,000 mR/yr).

A computer program has also been developed to permit calculation of the average exposure of all workers, as well as the average exposure for different working groups (e.g., in diagnostic x-ray departments, nuclear medicine services and industrial radiographers). The program's code has been used to evaluate exposures for radiation workers in Israel for the period April 1978 to March 1979. It was determined that the average annual exposure for some 4,000 workers in Israel was only 50 mR, less than that received from background radiation. About 80% of the workers did not show exposures above the detection level (15 mR/month). Approximately 18% of the workers had exposures above the detection level and up to 1500 mR/yr, and less than 2% of the workers experienced exposures above 1500 mR/yr. One may gain some insight into exposures according to the nature of the working group by noting the data in Table 1. These data include only the 20% of the total radiation-worker population receiving exposures above the detection level (15 mR/month).

Table 1

Average Doses to Different Groups of Workers

Occupation	Average Dose (mR/yr)
Research Institutes	90
X-ray Clinics	160
Industrial Radiography	177
Nuclear Medicine Services	215

There are some small groups not included in the table for whom the exposure levels are higher than those listed. An example would be the staff members of hospital cardiology departments whose average exposure is 300 mR/yr, probably associated with the angiographic procedures used in cardiac studies.

Nationwide Evaluation of X-ray Trends (NEXT) for Exposures of Medical Patients in Israel

In the 1960s, the Ministry of Health decided to institute a national program for surveillance of x-ray machines that are used for medical purposes in Israel. The purpose of the program was to insure conformity of x-ray equipment with Israeli radiation-hygiene standards. After some consideration about how best to achieve this goal, it was decided that the NEXT program operating in the US was the most suitable one. The US NEXT program was initiated in 1971 by the Bureau of Radiological Health (BRH) of the United States Public Health Service (USPHS). Israel's participation in this program started in 1974.

The essence of the program is to select a representative sample of x-ray machines, and to perform the most frequently used procedures with the machine operator setting the technique (choices of milliamperes, kilovoltage, exposure time, target-to-film distance, collimation). A standard testing device supplied by BRH is used to measure all the physical parameters for the chosen procedure. Then a comparison can be made between the parameter values selected by the machine operator and those measured by the standard testing device, on a "Post-Edit Criteria" basis. The extent of the agreement is an index for evaluating the reliability of the original machine settings.

During a 2-year period (1974-76), 102 x-ray units were surveyed in about 50 medical institutions selected from an approximate total of 200 medical institutions (non-dental) in Israel. Table 2 shows a comparison of some of the findings of machine-operator settings with the "Post-Edit Criteria" (in parentheses).

Table 2

No. of Surveys	Procedure	kVp	mAs	Beam Size	Skin Entrance Exposure mR
30	Chest PA*	60-105 (55-125)	5-50 (3-50)	10x10 (11x14)	3-75 (3-75)
55	Abdomen AP# (KUB)+	56-105 (60-95)	32-320 (25-150)	10x13 (11x14)	170-2000 (100-750)
32	Lumbo-Sacral Spine AP	60-90 60-95	30-240 (30-200)	5x12 6x12)	220-1600 (100-1500)

*PA ≡ posterior-anterior view
#AP ≡ anterior-posterior view
+KUB ≡ kidney ureter bladder

This comparison shows that the exposure parameters and skin-entrance exposure doses are rather widely dispersed among the various institutions and even among machines at the same institute. The considerable spread arises from variations in parameter choices, but also from inherent variations in the irradiation and development equipment (e.g. machine type, filtration, film, grid, screen, and differences in darkroom procedures).

Table 3 depicts the weighted median exposure doses by type of examination. The bracket values are based on measurements made by the BRH in the US during the years 1972-75 for the same types of examination.

Table 3

Procedure	Median Exposure (mR)
Chest PA	17 [16]
Abdomen AP (KUB)	528 [530]
Lumbo-Sacral Spine AP	511 [700]

The values for the chest and abdominal procedures are about the same in Israel as in the US. The difference in the lumbo-sacral AP procudure may be due to the greater collimation for this procedure in Israel.

In many instances, the NEXT program in Israel led to changes that lowered the radiation exposures to the patient. In one facility, replacement of an x-ray tube led to a drop from 1570 mR to 750 mR in skin-entrance exposure for an abdominal AP procedure. Similar reductions in doses by factors of 2 to 3 were achieved by using better-quality screens, substituting automatic for manual development, etc.

It may be concluded that the NEXT program is a useful tool for obtaining statistical data regarding mean exposure levels for patients, and for pointing out those instances where modifications might be useful. It also permits a given institution to compare its particular exposure values with the mean of others.

Research

Research is an important part of the total activities at both the Research Institute for Environmental Health and the Soreq Nuclear Research Center. An index to their productivity is the number of papers and reports published. From 1963 through 1978 some 265 papers were prepared and published in the fields of air pollution, radiation, noise, and environmental hygiene. Over 30% of these (81) were devoted to radiation, a category that includes a wide range of important applications touching many aspects of Israeli activities. A partial listing of the topics covered in the papers gives a good clue to the uses of radiation in Israel:

(1) Radiation protection: (a) Internal radiation: Fallout and food chains, radioactive wastes, occupational; (b) External radiation (x-ray), diagnostic, dentistry, television.

(2) Environmental radioactivity: Nuclear power plants, radioactive wastes, fallout.

(3) Control and supervision: X-ray machines, dental, radionuclide users, accidents.

(4) Health physics instrumentation and techniques: Radiographic quality, Secondary Standard Dosimetry Laboratory, thermoluminescent dosimetry, tomographs, computed tomography (CT), decontamination.

(5) Chemistry: Polarography, uranium.

(6) Legal and administrative.

Dr. Schlesinger and his colleagues at the Soreq Center are working on an especially interesting instrumentation-research development—a neutron dosimeter for personnel with the ambitious goal of covering a vast energy range from 1 eV to 14 MeV. The increasing use of higher-energy accelerators in radiation therapy (up to 18 MeV is now common in the US), and the renewed interest in high energy neutron therapy for the treatment of cancer have made it important to be able to monitor personnel for possible exposure to neutrons of all energies. Nuclear emulsion film used in the past had a number of shortcomings (e.g. rapid fading of recoil tracks and sensitivity to beta and gamma radiation). The details of the system devised by Dr. S Schlesinger will be the subject of a separate report.

Conclusion

This writer last visited Israel over 15 years ago. At that time there were just a handful of persons trained to work in radiation protection capacities as health physicists or medical physicists. It is noteworthy that in a relatively short span of time a rather complete infrastructure of highly trained personnel serving the varied needs of a modern society has been developed to exploit radiation for that society's wellbeing in medicine, industry, energy, and in many types of research. Second only to the investment in people is a comparable and impressive commitment that has resulted in well-equipped laboratories with adequate space and the resources needed for operation. Perhaps the key element is the enthusiasm of the people I met, from directors to the youngest technicians, to get their jobs done well. (Moses A. Greenfield)

OCEANOGRAPHY

MARINE SCIENCE IN BARCELONA

Spain's Instituto de Investigaciones Pesqueras de Barcelona (Institute for Fisheries Research of Barcelona) has probably received more attention from ONR London liaison scientists than any other institution on the Iberian Peninsula (ONRL-10-55, ONRL-28-58, ONRL-72-61, ONRL-14-66, and *ESN* 27-7:183). The last general review of the institute was written in 1966 (the subsequent *ESN* was concerned only with the relatively small chemical oceanography program).

Until 1979 the Institute consisted of headquarters laboratory in Barcelona and three smaller branch laboratories located in Vigo, Cadiz, and Torre de La Sal. Now, the smaller laboratories are independent of the Barcelona laboratory and all four come under the cognizance of the Centro Nacional de Pesqueras (CNIP) in Madrid. The smaller laboratories concentrate their efforts on fisheries research while the Barcelona laboratory is concerned with many additional aspects of oceanography and marine biology. The Vigo laboratory works on the fisheries biology and ecology of the fertile deep rios (fjords or estuaries) on the northwest coast of Spain. The Cadiz laboratory emphasizes the study of aquaculture in the 8,000 hectares of the nearby esteros. These are dredged rectangular basins in a vast salt marsh that formerly were used to evaporate sea water in the production of salt. The project is probably the largest aquaculture "farm" in the world. The chief fish that is "grown" there is the dorado (*sparus aurata*). The Torre de La Sal laboratory is also a large aquaculture research laboratory where several species of fish and two species of shrimp are reared in large tanks. Its official title is Planta Piloto de Aquacultura de Torre de La Sal (Aquaculture Pilot Plant).

The remainder of this article is concerned with activities in the Barcelona laboratory. Most of its support comes from the Ministry of Education through grants from the Consejo Superior de Investigaciones Cientificas (Superior Council for Scientific Investigations) which is roughly equivalent to the US National Science Foundation. Income is also received from various industrial firms for site visits and pollution studies. The research program at the laboratory is divided into three "Unidades Estructurales de Investigation" which I translate here as departments. There are the Departments of Oceanography, Marine Biology, and Marine Resources. In addition there are three service departments: Documents and Publications, the Public Aquarium in Barcelona, and the Public Aquarium of Blanes on the Costa Brava northeast of Barcelona. The Barcelona laboratory also operates a stern ramp trawler research vessel, the *GARCIA DEL CID*, which is based in Barcelona but used by all four fisheries laboratories. The ship is 37.2 m (122 feet) long and carries a scientific party of 7 in addition to a crew of 13. The Barcelona laboratory is housed in the upper two floors of a bright, modern, 3-story building that has a public aquarium on the ground floor. It is located on the base of a peninsula that forms the northern boundary of the large harbor of Barcelona. Across the street, one can take an elevator to the top of a large steel tower and from there ride an aerial tram on a wire high above the harbor to an old fort and public park on a hill on the other side of the harbor. The whole panorama of the city stretches off to the left, while an array of all sizes and types of boats and ships unfolds underneath the cable car as it passes from one end of the harbor to the other.

I interviewed the director of the laboratory, Dr. Buenventura Andrew Morera, through a most charming interpreter, Dr. Josefa Castellvi Piuluchs. The laboratory is large, with a staff of almost 90. There is an average of 15 graduate students in residence taking courses at the University of Barcelona and doing their PhD dissertation at the laboratory. They stay an average of three years.

The Department of Oceanography, headed by Dr. Antonio Ballester Nolla, is using LANDSAT and NIMBUS 7 data in a continuing study of the diffusion of contaminants from coastal outfalls. They are also utilizing aircraft to make a detailed chart of the Catalonia coastline.

In 1979 Ballester and his staff took part in oceanographic cruises in the area between Catalonia and the Baleraic Islands and around the delta of the Ebro River southwest of Barcelona. Bottom cores were taken to study the chemistry and radioactivity of the sediments. Chemical analysis of the cores in the Ebro delta region revealed considerable quantities of methane as well as unidentified hydrocarbons.

Ballester is carrying out a continuing study of the coastal currents of the Catalonian coast by deploying 8 Aanderaa current meters for about 30 days in each of several locations in order to determine where effluents from coastal outfalls will go. He has also made a detailed study of the coastal waters near the nuclear center at Vandellos, 100 km southwest of Barcelona. In these and other physical oceanographic studies of Spanish coastal waters they collaborated with the Institute of Oceanography in Madrid (*ESN* 34-4:191). Recent studies of the dynamics of water masses have been made in two regions, the coastal water of northwest Spain and the upwelling region off the northwest coast of Mauritania (formerly French West Africa).

A number of studies in microbiology were undertaken during the past year. These included the assimilation of nitrogen by bacteria, the physiological groups of bacteria in Venezuelan coastal waters, the bacteria in treated sewage from Barcelona, and the identification of 350 species of aerobic bacteria in eastern Atlantic waters.

A group in the Department of Oceanography is working on photosynthetic pigments. They have improved the reproducibility of photometric and densimetric techniques for the determination of the components of chlorophylls and carotinoids and have also studied the electrochemical properties of chlorophyll M.

The Department of Marine Biology, headed by Dr. Francisco Vives Galmés, is divided into three groups: Benthos, Zooplankton, and Phytoplankton. During the past year the Benthos Group has completed a study of local ascidians (25 species). In all, 20 species new to the area were identified. They have described the littoral benthos communities along the Catalonian coast with emphasis on the worms which live near the Medas Islands northeast of Barcelona. The group plans to establish an artificial reef near Barcelona and has selected a suitable site based on a study of the benthos present.

Another study involving the observation of painted panels submerged in the Barcelona Harbor is concerned with the effectiveness of 35 new formulae for antifouling paint.

Other investigations are largely concerned with the biochemistry of marine organisms.

The Phytoplankton Group does research on the biomass, primary productivity, taxonomy, and analysis of individual communities. In 1979 it studied the biomass and primary productivity in the waters of the highly productive, rich upwelling region off the northwest coast of Mauritania over the Arguin Banks and near Cape Blanco. Primary productivity oscillated between 1.4 and 3.2 g of carbon per m^2 per day. They also studied the distribution of the enzymes that catalyze the reduction of dissolved nitrate and found it to be higher than normal in the upwelling areas mentioned above.

This same group is finishing an inventory of the phytoplankton species along the Mediterranean Sea and the northwest coasts of Spain. Over 300 different species have been identified.

In another study in collaboration with biologists from the University of Barcelona, they have identified phytoplankton in fresh water empoundments. They also took part in a cruise to the Gulf of California where they identified 60 species of phytoplankton.

The Zooplankton Group is continuing the study of the biomass, structure of populations, and ecological aspects of several different groups of zooplankton in the littoral waters of Spain's Mediterranean and northwestern coasts. The principal groups under study include: protozoa, radiolaria, acantharia, medusasae, chaetognaths, ostracods, copepods, amphipods, molluscs, echinoderms, salps, and doliolids.

This group is also studying the distribution of zooplankton in polluted areas, especially in the Catalonian coastal zone near Barcelona and in the harbor of Barcelona. The distribution of species in polluted waters tends to vary with depth.

In a study of the diet, the zooplankton group have demonstrated that fish in their larval and postlarval stages feed almost exclusively on copepods.

In collaboration with biologists from the University of Ottawa the zooplankton group has studied the eating habits of copepods by means of high-speed movies. Their conclusion was that present theories related to the mechanics of filtration of copepods will have to be revised.

The Department of Marine Resources is headed by Dr. Carlos Bas Peired. It is primarily concerned with commercial species of fish and shellfish—their distribution, abundance, food supply, growth rate, and the effort required to catch them. In cooperation with the Sea Fisheries Institute of Capetown, South Africa, this department is making a major study of the fisheries of the southeastern Atlantic Ocean with emphasis on the rich upwelling region associated with the Benguela Current along the coast of Namibia (formerly South-West Africa). Emphasis is being placed on hake and shellfish. This study is being funded by the Subsection for Fisheries and Merchant Marine of the Ministry of Transport and Communication.

Last year the department completed a study of the distribution by size, age, and growth rate of most of the species of fish that are caught commercially in Spanish waters, with special attention to hake. A 3-year study of the food of these fish was completed as well.

This department is also investigating the biology of the sardine and anchovies along the coast of Catalonia and relationships between catching these species and the lunar cycle. Another project deals with variations with time of the whole mass of zooplankton in the same area.

Special attention is being given to the examination of annual growth rings of fish scales to determine the age, and from this the growth rate, of the fish being studied.

During the past year the Department of Documentation and Publications produced three issues of "Investigation Pesquera" and nine "Informes Tecnicos" (technical reports similar to practical sea grants reports in the US).

The aquarium in Barcelona is headed by Dr. Pedro Arte Cratacós. It maintains over 550 specimens of many different species, many of which are used for research at the Barcelona laboratory, the University of Barcelona, and other universities and schools. Over 5,000 students (at all levels) with 360 teachers and professors made use of the aquarium in 1979. Students came from 227 different schools.

The aquarium at Blanes is headed by Dr. Manuel Rubio Lois. It has about twice as many specimens as the Barcelona aquarium, about half of which are invertebrates. Many students at all levels make use of the aquarium. It is interesting to note that visitors were enumerated by the language they spoke (if they were not from Spain). In 1979 8,400 foreign visitors spoke German, 3,600 spoke French, 2,700 spoke Dutch, and 2,600 spoke English.
(Wayne V. Burt)

PHYSICAL AND CHEMICAL OCEANOGRAPHY IN ABERDEEN PLUS THE RIDDLE OF THE GRILSE

I visited the Aberdeen Marine Laboratory of the Scottish Department of Agriculture and Fisheries on a cold, blustery day in late December 1979. The gale that had passed over northern Scotland the night before had gusted to over 100 mph, turning umbrellas inside out (mine included), tearing barges from their moorings (over 200 people were evacuated by helicopters when a barge broke loose from an offshore drilling platform), and rocking the night-sleeper trains from London, keeping the weary travelers awake. It was reminiscent of the record storm that passed over the same area in December 100 years ago. That storm destroyed the bridge over the Firth of Tay with the loss of the Edinburgh mail train and 75 lives (*ESN* 34-1:33).

Personnel at the Marine Laboratory work on a wide range of problems concerning ecology, productivity, exploitation, conservation, management and health of marine fish and shellfish in near and middle waters that are exploited by the Scottish fishing fleets. The laboratory is a large one with over 250 people working in a complex of buildings on the waterfront of the city and on a fleet of 4 research vessels.

The research program is divided into the following divisions: Fish Resource Investigations, Shellfish Investigations, Microbiology and Parasitology, Biochemistry and Physiology, Fish Detection and Instrumentation, Environmental Studies (including pollution), and Statistics and Computing. This article discusses the research programs in physical and chemical oceanography, a part of the Environmental Studies Division.

The head of the physical oceanography group, Mr. H.D. Dooley, is a very energetic young man. His office is filled with reams of data in all stages of reduction, from raw copy to published papers. Dooley reminded me of a master strategist as he reached out to gather in charts and drawings to illustrate the many different subjects he covered during the interview. His primary interest is in the currents and water masses over the continental shelf and in the water surrounding Scotland, including the northern part of the North Sea. Water currents and the characteristics of water masses affect not only the food supply of fish but the fish themselves. Water currents disperse and move the fish in their planktonic stages (eggs and larvae) and may act as boundaries between parts of the total stock of some species.

Dooley's work can be divided into three broad categories. The first is to provide regular measurements of the main physical and chemical features of Scottish shelf waters so that a picture of the seasonal and annual fluctuations can be obtained and their influence on the distribution, composition, and abundance of commercial fish stocks can be determined. The second category has to do with continued current meter studies. Earlier studies led to the belief that the principal current systems of the area consisted of broad, slowly moving water masses. However, detailed current studies show narrow and relatively fast moving streams dominating the local current patterns. These fluctuate in position and strength of flow and can have marked effects on fisheries. Dooley's third category of research is related to North Sea oil exploration and exploitation and the potential these activities hold for adding stress to the marine environment at wellheads, along tanker tracks, at loading terminals, and at coastal or estuarine refinery sites. This has resulted in detailed local physical and chemical oceanographic studies in areas where oil pollution is a possible threat to marine environment.

In gathering historical hydrographic data for the area, Dooley is adding to the large library of data collected and analyzed by his predecessors. Some local data is available for most of the past 100 years. Dooley took part in the International Council for the Exploration of the Seas Expedition Overflow '73 in the Faroe-Shetland Channel. Warm, high salinity Atlantic water moves through that channel into the Norwegian Sea. Some of the Atlantic water apparently cross-flows over the shelf to form water which is characteristic of the northern North Sea in a region of very important fishing grounds. Dooley has studied these data for five years and is currently putting his findings into writing. He is still very much interested in the inflowing Atlantic water and is looking forward to further cooperative international studies in the early 1980s.

As regards current meter studies, Dooley and others working with him from the Oban Laboratory (*ESN* 33-11:468) and the Fisheries Laboratory at Lowestoft are reasonably well convinced that there is a northeast Atlantic Slope current running from the bulging Porcupine Bank west of southern Ireland around the north of Scotland. Evidence is fragmentary as to the consistency and lateral continuity of the current which has been measured at residual speeds of two to four knots. The three laboratories are planning to make a systematic study of the slope currents in 1981. They hope to deploy several sets of closely spaced current meter moorings from the shelf edge to the slope foot. (Unfortunately most of the long-period current meter data taken near the shelf-edge is too far inland to show the slope current.) They want to support the current meter measurements by neutral density float and drogue tracking and by temperature salinity surveys.

Dooley had identified a slower current (0.3 knots) on the continental shelf close to shore that runs from northern Ireland around the outer Hebrides and Orkneys into the North Sea. He speculates that this current transports herring larvae very rapidly into the North Sea from spawning grounds close inshore off the Hebrides.

Dooley has studied the physical oceanography of Sullom Voe in the Shetlands, the site of one of the biggest oil terminals in the world (*ESN* 34-2:34) and the industrialized Firth of Clyde on the west coast of Scotland.

Mr. J.H.A. "Tony" Martin is the senior physical oceanographer in the laboratory. His name should be familiar to anyone interested in the physical oceanography of Scottish coastal waters. Since the commercial catch of salmon in Scotland almost collapsed in 1976, he has been working on historical data to try to unravel the puzzling variation in the annual salmon catch. Next to French truffles and food products containing truffles, Scotch salmon is one of the most expensive foods sold in the United Kingdom. In its mildly cured state, it costs up to $18.00 a pound.

Martin has data on salmon catches and the environment for the past 97 years. Although just a single species of salmon is caught commercially, it appears in two different forms. Salmon that come back to spawn after one year at sea usually weigh under 8 pounds when they are caught. These are called grilse. Fish that stay at sea for two years before spawning usually weigh over 8 pounds. Both regular salmon and grilse taste the same, but the 2-year salmon parents produce 30% grilse and 70% 2-year salmon, while grilse parents produce 97% grilse and only 3% 2-year salmon. Incidentally, the grilse are not very prolific because an unusually high percentage are male.

After a great deal of trial and error Martin has determined two of the factors that influence the number of spawn from 2-year salmon parents that return from the sea in one year as grilse. These are their average weight when they leave the rivers for the sea, and the mean temperature in the area north of Iceland where they spend part of their adult life. His regression equation shows that the bigger the small salmon fry are when they leave the rivers for the sea, the more apt they are to return from the sea in one year. In addition, the colder the water is, the more apt they are to return early as grilse. Apparently the bigger and stronger they are the more able they are to make the round trip in one year and they also do not like the stress of living in water that is colder than normal. They prefer to winter in water temperatures of 3°C to 6°C, but no colder. One of the reasons for the current decline in Scotland's salmon population could be the slight drop that has occurred in sea temperatures north of Iceland during the past several decades. However, overfishing in the area north of Iceland could be another contributing factor.

Mr. E.W. Henderson is third in seniority in the physical oceanography group. Henderson came into the laboratory as an electronic specialist and works closely with Dooley on current meter maintenance and deployment. His main interest is mathematical modeling and programming for data reduction for the physical oceanographic group. He also assisted Dr. John Steele (now Director of the Woods Hole Oceanographic Institute) in his research in studying marine ecosystems and productivity in very large plastic bags. This work, which is still going on, takes place in a large, deep, narrow-mouthed sea loch, Loch Ewe, in western Scotland. Henderson spends about equal time on instrumentation for various projects, mathematical modeling and data reduction, and ecosystem studies.

Dr. R. Johnston heads the 6-man group working on chemical oceanography. He began the interview by emphasizing the fact that the group's work was directed entirely to fisheries science in that they try to relate all of their research to either fish or the food chains for fish. In the past the group has concentrated on research on nutrients in the ocean. Now they have shifted almost entirely to research on trace metals in relation to pollution, and the effects of trace metals and other pollutants on marine organisms.

Experiments are done both in the ocean and in large tanks in the laboratory. The bottoms of the tanks are covered with clean sand taken from beaches above the higher high water level. The principal species used are plaice and a small bivalve *Tellina Tenuis* that the plaice feed on. Sea water is circulated through the tanks at a rate that replaces the water every four days. Then copper, mercury, lead, and other contaminants are added one at a time in various concentrations. When the concentration of any heavy metal exceeds about three times its normal concentration in sea water, things start to go wrong with the experimental animals, and the effects of the pollutants can be seen. Recently this research has been moved to Loch Ewe where they can use larger enclosures for their experiments.

In addition to trace metals, they have experimented with various concentrations of petroleum hydrocarbons and have noted deleterious effects on experimental marine animals in concentrations of approximately 25 ppm or more.

The North Sea is one of the world's richest fishing areas, producing over 3 million metric tons of fish each year. One of the reasons for the trace metal studies is that countries surrounding the North Sea are very much concerned about the effects of trace metals, pesticides, and particulate matter entering the Sea from rivers such as the Rhine, which pass through heavily industrialized areas.

The International Council for the Exploration of the Sea has stimulated interest in measuring concentrations of all common heavy metals in commercial fish and shellfish in the North Sea. Johnston's group gathers the samples for this monitoring, but the actual analysis is done by a sister fresh-water-fisheries laboratory at Pitlochry, Scotland. The metals show up in hot spots usually near or in heavily industrialized estuaries and rivers. There are some isolated hot spots where higher than normal concentrations of a single metal are found in marine organisms. This is thought to be due to leaching from geological formations.

Occasionally pesticides "stick out like a sore thumb." These are usually easy to trace to their source because there is no discernible background of pesticides in oceanic waters.

The metal which these scientists are most concerned with in fisheries products is mercury, because the fish must meet long standing requirements for low mercury content if they are to be exported. Johnston and his colleagues are studying what forms of mercury are taken up by marine animals, i.e., as particulate matter or in dissolved compounds. They cage specimens from mercury-free areas and expose them *in situ* to known controlled mercury sources. Then they measure the various distances from the source and the rates at which the specimens take up the mercury.

Johnson and his group act as the advisory body for Scotland to assist the government in deciding whether or not dumping of wastes at sea should be allowed. They study and advise on an average of eighty dumping license applications each year.

I was very much impressed by the quality, quantity, and variability of research being carried out by a relatively small team of scientists at the Aberdeen Marine Laboratory. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH IN ITALY—PART TWO

PISA

The University of Pisa has the reputation of being very good, and 40,000 students come from all over Italy to attend it. Since the non-student population of the town is under 100,000, this makes for an unusual town/gown relationship. I visited the Faculty of Natural Sciences which is on the main piazza of the town (but not close to the famous leaning tower) and across from the "Normal School": founded by Napoleon I, the Normal School may be the most famous and best school in Italy.

The Institute of Mathematics in the Faculty of Natural Sciences at the University of Pisa is very large; it has 100 faculty including 14 chairs. This institute has set up, jointly with the Institute of Mathematics in the Faculty of Economics, an unofficial and experimental department of OR and statistics with 2 chairs: P. Manca from economics, and Franco Giannessi from natural sciences. I talked with the latter, a distinguished scholar who took his doctorate in mathematics in Pisa (when doctorates were still given in Italy) and has held the chair there for more than 10 years; he specializes in optimization and mathematical programming. He is the author of 3 volumes of a recent massive 6-volume work entitled "Methods of Mathematical Programming." His current theoretical research is based on the theorem of alternatives introduced by Mangasarian. Giannessi feels that such fundamental concepts as duality can be embedded in the even more fundamental concept of "alternatives." For example, the well-known theorem of complementary slackness states that an activity will enter the optimal solution at a positive level if and only if the corresponding slack variable is 0 in the optimal solution to the dual problem—which is expressed as alternatives. And he feels that this viewpoint may lead to very useful optimality criteria in nonlinear programming: a given vector is optimal if and only if positive values for certain functions of that vector are impossible. His main interest at present is in general imbedding.

Giannessi is also leading several applied research projects supported by the National Research Council.

One of these is concerned with developing generalized mathematical models for the national energy system, and another with mathematical models for traffic in urban areas. His most recent problem relates to structural mechanics, and concerns submarine pipelines. There must be a certain amount of excavation of peaks and filling in of valleys so the pipeline will lie smoothly on the bottom. This would be a routine optimization problem except for complexities due to the elastoplasticity problems in the pipe. This will eventually be applied to a pipeline to bring gas from Tunisia to Italy via Sicily. The model has been tested on data from the narrows between Messina in Sicily and Calabria in Italy.

FLORENCE

Firenze, as it is properly called, is the most beautiful city in Italy—perhaps in the world—and incidentally the location of a university where good research is taking place. However, here as in some other Italian cities, a number of people with whom I had a arranged interviews turned out to be mathematicians and in my opinion not really in the operations research business at all.

However, I did find three people doing operations research: an associate professor named Bruno Simeone and two very bright graduate assistants, Adriana Levi and Dorothea De Luca. These women already have several publications and are probably farther along than an average American student getting his doctorate, but (as indicated above) formal education ends in Italy with a laurea. They told me of a project that the two of them had recently completed, simulating a production line for wiring and winding electrical instruments. The capacity of the line had to be doubled, and the managers hoped to build a new line with fewer of the more expensive type of machine and more of the less expensive type. The purpose of the simulation was to check out whether this was possible. The result of the simulation was that this cost reduction would indeed be possible if and only if the production line were restricted to certain thread sizes. I naturally asked them how their predictions worked out when the line was actually built; they told me that in Italy no one ever reports back, so they did not know. They made their recommendations; they were never informed whether those recommendations were carried out or what, in fact, finally happened. If indeed this is typical of Italy, it is certainly unfortunate.

Simeone was a student of Prof. Aparo (*ESN* 34-5:245) and took a doctorate under Peter Hammer at Waterloo, after spending a year at MIT. He teaches the OR course at Florence University, but makes it much more mathematical than most of the courses with which we are familiar in the US, leaving out many of the standard tools, such as queue theory, inventory theory, and the like, and focusing on linear optimization and convexity. Simeone's current research efforts are on optimal graph partitioning, which is somewhat analogous to clustering. Given a region of Italy in which each town is characterized by a population, an income, and the like, the problem is to partition the region into connected zones (i.e. zones not divided into noncontiguous parts) in such a way as to minimize the variances (between zones) of total population, total income, and the like. Because of the connectivity constraint, graph theory is the appropriate tool. The results are useful in school districting and health districting, but the problem was motivated primarily by people working in housing and real estate. Simeone had developed a model to aid them to decide how to invest in new residential areas. The conclusions were quite different from what their intuition had originally indicated, but, Simeone assured me, after they had studied the model, they decided that the model was correct and modified their intuitive approach to such problems.

PADUA

The professor of OR at the University of Padua is Prof. Paolo Malesani of the Institute of Mathematics in the Faculty of Sciences. Originally a pure mathematician doing research in algebraic geometry, in 1961 he went to work for Olivetti, which was developing a computer (somewhat like the IBM 1411) called the ELEA 9003. There he led a group doing applied software, including programming algorithms for some OR techniques such as linear programming (LP). He has been at the University of Padua since 1969; most of his publication during this period has been on education and the like, especially on the use of computers in the classroom. He has a small but rather sophisticated Olivetti computer which he invariably carries into his classroom for his lectures in OR. There are two such courses, one in mathematical programming taken by about 60 students, and a follow-on course in OR taken by about 30 students. The latter is quite applied, with stress on model construction, and the students spend the last third of the course doing projects (in groups of 5). There is a good deal of required reading in the course, most of it from an Italian text written by Malesani and some of his colleagues. Students are also required to find a problem in the literature and report on it in a final exam. Actually, Malesani fails about 1/3 of the students (although many of them are able to pass a second examination without retaking the course). Under the circumstances I asked Malesani why the students come to his course and why it is so popular. His response was that it is one of the few applied courses in the entire university. I suspect that his teaching ability and his use of the computer in the classroom are also factors.

Malesani has some interesting research results, almost ready for publication, on the optimization of PERT networks with resource constraints. If the use of resources is not a linear function of time, this leads to a dynamic programming problem, as is well known. If they are a linear function of time, then it becomes a large LP problem. This has been known for some time, but in general the LP formulation is too large for practical manipulation. Malesani has demonstrated the reduction to many less constraints, and has proved that the constraint matrix is unimodular (which permits easier manipulation). His proof is now lengthy, but as soon as he is able to reduce it to more compact form he plans to publish it.

TRIESTE

Trieste, in the extreme northeastern corner of Italy, does not look like an Italian town so much as a town in Mittel-europa. For no apparent reason it has become the center of the insurance industry in Italy (just as Hartford, CT, became the center of the insurance industry in the US). The University of Trieste has just started teaching actuarial science, and is one of two Italian universities granting a laurea in this subject. The other is in Rome and is much larger, and its graduates tend to go into government and such things as the Italian analog of Blue Cross. Graduates here will go into the insurance companies, and they are expected to be snapped up. Any curriculum in Italy which guarantees a student a job after graduation is likely to be extremely popular, and this one is. It is run by the Institute of Mathematics for Application to Economical Sciences in the Faculty of Economics and Business. This is a large institute with three chairs, one of which is occupied by the head, Prof. Luciano Daboni, and another by Prof. Claudio De Ferra. In response to my question, they admitted that actuarial training is more like technician training than it is training of scholars; but, he said, because of the great demand for their graduates this was helping to build a strong institute with an excellent research environment.

Prof. Lucio Crisma and Associate Prof. Silvano Holzer are working on foundations of subjective probability. It must be remembered that this field, now so active in the US after having been popularized there by the late L.J. Savage, was originally developed by an Italian professor, Bruno di Finetti, who is still at the University of Rome, although he is no longer active. The research of Crisma and Holzer is rather esoteric, being based on "nonstandard analysis" and the use of finite additive measures. More interesting to me was the research by Associate Prof. Ermanno Pitacco on simulation methods for the study of merit rating systems in insurance, including the simulation of claims. I asked him if this was not similar to the familiar simulations of credit risks in the US. He said that it probably was; but credit is not extended as frequently in Italy as in the US, most transactions being for cash, and therefore this type of simulation was not as familiar to them as it was to us.

Assoc. Prof. Luciano Sigalotti and Asst. Prof. Marco Zecchin are working on optimum decisions in Markov processes, with applications to the management of insurance funds. The model is very much like one of inventory control: at each discrete time interval the inventory of insurance funds goes up or down by a random amount. Apparently they have not been very successful in applying this model, in part because the actual insurance fund is a continuous variable and does not behave like a Markov process.

Assoc. Prof. Flavio Pressacco studies analysis of insurance markets on the basis of uncertainty economics, following work by Arrow. He has obtained results for quadratic utility functions, and, in particular, closed-form expressions for Pareto-optimal equilibria. He has also been working on n-person game theory, developing and modifying certain theorems by Roger Myerson of the US.

In general, as Daboni and De Ferra pointed out to me, both their research and their teaching are centered around not only actuarial science but uncertainty in general. The actual degree is called the laurea in statistical and actuarial science, and their research interests are especially directed to the nondeterministic aspect of that science. There is one course entitled Operations Research taught by Zecchin, but the entire curriculum leading up to the laurea is not only heavily quantitative but also heavily flavored with probability and statistics courses.

MILAN

Milan is the largest city in Italy, the financial center, heavily industrialized, and with much less charm than many of the Italian cities farther south. It has at least four universities: The University of Studies of Milan, run by the national government; one of Italy's three polytechnics, which (as in France, but not the UK) are highly prestigious institutions, also run by the national government; a Catholic university; and a secular private university called the University of Luigi Bocconi. Although the tuition at this private school is about $2,000 per year, the college appears to have no difficulty getting students, partly because certain courses, such as economics, which are not offered at the University of Milan, are offered there, and partly because the prestige of the university makes it easier for its graduates to obtain jobs. Similar phenomena occur in the US, where tuition in private universities greatly exceeds that of public institutions; however, in Italy private institutions are comparatively small and, as noted earlier, rare.

I talked to Prof. F. Avondo-Bodino of the Institute of Statistics and Mathematics in the Faculty of Political Science at the University of Milan, who also teaches at Luigi Bocconi. At the latter school, there are 1,600 students in the first mathematics course, divided into three sections for lectures and 10 sections for "labs." Only about 1/2 of the students actually attend the lectures, he told me. He came to Milan from Turin, where he was professor of financial mathematics, and moved into a faculty of political science precisely because his interests were like those of di Federico (*ESN* 34-5:245) and he wants to generate more interest in a quantitative background for these subjects. His research is on investment analysis under uncertainty, and in particular on the uses of higher moments of the distributions. Most finance analysis, of course, depends almost exclusively on the first two moments of the distribution of returns. Avondo-Bodino uses a finite number of moments to approximate the cumulative distribution function. He has recently published a small book on the use of moments in analyzing stochastic investments, and is now publishing a criticism of internal rate of return as a criterion, recommending rather the investment which maximizes the probability of giving at least some prespecified rate of return. Avondo-Bodino explained to me that some of this financial analysis is peculiar to Italy, because there is a stochastic aspect to their bonds which is not found in our country. Specifically, bonds are paid off at par after 20 years or less, with certain bonds being chosen at random each year for redemption. Avando-Bondino has also applied his theories to a specification of insurance premiums. These are usually determined from the first moment (i.e. expected value) of the various outcomes, but he has shown that the higher moments may be expressed as linear combinations of the premiums calculated at different "technical rates" (by which he means discount rates).

Avondo-Bodino is the director of a new journal, *Mathematics for the Economic and Social Sciences*; the board of editors of this journal includes Aparo and Daboni, mentioned earlier. The journal appears twice a year; articles are in English, French, or Italian, with summaries of every article in English. People interested in further information on this journal can write to Avondo-Bodino at via Conservatorio 7, Milano.

At the polytechnic of Milan there is a large OR program in the Institute of Electrical and Electronic Engineering in the Faculty of Engineering, with almost 400 students enrolled in 2 OR courses. The OR work done by Prof. Francesco Brioschi and Assoc. Prof. Umberto Bertelè will be expanded and they hope soon to have a Department of Engineering Economic Systems (similar to that at Stanford; the only one now in Italy is at Calabria). Bertelè and Brioschi have published a book on nonserial dynamic programming. The idea is that in the absence of certain types of constraints the ordering of the stages is irrelevant. This leads to a quite different formulation of the decision problem than the classical one in dynamic programming. That book was published in English in 1972 in a series edited by R. Bellman.

Their more recent work has been on the application of mathematical models, especially OR-type models, to economic problems associated with food and agriculture. They are unusual if not unique in doing this kind of work in Italy, where (unlike the US) there is no land-grant tradition and therefore little stimulus to apply these types of tools to this type of problem. They have published a book on this subject in Italian and a number of papers in English. The basic approach is a Leontieff model of about 100 sectors. Unlike conventional models in which each box normally has many inputs but only a single output, the Brioschi-Bertelè model tends to have numerous outputs; that is, there are several entries for each column as well as for each row. This results in matrices which are less sparse than usual. This program has been written in Fortran and run a number of times, leading to interesting predictions on the variations of prices—for example, how fertilizer prices affect the prices of agricultural products. Finally, Brioschi and other members of his group have published a set of OR textbooks in Italian. Apparently the concept of doing joint work and publishing jointly is less uncommon in engineering than in other faculties.

On the whole I found operations research in Italy less exciting than in many other countries. There seem to be a number of reasons for this: the general feeling that the quantitative approach to decision problems may be antisocial; the lack of adequate funding for sponsored projects; the lack of doctoral programs; the avoidance of joint research projects; and the lack of a tradition in OR. Any or all of these may have some bearing on the status of OR, or it may be in part due to a national trait in personality. I know of no country where the people are warmer, kinder, friendlier, or more artistic; when they turn to mathematics, they make of it an art form, so that they do fine work in pure mathematics. But applying mathematics to real decisions problems does not seem to be an activity to which many Italians bring especial aptitude or enthusiasm. (Robert E. Machol)

PHYSICS

PHYSICS, PEACE AND PYRAMIDS IN EGYPT—PART I

Six universities, the Military Technical College, and the Helwan Institute of Astronomy and Geophysics were visited during a March trip to Egypt. This is Part I of a two-part article, and contains the highlights of visits to Alexandria University, the Military Technical College and the institute at Helwan. Part II, to follow next month, will contain reports on Ain Shams, Al-Azhar and Cairo Universities in Cairo and on Mansoura and Tanta Universities. Even though the emphasis during each visit was on optical physics, a number of other research topics were also discussed. In addition to the highlights of these discussions, this report contains some observations on the peace Egypt is presently enjoying, the exporting of skills from that country, and some general comments on the educational process and research environment as they exist there.

Many people, from professors to taxi drivers, volunteered their feelings about the peace Egypt is experiencing. A consensus existed among those whom I spoke with on the opinion that the peace is good and for that reason President Carter is admired for his peacemaking efforts. The peace has enabled the country to concentrate more on improving the standard of living, and building is occurring wherever one looks. Based on the expectations expressed by several people and on the comments made by a few regarding these expectations, I conclude that a large part of the population may expect too much too soon.

I naively thought that the income from the Suez Canal was Egypt's largest source of hard currency. However, far more is brought into the country by the Egyptian "technical" workers (skilled laborers to academians) employed in the oil-rich countries. Approximately 80% of the university staff members that I visited had taught for up to 4 years in Saudi Arabia or Kuwait, etc.

It is not uncommon in a number of countries for a relatively small percentage of academia to supplement their income by working at a second job, usually by teaching at a second university or by consulting. In Egypt, however, every staff member that discussed this topic with me was teaching at two universities; and one professor said that virtually all science/engineering staff members do this to enhance their income.

I was impressed by the large enrollments of the universities in Egypt. Cairo University has close to 96,000 students with more than 70,000 attending full time. Two other major universities in Cairo, Ain Shams and Al-Azhar, have approximately 68,000 and 32,000 full-time students respectively. I was told that pay scales and level of education are more closely linked in Egypt than in some countries and that increased income is certainly a strong motivator for continuing one's education.

I would like to present two observations regarding equipment that are applicable to all the laboratories that I visited. There is an obvious shortage of research equipment, obvious not only because of the visible shortage, but also because of the concern about equipment expressed by most investigators. It is also obvious that a trend is being established to alleviate this situation. An increased amount of financial support is becoming available for equipment and a limited number of expensive instruments, etc., were observed. The limitations set by the shortage of equipment on what experiments can be carried out and on the data collected (quantity and number of significant figures) have been offset to a degree by carefully choosing research projects that do not require unavailable equipment, by collaborating with investigators in laboratories that have the necessary equipment, by conducting experiments abroad, and by designing and constructing the needed equipment.

The other observation about equipment is that there is a shortage of personnel who are trained in maintaining and repairing sophisticated equipment. Also, it is not uncommon for those vendors outside Egypt who do send repairmen there, to send them so infrequently that many pieces of equipment are unusable for 6 months or longer. For example, one US laser manufacturer sends a representative to Egypt only twice a year. Hopefully, the expanding equipment market in this country will induce manufacturers to be more timely with their services.

The remainder of this two-part article is comprised of a university-by-university description of the physics/optical physics programs in each of the 8 institutions listed earlier.

Alexandria University I visited with three members of the Department of Physics: its chairman, Prof. M.A. Lasheen, who described the department; A.F. Serenko, who is studying the mechanical properties of Cu and Al; and a laser physicist, Yehia Negm, who is developing gas lasers at the University of Alexandria Research Centre (UNARC). The Department of Physics has a staff of 20 and as of this date, has graduated 3 PhDs. This year, the undergraduate program has 9 third-year students and 7 fourth-year students. Lasheen stated that "keeping students to do graduate work is a very big problem." Hopefully the future activities at UNARC will help solve this problem.

Serenko, who received his PhD one year ago from Kharkov University, USSR, is continuing his study of the mechanical properties of single-crystal and polycrystalline samples of Cu and Al at Alexandria. He is measuring the creep and stress relaxation of samples as a function of the applied tension and the rate of application of tension. This work is carried out over the temperature range of 77 to 500 K. The shortest time observed for full relaxation (to the limit of his measurement sensitivity), one half hour, occurred in a single crystal of Cu at 200 K. Serenko said that based on theory, complete relaxation for this case should take about one year. The creep is supplemented by photomicrographs of carefully polished surfaces on the samples. Serenko's future work will include measurements on Ni and the simultaneous measurement of the electrical and mechanical properties of samples.

Under Egyptian and United Nations Development Programme sponsorship, UNARC was started in 1972 as the Science Centre for Advancement of Post Graduate Studies and in 1979 its current name was adopted. UNARC is part of Alexandria University and is housed in a large, modern structure about a mile from the university's main campus. The determination of research priorities at UNARC is based upon international scientific developments as well as on current needs of local production and service sectors. To maintain a closeness between the scientists at UNARC and their home departments in the university, researchers are required to give a minimum of one lecture per week within their departments. Research is carried out in a number of areas, one of which is laser studies. The leader of the laser program, Yehia Negm, received his PhD from the University of Essex. He designed and constructed the first TEA CO_2 laser to be developed at Essex. This laser with an output energy of 50 J and a pulsewidth of 90 nsec is still very much in use.

As of January 1980, Negm is "on loan" to UNARC from the Department of Physics for a 4-year period. He has four graduate students assisting him in his work on CO_2 (pulsed and cw) and HF (double-discharge) lasers. Due to the safer handling characteristics of SF_6 and the elimination of pre-reaction problems achievable with it, as compared with F_2, Negm and his assistants use SF_6 in their HF laser work. However, the electronegativity of SF_6 makes the maintainance of an arc-free discharge difficult, even when Rogowski-profiled electrodes are used. As arc formation requires the flow of transverse currents in the electrodes, one would expect arcing to be partially inhibited by the use of electrodes made from a material having a resistivity equal to or exceeding that of the discharge. Based on the CO_2 laser results obtained earlier at Essex, Negm has constructed and is evaluating an HF laser in which a Rogowski-shaped Ge cathode is used. The length and thickness of this cathode is such as to minimize the resistance for a given resistivity. No performance data were available at the time of my visit.

Negm's laboratory has a limited number of high-quality state-of-the-art equipment, including high-bandwidth oscilloscopes and a 1 to 500 pulse per second N_2 laser/dye laser system. One of his objectives is to develop a user's laboratory where a number of lasers will be available to experimenters throughout the university and UNARC.

Negm is dedicated to two areas, the development of a strong laser program at UNARC and the education of laser physicists who are familiar with every aspect of the laser, from power-supply design to optical-resonator theory. I believe that he is one of the top laser physicists in Egypt and in view of his capabilities, his enthusiasm, and his interest in his students, I am convinced that he will succeed in both areas.

Military Technical College During my visit to UNARC, Negm introduced me to Dr. M.I. Shedeed, another laser physicist and the leader of the Applied Optics Group at the Military Technical College (MTC), Cairo. The following day Shedeed extended an invitation to me in the name of Major General Medhat Mostafa, the commandant of the MTC, to meet with the commandant and to tour the optics facility. During my visit to the MTC Mostafa discussed the college's mission and general activities and the staff of the Applied Optics Group described their efforts.

The college provides the academic training for officer engineers for the three military branches with degrees recognized throughout Egyptian academia and abroad. The BS and MS programs have produced many graduates and a PhD program is being established. The BS and MS programs are rigorous, the BS requiring 5 years and the MS an additional 3 years. The schedule of an undergraduate is tough—42 hours of classes and laboratories per week for 17 weeks per semester. Specialization does not begin until the third year. Each undergraduate student must complete a project which is defended before a committee and before a student can be accepted in the MS program, he (no females allowed) must spend at least 2 years in field service and complete another project that usually takes 9 to 12 months. His acceptability as a graduate student is determined by a committee before which he must defend his project. It should be pointed out that this committee is comprised of MTC staff and members of the university community. Purely theoretical MS projects are rare and must be outstanding since it is generally felt that engineers should do experimental work. The BS degree in applied optics offered by the college is, to the best of my knowledge, unique, with the following required courses: 4 semesters of optics, 3 semesters of lasers and 2 semesters of infrared technology.

The Applied Optics Group, which was started in 1974, is working in three areas: geometrical optics and optical systems design, lasers, and infrared devices and techniques. In the first area, work is underway in the design and fabrication of optical components, including laser resonators and thin film filters and mirrors. Techniques used in polishing optical components made from soft materials are also being developed. The optics laboratory has a variety of lasers including HeNe (up to 10 mW), ruby, neodymium, and an electric discharge pulsed CO_2 laser which is under construction.

The objectives of two MS projects under Shedeed's leadership follow. In a collaborative effort between the MTC and the Center for Remote Sensing, also in Cairo, holographic and infrared imaging techniques are being combined to provide information on the thermal distribution in hybrid integrated circuits. An attempt is underway to "calibrate" a double exposure hologram using data obtained from a thermal image. Another project involves the development of techniques to increase the accuracy of a laser rangefinder. Pulse slicing of a Q-switched laser pulse using an extracavity electro-optic shutter (KD*P), and increasing the counter resolution, will be implemented in this project.

I left the MTC with two main impressions: the MTC training program is one of the most rigorous I have seen anywhere; and Shedeed is an outstanding laser physicist who, with Negm, is one of the top laser men in Egypt.

Helwan Institute of Astronomy and Geophysics Helwan Institute of Astronomy and Geophysics is located some 40 km south of Cairo and has among its facilities a laser satellite tracking station. In addition to his responsibilities at MTC, Shedeed is the chief engineer in charge of the station's laser transmitter/receiver. One evening we went to the institute to observe the collection of tracking data but, in accordance with Murphy's law, something went wrong—high voltage problems precluded the use of the laser. This tracker which was described as reliable, is currently used to track 4 satellites, GEOS-A, GEOS-C, BEACON-C and the French STARLEETE. The following is a brief description of the normally healthy laser transmitter and receiver.

An intracavity Pochells cell Q-switch and an extracavity pulse slicer, both made of KD*P, are used in tailoring the emission from a ruby laser to yield a 4 nsec, 500 mJ output. A beam expander having a 10 cm diameter objective provides for a 0.2 mrad beam divergence. The receiver employs a photomultiplier detector and the receiver collecting optics is a Galilean telescope with a 30 cm diameter objective. A narrow bandpass ($\Delta\lambda \sim 1$ nm) is used to discriminate against background radiation and accurate timing signals are received from Rome, a distance (in time) of 5572 μsec from the tracking station.

One of the most impressive aspects of the tracking station was its truly international nature—for not only is it located on Egyptian soil and operated/maintained by Egyptians, but it uses a Czechoslovakian laser, a Hungarian air conditioner, a Polish electronic counter, a USSR tracking mount and US electronic equipment and financial support. (Richard S. Hughes)

SOLID STATE PHYSICS AT IMPERIAL COLLEGE, LONDON

The Imperial College of London, located approximately a quarter mile north of the South Kensington underground station, is certainly one of the leading scientific establishments in the UK. Its organization has been described in detail in several previous *ESN* reviews (see *ESN* 29-1:9, 32-1:7, 32-10:349), and therefore will not be discussed in this article.

We visited Prof. B. R. Coles, whose Metal Physics Group deals with such diverse subjects as magnetic alloys, dilute alloys, spin glasses, onset of long-range magnetic order, concentrated iron alloys, pressure effects in magnetism, and binary rare-earth alloys. In addition, they conduct neutron-scattering studies. Coles is also nominally in charge of the Surface Physics Group formerly headed by Prof. M. Blackman (FRS, Senior Fellow) who retired recently. This group has a broad-based, modern program and appears to have all of the latest equipment and to be well supported. Finally, due to a recent transfer of one of the Imperial College Faculty to Oxford, Coles currently heads the Theoretical Physics Group. Although these groups have the potential for interaction, we gleaned from our discussion with Coles that they are really independent of one another.

Coles is an extremely dynamic and vigorous physicist. He was trained as a physical chemist under Hume-Rothery at Oxford and transferred to physics after he received his PhD degree. The exposure to such a great scientist as Hume-Rothery had a lasting effect on Coles which is reflected in his enthusiasm for and dedication to science; and he, in turn, passes his enthusiasm, dedication, and inspiration on to his students.

Coles has just completed a term as chairman of the Physics Panel of the Science Research Council (SRC [the UK equivalent of the NSF]), which, in addition to funding basic physics research, also provides funds for graduate-physics-student stipends in the UK. It was fascinating to learn how Coles managed to juggle the operation of three large physics groups and his tour as chairman of the Physics Board at the same time. He pointed out that living very close to his laboratory at Imperial College permitted him to visit that laboratory after working the day with his physics committee at the SRC.

Coles is quick to acknowledge that, during this period, he has had an outstanding postdoctoral associate who managed most of the day-to-day laboratory operations for him.

One of Coles' associates, Dr. A. D. Caplin, discussed some of his recent work with a new amorphous/crystalline silicon compound, Na_xSi_{136}. This material with a variable sodium content is prepared by dissolving silicon into molten sodium and then distilling the mixture at approximately 300°C.

Although few of the compound's physical properties have been determined, its crystal structure as reported in *Science* (24 Dec 1965, p 1713) is enormous. The structure is face-centered cubic (fcc) with 136 silicon atoms per unit cell and a lattice constant of 14.62 Å. The 136 silicon atoms are grouped in subunits of 34 (136/4) in the fcc positions. The subunits, formed by distortion of the tetrahedral bonds in pure silicon, constitute "cages" or enclosures for the sodium atoms. A maximum of 24 sodium atoms can be accommodated; the exact number is controllable by the distillation process.

It should be emphasized that the material is actually crystalline—not amorphous. However, there is the possibility that it possesses nonstandard electrical properties since the silicons appear to be in an amorphous state from the local viewpoint. At present, since it has only been produced as a powder, neither the low-frequency conductivity nor the optical properties have been determined.

One of Coles' long-term interests is magnetism in metals. The Imperial College team investigated this phenomenon using magnetic, electrical, neutron-scattering, and magnetic-resonance methods. Recently a steady-state AC calorimeter has been developed. The main feature that differentiates this type of calorimeter from the standard adiabatic type is a weak thermal link between the sample and the liquid helium bath. An oscillating thermal power supplied to the sample sets its temperature oscillating about an average temperature. The heat capacity is derived from the amplitudes of the supplied thermal power and resulting temperature oscillation, and the frequency. This method has the advantage of requiring much smaller samples than does the conventional adiabatic calorimeter. Measurements in the 4 K range on a series of alloys of iron and gold show a peak in the heat capacity at approximately 15 atomic percent iron. This is close to the observed critical concentration (16 atomic percent) at which an infinite cluster of iron forms.

Dr. C. Guy, another member of the Metal Physics Group, is just beginning to assemble apparatus for studying magnetism under pressure. Guy expects to be able to work at pressures up to 15 kilobars and down to ordinary helium temperatures (1.5 K). It is anticipated that this apparatus will allow research on materials with incipient magnetism such as dilute solutions of iron in platinum.

Since these are only a few of the many outstanding research projects under Coles' direction, solid state physics at Imperial College is clearly in fine shape. (J.R. Neighbours and F.E. Saalfeld)

SYSTEMS ANALYSIS

EAST AND WEST, THE TWAIN DO MEET AT IIASA

The International Institute for Applied Systems Analysis (IIASA) has been written up in these pages approximately every two years (*ESN* 27-12:339, 29-7:314, 32-3:51), and it is an institute of sufficient importance that it will doubtless be written up from time to time in the future. The reader may well wish to review those previous articles, which are summarized here.

IIASA's charter was signed in October 1972 after 5 years of negotiations; a year later, 20 scientists were working there; and it has now grown to the point that it has approximately 100 scientists plus supporting personnel. The institute is located in Schloss Laxenburg in the village of Laxenburg, about 10 miles south of the center of Vienna. Schloss is the German word for castle, and this edifice was built by Empress Maria Theresa of Austria more than 200 years ago; having fallen into disrepair, it was recently refurbished by the Austrian government to house IIASA. We might note in passing that Austria, whose neutrality has been guaranteed by international treaty, has become the headquarters for a number of international organizations, including both those of the UN and those of OPEC, and has subsidized this magnificent housing for IIASA. The word schloss tends to bring up images of the Schloss Heidelburg and of the type of castle one sees along the Rhine. This is a much more modest structure, but still grander than the average scientific institute. The support facilities are in general excellent, and while IIASA still has only a small (PDP) computer, it has access to an extraordinary network of very powerful computers throughout Europe, both East and West.

IIASA is supported by 17 nations, consisting of the US, Canada, Japan, and 14 European countries, 6 Socialist and 8 from the West. The USSR and US are assessed an equal, large share of the costs, with the other countries all assessed an equal, small share. It also has contributions totaling about $1M/yr from such disparate sources as the Ministry of Science and Technology in the Federal Republic of Germany, the Austrian National Bank, the Rockefeller Foundation, and certain private American companies.

The first director of IIASA was Howard Raiffa (Harvard Univ.) and the second, and current, director is Roger Levien (Rand Corp.). The chairman of the council, Jermen Gvishiani (USSR Academy of Sciences), has held that position since IIASA was organized. It seems to be assumed that these two positions will be held by an American and a Soviet, respectively, for the foreseeable future.

The language of the institute is English. This was stipulated in the beginning and no one seems to question it, although when two Finns or two Russians or two Dutchmen meet in the hall they are likely to talk in their own language. That the East Europeans have not objected to the exclusive use of English is an example of how well IIASA works. In fact, I found it startling that IIASA is absolutely nongovernmental. Nobody cares whether an American works for a Russian, or vice versa. An East German can be friends with a West German. People invariably speak for themselves rather than for their governments when they are discussing official business. I asked Levien why it worked so well and he said there were three reasons. In the first place, people are not nominated by the State Departments of the representative governments, but by the national member organizations, of which there is one in each country formed entirely of scientists. These committees have apparently gotten into the spirit of the thing, and nominate scientists rather than politicians. In the second place, scientists come here as individuals. IIASA may go out to recruit an expert in food and agriculture or computer simulation or operations research, but it never says, "The last hire was Dutch; we had better hire a Bulgarian next." And in the third place, people have come to believe in the institute and the fact that it will work, and they take pride in it. I gather that if someone started to introduce politics into the technical material, he would meet with a good deal of peer disapproval, even from his own compatriots.

While recruiting is not allocated by countries, it clearly would be undesirable to have too great a disproportion. This turns out not to be a problem. Vienna is a very expensive place in which to live, and therefore it is not very attractive to outstanding scientists of most of the western countries except for the very young and the very old. Some slight compensation can be made for the high cost of living compared to such countries as the US, but in general one cannot pay an American, say, more than a Pole.

IIASA has three basic goals: (1) To foster international collaboration; (2) To advance science in general and systems science in particular; and (3) To solve applied problems of international importance. These goals inherently conflict with one another. A single-minded attempt to recruit the best scientists might leave an unbalanced staff; this would work against international collaboration. And those members of the scientific community who work to advance science often are not inclined to devote their efforts to its application. Some people feel that the first goal is most important: East-West collaboration is IIASA's *raison d'etre*. Another school of thought holds that because of its sponsorship by distinguished academic institutions, IIASA must perform at the highest level of science. The third school stresses the words "international" and "applied" in the title of the institute and feels that since IIASA is perhaps the only organization in the world that can attack some of these international problems, it should stress them. This conflict has been resolved through an agreement that while individual activities may emphasize one goal, the research program taken as a whole must serve all three.

Buzz words frequently heard around IIASA are "global" and "universal"—two entirely different interpretations of what is meant by "international." Global issues include such things as man's interaction with the climate and his utilization of the oceans. Universal problems, which lie within the boundaries of single nations but are shared by most nations, include such topics as the design and operation of national-health-care systems and the management of water resources. There has been a clear-cut decision that IIASA will work on both global and universal problems.

To accomplish these objectives, IIASA has been organized into a 2-dimensional, or "matrix," structure consisting of "programs" and "areas". Programs concentrate interdisciplinary teams on the investigation of major international problems over a period of about 5 years, while areas provide pools of expertise and have unlimited lifetimes. At the present time the institute has 2 programs: (1) an energy systems program under Wolf Häfele (W. Germany); and (2) a food and agriculture program under Ferenc Rabar (Hungary). It also has 4 areas: (1) Human settlements and services, under Andrei Rogers (US); (2) Resources and environment, under Oleg Vasiliev (USSR); (3) Management and technology, under Rolfe Tomlinson (UK); and (4) System and decision sciences, under A. Wierzbicki (Poland), who has recently been discussed in these pages (*ESN* 34-2:92, 94). Each of these groups has 15 to 30 scientists (the total adds up to more than 100 because it includes part-time people who spend only a few months a year at IIASA). There are also a miscellaneous group on "general research" and some support groups.

I talked with the leader of one of these support groups, H.J. Miser (US), the executive editor. This is a key post at IIASA because their principal output is paper. They publish a large number of reports and books, all of which are subject to Miser's approval. Many of the books are by non-IIASA employees, frequently by people who have formerly worked for IIASA. Miser told me that it is "the genius of this place" that it has many more people working for it than are actually on the payroll. Many of the books are from the East, mostly books which would not easily find an English-language audience if IIASA did not perform this service. All of the books and reports are refereed, usually by outside reviewers, but sometimes by people from a different area or program than the author or authors. One series of books, published by Wiley, is entitled *International Series on Applied Systems A Analysis*; it started slowly but now constitutes several volumes a year. Another series, the *IIASA Proceedings*, published by Pergamon, consists of the proceedings of the numerous conferences run at Schloss Laxenburg. There are other books, numerous research reports, and a recently begun series of executive reports designed to communicate the findings of IIASA research to "those who could put the findings into effect, such as executives in government and industry"—in other words, nontechnical people. Under Miser's stern insistance, the quality of most of this output remains high.

Most scientists stay at IIASA 1 to 2 years (Levien told me proudly that the average is now up to 22 months) but as he said, "Long-term leadership is important," and the leaders mentioned above generally have stayed periods of 5 years or more. Häfele, who came in 1973, has the longest tenure. He has led the energy-systems program since its inception, and will stay until it is completed in 1981, after which the program will be reduced from its present very large size to a core group of some 6 people. Häfele took a doctorate in theoretical physics at Göttingen Univ. and was in charge of West Germany's fast-breeder-reactor project for many years. In the 1960s he became involved in strategy calculations such as comparing fast-breeders with light-water reactors in terms of saving uranium. This brought him to an interest in systems analysis. He was at the KFA (Kernforschungsanlage: Nuclear Research Establishment) in Karlsruhe, FRG. At that time there was some systems-analysis work there, but that work now has been moved entirely to the KFA in Jülich (*ESN* 33-10:409). After leaving IIASA, Häfele will doubtless go to a university in West Germany. He presently teaches at the University of Vienna and has some doctoral students there.

The energy-systems program has emphasized global (as distinct from universal) aspects in studying the energy problem. The staff members recently completed the first analysis of the energy of the world as a whole, and have just finished a 1,000-page book on the subject. In the next 2 years they will have to translate these global insights into national policies for application to the European Economic Community and to such additional countries as Bulgaria, and also to apply it to investment questions. Thereafter, the energy program will become a "focal task" containing the network and modeling systems, but not involving ongoing research. The energy models developed at IIASA have already had a major impact on other energy research going on throughout the world, and have led to the conference on energy modeling at IIASA which is described earlier in this issue. Häfele told me that the key word in the energy study was "resources." Energy prices will surely be significantly higher in the future than they are now. The IIASA effort has looked into all aspects of the problem: demand, supply, risk, and constraints; and all sources: nuclear, solar, and fossil. The implications are on a truly large scale.

Häfele is moderately optimistic about the long-term future. He told me specifically that he disliked the Club-of-Rome kind of thing, because they say that no matter what you do, you will fail, and he does not believe that.

There are currently four candidate topics for program status to replace the energy systems program in 1982. These are: (1) Climate and human activities, (2) Risk and hazards, (3) Regional development, and (4) Industrial strategies. Levien told me that the first two have now been pretty well rejected and that the last-named is the most likely. It would be concerned with the issues facing national, regional, and sectoral decision makers who must decide how to develop industrial structures in the light of shifts in international development, increasing prices, scarcity of energy and raw materials, and rapidly changing technologies.

A. Rogers, chairman of the human settlements and services (HSS) area, is an extraordinary man. He studied architecture at the University of California at Berkeley; took a doctorate in city planning at the Univ. of North Carolina where he also studied statistics under the late G. Nicholson; and he took a postdoctoral course in operations research under R. Oliver at Berkeley. He was on the city planning faculty at Berkeley and then went to Northwestern University where he became well known in the field of demography. He also is a cross-country skier and a birdwatcher.

Rogers joined IIASA in 1975, when the HSS area was formed out of two existing projects, one on urban and regional systems and the other on biological and medical systems. The latter has evolved into a project on health care systems, which may well be completed in the near future. If it is not completed, its current operations research paradigm will at least be changed into an economics paradigm, which is almost equivalent to changing to a new program. Some new tasks have also been added; one on mathematical demography has essentially been completed, and a monstrous 3-volume work entitled *Migration and Settlement* has been published, along with 17 individual volumes about particular countries. Tasks on population and resources in growth have also been nearly completed. A major task on normative location modeling is continuing; it has universal applications to hospitals, schools, and other public facilities. This task will either be completed in the near future, or else be expanded to become a much more important task. The point of this listing is that both programs and tasks within areas do get completed at IIASA, which may be unusual; as those who grant funds know, the hardest thing in the world to do is to kill an ongoing project.

Tomlinson, leader of the management and technology (MMT) area, studied mathematics at Cambridge and took a master's degree in aeronautical engineering. He went to the Coal Board (the organization that runs that nationalized industry in the UK), where he first worked in statistics and subsequently in operational research. He became the head of that department in 1965 and retained that position until he left for IIASA in 1977. Tomlinson will be leaving IIASA about the time this article is published (an unusually short tenure for a leader at IIASA, but the move is necessitated by some personal problems) to take the chair in operational research at Warwick University (*ESN* 32-12:431). He will be succeeded as head of the management and technology area by A. Lee (*ESN* 33-6:259), who retired after a heart attack but now apparently feels capable of returning to work.

The MMT area is rather new. A good part of the last three years has been spent planning and recruiting, but results are now beginning to appear. Two basic questions were addressed early: (1) Who were they trying to help? The answer: not so much the decision makers as the advisors to the decision makers. This implies attention to universal rather than global problems. (2) What do management and technology mean? They have taken it to mean not the management of technology, but those fundamental problems of management which arise from technological change. They are attempting to define their problems from a management, rather than a scientific, point of view.

The MMT people are working on three major tasks. The first of these tasks is one of innovation, based on the premise that all governments feel they must interfere with the normal flow of change arising from economic pressures. Tomlinson's group has been investigating what use can be made of formal analytic devices to help governments decide how to do this. They have made specific studies of innovation in several industries, especially forestry, which is an industry of great interest to several member countries.

The second major task involves problems of scale; for example, how big should an industry be? A recent study by the General Electric Company has asserted that most nuclear power plants are now twice as large as they should be for maximum efficiency, while most power plants generating electricity from fossil fuel are four times as large as they should be. Not everyone agrees with these conclusions. Tomlinson feels that, for the first time, the economic, sociological, and technological points of view are being put together in studying the question of scale. This task will be completed before the end of 1980. Other tasks will then take its place, probably one on the computer/management interface; specifically, what is the impact of the new microcomputer, and what will happen when there is a computer in every office? This may eventually lead to a much larger program on computers, information, and organization. Tomlinson is also planning to start a small program on operational gaming. Inevitably in an organization like IIASA there is an overemphasis on modeling, and Tomlinson feels that gaming is a highly viable alternative to modeling.

The third major task at this time is the study of high-risk situations and how they should be managed. There exists a large set of new problems which are characterized by the investment of very large sums of money, the possibility of exceedingly expensive accidents, and extreme uncertainty as to what the probability of such accidents will be. These include the danger of nuclear plant explosions (made famous by the Three-Mile-Island incident), the dangers of nuclear proliferation from fast-breeder reactors, blowouts in the North Sea oil production, and the use of liquefied natural gas.

Finally, MMT people have been making industry studies, with emphasis on coal and forestry. Interestingly, the coal industry study is going badly simply because it has been studied too much in the past. The forestry industry study, likewise, is not going well; partly, Tomlinson told me, because the antitrust laws inhibit American industry from cooperating in such a study.

Rabar, leader of the food and agriculture program (FAP), studied economics at the Univ. of Budapest; although he never acquired a PhD, he became a distinguished scientist and scientific administrator and a professor of economic planning. He also was at Nuffield College, Oxford, in 1965; at Columbia, Stanford, and Case Western Reserve Universities in 1978 and 1979; and at NYU in 1971. He came to IIASA in 1975, and has headed FAP since it began in January 1977. He expects to leave in July 1980, and his place as leader of the program will be taken by K. Parikh from India.

Rabar decided early that the food and agricultural problems were different in different countries. In some they were caused by lack of natural resources, in others by overpopulation, and in still others by poor income distribution. He decided that studies should be done on a national basis, and chose to look at <u>all</u> countries which were important in any one of the following aspects: agricultural exports, agricultural imports, total agriculture, arable land, population, or hunger. It turned out that including only the EEC (as a unit), the Communist-bloc countries (also as a unit), and 18 individual countries, they could cover well over 80% of the world in each of those 6 aspects. They then attempted to get a model for each of these 20 countries or groups of countries, with each model being developed by natives of that country. As of now they have succeeded in almost all of the 20 (Argentina, Bangladesh and one or two others remain incomplete). There is a common framework for these models: a general-equilibrium approach assuming a fixed supply (determined by the decisions of the previous year) to which demand and prices respond. Thus the supply modules of the models become free, greatly simplifying the modeling procedure. There is a wide variety of production systems, and domestic prices are influenced by government policies which may not be consistent. As an example of such inconsistency, Rabar cited Brazil's practice of exporting food which was needed domestically in order to get foreign exchange to buy petroleum.

FAP now has an enormous data bank, with data obtained from such international agencies as the Food and Agriculture Organization and the International Labor Organization of the UN, and the World Bank. The FAP people can handle, aggregate, and create a model for a new country rather easily. They have also developed a networking method for putting these models together. Now they are in the process of exploiting these models; for example, by investigating agricultural policies for developing countries, to determine whether self-sufficiency is a realistic goal for the less developed countries (apparently it is for some of them).

Rogers told me that IIASA was not yet important, but was trying to be, and that doubtless it would be important in the future. Levien, on the other hand, told me that it already was important. These distinctions are semantic. IIASA is doing a remarkable job of demonstrating the ability of scientists from socialist and capitalist countries to work together. The institute is handling international problems which desperately need study and have not been undertaken elsewhere. And it is making significant contributions to the development of the discipline of systems analysis. It cannot really do these things well unless it increases significantly in size (it is smaller by orders of magnitude than many other international organizations). If it does so, it will change drastically in character. It will be interesting to come back in a few years to see what has happened to IIASA. (Robert E. Machol)

NEWS & NOTES

North Atlantic Navigation—An Update

In *ESN* 33-10:399 I reported on the attempts to establish "Minimum Navigation Performance Standards" (MNPS) for aircraft flying over the North Atlantic Ocean (NAT) and following that to reduce the lateral separation between flight paths from the present 120 Nautical miles to 60. It would be considered safe to do this if the "gross errors", which bring an aircraft more than halfway to the adjacent path, and the "60-mile errors", which tend to put it precisely onto that adjacent path, are sufficiently infrequent.

In the six months ending 29 February, 31,048 flights were observed by radars at the ocean's edge (in Ireland and Europe) as they have emerged from the oceanic area, and eleven errors of more than 30 miles were found, of which four were 60-mile errors. These observations are to be compared with 16.4 and 4.03 errors respectively permitted by the model and by the target level of safety. It was therefore concluded by the System Planning Group in March that the MNPS had been met, and 30 October 1980 was set as the date for introducing the new separation, subject to maintenance of this performance level.

Unfortunately, since 1 March somewhat more 60-mile errors have been observed. There is now a controversy over the interpretation of such errors. If it is assumed that the observed errors are typical of those maintained throughout the flight across NAT, then the target level of safety may not have been met; if it is assumed that they occurred only during the transition from oceanic to domestic control, then it has been met, probably with a comfortable margin. The navigational details of earlier flights have been completely recorded and carefully analyzed, and it seems clear that the latter is more nearly the true picture. This interpretation has been agreed to by the representatives of Canada, the Netherlands, and the UK; by the airline owners (IATA)—as might be expected because they have always advocated the reduced separation; and by the pilots (IFALPA)—even though they have historically strongly resisted reduced separations.

However, the representative of the US FAA prefers the alternative interpretation. Quite apart from the technical questions of statistics which may be involved, the majority seems motivated by questions of cost, time, and savings of energy, while the US position may be motivated by extreme considerations of safety. In any case, a unaminous vote is required before the International Civil Aviation Organization will reduce the separation and so the date of 30 October is now very much in doubt. (Robert E. Machol)

A New Max Planck Institute

Before the Max Planck Society establishes a new institute, a group is created for a 5-year trial period. During this trial period the importance of the field under investigation and the contributions to this field by the group are determined. The Laser Project Group at Garching has been in existence for about 4½ years and it has been voted to create from this group the Institute for Quantum Optics. It is expected that the new institute will be established in early 1981. This group has developed and used lasers including the Asterix III 1 TW iodine laser and the recently reported IF laser. An article describing current laser efforts at Garching will appear in an upcoming issue of *ESN*. (Richard S. Hughes)

Cosmic Testing Underground

A particularly bizarre implication of recent theories which seek to combine electromagnetism with strong and weak nuclear forces means that protons, the very kernel of matter, may only have a fixed life—about 10 million million million million million years!

This means that a man would have to live for more than a century before he could say that there was a good chance that just one of the protons in his body had disintegrated.

To test this hypothesis, two major European experiments are being constructed deep underground where the effects of cosmic rays will not confuse the results.

PERSONAL

Strathclyde University's next principal and vice-chancellor will be Prof. Graham John Hills, senior deputy vice-chancellor of Southampton University. He is expected to take up his appointment in November 1980, succeeding Sir Samuel Curran.

Dr. Alan F. Newell, senior lecturer in digital systems engineering at the University of Southampton, has been appointed to the NCR chair of electronics and microcomputer systems in the University of Dundee. The chair has been established to provide the teaching of microprocessing to undergraduates, to coordinate work carried out by relevant university departments and to liaise with local industry, both by organizing course and by advising them on the use of microprocessors.

OBITUARIES

Sir Vincent de Ferranti, internationally recognized for his achievements in the electrical engineering industry, and a member and past president of the Institution of Electrical Engineers, died on 20 May at the age of 87.

Dr. Montague H. Jupe, consulting radiologist to the London Hospital, died on May 6 at the age of 86. He was a recognized and respected pioneer in the development of the radiology of the central nervous system.

Dr. Seymour Cochrane Shanks, an eminent radiologist who practiced his chosen profession in London since shortly after the close of WWI, died on 14 May at the age of 87. He will perhaps be best remembered by many radiologists as senior joint editor of the 6-volume *Text Book of X-ray Diagnosis*, which ran into 4 editions and had an international reputation for its clarity and conciseness.

ONR Cosponsored Conferences

"Phase Transitions and Applications of Ferroelectrics," Ettore Majorana, Erice, Italy, 1-15 July 1980.

NATO Advanced Study Institute, International Summer School on Modern Statistical Distribution Theory and its Applications, University of Trieste, Italy, 10-31 July 1980.

VIII IUPAC Symposium on Photochemistry, Seefeld, Austria, 13-19 July 1980.

VI International Conference on Atmospheric Electricity, Manchester, England, 28 July-1 August 1980.

NATO Advanced Study Institute, "New Concepts in Multi-User Communications," University of East Anglia, Norwich, England, 4-16 August 1980.

Conference, "Physics of Transition Metals," The University of Leeds, England, 18-22 August 1980.

International Conference on "Physics in One Dimension," Fribourg, Switzerland, 25-29 August 1980.

International Conference on Adhesion and Adhesives, Durham, England 3-5 September 1980.

Conference on Physics of Dielectric Solids, University of Kent, Canterbury, England, 8-11 September 1980.

3rd International Symposium on Gas Flow and Chemical Lasers, Marseille, France, 8-12 September 1980.

IUTAM Symposium on Creep in Structures, Leicester, England, 8-12 September 1980.

International Symposium on Gallium Arsenide and Related Compounds, Vienna, Austria, 22-24 September 1980.

NATO Advanced Study Institute, "Singularities in Boundary Value Problems," Maratea, Italy, 22 September-3 October 1980.

NATO Advanced Study Institute, "Molecular Ions: Geometric and Electronic Structures," Isle of Kos, Greece, 30 September-10 October 1980.

International Workshop on "Ion Formation from Solids," Münster, W. Germany, 6-8 October 1980.

European Visitors to the US, Supported by ONR London

Name of Visitor	Affiliation	Navy Lab./Org. to be visited
	JULY	
Dr. G. Dearnaley	Nuclear Physics Div., AERE Harwell, UK	NRL
Dr. C.R. Pidgeon	Dept. of Physics, Heriot-Watt Univ., Edinburgh, UK	NRL, NSWC
Dr. J.M. Walls	Dept. of Physics, Univ. of Technology, Loughborough, UK	NRL, NSWC
	AUGUST	
Dr. S. Cornbleet	Univ. of Surrey, Guildford, UK	NOSC, NPG School
Prof. M.G.D. El-Sherbiny	Faculty of Eng., Cairo Univ., Egypt	NRL, ONR, DTNSRDC
Prof. P. Meares	Dept. of Chemistry, Univ. of Aberdeen, UK	NRL
	SEPTEMBER	
Dr. F.M. Harris	Royal Society Res. Unit, Univ. College of Swansea, UK	NRL, NSWC, DTNSRDC
Dr. A.P. Parker	Royal Military College of Science, Shrivenham, UK	NRL, DTNSRDC, NSWC
Dr. D. Price	Dept. of Chem. & Applied Chem., Univ. of Salford, UK	NRL, DTNSRDC
	OCTOBER	
Dr. K. Allen	Adhesion Science Group, City Univ., London, UK	NRL, NSWC

ONRL REPORTS

C-1-80

3rd Europhysical Conference on Lattice Defects in Ionic Crystals by Lawrence Slifkin

The 3rd Europhysical Conference on Lattice Defects in Ionic Crystals took place at Canterbury, England, September 17-21, 1979. The topics covered included ion transport, defect configurations and reactions, dislocations and their interactions with point defects, and color centers. This report summarizes the results and discussions pertinent to all of these papers, except those dealing with color centers.

C-6-79

Fifth International Conference on Erosion by Liquid and Solid Impact, Cambridge by Arthur M. Diness

The Fifth International Conference on Erosion by Liquid and Solid Impact was held at Cambridge University, 3-6 September 1979. The general chairman was the renowned Prof. David Tabor. The major topics treated during the meeting were (1) particle-caused erosion of brittle solids, (2) of ductile solids and (3) cavitation erosion of materials. The meeting provided a useful forum for new ideas on all aspects of erosion, as well as opportunities to couple parallel work underway across the world.

C-12-79

15th International Conference on Applied Military Psychology, 7-11 May 1979 by M.J. Farr

The Fifteenth International Symposium on Applied Military Psychology was held in Jerusalem, Israel, 7-11 May 1979 with the Israeli Defence as hosts. The theme of the conference was "Psychology Aspects of Recruitment and Adjustment to Military Life."

Twenty-seven representatives of 12 countries were present. This conference report reviews the formal presentations that were the substance of the symposium.

R-5-79

Current Perspectives in Hyperbaric Physiology, Ultrasonic Doppler Bubble Detection, and Mass Spectrometry by B.G. D'Aoust

Two important analytical techniques in biomedical research have been increasingly utilized in hyperbaric physiology over the past 12 years. Doppler ultrasonic bubble detection on the one hand and mass spectrometry on the other have been used to demonstrate responses to both elevated pressure and decompression which have previously been only conjecture. Both techniques have raised controversies, yet both, properly used, are capable not only of resolving them but also of resolving many of the questions which have remained unanswered. The article discusses the state-of-the-art of these two techniques in hyperbaric medicine and some of the more promising areas for the future.

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