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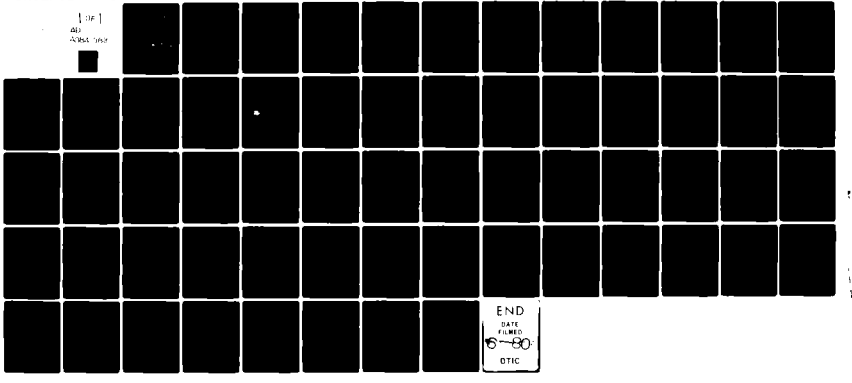

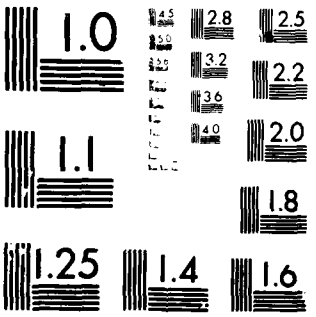
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-This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists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

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edited by Willard D. Bascom and Don J. Peters

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CHEMISTRY

MIXED-VALENCE COMPOUNDS, A NATO ADVANCED STUDY INSTITUTE

Although mixed-valence materials have been around for a long time, e.g., the common and highly colored minerals such as magnetite, only in the last decade has their study emerged as a coherent field of investigation. These materials are formally defined as those compounds which contain the same element in more than one oxidation state. They may exhibit this nature in their stoichiometry, as in nonstoichiometric compounds such as $Li_{1+x}Ti_{2-x}O_4$, $0<x<0.33$, or by containing elements with an apparent nonintegral number of valence electrons, as in magnetite, Fe_3O_4, where iron has an average oxidation number of 2.67. Alternatively, mixed-valence compounds may appear to have integral oxidation states, but they may be unusual ones, as in Pb(III) compounds, or the compound may be otherwise peculiar. Investigations in the last century focused primarily on stoichiometry and color, but the development of an impressive array of structural and spectroscopic tools in the intervening years has made possible more detailed study of their structure and properties.

Mixed-valence compounds are known for almost half the elements in the periodic table, most of them metals. Their study has implications for some very diverse fields ranging from solid-state physics (e.g., molecular metals) to chemistry (e.g., oxidation-reduction mechanisms) and biology (e.g., 4-Fe, 4-S ferredoxins).

The growing importance of this class of compounds was evidenced by the decision to hold a NATO Advanced Study Institute (ASI) on "Mixed-Valence Compounds in Chemistry, Physics, and Geology." Organized for NATO by D.B. Brown (Univ. of Vermont, Burlington), the meeting was held from 9-21 September 1979 at St. John's College, Oxford, the home turf of P. Day, another member of the organizing committee. The ASI drew approximately 80 participants from over a dozen European and North American countries. Originally billed as an ASI on Mixed-Valence Compounds in Chemistry, Physics, and Biology, the title and emphasis of the meeting were changed to feature geological materials. However, biochemical mixed-valence compounds were still included in the range of topics presented.

In keeping with its formulation, the ASI's emphasis and format were somewhat different than that normally encountered at a scientific meeting. Many of the participants were young faculty members, post-doctoral fellows or graduate students with widely varying levels of expertise in the subject matter. The major portion of the material was presented over the 10 working days of the meeting in 24 relatively informal lectures. Varying in length from 1 to 3 hours, each dealt with a specific part of the subject area considered, and was generally presented at a level understandable by those who were not experts on mixed-valence chemistry. (I speak from experience, as I am not.) Questions were encouraged during the presentation as in a university lecture, and additional time was allotted at the end of each lecture for additional discussion which was generally well used by those in attendance. In addition to the invited lectures, there were 3 sessions of short contributed papers and 2 poster sessions, which allowed the presentation of new results by both participants and lecturers.

The subject matter can be divided into three main categories. Lectures dealing with models for mixed-valence compounds were introduced by a talk on the properties of mixed-valence materials, followed by expositions of the relation of properties to the extent of electron delocalization. Electron-transfer processes in the electronic structure of these compounds were emphasized, and a number of models for mixed-valence behavior were presented.

The second category dealt with specific mixed-valence compounds with reference to both a bonding classification scheme and also to their roles in specific disciplines. Methods of synthesis and characterization were also presented. The lectures in the third group discussed experimental techniques used in these studies. A variety of experimental probes were examined, with emphasis on the specific application to mixed-valence systems.

The first lecture was an "Introduction to Mixed-Valence Chemistry" by Day. Beginning with definitions he suggested that we consider as mixed valence only those compounds which have the same element in two different oxidation states [as in Pt(II) Pt(IV) compounds] or have a noninte

average number of valence electrons (as in Fe_3O_4). After a short tour of the periodic table to visit the more than 40 elements which form these compounds, we were given a quick glimpse of the specific areas in physics, mineralogy, chemistry, and biology in which the study of mixed-valence systems has furthered progress. Next came a short presentation of simple theory, with justifications for classifying mixed-valence compounds into three types: Type I, strongly localized, where discrete integral oxidation states are maintained; Type II, intermediate, where discrete oxidation states can be identified on some timescales, but the activation energy is small enough to allow some electron transfer; and Type III, strongly delocalized, where most properties are an average of those for the constituent oxidation states, electron transfer is energetically feasible, and high conductivity is found if the system is based on an infinite lattice. This classification scheme has gained wide acceptance and was used extensively in the days that followed.

The next day began with a well-thought-out presentation of "Electron Transfer in Mixed-Valence Systems" by T.J. Meyer (Univ. of North Carolina, Chapel Hill). This lecture was extremely helpful to listeners with little background in the theory of mixed-valence systems, since it started from ground zero, using H_2^+ as the prototype mixed-valence system. On this basis, a semiclassical quantum mechanical treatment was built up, using the harmonic oscillator approximation. More complex systems were considered by means of reduced normal coordinate analysis, with the end result being the derivation of some of the major relationships in, e.g., Hush-Marcus theory. A marathon presentation of "A Vibronic Coupling Model for Mixed-Valence Compounds and its Application to Real Systems" by P.J. Schatz (Univ. of Virginia, Charlottesville) later gave an alternative view of the theory of these complexes. According to Schatz, the usual theoretical discussion deals only with the static problem and yields results valid only in the localized limit. His method essentially solves first the electronic problem, then the vibrational problem, and finally the dynamic problem, all to zero order, followed by a further refinement, solving each to first order. Besides predicting the usual Hush-Marcus relationships, various other predictions and rationalizations are possible, including intervalence transfer band contours, tunneling transitions, and the kinetics of electron transfer. Lively discussion followed.

The emphasis on geological materials was illustrated by an excellent talk by R.G. Burns (MIT, Cambridge, MA) on "Mixed-Valence Minerals of Iron and Titanium: Correlations of Structural, Mössbauer and Electronic Spectral Data." Interestingly, many minerals and gemstones containing iron and titanium owe their coloration to intervalence transfer (IT) absorptions. The principal IT absorption found in earth minerals is due to electron transfer between Fe^{2+} and Fe^{3+}, while in moon rocks and meteorites Ti^{3+} to Ti^{4+} electron transfers are found. Recently Fe^{2+} to Ti^{4+} electron transfers have been proposed to explain absorptions found in rocks from the earth, moon, and meteorites.

Sunday was a free day, and I believe almost everyone utilized the chance to get out and take advantage of the beautiful weather. A busload went to visit Salisbury with its cathedral (tallest spire in Britain) and nearby Stonehenge. There was also free time most afternoons or evenings to explore the beautiful parks and college grounds of Oxford and its environs.

The second week was led off by Brown, discussing "Synthetic Approaches to Mixed-Valence Compounds." He began by saying that it is impossible to write a paper with the above title, since many syntheses occur largely by accident, a classic example of which is Diesbach's synthesis of Prussian Blue. Still, Brown discussed three classes of syntheses. The first is made up of reactions that are trivial. The major product of this reaction is often the material that has the lowest solubility in the reaction medium. Since many methods for studying mixed-valence compounds measure solid-state properties, this low solubility is not much of a liability. Reactions of the second class, clusters, can be prepared by rational syntheses, and their stability is often determined by the relative potentials of the mixed-valence state and its oxidation and reduction products. The third class of reactions involves the formation of solid-state materials. Most of these reactions are polymer-growth processes or other solid-state reactions.

The other conference lectures covered various aspects of instrumental measurements on, or specific subsets of, mixed-valence compounds. The pri-

mary research tools in this area include electronic spectroscopy, Mössbauer spectroscopy, conductivity measurements, photoelectron spectroscopy, resonance raman spectroscopy, magnetic measurements, and x-ray crystallography.

The Advanced Study Institute concluded Thursday night with a banquet which was enlivened by some tongue-in-cheek toasts and awards. I feel that the Chairman, Brown, and the rest of the organizing committee, Day, A. Ludi, and T.J. Meyer, are to be congratulated on an excellent meeting. The texts of the invited lectures will be published in book form by D. Reidel Publishing Co., Dordrecht, The Netherlands, sometime in 1980, with Brown serving as editor. (Harmon B. Abrahamson, Univ. of Oklahoma)

POLYMERS AND SURFACES AT DURHAM

Few of the castles and fortresses which figured so importantly in English history during the Middle Ages have withstood the ravages of time; today they are rarely more than elegant hulks hinting of a colorful and turbulent past. Not so Castle Durham. From Norman times to the 19th century it has been the home of the Bishops of Durham who exercised religious, political, and military authority along the border between England and Scotland. The key to their survival is that as late as the 16th century, the Bishops' armies protected England from the raiding Scots, a service for which the Monarchy was generously grateful. Even after the need to control the Scottish tribes, the Bishops continued to be the only effective political power in the region around Durham. Finally, in the early 1800s, the political power of the Bishops passed to the secular authority and the Castle became part of the University of Durham. Now it is a students' residence, except for a few suites available to University guests.

Our host in the Chemistry Department was Dr. David Clark, who arranged accomodations in the Bishop's Suite with its tapestry-lined sitting room and four-poster bed. Clark is very active in characterizing the chemical composition of polymers using x-ray photoelectron spectroscopy (XPS) which can identify chemical species on the surface of a solid. It is one of the few techniques that can differentiate chemical composition of surfaces from the bulk composition. Interpretation of the spectra is quite complex and, indeed, much of Clark's efforts have been to identify peaks in spectra taken from well characterized polymers. Specifically, the binding energies of different chemical groups in the surface (C=O, COOH, CF, CF_2, etc.) are catalogued.

In addition to characterizing XPS spectra, Clark has turned his attention to the polymer films formed by plasma polymerization. It has been known for many years that RF plasmas of hydrocarbons or other organic gases deposit thin polymeric films on substrates placed in the plasma. This phenomenon received little attention because of the extreme difficulty in controlling the chemical composition of the films. Clark has made a systematic study of plasma-formed polymer films using XPS to characterize their chemical constitution. He sees a commercial future for plasma coatings for surface modification, for example, an ultrathin fluoro-coating on an elastomer to render it oleophobic. To realize this potential, Clark has been sorting out the experimental variables and plasma chemistry that determine the chemical and physical properties of the deposits. He finds, for instance, that film formation can occur by polymeric species forming in the plasma and depositing on the substrate or by ionic species of the monomer first adsorbing on the surface and then polymerizing. Either mechanism is possible for a given monomer depending on the experimental conditions. Some of the variables that Clark finds affecting the deposit are the flow rate of the monomer gas into the chamber, power input, RF frequency, and substrate geometry.

In Clark's work, the plasma chamber is attached directly to the XPS spectrometer, and the substrate, on a sliding probe, can be pushed into the x-ray beam. His studies with C_2F_4 indicate that at very low powers ($\sim$1W) all of the isomeric of the monomer forms produce an amorphous film with a $-CF_2-$ stoichiometry. Perfluorobenzene produces a $-CF_{0.8}-$ film in the plasma, but downstream (out of the plasma) the film has a stoichiometry of $-CF_{1.6}-$.

In other work with plasmas and XPS, Clark is investigating the functionalization of polymer surfaces by O_2 and CO_2 plasmas to create a specific oxygen or carbon-oxygen groups on the surface. Inert-gas plasmas can be used to cross-link a polymer surface by radiative (uv) and direct energy transfer, and Clark plans to study this penomenon. In somewhat more applied work he is investigating the weathering of polymers.

Samples are being exposed in San Jose (California), Saudi Arabia, and Durham, and surface changes are being monitored using XPS. He hopes to detect early changes in surface composition which can be extrapolated to long exposure times. Also, by studying the reaction of singlet oxygen with polymer surfaces, Clark will try to model the weathering process.

Dr. W. James Feast is an organic chemist with a range of interests in polymer synthesis. In recent years he has given considerable attention to methathesis polymerization using metal chloride catalysts with organometallic activators. In a project sponsored by the Royal Aircraft Establishment (Farnborough), he is trying to produce solvent- and heat-resistant elastomers by the methatesis polymerization of 1H, 2H-hexafluoro-cyclopentane. Some interesting chemistry has resulted, but a good heat-resistant polymer has eluded Feast because of the persistence of a labile, ring hydrogen in the products. His results show that metathesis polymerization of fluoro-carbon monomer is possible, which had not previously been generally appreciated. Feast has also worked on self-polishing paint coatings based on a tributyltin acrylate monomer. As ship hull coatings, these paints self-ablate by a controlled hydrolysis reaction to smooth off surface roughness. The paints also have antifouling capability.

The Chairman of the Chemistry Department is Prof. Thomas C. Waddington, whose work over the past few years has been on inelastic small-angle neutron scattering (SANS). He began by investigating the torsional mode vibration of small molecules in crystalline structures, and then the vibrational spectra of H_2 adsorbed on palladium black. This work was done using the neutron source and spectrometers at the Atomic Energy Research Establishment (Harwell, UK) and later with the more advanced facility at the Institut von Laue-Langevin in Grenoble, France. Waddington's most recent SANS studies are with small hydrocarbon molecules, C_2H_4 and C_2H_2, adsorbed on type-X zeolites. Albeit complex adsorbents, the zeolites provide a high surface area and the ionic species in the surface can be changed by ionic exchange. On Ag^+ exchanged and Na^+ exchanged zeolites, Waddington has been able to observe and in some cases assign the vibrational modes of the adsorbed molecules. Some of these modes are intramolecular and others correspond to vibrations relative to the adsorbent surface. (Willard D. Bascom)

ELECTRONICS

MOSES WATCHES OVER ELECTRONICS AT THE UNIVERSITY OF ROME

Just a short distance from the church of San Pietro in Vincoli, the home of Michelangelo's powerful statue of Moses, at Via Eudossiana 18, Rome, is the Istituto di Elettronica della Universitá di Roma (IE). Founded in 1956 by Prof. Marino, with Dott. Giorgio Barzilai as one of the professors, this institute has as its mission to teach and perform research in electronics. Barzilai, who is well known to many in the US for his work in microwaves and antennas and who lived in the US for a number of years, became director in 1964. Although still at IE, Barzilai resigned the directorship in 1977; the present director is Prof. C.M. Ottavi.

The University of Rome has a Faculty of Engineering, but there are no separate departmental designations (such as Electrical or Mechanical Engineering). Instead, there are a number of institutes. Barzilai told me that there are approximately 1200 students whose specialties fall within either IE or the Institutes of Telecommunication or Automatic Control. All are in a 5-year program roughly equivalent to a BS/MS degree program of the US.

As readers of past issues of *ESN* will recall, the graduate-student program as we know it does not exist in Italian universities. The first degree, known as the *laurea*, is the doctor's degree (*dottore*), which should not be confused with an American Ph.D. or Sc.D. There is also a degree of *professore*, which, however, can be awarded only after 5 years or more of practicing the profession. (See *ESN* 30-4:155; 30-7:303.)

According to the catalog of the Faculty of Engineering, a student must take courses that add up to at least 5 years of study. During the first 2 years this means the usual mathematics/chemistry/physics series. The other 3 years consist first of a basic program in electrical engineering/electronics, followed by such courses as Numerical Analysis with Computer Programming, Electric Fields and Circuits applied to Electronics, Statistical Theory of Communications, etc. Then there is a choice of a program of 4 to 5 courses that depend on the specialty

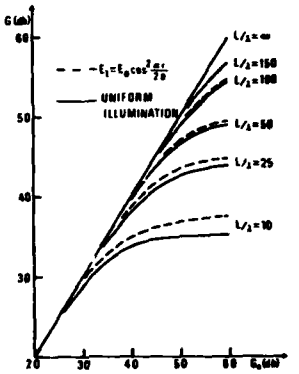
hosen. Out of 17 specialties listed, examples of such a program are: 1) Computers, Telecommunications, ombinational and Sequential Systems, igital Systems, Techniques of Telegaphy and Telephony; and (2) Antennas nd Propagation, Electroacoustics, icrowaves, Radio Relays, Radio Navigation, and Telecommunication Networks. n addition to passing examinations n these subjects, the student must rite a thesis on some topic. The *laurea* s awarded after the thesis has been ccepted.

As is the case elsewhere, a number f the staff members of IE teach only, hile some are also engaged in research. n contrast to earlier times, the type f research and the amount performed o longer appear to be determined by he director. In fact, whereas formerly he director of an institute was all owerful, his function now is principally to be a coordinator. This means hat all problems arising within the nstitute must be arbitrated by agreeent with the parties involved; the irector's decision alone will not preail. The activities of IE must therefore depend almost completely on the agerness and enthusiasm of the indiiduals involved. Fortunately, there re indeed some eager and enthusiastic eople in IE.

Although he retired as director n 1977, Barzilai is still very active. le appears to be highly respected by thers as the father of IE. In fact, e was the teacher of all of the indiiduals who are presently on the staff.

Now to the research that has been n progress at IE during the past sevral years: The group headed by Prof. . D'Auria has been engaged in work elating to coherence in propagation nd antenna systems and in radiometry f the atmosphere. As long ago as the ate 1960s this group was engaged in easuring the degree of both horizontal nd vertical coherence across a microave beam. In this study, an experiental system was built which monitored he correlation of two parts of an X-and microwave beam sent over the same 9-km path from the same transmitting ntenna, but received by two horns paced from 13 to 60 m apart. Measurements were made with an interferometer ystem. It became obvious from this tudy that there is a limit to the gain f an antenna that can be built (no matter what the size), with the limit etermined by the amount of fluctuaticn of the dielectric constant in the ath of propagation.

The results of this and similar studies are perhaps more easily illustrated by the curves of the figure, which shows the actual, or effective antenna gain as a function of ideal antenna gain for different parameters of the ratio L/λ. Here L is the coherence length, which is roughly the distance over which waves to the two extreme parts of the antenna can be expected to stay nearly in phase; λ is the wavelength. It can be seen that for the ratio $L/\lambda = 10$, the gain goes down from an ideal value of 60 db to 35 db. Similar studies were carried out by considering the most effective size of an antenna in terms of wavelength when there is some randomness in the shape. Again one reaches an optimum dimension of antenna above which no increase in gain can be obtained. Individuals who carried out this work in addition to D'Auria were Barzilai, S. Marini, and D. Solimini. It will come as no surprise that the experiments demonstrated that the nearer the path of propagation is to the ground, the greater the randomness in dielectric constant of the path, since this randomness is due to thermal fluctuations.



Effective gain of circular aperture antenna as a function of its gain for coherent field for various rations L/λ and uniform and cosinusoidal illumination functions. *L*—coherence length; λ—wavelength of incident field. (After D'Auria and Solimini.)

The more recent work of D'Auria's group has been in the infrared range. D'Auria's co-workers here are D. Solimini, P. Basili, P. Ciotti, and others. Here, ground-based radiometric observations have proven to be effective means for remotely determining both the static and the dynamic thermal vertical structure of the lower troposphere. Since meteorological parameters are random fields,

the atmospheric radiance measured by a ground-based radiometer fluctuates randomly in time. Under suitable conditions, these fluctuations result essentially from atmospheric temperature fluctuations. A relationship between the time-spectral density of the output of the radiometer and the space-time spectrum of the atmospheric temperature can therefore be obtained. In one recently reported experiment, the downgoing radiance was measured in several bands of the infrared region in which the atmosphere exhibits different absorptions. The low-frequency spectral density of the fluctuating radiance was then computed both by a suitably windowed fast-Fourier transform and by the maximum-entropy method. The latter technique was shown to yield a high spectral resolution or enhanced smoothing according to the order of the prediction filter which controlled the spectral estimation procedure. Work of this nature is continuing.

Research of an entirely different nature has been in progress by the group led by Prof. P. Bernardi. This has had as its objective to determine the biological effects of non-ionizing radiation. Specifically, the immediate objective was to look at the thermal effects of microwave radiation on man. Bernardi told me that US specifications for safe exposure levels to microwave radiation are given in terms of a power area density, such as 10 milliwatts per square centimeter, but that according to his experiments and calculations this type of specification does not give the true picture. For, suppose that a person happens to step into a shed in which, before entrance, the power density at a particular location was less than 10 mW/cm^2. Does that mean that it is safe for the person to enter? Since the shed can act as a resonator in which very low fields can exist in one location and high fields in others, the power level impinging on the person may be much larger than 10 mW/cm^2. This calculation and those for some other cases have led Bernardini, F. Giannini, and R. Sorrentino to recommend that better characterizations of safe power levels should specify wave impedance and power conveyed rather than power density.

Work of a related nature, in particular the temperature distribution in a body subjected to electromagnetic radiation, has been under study by another senior member of IE, Prof. G. Gerosa, who is known for his work with Barzilai and Bernardi on propagation and resonance characteristics of ferrites in microwave systems. Gerosa's objective has been somewhat different than Bernardi's, for he has been trying to determine the temperature distribution for human tissue under higher power radiation, as in cancer therapy.

Work that is not only of a utilitarian nature (i.e., the design of microwave transmission lines) but also visually attractive is the liquid crystal technique for field detection that was described by G. Giannini, P. Maltese and R. Sorrentino, who used the temperature-sensitive color changes of cholesteric liquid crystals to map electric and magnetic fields in microwave integrated circuits, with good correlation between experimental and theoretical plots. The field structure is reflected in the color pattern on top of the microwave circuit. The error introduced by the experimental apparatus in the frequency behavior of the circuits was shown to be less than 2%. Power levels required at X-band for obtaining good spatial resolution were on the order of a watt. The investigators stated that this is a powerful method for the analysis and design of the microwave integrated circuit structures.

Giannini showed me the facility for fabricating microstrip circuitry, including the equipment necessary for making patterns. Actually, he showed me much more—a semiconductor processing facility. Back in the sixties Ottavi, the present director of IE, set up this laboratory to do semiconductor device work. For example, Giannini showed me a vapor phase epitaxy furnace that he constructed about 10 years ago, to deposit GaAs for use in the fabrication of microwave semiconductor devices, plus a lot of other semiconductor processing equipment. But none of it was operating. According to Giannini, the reason for the inactivity is that there are now no technicians to operate and maintain the equipment. The salary that the university is allowed to pay a technician is very much lower than he or she could earn in industry. As a result, many technicians have left the universities. This story was repeated by several other individuals, who told me, in addition, that virtually all electronics research in Italian universities has become theoretical only, since there are no technicians to operate the laboratories.

The final subjects discussed during my visit were some additional liquid crystal studies. One

of these dealt with the behavior of a semiconductor in contact with a liquid crystal film. Here it was found that the interface appeared to have the characteristics of a Schottky barrier diode in which the contact was essentially between a semiconductor and a weak electrolyte. Another study dealt with an application. Here a very thin homeotropic layer of negative dielectric anisotropy liquid crystal is placed between crossed polarizers. By suitable selection and application of electric field pulses and modulation wave forms, the alignment in the liquid crystal is deformed and allowed to relax between the pulses at a rate high enough to avoid flickering. This has allowed construction of a very satisfactory multiplex-mode display. Ottavi told me that the scheme has been patented in a number of countries, and he hoped that industrial firms will utilize it.

In summary, my impression of the Istituto di Elettronica della Universitá di Roma is that there are a number of eager individuals on the staff, and in those disciplines in which experimental work can be performed without the aid of technicians, the work continues successfully in combination with theoretical work. On the other hand, in those disciplines, such as semiconductor work, which require constant attendance by technicians, the work has ceased. Regrettably, until technicians' salaries can be increased to reasonable levels, it appears that no progress can be made in such areas. (*Irving Kaufman*).

ENERGY

IN SAVING ENERGY, IT'S THE LITTLE THINGS THAT COUNT

My education in energy conservation began abruptly over half a century ago when my red-haired Scottish grandmother turned me across her knee and "scalped my doup" because I had not turned out the lights in our living room when I was the last person to leave it on the way to bed. She was not one of the permissive society and often punctuated her lessons to her many grandchildren with a bit of corporal punishment. Do we citizens of the United States need some sort of shock treatment to make us more conservation minded?

Most Europeans have had their shock, e.g., two-fifty to three-dollar-a-gallon fuel, and are reacting on all scales to save energy wherever they can. One thinks carefully about driving fast or driving at all when it costs about $50 to fill the gas tank. Some of the simple things being done over here to save precious fuel are discussed below. It is not a complete listing and some of the items are not new, but I believe they are worth repeating.

I came to Europe with two sweaters and now have about a dozen. Our first electric heating bill last winter was an eye-opener, more than $300 for 6 weeks for a 2-bedroom apartment. Needless to say, the thermostat went down, and sweaters and down vests went on. Now except in summer, I almost always wear a heavy wool one for warmth. At a recent dinner party at a reasonably well-to-do university professor's home, almost everyone was wearing a heavy long-sleeved wool sweater because the house was so cool. The house had recently been double glazed, and heavy insulating curtains were drawn across the doors to the outside. The inside temperature was held to a bone-chilling level to save on fuel.

In Vienna, Austria, some of the public parks have vast underground shopping centers. Thus, the ground is used as a natural insulator. Automatic escalators lead from the parks to the shopping malls and then to subway stations below. Each escalator turns on automatically when someone steps on, and turns off when the last person steps off.

Some hotels in France and Spain have elevators that are dark when not in use. A subtle automatic-switching system turns the lights on and off when people enter and leave. An oldie but goodie on the continent is the fact that hall lights in many hotels are dark most of the time. At night luminous light switches glow faintly in the dark. When one is pushed, the lights go on and then turn off automatically in half a minute or so. Some hotels have timing devices similar to those on electric ovens, that can be set to turn the heat off completely, as at night or when one is gone during the day, and then on again at set times. Fifteen-watt bulbs are universal in the halls of small hotels and homes. Hotels, even new ones, have windows that can be opened, thus making it possible to limit the use of forced-air air-conditioning. In the less expensive hotels, heat and hot water are metered, and one has to feed the meter. Water is heated right at the sink or shower so that no heat is lost in hot-water storage tanks. In one system, the water passes

through a small but high-powered, gas-fired Scotch boiler that automatically turns on and off when the hot water tap is turned on and off. In another, the water passes through a tiny boiler that is heated by a 220-volt resistance-wire heater.

One of the simplest and most effective ways I have observed to save energy is the use of bathtubs shaped like old-fashioned wooden coffins. The tubs are narrow at the foot, and thus save several gallons of hot water each bath.

Twenty-five years ago I was impressed by the solid phalanxes of bicycles on the streets of Amsterdam when people rode to and from work each morning and evening. During the affluent 60s, bicycles were not nearly so plentiful in the Netherlands. Now, with the fuel crunch, they have returned en masse.

An absolute horror for an American getting adjusted to living in the United Kingdom is learning to drive on the left side of the road. The problem is compounded by the many roundabouts that are used in place of traffic lights. Worse yet is the lack of stop signs. If there is no traffic light at an intersection one can simply drive right out onto a main road without stopping. In addition, drivers can make u-turns almost anywhere.

To the uninitiated, these practices seem suicidal. However, cutting down on the majority of stops and starts saves a tremendous amount of gas, a fraction of a cupful for every such start-up, not to mention the wear and tear on brakes and engines. Unless traffic is thick, cars from four and sometimes five or six directions can approach a roundabout and mesh in and out with only infrequent use of brakes. Drivers in England are quite polite and normally take their turns in an even flow of traffic. In 20,000 miles of driving here, I have not seen a single accident on a roundabout.

Every city I have visited in England has good public transportation systems: tubes, trains, or busses with frequent regular services. For example, most London buses run on a 6-12 minute schedule and the subway (the Underground) runs even more frequently during peak hours. One segment of the subway near the ONRL office carries 20,000 persons an hour during peak periods. Some commuter trains run into London more than forty times a day. Public transportation is an absolute necessity in the UK. There are eleven trains a day from London to Glasgow, the faster trains traveling up to 125 mph and on some runs averaging close to 100 mph.

Automatic kettles for heating tea water can be found by the bedside in nearly every British home. Modern versions can be bought complete with built-in clocks, radios, and alarms. Here again, the design is meant to save energy. The kettle is turned on and off automatically and the water is heated by an immersion heater which is a much more efficient way to boil water than on an open burner. Considering the gallons of tea consumed in England each day, these automatic kettles must save considerable energy.

Some of the tricks I have mentioned have been around for some time and were invented not to save fuel but to save money. For passive ways of saving on home heating bills, see *ESN* 34-1:33. (Wayne V. Burt)

LIKE GENERAL SHERMAN, THE UK MARCHES INEXORABLY TOWARDS THE SEA...FOR RENEWABLE ENERGY

In late June 1979, yet another conference was held on the subject of alternative energy development, this time entitled *Power From Sea Waves*. Scientists from as far away as Australia, the US, and Norway journeyed to the University of Edinburgh, a not altogether inappropriate site, since it was in 1973 that one of this distinguished institution's professors, Stephen H. Salter, developed his now-famous "ducks" (floats that convert wave energy into mechanical energy through a rocking action, *ESN* 32-4:124). This article highlights current aspects of renewable energy technology that were covered at the conference but have not been addressed in previous *ESN*s.

Prof. Sir Hermann Bondi, the ebullient Chief Scientist for the UK's Department of Energy (DoE), gave the keynote address. Total annual government R&D allocations toward renewable energy programs amount to almost $35 million, of which about $11 million goes into wave-energy projects. Nowadays, UK scientists are espousing estimates of eventually tapping perhaps 30% of the 50-60 GW of wave-energy potential off their coasts. Sir Hermann predicted that, based on projected interest and inflation rates, little commercial incentive will be generated unless companies foresee at least a 70% probability of profitable returns

from such a long-term project. Also, past experience has shown that, even with no political or economic setbacks, 8-10 years are usually required to scale up from a basic prototype to a full-sized working system based on new technology.

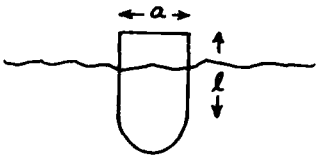
Dr. Brian Count of the Southampton branch of the Central Electricity Generating Board (CEGB) updated current British policy with respect to this form of alternate energy. Just-released studies show that, in spite of today's spiraling OPEC prices, electricity derived from wave power would still be 10 to 20 times more expensive than its conventional counterpart. One of the most bothersome problems to date is to determine what sea-to-shore transmission system would be most efficient. Thermal and hydraulic systems appear to be too expensive and to have limited market value. A chemical system based on the production and shipment of hydrogen might be a good bet. However, an electrical production scheme would most likely be required on platforms at sea, which brings the researcher back to basic electrical generator/cable transmission techniques, nothing revolutionary, but the technology is there and the expense is not prohibitive. Count outlined the breakdown of device types: passive vs active. The only passive system presently funded by the DoE is the Russell Rectifier, under development by the Hydraulics Research Station, Wallingford. In the long run, it is expected that most passive devices will be rather bulky and relatively inefficient. Conversely, active devices, if designed correctly, should be able to extract up to 90% of the incident wave energy. To date, the DoE has authorized work on 7 active designs, 6 of the terminator type, i.e., parallel to the wave front (ducks, rafts, oscillating water columns, submerged ducts, oscillating cylinders and flat-plate oscillators) and one of the alternator type, i.e., perpendicular to the wave front (flexible bags).

As would be expected in such a fledgling technology, engineering problems abound as scientists attempt to narrow the gap between theoretical capabilities and experimental results. After poring over countless computer-produced efficiency curves and reams of climatological data, UK wave-energy-device designers feel that the maximum available energy spectrum lies in the range of waves with 8-12 sec periods. Theoretically, if a device is "tuned" to this part of the spectrum, an efficiency rating of up to 95% will result when wave periods are, in fact in the 10-12 sec band. Outside of this window, one can expect at least 30-35% power generation efficiency. Some technological thumb-rules now in use in Britain are: (1) To ensure 80% average efficiency, a system must be built to 3 times design specifications for an average wave height (e.g., if a raft of 100-m length were to extract maximum energy from a wave of average height, 300-m length would be required to extract an average of 80% of the incident wave energy over a long time period). (2) System element movement distances of 20 times that required for the average wave must be factored into design specifications for the "1 in 20-years wave" (i.e., mooring lines, valves, flaps, rams, etc.). (3) Final versions of wave energy devices will be comprised of many elements, each displacing 100-200 tons. (4) Approximately 20-km breadth of structure will be required to extract 1 GW of power. (5) About 20 MN of force are generated for every meter of structure, under normal wave-loading conditions.

The flexible-bag scheme (*ESN* 32-4:127) was originally devised by Prof. M. French (Lancaster University, UK); Dr. R. V. Chaplin of the same school delivered the paper at Edinburgh. The University had just received a renewal funding grant of $350,000. The university's latest version is actually a closed-circuit bellows floating in the sea with about 80% of its volume submerged. The hull, lying head-on to the waves, contains high- and low-pressure ducts connected through a pair of air turbines. As wave crests move along its length, sequentially collapsing the 20 cord-reinforced rubber bag elements, the displaced air enters the high-pressure duct and runs the turbine. Conversely, in the wave troughs, the bags are refilled with air via the low-pressure duct. At this stage of development, sideways movement of the bag walls have been maximized for minimum wave heights. The conclusion is that the most power is generated when the bags are emptied the fastest. To this end, plans are underway to build a prototype with cascading valves. Tests using a 1/40th scale model have shown: (1) Short period waves give the most power output, (2) At least 40% efficiency is possible, (3) Maximum mooring stress forces of about 900 t will be experienced with a device of 13 kt displacement. Currently, the disadvantages of this system are either

relatively minor or almost unresolvable: (1) Material and structure of inner-wall diaphrams between bags (minor); (2) Stern half of device works in waves that have already given up part of their energy (unresolvable, barring major design modifications); (3) More power is derived from shorter period waves (hardly minor but not unresolvable; attempts to "tune" a device to within the 8-12 sec average range are underway). In spite of these apparent drawbacks, the advantages of this scheme make for a rather promising outlook: (1) Mooring problems appear to be less than those experienced with other devices; (2) No damping of incoming waves is required; (3) It is a quick low-mass coupling system; (4) As an alternative, it should be cheaper because "fail-safe" design factors will be less than for a terminator that has its bulk parallel to wave fronts; (5) Natural frequency appears to be about ten times that of the average waves, alleviating resonance problems. Future design alternatives presently under consideration include total system submersion and pitch control optimization. At full scale each system will be approximately 200-m long, 6.5-m wide and 14-m high.

Mr. K. Budal of the Institute for Experimental Physics in Trondheim, Norway presented a paper on resonant point absorbers that proved both enlightening and encouraging. He has conducted extensive testing in both harmonic and irregular waves, placing the emphasis on controlling the motion of point absorbers so that near-total wave energy absorption is realized, thus resulting in linear efficiency approaching 100%. To achieve this goal, two modes of control must be built into the syster: phase control, or resonant tuning (difficult in the sea) and amplitude control through damping with high-pressure hydraulics. The latter is most important; the trick is to fix the device—say a buoy—until the moment of maximum upward wave force, then release it, and vice-versa for maximum downward wave forces. Thus, power is always being extracted *from* the waves and not the converse. A properly programmed computer could readily handle this time-sensitive chore. Budal claims that mathematical analysis shows that, built to the necessary specifications, a wave-riding buoy should generate maximum power of 1.6 kW/m^2 of buoy surface area. This is based upon the condition that both a and ℓ (see figure) must be less than $\lambda/2\pi$ (λ being ocean wavelength). Furthermore, a row of buoys, placed about 50 m apart, should increase available absorbed wave energy by as much as 25% through interaction processes. As optimistic as this theory sounds, even the Norwegians are not counting on the development of a working system prior to the turn of the century due to the following difficulties: (1) Present construction costs would be greater than energy costs from hydroelectric plants (where 99% of Norway's power is generated today); (2) A low-cost reliable anchoring system must be developed; (3) Maintenance and repair costs for the necessary hydraulic machinery appear to render this design infeasible today; (4) More analysis is required with respect to risk potential in high-sea states.



Dr. N. Hogben from the UK's National Maritime Institute (NMI), Feltham, cast some doubt over the science of climatological predictions pertaining to wave-energy extraction. After correlating wave-rider buoy data, hourly wind readings and historical climatology, NMI believes that any wave-energy device will ultimately be generating about 65% of its power from swell energy. At separate sites, measurements indicate 35-50 kW/m average power available, but this can reach as much as 500 kW/m instantaneously. Another unanswered question is whether to "tune" a device to the spectrum peak (around 14 sec according to NMI) or to the level where approximately half of the under-curve power area lies equally to the left and right of the peak (about 11 sec based on NMI's calculations). Disagreement among the experts was the rule, at least at Edinburgh, when this topic was broached.

On the international scene, Canada, the UK, the US and Ireland are involved in testing the oscillating-water-column (OWC) concept on a full-scale ship-like buoy from Japan, the 80-m *KAIMEI*. Under the auspices of the International Energy Agency, Japan, the UK and the US have each provided generators to go aboard the *KAIMEI* for testing that commenced recently in Japanese waters. In initial simulation tests on the UK's entry, mean power output was 100 kW, reaching maximums of 170 kW for high waves.

The DoE's Energy Technology Support Unit (ETSU) at Harwell manages the UK's wave energy program; its prime objective is to ensure that wave energy is fully researched as a possible solution to any impending future energy shortage. In general, most properly designed devices will capture some energy and generate some useable power; the criteria for success in this burgeoning field are more stringent—to seek out cost-effective solutions that will survive extreme environmental conditions. Perhaps one speaker's parting shot is most apropos, "If maximum scientific and technological effort is expended towards alternate energy development for the next 25 years, with a little luck, we just may survive the energy crisis." (C.H. Spikes and W.V. Burt)

ENGINEERING

ANTENNA RESEARCH AT THE ROYAL MILITARY COLLEGE OF SCIENCE

The Royal Military College of Science (RMCS) has a delightful campus near Shrivenham, England. It is situated on a 780-acre estate in the Vale of the White Horse, on the border of Oxfordshire and Wiltshire. The estate was bought by the UK government from Lord and Lady Barrington in 1937 and has been used as an officers' training center since then, except that during WWII it served as a US hospital. It received its royal charter in 1960. At the present time it provides technical education not only to the British military, but also to foreign military, to Department of Defence employees and to independent civilians.

ESN 33-8:324 contains a note by Jeff Perkins in which the materials research at RMCS is described and the College is compared with its German counterparts and equivalent US institutions. This note concerns the excellent research work on antennas and particularly printed circuit antennas that is being carried out there.

The college has three divisions. The first two offer separate 10-month courses to officers with scientific degrees or with scientific backgrounds respectively. The third division has 2-month courses and is tailored for officers without scientific backgrounds. Regardless of division, the courses are followed by 10-months general army training at Camberley. Officers and a number of civilians are offered undergraduate courses leading to a degree of the Council of National Academic Awards (CNAA), which is the institution that also awards degrees to polytechnics. CNAA MSc degrees can be obtained with one year of postgraduate courses which are offered at RMCS in various military-scientific subjects, such as Guided-Weapon Systems or Military-Vehicle Technology. Civilians are also accepted for research degrees (PhD), and research fellowships are offered by the Ministry of Defence. Some of the research work is sponsored by independent outside organizations.

Considerable emphasis is placed on adventurous pursuits during vacation time and a student is encouraged to lay his neck on the line. Students have crossed the Sahara, explored the Upper River Nile, and climbed the Andes.

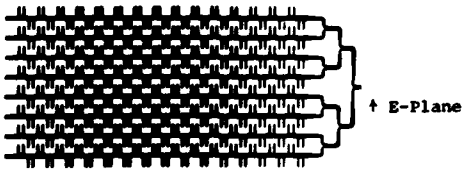
My hosts for the visit were Prof. J.R. James and Dr. A. Anderson, from the Department of Electrical & Electronic Engineering. James spends most of his time on research projects but also does some teaching. He is presently writing a book on printed-circuit antennas. Anderson is on the research staff.

The most prominent of the research efforts concern printed-circuit-type antennas. This writer is familiar with some of the initial work in this area which was carried out by the Applied Physics Laboratory of the Johns Hopkins University about ten years ago (E.V. Byron, "A New Flush-Mounted Antenna Element," Proc. 1970, Phased-Array Antenna Symposium, pp. 187-192, 1972). In the last few years there has been a continuously rising interest in this form of antenna. There was a one-day symposium in May 1978 (Flat-Plate Antennas) held at the Royal Signals and Radar Establishment in Malvern, England, sponsored by the British Ministry of Defence, and in October 1979 there was a three-day workshop at the New Mexico State University (Printed Circuit Antenna Technology) sponsored by the US Army.

The main advantage of the antenna is its lack of bulk. It has the form of a thin flat sheet or a thin layer conformal with existing surfaces. Further, it is light in weight and can be produced cheaply and yet with high precision. The antenna typically makes use of printed circuit boards, etched on one side to give radiating elements separated by a relatively thin layer of dielectric from a ground plane. The elements will normally not radiate

because of the presence of the anti-phase mirror image in the nearby ground plane, but they can be made to radiate and efficiently couple to space. For example, elements will radiate readily if they are in the form of a half-wavelength diameter circular patch. Patches may be fed (energized) through the board with probes and will then radiate like dipoles, but with arbitrary polarization. Alternately, patches may be fed from a strip-line etched on the printed circuit board.

A somewhat different radiating element has been developed by James and his associates. It utilizes radiation from the open-circuit end of a strip-line stub. Half-wavelength-long, strip-line stubs extend either to the right or, with phase reversal, to the left of a feed strip-line. The amount of coupling from the feed to space (by radiation) is determined by the width of the stub. For heavy coupling, the stub then effectively becomes a patch. In one configuration, a complete flat-plate, printed-circuit antenna, "The Comb-Line," is shown in the figure.



COMB-LINE

A printed-circuit corporate feed connects eight Comb-Lines in parallel. Each Comb-Line has stubs that are separated by quarter of a wavelength, which ensures a good impedance match. The stubs are arranged so that adjacent pairs point alternately right or left to give a phase reversal every half-wavelength. This technique gives, in effect, two traveling-wave antennas that radiate in phase quadrature. The aperture illumination is tapered by varying the widths of the strip-line stubs. The antenna shown in the figure was drawn by computer. Antennas of this type have been built and tested and their limitations are now being examined in terms of accuracy, material imperfections, and frequency. In particular, there is interest in extending the technology to the millimeter bands. Narrow band resonant arrays have also been built with half-wavelength element spacing and a short circuit terminating the end of the feedlines.

A 6-element, circularly polarized printed-circuit phased array was being developed by Mr. Colin Wood and Dr. P.S. Hall. Good circularity to very large scan-angles is claimed. The radiating elements could be regarded as crossed slots, although, to look at, they appeared quite complicated. Small curved strip-line radiators had previous been developed at RMCS. They give good circularity and bandwidth and are described as an improvement over the bette known spiral radiators. Hall has devised a traveling wave line-array which can be designed with any type of polarization. The array, named "Rampart Line," consists of a strip-line that meanders to resemble a rectangular wave. Radiation occurs primarily at the right angles and the polarization is determined by the distances between the bends.

Electrically small antennas are studied, particularly by James and Henderson. Those antennas are meant for use on vehicles or to be hand held and will operate even with a poor ground-plane. It was found that considerable improvements in sensitivity could be obtained with various types of coil-antennas. Different types of coils were found suitable using double counter-winding, winding with periodic reversals, or even just plain coils. Various types of coatings were also investigated. The best combination would be one having low losses and high and equal values of permittivity and permeability. In many cases insertion losses were incurred perhaps as much as 6 dB. Nevertheless, the antenna sensitivity was improved by a better impedance match.

Other research and development work was directed at finding a good microwave absorber for naval applications, developing an antenna for a submarine conning tower, and investigating microcircuits with the aim of finding cheaper passive components.

The laboratory was well equipped for centimeter wave work and had a microwave darkroom. It is presently planned to expand the work to the millimeter field. Some of this work may be US Army funded.

It was a real pleasure to visit this center of excellence and to learn of their work, carried out under the pleasant mantle of the RMCS. (T.C. Cheston)

HIGH-FREQUENCY SECTOR-SCANNING SONAR

"Progress in Sector-Scanning Sonar" was the title of a British conference held by the Institute of Underwater Acoustics on 18-19 December 1979. It was called to discuss topics related to a specific high-frequency, within-pulse scanning, sonar system that had been used for 10 years of research in trawler fishing. The conference was therefore held at the specific research establishment where the work had been carried out, the "Ministry of Agriculture, Fisheries and Food, Directory of Fisheries Research, Fisheries Laboratory" in Lowestoft, Suffolk, a major fishing port on the eastern shores of England. The full name of the establishment, although most apt and descriptive, lacks the certain crispness that one has become accustomed to in this distinguished publication, and will therefore not be mentioned again, but it will rather be referred to by its unofficial name "The Fisheries."

The meeting was well attended with the register showing 55 people of whom a little more than one third came from universities, about as many from industry, and the remainder from government establishments. The meeting lasted 2 days, and 12 papers were presented in 2 sessions.

The Fisheries have been using their scanning sonar for research on trawler fishing. The trawler tows a large funnel-shaped net which is kept open by a set of chains and floats in the vertical plane and paravanes, called "otters," in the horizontal plane. The sonar display gives a vivid on-line picture of the complete operation, and both fish and net extremities are seen. Improvements in the fishing gear and methods have been obtained and the fishing efficiency has been increased as a result.

The within-pulse, modulation-scanning sonar system itself consists of a high-frequency pulse transmitter that illuminates the whole area of interest (typically 30° in the plane of scan, by 10°). In at least one of the configurations, the transmitter consists of a multiplicity of projectors that are placed on the arc of a circle and energized in phase. This method can give an efficient, wide radiation pattern with sharp sides and has the advantage of a large aperture over which high power can be generated. The receiver is a planar array giving a narrow beam in the plane of scan (typically 0.5°). The received signal at each of the array elements is translated to an intermediate frequency with a local oscillator frequency that is changed by an incremental amount between successive adjacent elements. The phase at one element then rotates relative to that of its neighbor and the beam is scanned.

An active transponder tag was developed that could be attached to an individual fish for identification and tracking. Tagged fish were tracked and observed for long periods to determine their life pattern as well as their behavior during various fishing experiments.

Not included in the papers but brought out in private discussions over coffee was a new sector-scanning sonar system, "Hydrosearch" that was then undergoing acceptance testing. It was built by Marconi Space and Defence Systems, Ltd., in Frimley, Surrey, under the technical direction of the Atomic Energy Research Establishment at Harwell which provides expertise in many fields. The sonar's prime mission is the exploration of the sea-bottom. It operates at 180 kHz and covers a 60° wide sector with an 0.5 degree wide beam.

The first two papers were from The Fisheries, giving the history of the sector scanning sonar as related to fishing and describing the programs, experiments, and results: "Sector Scanning Sonar and The Fisheries since 1969" by D.H. Cushing and F.R. Harden Jones, and "A Sector Scanning Sonar System: 10 Years of Use" by R.B. Mitson, E.G. Shreeve, and C.R. Hood. Both papers were presented by the first-named authors. Dr. Cushing described how the interest of The Fisheries was aroused in 1958 by a sonar demonstration by Prof. Tucker (Univ. of Birmingham). This eventually led to the installation (in November 1969) of an Admiralty Research Laboratory (ARL)-designed system in The Fisheries R/V *DIONE*. The original receiving equipment was replaced 5 years later by a solid-state version. The sector scanner was mounted on a stable platform in a sonar dome. A switch could position the array aperture for vertical or horizontal scanning. The operating frequency was 300 kHz. With the help of the sonar the otter travel could be observed in detail. Occasionally shoals of fish could be seen avoiding capture, for example, by slipping over or below the net. Improvements were made to the towing configurations and the efficiency in catching fish in a shoal

increased from 50% to about 70%. Individual fish were tagged with a transponder and tracked for periods up to 80 hours and over distances of 100 kms. It was discovered that one of the common local fish, plaice, used the tide for transport, waiting at the bottom between tides. In this way the fish covered substantial distances with little active swimming and it was suggested that this mode of locomotion forms the basis of some migratory movements. Cushing further listed other research work carried out with the sonar which ranged over a wide field, from bottom topography studies to the measurement of the tail-beat frequency of a large shark.

Mitson gave some technical background and details of the equipment and its modifications. The operating frequency of the sonar is 300 kHz, and up to 20 kW may be generated from the solid state transmitter, installed in 1977, which is composed of ten 2-kW modules. Array processing is done at the dry end and the signal is brought from the transducers with a multiple coaxial cable. Mitson described the acoustic transponder fish tag. It was 50 mm long, 8 mm in diameter, radiated about 1/5th of a Watt (peak) with 3 msec pulses and was powered by three mercury cells. Total weight was 3.5 g in water and it operated for 96 hours when the demand was 1 pulse/sec.

According to Dr. J. Cook, sector-scanning sonar development at the Admiralty Marine Technology Establishment (AMTE, formerly ARL) goes back some 30 years. Cook presented a paper co-authored by A. Rushworth (also from AMTE) entitled "Digital-Signal Processing of High-Resolution, Within-Pulse Sector Scanning Sonars" in which he described three recently developed sonars with the characteristics listed in the following table.

Frequency (kHz)	300	150	75
Sector Scan (deg)	30	30	60
Pulse Length (μs)	100	100	500
Range Resolution (m)	.075	.075	.375
Scan Frequency (kHz)	10	10	2
Array Length (λ)	150	90	45
Beamwidth (azimuth deg)	0.4	.56	1.1
Beamwidth (vert. deg)	7	10	22
Detection Range			
0dB target (meters)	300	400	800

The two high-frequency systems were on the same stabilized platform. The 75 kHz system was on an independent mount. In all systems the data is digitized. For general large area surveys or for detailed inspection of small targets, less than full storage capacity was acceptable and was therefore limited to 320 scan lines for the 300 kHz sonar. A new system is presently being developed. Cook described it as providing full range storage capability, for example, for inspection of oil rigs or wrecks, with a Random Access Memory matrix of 512 × 512 storage capacity. Whole successive frames of the sonar data can be continuously digitized and recorded. Display is on a 625 live, color TV with a color look-up table allowing the echo intensity to be represented as a particular color; hopefully, this will give a measure of the abundance of fish available in a particular shoal. This special question of abundance was addressed by two further papers, one by Dr. K.G. Foote (Univ. of Bergen, Norway) and the other by Prof. Griffith [Loughborough Univ. of Technology (LUT)] for the absent author, Dr. John E. Ehrenberg (Univ. of Washington, APL, Seattle). In both of these papers the target strength of fish was examined for an estimation of the number and size of fish available.

Test and calibration of the sonar was described by Dr. P.J. Stevens (Universal Sonar, Hull) in a paper with L.A.A. Warner from LUT where this work had been carried out. The main difficulty found was in measuring the actual array gain of the system. Electronic stabilization was examined in a paper by Dr. Brian Phillips (Bell Electronics, Bracknell). He concluded that it could not be done in a satisfactory way and recommended retention of the stabilized platform.

There were four further papers from LUT, an indication of their considerable involvement. Two were by Dr. A.R. Pratt, who described the design of the solid-state transmitter that had been installed in the system of The Fisheries in 1977 and of which variants were available with up to 20 kW peak power covering frequencies from 30 kHz to 300 kHz. In his second paper Pratt discussed limitations to the sector scan system due to digital local oscillators. The other two papers from LUT concerned the display. Dr. D.J. Quarby described a scan converter offering an improved technique for display and recording and providing a convenient tool for computer processing of the information. The paper was co-authored by G.M. Duct and A.D. Goodman. Prof. Griffith, in a paper written with R.M. Moreno and Duct, discussed the use of color in display. He used the term pseudo-color,

since arbitrary color coding may be used to distinguish between different signal levels. He referred to the controversy as to whether or not improvements might be obtained by such psychedelic displays. He pointed out that in his paper he had presented the apparatus for providing pseudo-color options in a flexible way so that experience may be obtained in its use.

The last two papers were from the University of Birmingham where there has also been much activity concerned with the scanning sonar. Mr. L.H. Ong presented an analysis of within-pulse scanning of high resolution sonars and gave a method for reducing approximation errors which can arise. In the final paper, Prof. V.G. Wellsby examined correlation scanning and conditions where improvements by a factor of two were possible. He suggested that studies should now be directed to the problem of storage and integration of the output of correlation scanning systems, using modern circuit technology.

The pre-prints of the conference were published by the Institute of Acoustics, Underwater Acoustics Group, 25 Chambers Street, Edinburgh EH1 1HU, Scotland. (T.C. Cheston)

SEVENTH INTERNATIONAL COLLOQUIUM ON GASDYNAMICS OF EXPLOSIONS AND REACTIVE SYSTEMS, GÖTTINGEN

The Seventh International Colloquium on Gasdynamics of Explosions and Reactive Systems (ICOGERS) was held in Göttingen, FRG, 19-24 August 1979 under the sponsorship of Göttingen Univ. and the Max Planck Institute (MPI) for Gasdynamics. Dr. A. Preuss of MPI and Dr. H. Wagner of Göttingen Univ. were joint hosts. The dynamic evolution of distinct communities within the scientific population as a whole is well illustrated by the conception, organization, and subsequent maturation of this Colloquium over the last twelve years. The idea for the meeting arose at the 1966 International Combustion Institute Symposium in Berkeley, when a number of researchers decided that more scientific attention should be paid to the interaction of chemical kinetic-energy release and the strongly coupled fluid dynamics which results. The first colloquium was held in Brussels in 1967, and they have been held biennially ever since.

This community has naturally concentrated on the reactive flow aspects of strong deflagration and detonation phenomena and has placed relatively little emphasis on detailed chemical kinetics and phenomenological combustion modeling per se. Six of 15 sessions at this Colloquium were devoted to detonations and related reacting shock phenomena, 3 to the initiation, propagation, and fluid mechanics of flames, and 2 to turbulent combustion in general. Thus most of the program was relatively closely aligned to the strongly exothermic combustion dynamics and reactive flow problems for which the Colloquium was set up. The 4 remaining sessions included reports on laser and molecular non-equilibrium phenomena, chemical kinetics, analytical methods, and computational methods.

"Gasdynamic lasers" is a new subject which belongs in this community, depending as it does on the strong interactions between chemical kinetics and fluid dynamics. Even the chemical kinetics studies reported were conceived from the perspective of thermo-mechanical interactions with fluid dynamics. The University of California papers, given by A.K. Oppenheim et al. (Berkeley) and C. Westbrook and L. Haselman (Lawrence Livermore Labs) compared favorably with the excellent presentations of J. Warnatz ("Flame Velocity and Structure of Laminar Hydrocarbon-Air Flames", Inst. Physikalische Chemie der TH, Darmstadt, FRG) and of S. Galant ("Analysis of Inhibition Phenomena in Halogenated Flames", Société Bertin DT CIE, Tarnos, France). Even the sessions on asymptotic methods and computational approaches, about which more will follow, focused on initiation, deflagration, detonation, and the related chemical kinetic-fluid dynamic interactions.

Since concurrent sessions were the rule rather than the exception, I was not able to attend all the papers. This report will thus continue with a discussion of several thematic topics from the meeting.

The scientific community represented at this meeting, more than any other, has taken on its shoulders the task of evaluating the explosion hazard associated with shipping and storing enormous quantities of liquefied natural gas (LNG). Numerous papers throughout the meeting and a special session on Explosion Hazards held Friday afternoon addressed this issue and the related problems of gas and dust explosions in mines and silos.

The LNG problem covers a much broader area than the usually quoted "up front" question of minimum detona-

tion energy for methane. A. Kuhl (RDA) took several minutes at the special session Friday to explain some of the intricacies of the vapor-cloud dispersion problem that precedes and, in many ways, supersedes the specific detonation question. He began by discussing a model problem in which 25,000 m^3 of liquefied natural gas spilled into a 100 m × 100 m diked area and became the source of a rapidly growing vapor cloud at atmospheric pressure. At equal temperatures methane is barely half as dense as air, but at ∿ -160°C it is about 1.4 times as dense as the warmer air, so a hydrodynamic bore of pure methane gas runs along the ground (or water) at up to 15 m/sec. The methane-air interface has strong shear flows established from the density gradient, so mixing of air and methane begins on the periphery of the cloud almost instantly.

On the air side of the (probably) turbulent interface there is a lower-flammability-limit "skin" over the cloud, outside of which combustion cannot occur. On the methane side an upper-flammability-limit "skin" delimits the volume inside of which combustion cannot occur for lack of oxygen. Between these two surfaces the gas-air mixture is flammable, at least in the mean, and varies from lean through stoichiometric to rich mixtures. To predict location and structure of this flammable shell as a function of ground topography, spill rate, winds, etc., is the goal of the vapor-dispersion problem.

At one inch of liquid evaporation per minute, the 600:1 LNG expansion gives a new volume of 2×10^5 m^3 of atmospheric pressure methane every minute. Attempts to simulate these conditions in scaled experiments are being considered for 12' and 120' wind-tunnel experiments and 1/4 scale field tests. The exact scaling considerations are based, according to Kuhl, on maintaining the Froude number $\frac{\Delta\rho g h}{\rho v_2}$ constant. A 125 to 1 reduction in size would therefore require a corresponding reduction of 11:1 in the flow velocity (from 10-15 m/s to about 1 m/s). The problem of suitably scaling the heat transfer from the ground means that these smaller gas simulations run the risk of evolving the gas too quickly from overrapid evaporation. An alternate approach to this problem is to use a liquid flow tunnel in which a second liquid of greater density could be introduced from the ground plane of the diked region as if it were a gas expanding upward from evaporation. By allowing $\Delta\rho/\rho$ to be smaller than 0.4, additional reductions in the flow velocity could be achieved while maintaining the "Froude" scaling.

The question of maintaining a high enough Reynolds number for the scaled-down flows also remains. If the Reynolds number becomes too low, the enhanced mixing that is expected because of turbulence will be absent from the simulation and the predictions correspondingly suspect. Using a liquid also has the benefit of increasing the effective Reynolds number.

Since even the best wind-tunnel tests and computational simulations will leave some doubts, the eventual need for carefully documented large-scale tests is escalating into an international "big boom" contest. While there is undoubtedly some value to these big, expensive experiments, the view of many of the scientists seems to be that the technical questions and issues are not yet well enough defined to ensure maximum utilization of such experiments. As a case in point, the environment of proposed large US tests have come into question. Since obstacles and complex topography are felt to play a large role in flame acceleration, the potential desert sites being considered by the US occasioned a certain amount of skepticism on the part of some of the combustion and detonation experts present. Water may even be necessary as a lower boundary to reproduce the mixing environment occurring in dockside spills.

Assuming a dispersing vapor-cloud, there still remain a number of technical issues in evaluating the potential hazards here. Turbulent mixing of the air and methane becomes a necessary precursor to explosion. This mixing is governed by density-difference and transient effects which standard one-equation and two-equation turbulence phenomenologies exclude. The question of whether a methane cloud actually detonates has been taken in the past as an important factor in LNG safety. A preponderance of opinion in this community places secondary importance on the detonation question, since an explosion will occur in any case even if that explosion cannot be technically classed as a detonation. A statement about the difficulty in detonating methane, and studies of how strong a localized explosion is required to cause detonation and of the likelihood of such an event, induce a false sense of security by distracting attention from the fact that faulty wiring or a match

will "explode" a big, mixed methane cloud even if it doesn't "detonate." R. Soloukhin (Academy of Science, Minsk, USSR), in the explosive hazards session, described an experiment in which 10 barrels of kerosene arranged in a circle on the ground were vaporized to form a short vertical cylinder of kerosene-air mixture. The mixture was then ignited by a small explosion at the center of the cylinder. Although "detonation" did not occur, the fireball reached 15-km altitude!

LNG, as a number of people are quick to point out, consists of only about 90% methane. The remaining "impurities" include ethane and propane which increase the detonability. Thus the classical pure methane cloud, which has become the reference case for LNG safety, is not as dangerous as real LNG mixtures. Nonetheless the detonability of a spherical methane-air mixture is still an unsolved problem. The amount of high explosive quoted as probably necessary to detonate a large methane-air cloud is a controversial issue. Experiments with up to 35 kg of high explosive have not shown detonation although earlier theoretical/experimental extrapolations indicated that as little as 22 kg may be sufficient.

At this meeting C. Westbrook and L. Haselman (LLL) presented several calibrations and extrapolations of methane-air and enhanced methane-air kinetics to estimate minimum detonation energies requiring 50-100 kg charges of high explosive for pure methane. These idealized but experimentally based estimates are considerably lower than 1-D estimates obtained earlier. Thus the minimum detonation energy remains undetermined. In real life the detonation process is multidimensional with the potential for multishock enhancement of detonability. P. Urtiew and C. Tarver (Livermore) performed some theoretical estimates of the survival of a detonation wave in a strongly transient condition as a function of the number and size of the multidimensional cellular structures that form. With a cell size of 9 cm, estimates of 44-kg minimum detonation energy result for methane-air from the approximate analysis that was performed.

Thus several competing mechanisms are being proposed and analyzed as possible explanations for a presumed enhanced detonability in multidimensions as opposed to the rather large minimum energies that are quoted from purely 1-D analyses of a pure methane-O_2 explosion: 1) cellular structure/critical diameter, 2) diffraction phenomena at effective area changes, 3) induction time changes from local fluctuations, and 4) volumetric combustion of extra fuel. The paper by A.A. Vasiliev et al. (Academy of Sciences, Novosibrisk, USSR) considered the initiation energy for multi-headed detonation, pointing out that several reinforcing shocks make the overall critical energy lower. D.H. Edwards, G.O. Thomas (Univ. College of Wales, Aberystwyth, UK) and M.A. Nettleton, (Central Electricty Research, Leatherhead, UK) reported on the diffraction of a planar detonation wave at an abrupt area change, relating the critical diameter concept to cellular structure. In a combination of experimental and computational work, M. Dormal, J-C. Libouton, and P.J. Van Tiggelen (Univ. Catholique de Louvain, Belgium) have studied the structure of detonation cells and the re-initiation process at the end of a detonation cell. This work invokes fluctuations in the shocked after flow as providing natural sites for self-ignition and subsequent detonation propagation.

S. Wojcicki and M. Zalesinski (Warsaw Technical Univ.) considered the generation of detonations by two-stage burning. After the propagation of an ordinary flame through a mixture, additional fuel or oxygen is injected into the combustion products. A second volumetric ignition is induced which "generates a strong compression wave" and "converts the flame generated in the first stage of burning into detonation." There are more similarities in the way the various detonation-structure researchers view the multidimensional detonation than there are differences. Via one hydrodynamic mechanism or another, almost all feel that the sensitivity of the chemical induction time to temperature variations in the once-shocked flow must be exploited. The experts differ on how best to deal with this effect analytically and computationally, and on whether the necessary flucuations arise as a natural and geometric consequence of the flow and its boundaries or whether more statistical concepts of fluctuations are required, akin to the phenomenological source and sink terms of turbulence modeling.

Perhaps because of a very strong attachment to the detonation problem and related reactive flow dynamics, the ICOGERS community does not seem to concern itself with the forms of turbulence research and modeling which have their

foundation in more classical constant-density, nonreacting shear flows. The emphasis, both scientifically and psychologically, seems to be directed toward fast, strong effects where transient and onset phenomena are important. In these dynamic situations the physics must be done correctly before statistical methods are applied. As we have seen in the discussion of LNG hazards above, flame acceleration caused by the presence of obstacles that induce turbulence in the flow upstream of the flame is a key issue. The joint McGill/Göttingen paper delivered by I. Moen showed quite explicitly how the upstream, subsonic flow induced by thermal expansion in the flame front interacted through flame stretching and wrinkling to speed up the flames. The presentation of T. Suzuki (Sophia Univ. Bulgaria) concentrated on the similar but essentially nonturbulent situation of a flame jumping over an obstacle in a flammable liquid surface. The compressible but subsonic flow preceding the flame causes motion and hence accessibility of the flammable mixture beyond the obstacle, as verified both experimentally and theoretically. F.A. Williams and P. Clavin (Univ. of California at San Diego) have also extended their analysis of the propagation of flames which are wrinkled by the presence of turbulence at long enough wavelength to leave the laminar flame structure essentially unchanged.

Phenomenological turbulence models of the Imperial College two-equation type are not being applied to strongly hyperbolic, time-dependent problems such as computational multi-headed detonation and turbulent flame propagation. The problems of multiple scales in the turbulence and chemical energy feedback into the hydrodynamic mixing have not yet been solved in any of the turbulence phenomenologies, and there is almost no data available for detailed calibration of even the standard models currently in use for simpler flows.

The application of computational approaches to those reactive flow problems, which form the backbone of this scientific community, is an increasingly important research option as new software and hardware capabilities continue to be made available. In this observer's view, this meeting marks a sort of watershed where, for the first time, the United States computational papers did not dominate in either number or quality the contributions from other nations. This technological broadening of all the nations' research programs can only bring good.

Soloukhin and Dr. W. Sirignano, (Princeton Univ.) reported on phenomenological turbulence models incorporated in numerical simulations of mixed-flow lasers and splitter-plate experiments, respectively. Essentially time-averaged steady-state flows are calculated using these parabolic marching algorithms. Sirignano indicated that these models, however, must be calibrated and perhaps extended significantly before any calculations concerning strongly reactive systems will predict rather than postdict.

It is clear that improved turbulence models will have to deal with nonlinear mixing from Rayleigh-Taylor and convective instabilities as well as various geometric ramifications of jets and shear layers. The computational community seems capable of recovering the statistical properties of many turbulent flows more than adequately in those cases that are dominated by shear in a fluctuating stationary flow, but not in steady flows. Equivalent or generalized models have not been shown to work in the cases of gravitationally unstable density gradients or forced nonlinear convection of fluid, both of which arise naturally in combustion dynamics.

In addition to the Livermore and Berkeley papers discussed earlier in conjunction with methane kinetics and detonation, Kuhl and J. Seziew, (TRW Defense and Space System, Redondo Beach, CA) and F.E. Walker (LLL) delivered excellent analyses of real physical problems using computational techniques. In the first of these papers, rather mundane but real effects in the detonation of high-explosive charges were shown to have large effects in the late time expansion of explosions in hard vacuum when compared to the usual analytic approximations. The latter paper, on the molecular dynamics of shock and detonation phenomena in condensed matter, provided an elegant demonstration of how computers can be used to solve problems in physics. Each particle of small colliding crystal lattices was represented, along with detailed force laws between these particles. In this way the details of shock propagation through solids can be simulated in great detail. Several calculations of spall were presented, and the potential power of the method for these and other problems such as fracture mechanics and tribology was obvious.

Prof. S. Penner delivered the inaugural lecture on "Particle Sizing in Flames after 100 Years of Study."

For his many varied contributions to combustion dynamics research and to science in general, Penner was awarded the H. Manson Award by the international organizing committee in a special ceremony at the colloquium dinner. (Jay P. Boris, Naval Research Laboratory, Washington D.C. 20375)

MATERIALS SCIENCE

COMPOSITES I

With this article we begin a series of reports on research and development in composite materials. So many laboratories in the UK, Europe, and the Middle East are working on composites that it would be impossible to describe all the work adequately in a single article. We define the term composite rather broadly. Although most of the research is on polymer-matrix fiber-reinforced materials, there are many ways that two or more substances can be combined to develop properties none of the components has when taken alone. In this article, for instance, we describe as a composite a sandwich of sheet steel and cement. Also, work on adhesive bonding will be covered in these articles, since it is often the method of choice for joining composites.

We begin with some interesting work at the Propellants, Explosives and Rocket Motor Establishment (PERME, Waltham Abbey, Essex, UK) which was described to us by Dr. N.J. Parrott. Essentially, what the PERME people have developed are composites consisting of resin and highly aligned, discontinuous graphite fibers; such composites have properties nearly as good as continuous fiber materials. Moreover, the short-fiber prepreg (fiber impregnated with uncured resin) can be formed into complex shapes more easily than continuous fiber prepregs.

The discontinuous, aligned fiber prepreg is made by dispersing short fibers, usually a few mm in length, in glycerine and spraying the suspension onto a filter bed. The fibers are aligned by convergent flow through the spray nozzle. The filter is a rotating cylindrical screen and several nozzles are situated along the central axis of the cylinder. Centrifugal action removes the glycerine, and the felt of fibers that form on the screen is washed, dried, and impregnated with resin to give prepregs 1 × 2 m. Parrott and co-workers are building a larger centrifuge to determine if there are scale-up problems.

The first of these felts was made by a vacuum filtration process, but had disappointing mechanical properties compared to continuous-fiber composites. Later, using the centrifugal filtration, highly aligned, discontinuous composites were made which had the same stiffness and were only 10% below the tensile strength of continuous-fiber materials. These results contradict accepted theoretical predictions. It should be pointed out, however, that the comparisons were made on the basis of a corrected fiber volume. The principal deficiency of the PERME short fiber composites is low fiber volume (V_f, expressed in volume %). The prepreg V_f is slightly greater than 40%. Autoclave processing and compression molding increase V_f to 50% and 60% respectively. Continuous-fiber composites have V_f values of 65-70% and higher, and so if the properties are not normalized to constant V_f they would be the stiffer of the two types of composite.

Nonetheless, the great merit of the PERME development is that the short-fiber prepreg felts can be shaped into complex geometries with very little disturbance of fiber orientation. Uniaxial continuous-fiber prepregs and woven-cloth prepregs suffer considerable fiber bunching and misalignment during shaping. Dr. K.D. Potter (PERME) has worked out the detailed flow characteristics that give these felts their unique shaping capability (*Composite*, July 1979). PERME's showpiece for this feature of their material is a shell for a gear box. A conical shell was formed and then autoclave molded into final shape with a heavy metal flange at one end.

The PERME people have found synergistic effects when two different fibers (hybrid composites) make up the felts. Parrott has prepared prepregs in which short, high-tensile-strength (HTS) and high-modulus (HMS) graphite fibers are intimately mixed. The key word is "intimately", since the inherently brittle character of the HMS fibers is suppressed in the hybrid composite. For 50-50 mixtures, the tensile strength exceeds what would be predicted from the rule of mixtures. Parrott's explanation for this result is that at these proportions, if the fibers are well mixed, each HMS fiber

is surrounded by tougher HTS fibers so that the failure of one HMS fiber cannot propagate. It would be very difficult to get the same kind of intimate mixing of continuous fibers, especially under production conditions.

The National Physical Laboratory (NPL, Teudington, *ESN* 34-1:35) has had on-going research programs on organic-matrix fiber-reinforced composites for many years. Dr. John Lockett heads the Polymeric and Composite Materials Section of the Materials Applications Division. The section has a staff of 18 people of whom half are professional. Their mission is to define the relevant properties of composites and to determine methods of measuring these properties. In addition, they are much involved in how the property data can be used for design purposes. The work is for the most part fundamental, much like that carried out in a university; the engineering development effort is assigned to their sister laboratory, the National Engineering Laboratory near Glasgow.

Lockett indicated that a strong involvement with industry means that the research also must be relevant to industry's needs. The NPL group tries to see what the problems are and orient their programs accordingly. The work of the Division breaks down into three basic categories. First there is the development of design methods for composites. Designing with composites differs from conventional design because of the anisotropy of the mechanical properties of composites and the viscoelastic behavior of the polymer matrix. Secondly, there is considerable work on the mechanical properties of polymers and composites with emphasis on the mechanisms of failure and on data "normalization" (standardization of data.) Finally, they are part of a government-industry consortium to develop design methods and design criteria for glass-reinforced plastics (GRP). The emphasis is on random, chopped-fiber materials which are finding application in automobiles, housing, and heavy equipment (*ESN* 33-5:186, 33-9:368). In this consortium both industry and the government (including NPL) are funding university research which is highly focused on engineering with GRP. The consortium was started by the British Plastics Society which recognized that many of its member companies selling GRP are too small to generate design data and methods. It is interesting that two of the principal members of the consortium—Imperial Chemical Industries Ltd. and Ford Motor Co., neither of which sell GRP, have vested interests in seeing that GRP structures are designed for reliability.

We spoke with Dr. Alistair Johnson, who is in charge of NPL's research on GRP for the consortium. He has accumulated engineering data from the literature and compiled it in a monograph, *Engineering Design Properties of GRP* (A.F. Johnson, British Plastics Federation, London). He is now compiling a companion monograph on design methods which will include procedures for continuous-fiber composites (mostly from work in the US), procedures for short fiber composites where they exist, and design methods for isotropic materials that have some hope of working for anisotropic GRP. It is expected that much of the work supported by the consortium will appear in future additions or supplements to both monographs.

Finally, we visited with Drs. G.D. Dean and G.D. Sims at NPL, who are investigating the dynamic mechanical properties and fracture behavior of composites and polymers. The dynamic tests are aimed at evaluating the level of accuracy of various test methods including torsion pendulum and forced vibration for low frequencies (~1hz), resonance techniques for the kilohertz range, an ultrasonic pulse technique at 5 megahertz. In their fracture work, they are concerned with the long term strength of polymers and composites, i.e., low-stress-level fracture. Using creep rupture tests, they are evaluating various specimen configurations subjected to time-dependent, multiaxial stress. Ultimately, they want to determine the effect of formulation and processing on flaw initiation and growth.

On the Continent, we visited Prof. T. Vinh, Director of the Laboratoires d'Electronique de Rhéologie et de Traitement du Signal in the Institute Supérieur des Matériaux et de la Construction Mécanique (Paris). His general interests are in the dynamic mechanical properties of solids and much of his work is on continuous fiber, organic matrix composites. Along with his principal co-workers, Dr. D. Le Nizerhy and Prof. Y. Chevalier, Vinh has a strong theoretical and experimental effort on the dynamic elastic properties of composites and also their plastic behavior at very high loading rates and large deformations. On the theoretical side, they are comparing various analytical methods to see which, if any, adequately describe the dynamic elastic experimental data. Two experimental techniques are being used to characterize the ani-

sotropic elastic constants. In one case, thin plates are mechanically vibrated either by wave propagation or in three-point flexure. The other technique uses ultrasonics with the transducers and specimens in a water bath or with the transducers in direct contact with the specimen. In the ultrasonic testing, Vinh is especially interested in the effect of voids and poor fiber/resin adhesion on wave dispersion.

Recently, Vinh and his coworkers have ventured into the realm of plastic deformation of composites at high strain rates with emphasis on the adiabatic effects which may occur. They examine failed surfaces with an electron scanning microscope, and hope to apply dislocation theory to interpret their results.

At the Technion (Israel Institute of Technology, Haifa) Prof. Ch.H. Lerchenthal has developed a sandwich of portland cement between thin steel sheets. The cement contains 20-25% by weight of an organic resin which toughens the cement and bonds the sandwich together. Lerchenthal has prepared sample sandwiches using mild steel and finds the 4-point bending strength to be greater by a factor of 9 than that of a plate of mild steel of the same total thickness. The adhesion between steel and cement was sufficient to prevent debonding in the bend tests. Furthermore, the laminates survive heating the metal facings to 700°C (for short times) and are better heat barriers than steel plate. Lerchenthal suggests that these materials could be used as low cost, light-weight replacements for metal plate. (Willard D. Bascom)

FRACTURE MECHANICS IN DESIGN AND SERVICE

A Royal Society meeting entitled, "Living with Defects" was held in London, 5-6 December, 1979. The purpose was to bring together persons working with large metallic structures (such as ships, offshore platforms, bridges, pressure vessels, and the like) with people studying fracture mechanics (which includes fatigue). Sir Hugh Ford, (Imperial College, Univ. of London) one of the meeting's organizers, opened the proceedings by stating that the objective of the meeting was to see how far this science had progressed. Were designers using fracture mechanics? If so, in what form? And if not, why not? It was supposed to be a chance for both designers and fracture mechanics experts to learn.

G.P. Smedley (Lloyds Register of Shipping) discussed some catastrophic ship failures and talked about what was being done to stop hull fractures; e.g., tough strakes, decks, and bilge plates, are being used on the high-stress areas and as crack stoppers. But failures are still occurring, particularly in seas on the beam, and often the crack runs in a weld. In Smedly's words, "Engineers must get away from the idea that there is a lower level of charpy shelf life which is safe."

Next, Mr. M. Dawes (Welding Institute Research Lab., Cambridge, UK) reviewed the concepts of determining fracture toughness. Then B. Tomkins (Springfield Nuclear Power Development Laboratories, UKAEA, Preston, UK) discussed the principles of fatigue crack propagation (FCP), J. Knott (Cambridge Univ.) summarized metallurgical parameters controlling toughness, and J.G. Williams (Imperial College, Univ. of London) talked about the application of fracture mechanics to polymers. After tea, C.E. Turner (Imperial College) reviewed J integral methods for looking at elastic-plastic situations, and J.M. Coffey of the Central Electricity Generating Board (CEGB, London) told why ultrasonics was the only good NDT (nondestructive testing) method. Finally C.A. Rau (Failure Analysis *Associates*, CA) told how to do probabilistic fracture mechanics and gave examples of its application. The next morning, J.F. Poyner (Babcock Power Ltd., London) reviewed the relevant design codes for pressure vessels in the petroleum industry, especially liquified natural gas (LNG) carriers. The final speaker, H.C. Cotton [British Petroleum, (BP) London], said he thought he was in the wrong meeting, because BP didn't use all the fancy techniques that had been discussed. BP, in fact, uses COD (crack opening displacement) testing, as developed by the Welding Institute. "Dr. Wells is the Ayatollah and I am his Mullah," is the way he put it. Cotton was referring to Dr. A.A. Wells (Welding Institute Research Lab Cambridge) who was ill and unable to attend the conference. Cotton has as British Standards to review its use of charpy values. He has done some interesting comparisons between COD tests and charpy tests, showing that they do not correlate well. In the final analysis, he believed, "Current practice must be pretty good because very few structures fall down." Between Cotto

and Smedley, it seemed clear to me that designers do not pay much attention to what fracture mechanics researchers have been doing.

From the controversy which exists about ways of conducting and interpreting fracture toughness tests, it is no wonder that engineers and designers avoid the concept except in its simplest and most straightforward forms. Wells was quoted as saying, "If a material can be measured in plane strain on a laboratory testing machine, it is too brittle for use in service."

It was Turner who raised the question as to whether it is, in fact, possible to describe the fracture resistance of a material by a single parameter. His point was that in view of the continuing plane-stress, plane-strain controversy, there is need for parameters which give both the level of material toughness (he clearly favored J-integral) and the degree of constraint imposed by the test, or the amount of triaxiality imposed. (What he did not suggest was a way to quantify this factor).

The speakers, Drs. Harrison and Milne, gave a detailed look at how CEGB assesses defects—they use a two-factor analysis, which combines K_r and S_r ($K_r = K_I / K_{IC}$ and S_r = applied load/collapse load). The position $K_r = 1$ and $S_r = 1$, (on cartesian axes), of a defect defines the degree of severity of a defect within a structure. The other bound of this diagram is defined from the strip yielding model where $K_r = S_r \left(\frac{8}{\pi^2} \ln \sec \frac{\pi}{2} S_r\right)^{-\frac{1}{2}}$, but they emphasized repeatedly, that the exact form of this line has little effect on the analysis. They also emphasized that this assessment technique is simple, yet recognizes that for failure, a structure can either collapse or fracture. They also have a method for incorporating cyclic loading in their assessment.

Dr. H.D. Williams (CEGB, Midlands Region) described how they use fracture mechanics to keep plants with known defects in operation by assessing the severity of flaws and adjusting operating conditions to allow continued operation. The procedures have saved CEGB millions in downtime, which currently runs about $160,000 per day.

Another CEGB speaker, J.M. Coffey, looking at NDT (nondestructive testing) techniques, systematically dismissed all but ultrasonics as unreliable or not sensitive enough to find small defects. Even ultrasonics can only give a pseudosize. Cracks less tha 2-3mm cannot be located, and those than 1 mm cannot be detected, altho a new pitch-catch technique has the potential to decrease detection to 0.2mm. This technique is sensitive to crack tip compressive stresses (sometimes cracks appear to get sho due to this effect). Cotton dismis ultrasonic inspection as aviable te nique for NDT of offshore platforms and drilling rigs due to the large of these structures. Whether NDT should be a part of defect assessme therefore, seems to depend upon the scale of structure.

Presumably, at any scale, the niques of probabilistic fracture me ics can be used in defect assessmen Rau discussed both the methodology making assessments by this techniqu and gave examples of the use of the technique. He gave this in clearly defined terms and with understandab logic, but it was apparent that suc an analysis is useful in only some instances. Particularly, those instances where the system is complex and the failure mode not well defin indeed, one of the reasons for doin a probabilistic analysis is to make the essence of a sensitivity analys of a system to find out what is lik to fail and what sort of NDT effort is warranted.

Prof. Hirsch (Oxford Univ.) asked a key question: "Isn't the 't on the distribution function of som variable, say K_{IC}, an important fac Answer, it depends on the system, b it may well be, and so it must be c fully determined. The analysis, ho ever, may show that it is the mean value rather than the tail that is portant. This is a value of the an ysis. Rau pointed out that histori field experience was brought into e gineering design. If deterministic fracture mechanics is used in defec assessment, this field experience i largely excluded. Probabilistic fr ture mechanics is a way of bringing that experience back into design in a systematic, statistically rigorou way. In context with the other tec niques of assessment discussed, thi technique seems to have a definite place, but like all the others it m be used carefully and with intellig

Both Poynor and R.S. Nichols o the UK Atomic Energy Admin., Warrin discussed the relationships between codes and design. In the case of building tanks for LNG, Poynor said

the British standards which are applicable seem to be conservative even though nothing but charpy values are required. Nichols, in examining the American Society of Mechanical Engineers (ASME) codes on nuclear pressure vessels seemed to indicate that the idea was to design for the tolerance to defects which are at least a factor of 10 larger than those that are of minimum detectable size. Nichols thought the ASME Code was adequate for the nuclear-pressure-vessel situation and disagreed with the remarks made by Sir Alan Cottrell (Cambridge Univ. UK) about Pressurized Water Reactors (PWR) pressure vessels which led to the Marshall Report and the current large effort in the UK and elsewhere to obtain fatigue crack propagation data in PWR environments. A private discussion with an engineer from the Office of the Nuclear Safety Inspector indicated, however, that they had not so lightly dismissed the remarks by Cottrell. A political decision has switched the emphasis in nuclear generating stations from Advanced Gas (cooled) Reactors (AGR) to the PWR because "that is the standard reactor for the rest of the world."

One industry where fracture mechanics does seem to be utilized in design is in the plastics/gas distribution line system. This was emphasized by Dr. G.D. Fearnehough of British Gas Research. Prof. J.G. Williams discussed methods of determining fracture mechanics values for polymers. He is also trying to determine ways to derive mechanisms of failure from his fracture mechanics results. Williams has worked with the gas industry to derive couplings and joining techniques utilizing fracture mechanics principles. British Gas claims excellent operating results.

The biggest reason given for not using fracture mechanics in design is a lack of knowledge by designers of the stresses in the parts under design. The reason for not knowing these stresses is that the exact operating parameters the structures will be subjected to are not known. On pressure vessels, the operating transients and thermal stresses are not known. On no structures are the residual stresses from welding known, and there are too many variables in the welding process to predict what they might be.

In the context of pressure vessels, conflicting ideas were expressed over the values of hydrostatic testing. Should it be done? At what temperature? And what are the benefits of reevaluating hydrostatic testing? Hydrostatic testing appears to offer two benefits mentioned by several speakers: (1) it gives tangible evidence of the integrity of the vessel, and (2) it acts as a mechanical means of stress relieving a welded structure, especially when the hydrostatic test is done warm. Again, as with other assessment techniques, it appears that hydrostatic testing can be a useful technique if it is employed carefully, intelligently, and specifically. The overall impression which could be derived from this meeting is that fracture mechanics is indeed a useful technique, but its application must be done very carefully; there is no overall, unified technique or method which can be used by everyone on everything.

Finally, it is evident that controversy over the J-integral still exists. Bilby (Univ. of Sheffield) pointed out that there are actually numerous J's (that is different, non-equivalent concepts of the same thing). Turner thinks that "anything K can do J can do better, J can do anything better than K". He also added a useful bit of insight: linear elastic fracture mechanics, of K, is actually the lower limit of the concept of plastic work when the energy-release rate of the specimen becomes greater than the energy absorption rate of the material.

The book which the Royal Society plans to produce from this meeting should, if read carefully, provide an excellent reference for an upper-level course in the engineering of structures. The conference provided numerous insights into how elastic-plastic and linear elastic fracture mechanics fit together. (David L. Davidson, Southwest Research Institute)

MEDICINE

AMNION AND SKIN GRAFTING: NEW HOPE FOR THE WORST CASES

The healing of healthy tissue under ordinary circumstances requires only that the edges be brought together. This rather remarkable and rapid knitting of normal skin and subcutaneous layers is termed primary healing and leaves a fine linear scar or, if sutured subcutaneously, virtually no scar at all. If infection has occurred or the amount of skin destroyed prohibits approximation of the edges, healing will take place secondarily, that is, by granulation tissue filling the wound from the

bottom up. Occasionally the destruction of skin and underlying tissues has been so extensive that a skin graft becomes necessary. Depending on the location to be grafted, autologous split thickness, full thickness or pedicle grafts have been successfully employed for many years. A small minority of wounds not only do not heal spontaneously but will not accept a skin graft. These non-healing ulcers are usually the result of insufficient vascularity or damage to the skin and underlying tissues by burns or radiation. If the vascular supply of the ulcer bed is insufficient in many instances a skin graft will not be accepted.

Prof. W. Page Faulk (Blond McIndoe Centre for Transplantation Biology, Queen Victoria Hospital, East Grinstead, Sussex, UK) has rejuvenated and refined an old idea for treatment of non-healing ulcers. The essence of the procedure is the use of amnion to revascularize the ulcer bed. Amnion is fetal trophoblastic tissue, which forms the inner layer of the amniotic sac within which the fetus develops. There have been sporadic reports over many years describing attempts to make use of amnion to promote healing but consistently good results were never achieved. In addition, it seems that a firm scientific foundation for this method has, up to now, been absent.

Every newborn emerges from an amniotic sac, which actually consists of two structures; the amnion and the chorion. The technique developed by Faulk and his colleagues has two essential components: 1) the fetal amniotic sac must be maintained as a tissue culture in a properly prepared culture medium and 2) the amnion must be separated from the chorion immediately prior to use on a non-healing ulcer. The other steps in the procedure are straightforward. Initially, the ulcer bed must be free of infection. Amniotic tissue after separation from the chorion, is laid on the ulcer bed, followed by a split-thickness or full thickness graft.

19 patients have undergone pregraft preparation of non-healing ulcers by amniotic tissue in the current experimental study. Faulk chose only those patients who had previously rejected skin grafts and whose ulcers were poorly vascularized microscopically as well as macroscopically. In the first few patients the amnion was removed from the wound for inspection prior to application of the skin graft. It was obvious from even gross inspection that the ulcer bed had become quite bloody in contrast to the dull gray appearance of the same poorly vascularized tissue before application of amniotic tissue. Histological sections demonstrated a qualitative as well as a quantitative difference in the appearance of the small blood vessels. Faulk and his colleagues are preparing a paper for publication in which they will describe the results of the first 10 patients all of whom have had successful skin grafts after the application of amnion. The remaining 9 patients of the first group of 19 have not as yet had sufficient follow-up time (6 months) to allow them to be included in the initial publication.

Application of amnion to an ulcer bed to induce neovascularity depends on its acceptance by the host tissue. The amnion is genetically fetal and, although closely applied to the maternal uterus, is not rejected as foreign protein. This raises the entire question of maternal recognition of the fetus as foreign protein. Trophoblastic modulation or elimination of maternal allogeneic recognition is not only one of the keys to its use in skin grafting but undoubtedly has considerable general immunological importance. (Faulk has done previous work along these lines. He has shown that maternal immunoglobulins are able to block the reaction which occurs when two allogeneic lymphocyte populations are mixed and cultured. In later work he demonstrated that antibodies to one of the trophoblastic membrane antigens also inhibited the reaction of mixed lymphocyte populations.) Pursuing this point in the current experiments, Faulk found that the immunoflorescent characteristics of cryostat sections of ulcer bed biopsies were quite different, if treated with factor VIII serum, before and after the application of amnion. There was a striking increase in factor VIII granules in the endothelial cells of the vessels as well as an increase in the number of vessels. The mechanism is undoubtedly complex. There is recent evidence that trophoblastic tissue (amnion) might be protected from maternal recognition by transferrin.

Except for two patients whose skin and subcutaneous tissues were injured by radiation, all the patients have had non-healing chronic ulcers due to vascular insufficiency. The common site is the lower portion of the leg just above the ankle. From a clinical point of view Faulk and his colleagues

would like now to utilize this technique with burn patients who have non-healing wounds and who have rejected grafts. From an investigative point of view they are attempting to determine how amniotic tissue revascularizes an ulcer bed. It is suspected that the amniotic cells secrete various substances which not only block rejection but induce the neovascularity.

As Faulk explains it, his ultimate goal would be to bottle whatever the amniotic tissues are secreting for plastic surgeons to paint on the wounds prior to skin grafting. As a maternal-fetal biologist Faulk is eminently qualified to pursue this line of investigation. The results of his work may have far-reaching results for those unfortunate victims of extensive injuries particularly those caused by burns. (Irwin M. Freundlich)

GENETICS AND GENETIC DISORDERS IN ISRAEL

The "in-gathering" of Jews into Israel is occurring more than 25 centuries after the beginning of the diaspora. This event, one of the most dramatic in the history of the Jewish people, also has unique medical significance. It has provided an opportunity to study the long-term genetic effects of migration and isolation, of intermarriage and consanquinity on a specific population. Inherited traits and diseases, some unique and some shared, have been carefully evaluated in multiple long-term and on-going studies. The central figure in this endeavor is the Israeli Internist and Geneticist Richard Goodman (Chaim Sheba Medical Center, Tel Hashomer, Israel). American born and trained, Goodman emigrated to Israel in 1969 where his research and scholarship have placed him among world leaders in the study of genetic disorders. The many physicians associated with him on multiple projects are too numerous to include here; however, the radiologists, Marjorie Hertz (Chaim Sheba Medical Center) and Samuel Schorr (Ichilov Hospital, Tel Aviv, Israel) were particularly helpful to my understanding of the nature and scope of the work.

One might mark the beginning of the dispersion of the Jewish people with the conquest of the kingdom in Israel in 720 B.C.E. and the fall of Judah 135 years later. The leaders of these communities were taken into Babylonian captivity but many maintained their Hebraic identity and their descendents reside in Iraq to this day. The residual Middle Eastern and North African groups are broadly known as Oriental Jews and represent the original gene pool. With the rise of the Greco-Roman Empire and westward migration, a significant portion of Oriental Jews made their way to Spain and Portugal where they evolved into the group broadly known as Sephardi. After dwelling for centuries on the Iberian Peninsula during the Islamic "Golden Age," Sephardi Jews were assimilated or expelled after the Christian conquest, culminating in the Ferdinand and Isabella order of expulsion in 1492. Ashkenazi Jewry also grew out of the original Oriental group and settled in Western Europe during the Roman rule. During the Crusades and thereafter they were gradually forced into Eastern Europe. After the "Golden Age" some mixing must have occurred, Sephardi with Oriental Jews when the Sephardi returned to North Africa, and Sephardi with Askenazim following migration of the former into Western Europe. Despite these migratory periods certain distinct environmental and genetic subgroups have emerged, particularly from the Sephardi and Oriental communities. However, the Ashkenazi, Sephardi and Oriental groupings are actually so broad that distinct features of subgroups are lost. According to Goodman, it is, therefore, preferable to classify groups or individuals in terms of the place or country of origin. From a genetic point of view the Jewish people as a whole make up a heterogeneous population but recent studies are beginning to show genetic markers that reflect a common Middle Eastern origin.

In searching for links between modern Jews and the ancient Hebrews, Goodman notes that many diseases are described and discussed in the Old Testament and Talmud. While there is as yet insufficient evidence to confirm that specific mutant genes were present in ancient times, additional analysis may in the future prove this contention to be true.

Polymorphism is the occurrence of two or more genetic variants of the same trait within a given population, the great majority of which are not associated with a disease. Considerable data of comparable gene frequencies in a number of polymorphic systems have been accumulated with two major trends emerging: 1) there is great heterogeneity among Jewish ethnic groups, particularly Ashkenazi, reflecting an add-mixture with non-Jews, and 2) a common

iddle Eastern origin can be detected. omparative gene markers can be used o better understand the degree of homgeneity or heterogeneity of a given ommunity. As an example Goodman cited randomized study of 148 Libyan Jews ow living in Israel. Using as genetic arkers blood groups, serum proteins, nd red cells enzyme frequencies, the ata were compared with non-Jewish Libans. The results indicated a high egree of genetic isolation of the Jewish community from the surrounding opulation.

Normally humans have 22 pairs of autosomes and a pair of sex chromosomes, either XX or XY. The term sex-linked refers to genes located on the X-chromosome while the Y carries very little information other than maleness. Hereditary traits and diseases depend upon the chromosome location of the mutant gene and upon gene dosage. The terms dominant and recessive usually refer to the phenotype (observability) of a trait in an individual and not the genotype. Therefore, a patient with an autosomal dominant gene causing a disease will usually be heterozygous because he has received the mutant gene from just one affected parent. This type of inheritance is characterized by several features: 1) one of the parents must also have the disorder, 2) an affected parent will transmit the disease to about half the offspring and, 3) an unaffected offspring cannot transmit the gene. These diseases are frequently associated with gross clinical alterations that usually appear later in life with a wide variability indicating differences in gene penetrance. Homozygous (from both parents) autosomal dominant mutant genes are rare and are frequently lethal to the fetus or infant.

The presence of an autosomal recessive disease requires that one mutant gene is inherited from each parent. If the parents are heterozygous, they are clinically normal but on investigation may demonstrate a biochemical alteration. Theoretically, when two heterozygous individuals mate, 25% of the offspring will be phenotypically abnormal. The mating of an entirely normal individual with one carrying an autosomal recessive trait will result in all the offspring carrying the trait. A dominant pattern of transmission will result if a homozygous abnormal individual (has a disease) mates with a heterozygous carrier. Consanquinity plays an important role in recessive inheritance.

In sex-linked inheritance the female carries the trait on one of her X-chromosomes, which she transmits to half her daughters, who will be carriers, and half her sons, who will be affected. An affected male transmits the mutant gene to all his daughters who will be carriers, but cannot transmit it to his sons. Male to male transmission may appear to take place when an affected male mates with a female carrier. Sex-linked inheritance may also be dominant or recessive. The mating of an affected male and a carrier female (recessive) will produce an affected female.

Autosomal recessive diseases constitute the most important group of inherited disorders among Jews or among the members of any group. Autosomal dominant diseases are severely selected against as the carriers are clinically abnormal. In sex-linked recessive diseases the affected males are selected against and the female heterozygotes are frequently normal. The selective pressures are much less effective in the autosomal recessive diseases as the carriers are phenotypically normal.

The genetic disorders common among Ashkenazi Jews display a marked frequency variation. Most, as expected, are autosomal recessive and many involve the central nervous system, primarily or secondarily. In three of the more common diseases, Tay-Sachs (TSD) Gaucher and Niemann-Pick, the enzymatic aberrancy shares a common metabolic pathway. It has been estimated that 80% of Type I Gaucher disease, as an example, occurs among Ashkenazi Jews. The estimated frequency at birth for the homozygous state among Israeli Ashkenazim is about 1:2,500 with a carrier frequency in this group of 1:50 to 1:70. However, in contrast to reports from the United States, it is now known that Gaucher disease occurs in Israeli Sephardi and Oriental communities as well. TSD has been reported from many ethnic groups but 90% of affected infants are Ashkenazim and primarily from the Lithuanian and Polish provinces of Korno and Grodno. Among Ashkenazi Jews in several countries an average carrier rate of 1:27 is suggested with an estimated true incidence of TSD of about 1:3600 births.

Among Sephardi and Oriental Jews hereditary disorders are more likely to be shared with non-Jewish Middle Eastern and North African people than with Ashkenazim. Ataxia-Telangiectasia, for example, is an autosomal recessive central nervous system disorder found in families with a high degree of consanquinity. Of 23 families investigated, 18 were Sephardi, 4 Arabic, and 1 Druze.

Thalassemia, an inborn error of hemoglobin synthesis, is remarkably heterogeneous and actually represents a group of diseases. Because of the number of gene combinations able to produce this disorder, it has become widespread over most of the world. One type, however, found in Kurdish Jews, originates from a well-defined geographical area in Kurdistan.

The genetics of a number of hereditary diseases have been worked out by the group at Tel Hashomer. Familial Mediterranean Fever, an autosomal recessive disorder, one of the earlier ones studied, was found to occur in a wide spectrum. It is very common among Libyan Jews with 1 in 600 persons affected but rarely found among Ashkenazim with a rate of approximately 1:3 to 1:5000. Recently, two new syndromes have been reported, one in three Oriental Jewish siblings and another in a Sephardi child.

A number of misconceptions have arisen over the years regarding genetic hereditary diseases among Jews. Primarily, it seems that lack of controls and biases in data gathering have been responsible. Several diseases were thought to be virtually confined to Jews because they were reported by Jewish physicians, predominantly American, whose patients were not only largely Jewish but even emigrated from rather well defined European areas. An alleged increased prevalence among Jews of other disorders such as diabetes, obesity and myopia has no basis in medical research but results from a social or political bias prevalent at various times. Mental illness and retardation have been thought to be more common among Jews but, according to Goodman, statistically valid epidemiological evidence is lacking and at this time no conclusions can be drawn. Alcoholism is approximately 20 times more common in non-Jews than in Jews, a phenomenon which apparently has no genetic basis and which is difficult to explain. However, despite the virtual absence of drunken driving in Israel, the auto-accident rate is among the highest in the world. Presumably, other adverse psychological factors are at work.

The relatively large number of Jews obtaining academic or professional careers despite obvious obstacles common until recently has led to speculation regarding a possible genetic basis for this achievement. There is no evidence to support that contention but it is likely that community-wide self selection (as opposed to natural selection) was in effect over many centuries. Marriage customs and match making put highest value on scholarship and learning in young men while Jewesses of beauty and wealth were held in high regard. On the other hand there was community pressure for all to mate so that not only those of less than average intelligence but also many with physical and mental handicaps were encouraged and actually assisted in obtaining spouses. This trend as well as relative isolation and consanquinity probably accounts for the large number of genetic disorders among Jews.

The study of these complex and often confusing disorders and the genetics involved has occupied the attention of many scientists in various disciplines. Led by Goodman, much has been accomplished in understanding the problems which should promote sensible genetic counseling and the eventual control of the effects of adverse mutations. (Irwin M. Freundlich)

METROLOGY

THE FIFTH INTERNATIONAL CONGRESS FOR STEREOLOGY

Why should an orthopedic surgeon from the USA, a crystallographer from England, a concrete engineer from Norway, a metallurgist from Czechoslovakia, a geologist from Australia, an instrument maker from West Germany, a mathematician from East Germany, a nuclear chemist from France, together with assorted biologists, electron microscopists and computer scientists, about 200 altogether from 24 countries, gather for a conference? These were the participants in the 5th International Congress for Stereology, that took place from 3-7 September 1979 in the splendidly baroque city of Salzburg in Austria.

Salzburg is still a medieval city of palaces, churches, and fountains. A river flows through the town, and surrounding it are three tree-covered hills, on one of which is a fortress, and beyond are mountains. Such are the views between one's hotel and the University where the conference took place.

But what is "stereology"? It is defined in the conference program as being "a group of (mostly statistical) methods for the inference of true spatial structure on the basis of only partial information, provided by plane sections or projections."

The participants were all keen investigators of the 3-D structure of materials from 2-D images. The orthopedic surgeon, Dr. C.C. Schock (Case Western Univ., Cleveland, OH), spoke about identifying the 3-D configuration of spinal deformity by the automatic computer analysis of a pair of orthogonal x-rays. The crystallographer, Dr. A.L. Mackay (Birkbeck College, University of London, UK) spoke on the use of generalized inverses of matrices as a tool for reconstructing, from the linear equations representing a projection of the co-ordinates of a 3-D structure onto a surface, the general form of all possible 3-D structures that could have given rise to the projection. Indeed 90 short talks were given by participants about their discoveries, while a further 55 papers were presented as poster displays. Demonstrations of image analysis equipment were given throughout the week by 8 manufacturers. The organisers are to be congratulated for having brought together in harmony scientists from so many disciplines; and in having arranged a program from which no-one walked out when a mathematician rose to speak, or a biologist, or a materials scientist. The Conference Secretary, Dr. Gustav Bernroider (Zoological Institute, Salzburg University, Austria) in his little speech at the end of the Congress, referred to complaints he had received from the coffee bar staff about the lack of demand.

The three groups of participants most widely represented were the life scientists, whose interest was in the microstructure of such organs as the brain, the lungs, and the kidneys; the material scientists, whose interest was in the microstructure of such materials as rubber, concrete, man-made fibres, and metal alloys; and the electron microscopists demonstrating the computer processing of their images.

The first paper of the scientific program, entitled "The Scope of Stereology", was presented by the President of the International Society for Stereology, Prof. Herbert Haug (Institute of Anatomy, the Medical School of Lübeck, FRG). He spoke of the history of stereology from the original ideas of Buffon in 1777, through its early development in the material sciences by Delesse in 1847 and Rosiwal in 1898 and in life sciences by Chalkley in 1943, to the foundation of the Society in 1961. Since 1961 we have seen (a) the development of new theory and procedures, (b) an understanding of shape and size, (c) a clarification of definitions and nomenclature, (life and material scientists now use similar nomenclature), (d) the development of rules for the daily application of stereological methods, and (e) the introduction of new technical equipment.

For the future, Haug posed three problems: (i) The present theory assumes that structures are randomly organized, which in reality will be true only for small areas of tissue. Procedures are needed for inhomogeneous material. For example, in studies of the shrinkage of brain tissue by degeneration, the brain is seen to be a layered mixture of cell types of different size and shape. (ii) The characterization of shape from sections is at present unsatisfactory. How can a cross-section through a banana reveal its shape? Whereas pattern-recognition works with highly computerized procedures, a logical procedure based on relatively simple measuring instruments is still needed. (iii) Microprocessors have led to huge advances in instrumentation. Intense collaboration will be needed between instrument designers, mathematical stereologists, and stereologists of the life and material sciences in order to make the equipment easy enough for morphologists, with no programming experience, to use and achieve results that will prove acceptable to stereologists.

As at previous Congresses of the Society, there were very few parallel sessions. Furthermore, within sessions the organisers mixed microscopists, biologists, mathematicians, and so on. This is a policy of the Society. It appeared to work quite well, although it required that the papers be very short. In reporting on the meeting, however, I have separated the several themes.

Stereology in the Life Sciences

Prof. Ewald R. Weibel (Anatomy Institute, Univ. of Bern, Switzerland) spoke on stereological analysis of the dependence of lung function on structure. Weibel has applied stereological methods to his work for nearly 20 years and has developed experimental equipment to facilitate it. The diffusion of oxygen into the blood in the lung depends on the resistance of the lung tissue, which can be calculated from such parameters as the surface area of lung tissue (in man this is about the size of a tennis court), the thickness of the membranes separating the air from the blood, and the volume of the capillary blood. Each of these can be estimated by stereological methods applied to electron micrographs of lung tissue. Diffusion capacity corresponds well with the oxygen needs of different mammals (for example, the pygmy shrew at one extreme).

One of the particular problems of stereology is that of estimating the number of cells in a 3-D structure from a 2-D section, when the boundaries of the cells are indistinct. Dr. Luis-M. Cruz-Orive, from Weibel's group, spoke on the design of sampling schemes, in which the organ is randomly sectioned and subsectioned, until micrographs are made from which the measurements are taken. A statistical theory leading to an estimate of cell numbers in which precision and cost are balanced was described.

Some problems still remain, for, if a section is random, we cannot take a second random section without first sewing together the pieces. Furthermore, the theory might point to our weighting the probabilities for choosing the section randomly according to what can only be observed in the section itself.

This same problem of counting and measuring cells was described by Dr. R.P. Bolender (Dept. of Biological Structure, School of Medicine, Univ. of Washington, Seattle). The particular application in his case was in the interpretation of changes in the cell structure caused by drugs.

Drs. Ruth Østerby and Hans Jørgen G. Gundersen (Institute of Experimental Clinical Research, Department of Cell Biology, Denmark) described their sampling procedures in investigations of changes in the surface area and the thickness of basement membranes from glomeruli in the kidney caused by the onset of diabetes. They showed how they could balance the variability at each stage of the sampling in order to achieve the most precise results for the minimum expenditure of time. They concluded that great precision at the final stage of taking measurements from the micrographs was not essential, and that the great accuracy given by an expensive image analyser would not be worthwhile.

Dr. Roger E. Miles (Institute of Advanced Studies, Australian National Univ., Canberra) asked us to clarify the model we adopt for our structure before we seek to analyse it, since it is crucial to the stereological theory. Is the specimen within which the observations are made the only particle of interest, or is it sampled from a population of specimens? If this latter, is the population finite or is it part of a realization of an infinite process of particles? He outlined the techniques that would be appropriate for taking a sample from the specimen in each case, and the subsequent estimation procedures.

Stereology in the Material sciences.

Prof. E.E. Underwood (Georgia Insititute of Technology, Atlanta) presented a paper by him and C.J. Aloisio on the microstructure of foamed rubber. Changes in the structure of foamed ethylene-propylene rubber caused by compression for various times at various temperatures cannot always be identified visually. Underwood demonstrated the relationship between three stereologically derived parameters of the structure and the so-called WLF time-temperature parameter for a rubbery material when it is subjected to deformation. He suggested that this type of analysis might be applicable in quality control, or in the design of foamed rubbers for use at high temperatures.

The permeability of nonwoven fibres was the subject of the paper by Drs. J. Masounave, A. Rollin, and R. Denis (Ecole Polytechnique de Montréal, Canada). These fibres are used extensively in civil engineering for soil retention purposes and earth reinforcement, for example to line canals. A simple model of randomly organized linear segments led to formulas for the largest particle that could enter the fabric and the largest particle that could pass through. A comparison with the true permeability revealed that the clogging level with a particular soil could be predicted.

Image Analysis.

Impressive demonstrations were given of image analysers which take the output of a microscope (light or electron) and process it by computer before displaying the result on a television screen. The computer will remove features, rearrange them, change their colors, and so on, and carry out a wide range of measurements which are given automatic statistical analysis. Besides the physical presence of these machines, many papers describing their application were presented.

Prof. G. Materon invented mathematical morphology in the 1960s and, with Prof. Jean Serra, developed it at the Centre de Morphologie Mathématique of the Ecole Nationale Supérieure des Mines de Paris at Fontainebleau. Since then the mathematics of image analysis has been in advance of the development of the equipment. In particular, the Leitz-T.A.S. was designed in Fontainebleau. At this meeting we saw that, suddenly, with the current widespread use of microprocessors, the range of operations that can now be provided

by these machines has far outstripped the mathematics and the theoretical stereology which their most efficient use demands. The sophistication, for example, of the Cambridge Instruments Quantimet 720 is quite breathtaking.

The Mathematics of Stereology

Advances in the study of curvature were given in papers by Prof. Robert T. DeHoff (Dept. of Materials Science and Engineering, Univ. of Florida, Gainesville) and Dr. Roger E. Miles (Canberra, Australia).

Smooth planar curves appear in plane sections through materials containing smooth surfaces, or as the orthogonal projection of smooth curves onto a plane.

DeHoff described in a poster display a new stereological measurement, the number of inflexion points (where the curvature changes sign) in the planar curve, per unit area of the observational field. He gave the interpretation of this statistic as it relates to the 3-D specimen from which the curve was derived, and explained how it might be used as a descriptor of the shape of the specimen.

Miles spoke on the stereological use of the integral of powers of the curvature of planar curves.

Dr. Dieter König presented a paper by him and Dr. Dietrich Stoyan (Mathematics Dept., Bergakademie Freiberg, East Germany). In it, the process of convex particles, which is to be subjected to stereological analysis, is considered to be a marked point process. The "centers" of the particles form a stationary point process, and the size and structure information is contained in the marks. The standard stereological formulas are derived. The usual conditions of a Poisson process model for the centers with independence for the sizes and isotropy for the orientations are therefore considerably weakened.

Dr. Rodney Coleman, (Dept. of Mathematics, Imperial College, London, UK) spoke on the determination of the size distribution of opaque spheres embedded in a transparent specimen from the profiles (silhouettes) observed through a thin slice of the specimen. Such slices are used in the preparation of slides for light transmission microscopy. A resolution interval excludes from the observations those profiles which are too small or too large or indistinct because the slice has just grazed a sphere. A comparison was made with the case of transparent spheres in an opaque material, when the problem is that of determining the sizes of the holes in a block of Swiss cheese from just a thin slice.

The geodesic arc between two points in an irregularly shaped specimen is the shortest path between the points that does not go outside the specimen. The length of the geodesic arc is a distance function and defines a metric space within which all the classical morphological transformations (dilation, erosion, etc.) can be defined. Drs. Ch. Lantuejoul and S. Beucher (Centre de Morphologies Mathématique, Fontainebleau, France) introduced these ideas. For example, the length of a specimen can be defined to be the length of its longest geodesic arc.

Particle Size Analysis

Outside the official program, several round-table discussions were held. One of these, chaired by Prof. H. Fischmeister (Department of Engineering Metals, Chalmers Institute of Technology, Gothenburg, Sweden), examined why we should be concerned with trying to convert our measurements made on 2-D sections through particles into estimates of the actual size distribution of the particles. After all, in quality control applications it would be sufficient to fingerprint unambigously the distribution by way of features seen in the 2-D image. In quality control, moreover, the very large particles alone will often determine the important properties of the material. In any case, we cannot in general obtain satisfactory estimates of the tails of the 3-D size distribution. The very small particles contribute heavily to properties that depend on surface area, yet these particles can easily be missed. The large particles are rare, yet contribute heavily to properties that depend on volume. On the other hand, for problems of diffusion or porosity, we cannot avoid the reconstruction of the 3-D distribution.

Conclusion

The final session of the program was at 5:00 p.m. on the Friday, and nearly all the participants stayed for it. It was a discussion on the gap between the theory of stereology and stereology in practice, an airing of views as to what are the unsolved problems of stereology. (Rodney Coleman, Department of Mathematics, Imperial College of Science and Technology, London)

OCEANOGRAPHY

MARINE SCIENCE IS LOOKING UP IN PORTUGAL: I. NAVAL PROGRAMS

In 1967 I visited most of the marine science laboratories in Portugal and found that the level of effort was sparse when compared with programs in other countries in western Europe. In the past, ONR London Technical Reports have stated: "There is almost no oceanographic work going on in Portugal" (R-10-55); "No notable expansion in research (in marine sciences) can be foreseen in Portugal" (R-72-61); and "It is felt that the development of oceanography in Portugal must take place in three steps: (1) Obtaining and preparing people, (2) Assembling equipment and facilities for laboratories, and (3) Building an oceanographic ship designed for the purpose" (R-14-66).

I have recently revisited Portugal and I am happy to report that it is making rapid strides in "catching up" in marine science with other countries in western Europe. A number of Portuguese people are in training in oceanographic programs in the United States. The University of Lisbon has a fledgling program of instruction in environmental geophysics that includes some physical oceanography. New and larger quarters along with modern research equipment have been acquired for marine science programs and several suitable research ships are available for work at sea.

This report will discuss programs sponsored by the Portuguese Navy. The report following will describe civilian marine science programs in Portugal.

The Hydrographic Institute of the Portuguese Navy in Lisbon is now housed in a much larger and more adequate building than in 1967 when I first visited it. Although the present building was a monastery and is centuries old, it has been modernized and is quite pleasant with its quiet interior, cloistered courts, and numerous blue tiled walls. A modern new building is scheduled to be built for the Institute in the near future.

The oceanographic program at the Institute is divided into three divisions: (1) Physical Oceanography, (2) Coastal Dynamics including Sediment Movements, and (3) Waves and Tides. The senior staff consists of a total of eleven naval academy graduates with twenty supporting personnel. LCDR Antonia Souta (MS, USN Postgraduate School) and Lt. Vitor Goncalo, both of whom spoke excellent English, discussed the research programs, equipment, ships, and training programs with me.

Three research vessels are dedicated for use of the oceanographic program. The largest is the *ALMEIDA CARVAL CARVALHO*. It is 58-m long and was the USNS *KELLER*, T-AGS 25. Two smaller vessels are used for coastal dynamics and tidal and current studies. These are the *DOM JEREMIAS* (19-m long) and the *MIRA* (19-m long). Occasionally one of the survey ships of the Hydrographic Institute is also used for oceanographic research. It is the 94-m long *ALFONSO DE ALBUQUERQUE*, an ex-British frigate.

The oceanographic program in the Navy is in a rapid stage of development that began with a resurgence of interest in the oceans in Portugal in 1974. Ten naval academy graduates are presently undergoing training programs in oceanography in the United States. Half are stationed at the US Navy Postgraduate School in Monterey, California working toward their MS degrees in either oceanography or a combined oceanography-hydrography program that takes 27 months to complete. The other 5 officers are enrolled in a year-long formal course in oceanography at the Naval Ocean Research and Development Activity (NORDA) at Bay St. Louis, Mississippi. At the present time the Hydrographic Institute has an in-house short course for training enlisted men to be oceanographic technicians. A formal postgraduate program in oceanography is scheduled to be initiated in 1980 as soon as enough trained officers return from Monterey to act as instructors. These training programs indicate a high level of dedication to the importance of oceanography for such a small nation.

The principal efforts in the oceanography programs in the Portuguese Navy are in practical and applied research which will be of direct benefit to the civilian community of the country. One project is to be in connection with planning for an atomic power plant at Ferrec on the coast north of Lisbon, and the other with a coal-fired plant to be located at Sines on the coast south of Lisbon. Portugal has no coal reserves and will have to purchase coal on the world market. Both projects include the determination of the current pattern near the plant sites, obtaining data to be used to estimate the rate of diffusion of the cooling water discharges, carrying out detailed meteorological studies of each area, and measuring the sea and swell climatology.

Another on-going program is to record the wave climatology all along the Portuguese coast. The Institute operates four mobile stations. Each station consists of a wave rider and sea bottom pressure gauge to record the spectrum of sea and swell. One station also has a shore-based radar to record the direction of sea and swell as a check on the wave rider data (*ESN* 33-7:294). A second radar-wave direction station will be activated shortly.

Portugal has numerous bays, estuaries, and coastal lagoons that are important for natural fisheries resources, are potential sites for aquaculture, and are used in a number of ways by various industries. The Institute is gathering data to aid in making decisions regarding the management of bays, estuaries, and lagoons.

Another study involves detailed mapping of the sediments on Portugal's continental shelf areas. The south coastal area study has almost been completed. Small piston corers are used to obtain 2 to 4-m long core samples.

There is also a program to define precisely the ocean circulation around Portugal through the use of both anchored current meters and geostrophic techniques. The staff has two chemical engineers who are studying the distributions of salinity, temperature, dissolved oxygen, and nutrients mainly in support of the studies of the circulation and in mixing studies. It was reiterated several times that the Institute was leaving strictly basic scientific research for the future and that as much as possible of their present efforts are dedicated to obtaining data that can be used at the present time to answer practical questions.

The Institute has an impressive array of modern equipment, including a Neil Brown computerized Salinity-Temperature-Depth recorder. They also have over 20 Aanderaa current meters and about the same number of other types made by Hydro Products, EGG, Sea Track, and the latest March McBurney electro-magnetic current meters.

The most recent shift of emphasis at the Institute has been to increase their level of effort in pollution related research. They are moving into monitoring marine pollutants and are studying present water quality near potential power plant sites. The pollution field work is being carried out under a contract from the National Commission against Pollution at Sea (Commissão National contra a Poluição No Mer). In fact, about half of the research done at the Institute has been requested and is usually paid for by other governmental departments and various industries.

It was a real treat to see the enthusiastic progress being made in oceanography by the Portuguese Navy.

By some historical accident the Navy supports and runs a small but venerable marine biology laboratory located on the waterfront on the western outskirts of Lisbon. It is associated with a popular public aquarium and museum called the Aquario Vasco de Gama. The Director, Manuel Lopez de Mendoca, is a retired Navy captain. There are only five senior staff members. I had not planned to visit this facility, but had some extra time so dropped in unannounced late one afternoon. The only persons I met were the curator, Antonio Ferreira, and a visiting fisheries technologist, Dr. Fernando Costa. The latter interpreted while Ferreira graciously showed me the new laboratory building (2 years old) and explained some of the research programs to me.

In keeping with Navy dedicated interest in applied research, the laboratory staff is concentrating on aquaculture. They have perfected a system of raising sole from eggs to commercial size. Their aim is to develop fish farms for growing sole on a commercial scale in captivity. A second project has to do with raising eels in captivity. Some Portuguese rivers teem with elvers at certain times of the year. These are caught while they are small and raised in the laboratory. This project did not appear to be in as advanced a stage as the sole project.

There is no formal course work at the laboratory but there is usually an average of 2 to 4 graduate students from the University of Lisbon who are there working on their PhD theses.

While I was at the aquarium, Costa informed me that a new marine biology laboratory and public aquarium was to be built by the city of Cascais, a few miles west of Lisbon. He also suggested that I visit the new National Fisheries Research Laboratory, just commissioned in October of this year. The visit to this Laboratory is reported on in the following article along with other marine science programs in Portugal that are not funded by the Navy. (Wayne V. Burt)

MARINE SCIENCE IS LOOKING UP IN PORTUGAL: II. CIVILIAN PROGRAMS

The biggest surprise of my trip to Spain and Portugal during November 1979 was the massive new Instituto Nacional de Investigação Pescados (National Fisheries Research Laboratory) located on the waterfront a few miles west of Lisbon. My host was the acting assistant director, a chemical engineer, Luís Correia de Matus. The Laboratory was officially opened the month before, although it was obvious that personnel had been hired and equipment ordered prior to the official opening date. The Laboratory comes under the Ministry of Agriculture and Fisheries.

All aspects of fisheries research in Portugal had been brought together under one roof. The three story building had over 100,000 ft^2 of floor space. It was essentially new, having been built as a national convention center just prior to Salazar's fall and the change in government in 1968. However it had not been used much until the Fisheries Laboratory moved in. At the present time there are 71 senior scientific personnel on board out of a total complement of 242. Over half of these personnel had previously been employed in fisheries research laboratories in Portugal's overseas colonies. The law setting up the Laboratory authorizes a total staff of 345 which will make it one of the largest fisheries laboratory in the world. My host took me through many of the individual laboratories and it was immediately apparent that they were well supplied with the latest scientific equipment available.

The Laboratory is divided into a number of different departments including: Limnology and Oceanography, Food Technology, Methods and Techniques (used in catching fish), Fish Detection, Fisheries Biology, Fisheries Resources Estimation, Aquaculture, Training, Extension, and a number of service departments. It owns and operates the 47.5-m long fisheries research ship R/V *NORVEGA*. The Laboratory is a most impressive indicator of the importance of the fishing industry to the economy of Portugal.

Another program is being carried out at the Universidade de Lisboa by the physical oceanography group, affiliated with the Geophysics Center and the Physics Department of the Faculty of Sciences. It consists of a husband-and-wife team, Armando Fiuza and Dr. I. Ambar. He received his masters degree in physical oceanography from the Department of Oceanography of the University of Southampton (UK) in 1974. His wife received her PhD from the Department of Oceanography of the University of Liverpool (UK) in 1978 under Dr. M.R. Howe (*ESN* 33-10:425). Both teach classes at the University. Fiuza has written the first textbook on oceanography in the Portuguese language.

The Department of Physics is divided into two sections, classical physics and environmental physics, or what we in the US would call geophysics. The latter teaching program consists of geophysics of the solid earth, meteorology, and physical oceanography. After five years study and a minithesis, students receive a "Licencia" degree. Of the ten students enrolled in the environmental physics at the present time, six are majoring in physical oceanography.

The oceanography research program is supported by two agencies that are roughly equivalent to our National Science Foundation. One is in the Ministry of Education and the other is in the Ministry for Culture and Science.

Ambar is continuing her cooperative study with Howe on the outflow of water from the Mediterranean Sea. A UK ship has been scheduled to make a Salinity-Temperature-Depth (STD) study of the area south of Portugal eastward to the Straits of Gibraltar next year. This time instead of just studying the core of the outflow, they plan to study the water column from the surface down through the core.

Fuiza's latest paper is on the results of a two-year study of coastal upwelling off the west coast of Portugal. He found (as others have) that the response of the water to wind forcing is very fast (0 to 1 day). An airborne radiation thermometer was used with a Portuguese Air Force plane to repeatedly map the surface temperature over the upwelling area. Fishermen found that sardines were concentrated on the cold side of frontal structures in the upwelling area and seemed to prefer water of about 14°C. Fuiza believes the satellite infrared photos could assist in finding and predicting the location of sardine stocks. Much of Fuiza's research has been on upwelling and the study of eddy structures that show up on satellite photographs all along the coast of Portugal.

The biggest problem the team has to face is the difficulty of obtaining ship time. Although I did not ask the question, there unfortunately did not seem to be much exchange between the University team and other marine research centers in Portugal. However, both husband and wife are hard working and are very enthusiastic about their program and as the Navy increases its efforts both the Navy and the University group could help each other with cooperative efforts.

Marine science has continued to grow also in Portugal's Laboratorio National de Engenharia Civil, located in Lisbon. Since previously visited by this Office, the Laboratory has expanded to accomodate a staff of over one thousand. I spoke with the Director, Julio Ferry Borges, the Chief of the Hydraulic Division, Eng. F.M. Manzanares Abecasis, and the heads of the Estuary, Sanitary Engineering, and Beach and Harbor Sections of the Hydraulic Division. They said that the Laboratory had stagnated during the 2 or 3-year transition period after the "revolution," but that things are now improving rapidly.

Since the last report (ONRL R-8-75) they have built a new wave generator that will generate any desired multi-directional wave spectra. Its principal use is in studying ship movements in harbors. They are now planning a new 80-m-long wave channel to study the effects of waves on marine engineering structures and different types of grains for protecting beaches. The Estuary Section is also building an experimental tank in which they hope to be able to produce various current patterns to study thermal diffusion from simulated power plants along the coast. They are studying the same sites as the Portuguese Hydrographic Institute (see above).

The Laboratory is collecting current and tidal data on four major lagoons in order to design physical models to study how navigation can be improved in their inlets. Concurrently they have a mathematical model in operation to study lagoons and estuaries. They also have mathematic models for wave diffraction, littoral drift, and resonate seiches in harbors. In each case they have constructed physical models to test and improve the mathematical models. One of their staff is spending a sabbatical at the French National Hydraulics Laboratory at Chatou studying French models used to study thermal diffusion from thermal power plants. The Portuguese Laboratory's $10,000,000 budget comes from the Ministry of Public Works, other government agencies, and specific contracts with industry and various government agencies. A small amount comes from harbor engineering studies for former Portuguese colonies.

Many engineers come to the Laboratory for postgraduate training after they have left the universities. They do two to four years of on-the-job training, complete a thesis, and must read French and English to obtain the highly valued title of "Specialist" or "Research Engineer."

When I talked to the Head of the Sanitary Engineering Section, he told me that all his work was with "peeps." At first I looked blank, but then realized he meant "pipes." (Wayne V. Burt)

OPERATIONS RESEARCH

THE BRITISH POST OFFICE

The postal service in most developed countries had, by the middle of the 19th century, become a government service and a monopoly. The telegraph, when it was invented, appeared to be another method of sending letters, and so in most countries telegraphy was taken over by the post office. (In the US, because of our commitment to free enterprise, this did not happen, and in fact there were competing telegraph companies in the US until well into the 20th century.) When the telephone came along in the 1880s, it was gobbled up in most European countries by the same bureaucracy. Since 1902 the British Post Office has had a telephone monopoly except, oddly enough, for Plymouth and Hull. Plymouth has been absorbed but Hull is still independent (publicly owned, of course, but not by the national government) but it is unlikely that this can continue. The telephone system is now beginning to install what they call System X, with digital switching and digital transmission, which is very expensive. It seems doubtful that the small system at Hull can afford this, and since all of Britain will have gone to this system by the year 2000, by then Hull will probably have been absorbed into the national system.

Today there is comparatively little telegraphy. Telephones are an enormous and rapidly increasing business,

which has little to do with the postal service, especially since the introduction of digital communication (computer to computer). The British Government is now engaged in the painful process of breaking these two apart. At the moment, however, British telephones are still run by the British Post Office, and one still goes to the post office to pay one's telephone bill. And the most visible building in London, the great Post Office Tower, is in fact covered with antennas and other electronic devices concerned with telephony.

In a couple of years it seems probable that postal and telephone services will be completely separate administratively. To some extent this depends on the unions. The postal system is labor-intensive and somewhat poorer; the telephone system is capital-intensive and somewhat richer. For these and other reasons the telephone unions tend to favor the split and the postal unions tend to oppose it. The Labour government was not anxious to make a decision on this but the Conservative government appears at the moment to be in favor of it.

Operations research (OR) in the British Post Office is under the direction of L.W. Hill. He was formerly in charge of a division in the Department of Statistics and Business Research, with most of his work being on the postal side. In 1971, when telephone OR was split from postal OR, Hill took responsibility for both operations research and statistics on the telephone side, and now has a group with 14 professionals doing perhaps a bit more statistics than OR. On the postal side, statistics and operations research were split, with Kazimierz M. Jasinski now heading the Postal OR and Systems Development Division in the Postal Operational Research and Management Services Department, with 11 scientists plus support personnel.

Jasinski and Hill both belong to the problem-solving school of operations research (as distinguished from the theoretical or optimization school). Both are quite knowledgeable, even though neither has had any formal education beyond the bachelor's level. Jasinski, for example, recruits primarily graduates of MSc courses (*ESN* 32-12:427). He has no doctorates on his staff, and he feels that MSc's in statistics are better at operations research than MSc's in OR. These recruits are on probation for two years and then, if they do good work, are promoted through the various civil service ranks. These ranks have titles implying administrative responsibilities, but in fact such people are paid for their problem-solving rather than administrative abilities; and Jasinski told me that even he spends 60% of his time on technical work and only 40% on administration. I was surprised not to find more optimization studies, such as those aimed at reducing queue sizes, but apparently the British don't object to long waits in queues nearly as much as Americans do.

Neither Hill nor Jasinski seems to be consulted when major decisions are being made. This is partly because certain major decisions that have been made in the past cannot be changed, specifically the postal code (what we call zip code, *ESN* 31-2:45) system, which was established some years ago at about the same as in the US. Furthermore, the OR groups are insulated from hardware responsibility; that is, the hardware is ordered by someone else, and what responsibility the OR groups have involves the optimal tactical use of such hardware. Finally there are many other groups with different names doing similar work; for example, on the telephone side there is a "network planning" group forecasting changes in traffic and therefore demands on equipment; there is a "marketing research" group forecasting demand for services; and there is a "manpower problems" group forecasting the demand and supply for manpower. All these groups are doing OR but they do not have OR in their titles.

In the British post office, as in the American post office, there was a wave of unjustified optimism 10 to 20 years ago about automation, with the use of optical scanners to read addresses, automatic sorting equipment, and the like (*ESN* 31-11:447). Some unfortunate decisions were made because of this optimism. At the present time there is a much more realistic approach to what can be done. For example, it is clear that some mail will never be marked with postal codes. Similarly, the British have not yet followed the American lead of charging extra postage for mail which is not in standard sizes. Within these constraints, the OR group has made some studies of what can be done by way of sorting automatically. Jasinski has discovered the famous paper by Huffman (published in the *IRE Proceedings* in 1952) on "Minimum Redundancy Coding" and applied it cleverly to the sorting problem. He has found that each letter is sorted on an average of three times—receiving

about 1.3 sorts in the outward (or posting) office, another 0.4 sorts in the "office of exchange," and an additional 1.3 sorts in the inward (or delivery) office. The sorts in the office of exchange cannot be automated; and of the remainder, much of the sorting takes place in small offices of delivery where it doesn't pay to mechanize. On the average, therefore, there is an absolute upper limit of about 2 of these 3 sorts that can be mechanized.

In the course of these studies Jasinski's group built what he calls a "delivery model," reported in *Computers and Operations Research*, 4, 287-294 (1977). The model describes the number of delivery staff hours required for a particular post office in terms of four times: (1) preparation time—before the deliveryman leaves the post office, while he is sorting the mail and otherwise preparing it; (2) traveling time—from the post office to the first delivery address and from the last delivery address back to the post office; (3) street-walking time—the time it would take to walk the streets from the first delivery address to the last delivery address if no deliveries were actually made; and (4) calling time—the time spent walking from the street up to the front door, delivering the mail, and walking back to the street. Calling time is dependent upon the fraction of houses to which no mail is delivered on any given day (handled by a neat Poisson model) and on the distance from the sidewalk to the front door or mailbox, which depends on the nature of the area.

This delivery model has been extremely useful, both in assessing staffing levels and in predicting changes in workload. For example, if traffic is declining, how often should one revise the delivery layout? If traffic is growing because the number of houses is being increased, how many more postmen are needed? Basically the model asserts that the number of staff hours required is a linear combination of the amount of traffic (that is, the number of letters and parcels to be delivered) and the number of delivery points. With certain additional modifications, the model has been very effective in predicting the marginal costs of anything one wants to compute, and has been used to plan the number and location of offices. It has, of course, been necessary to convince both the management and the unions, but both now seem to have bought the model.

The extension of the delivery model to a collection model is fairly straightforward. The latter is actually easier because every letterbox must be visited every time (not every house is visited every time there is a delivery). They are also building a model of what they call circulation; that is, the stages between collecting and delivery, including outward sorting, transport, and inward sorting. Even when this is completed (and that is a couple of years down the road), it will model only delivery of letters. Parcels have been more or less completely omitted, and there is still much to do in other respects. For example, 4,000 addresses (most of which are large companies, but some of which are government offices) receive 40% of all UK mail. The smallest of these receives more than 300 letters a day, and by comparison the average residence receives about 300 letters per year. Letters to these addresses receiving a great deal of mail are delivered by van, not by a postman on foot (or bicycle or moped or whatever), and clearly such delivery requires a separate model.

The other new line along which they are working is to provide information to managers at various levels which these managers may use for control. "Control problems," Jasinski told me, "are becoming fierce." In case of disruptions caused by weather, railroad troubles, or strikes, for example, managers need better information than they now have in order to control the organization. Jasinski's group is working on models of how such information can be supplied.

Hill's group on the telephone side, which is somewhat larger than Jasinski's, does a great deal of statistical work. By this they mean descriptive statistics to supply accounting information, such as the average life of various categories of plant, as well as quality of service and indicators thereof. These quality-of-service indicators can be rather tricky. The customer's perceived quality of service, for example, which is subjective, may be rather different from the customer's experience, which is objective; the former may vary depending, for example, on how big his last bill was. Furthermore, the customer's experience, even though objective, is different from the network performance. In general, for example, the fraction of attempted calls incompleted because of busy lines will differ for a partic-

ular customer from the number measured over the network as a whole, because an individual customer does not make average calls—he calls particular individuals.

Again, when attempting to build a model of traffic flow to test the assumption that this is proportional to the densities at the end points (i.e., that the traffic between city A and city B is proportional to the populations of these two cities), one notices that what seem like the obvious definitions of traffic and peak traffic are far from obvious. It often turns out the number of calls from city A to city B drastically differs from the number from city B to city A, for example; and since the traffic does not peak in different places at the same time, there can be considerable discrepancies between the hourly and daily peaks.

There has been some quite sophisticated work done in attempting to determine for the accountants the life of building-and-plant from incomplete records. Hill's group compared available specific information with judgment, using Bayesian techniques, to obtain estimates that have been accepted as the basis for financial statements. They have also become involved in the question of scheduling operators on the switchboards, a fairly standard scheduling problem, modified of course by queuing theory concepts that depend upon how long one is willing to have a customer wait before being served by the operator. There are now boards that automatically sequence calls in the queue, and there is a question as to how many places should be available in that queue. By increasing the number of places one decreases the number of calls that are lost (by the incoming call receiving a busy signal) but increases the average delay of calls that do wait. In determining what is optimal one has to know how the customer reacts and what he prefers. Hill's group has a huge amount of data on this kind of thing and has built a preliminary model.

I gather that the future of operational research at the Post Office and Telephone in Britain is promising in the sense that this kind of work will continue to be done, and unpromising in the sense that it will probably not be done under the name of operational research. In particular, Hill will retire in the near future, and he tells me that after his retirement his division will probably do more statistical and less operational research work. (Robert E. Machol)

STRATEGIC CHOICE

A meeting on "Operational Research, Social Science and Strategic Choice", sponsored by the Operational Research Society was held on Wednesday, 24 October 1979. The locale of the meeting, or "venue" as they say in these parts, was the Royal Society on Carleton House Terrace in London, with the front windows looking out on Pall Mall onto St. James's Park. The portraits hanging on the walls of this building are a bit intimidating: Isaac Newton, FRS; René Descartes, FRS; Charles Darwin, FRS; Michael Faraday, FRS; and our own P.M.S. Blackett, who was first a physicist (and subsequently Nobel laureate), next (in 1940) founder of operational research, and lastly (1970-74) President of the Royal Society. It would be nice to talk about feet having trod hallowed halls, but in fact the Royal Society has moved into these quarters only recently. Nonetheless, the quantitative thinking that characterized all of these men was totally absent from the present session, which was given over exclusively to qualitative social scientists.

Forty-two attendees paid £30 apiece to spend the day listening to 6 speakers, 5 of whom work for a London organization called the Centre for Organizational and Operational Research (COOR), the sixth being an alumnus of this organization. As John Friend, chairman of COOR, said at the opening, "The main aim of this event is to stimulate some discussion about the relevance to the wider OR world of what we in COOR have been doing over the 16 years of our existence so far." Actually the organization began as an Institute of Operational Research" (IOR) established in 1963 under the joint aegis of the Operational Research Society and the Tavistock Institute of Human Relations (TIHR). Ten years later, in 1973, IOR merged with the Human Resources Centre of TIHR to form the present group, which has only recently adopted the name COOR. It is now housed with, and supported by, TIHR, with ORS offering mainly moral support. Friend also explained to his British listeners that in the US, COOR is a beer; I refrained from telling him that it's Coors.

The next papers were given by Don Bryant and John Luckman, on "Organizational Change and Operational Research." Bryant talked about the "Two O's" (as in the title of his paper), following somewhat the vein

of C.P. Snow's "Two Cultures." He even drew a graph "where the y axis becomes the degree of concern for (or utilization of) organizational research (using explicit social science concepts)and the x axis relates to the degree of concern for (or utilization of) operational research methods," and talked about "a (1,9) style as a deliberately conscious attention to the social and psychological process," and so forth. There was a good deal of talk in his presentation and in the subsequent discussion about a "(5,5) man" and a "(9,9) man"; but in spite of my requests during the following discussion, I was never able to find out exactly what these numbers meant, and I suspect that there were different meanings in the minds of a number of people. (During tea afterwards someone asked me "What's a hardliner like you doing at a meeting like this?")

The second half of the paper was delivered by Luckman and was a fascinating case history where both O's had been applied. They had been called in as OR people to adjudicate a dispute between ambulance drivers on the one hand and controllers on the other, the latter being located about 15 miles away from the city where the ambulance drivers operated. The control staff perceived the ambulancemen as lazy and uncooperative, whereas the ambulancemen saw the controllers as insensitive and dictatorial. Both parties were anxious to have a statistical study made, each party being confident that unbiased outsiders would demonstrate that he was "in the right." While in fact such statistical studies were eventually made, what was chiefly required was better appreciation by each party of the other's point of view. That this was achieved was the principal success of the project, although there was ultimately some improvement of efficiency which gave the ambulance drivers more of the rest breaks that they had been demanding.

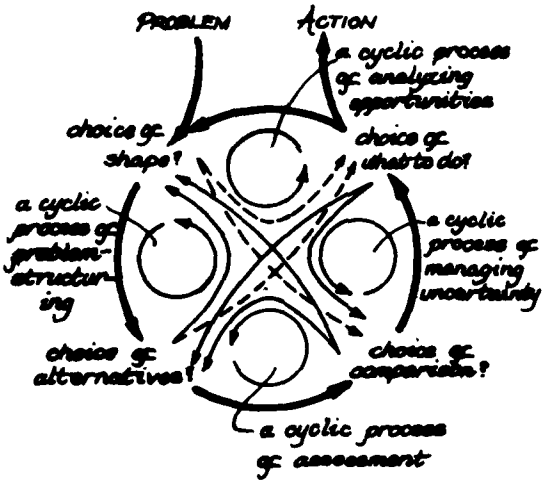
The next paper, by Michael Norris, was on "Operational Research and Multi-Organisations." Norris did not specifically define "multi-organization" but apparently he was talking about multi-criteria decisions problems, in which there are two or more organizations, each with a different criterion function. He talked about "a more scientific" approach to decision-making, but I had difficulty understanding this approach. Being a "hardliner," I have always had trouble with papers that use phrases like "social ecologies," "cultural gradients," and "reticulist (or networking) skill." There were some "case studies"; in one such case study, one organization did not understand the power structure of another and therefore addressed their correspondence to the wrong people, with the result that there were delays in getting response to written material.

At the end of his talk Norris listed a dozen propositions as a summary. The first was "multi-organizational studies provide useful ideas for other OR work." The last was "beware of splits." In between there were a number which were rather vague, such as "coordination has to be selective," and one which was quite specific: "Seek agreement on actions, not necessarily on aims." This is probably a useful prescription in some situations, but I am not clear on exactly when Norris felt it should be followed.

The following two papers, one by Allen Hickling and the other by John Friend, discussed strategic choice, which was a basic part of the nominal subject matter of the meeting. Hickling stated that he used "the word strategic in a particular sense to imply interconnected as opposed to high-level decision making." He asserted that the strategic choice approach was very useful, but that he had time only to describe one aspect of it, namely its use as a framework for communication in group working. His example of inadequate communication involved a structural engineer, a social scientist, and an architect discussing a metal handrail on a bridge. They claim that it is too high, too low, and just right, respectively. The engineer thinks it is too high because of stresses and bending moments; the social scientist thinks it is too low because of human behavior; and the architect thinks it is just right because he is thinking in terms of economy of materials, of form and aesthetics (and because he probably designed it in the first place). For improving communications, Friend recommended that people write things down on large sheets of paper (on which many people can work at the same time) and then paste them up on the wall where everyone can see them and where, unlike a blackboard, nothing is erased, so that all their ideas can be recovered if necessary.

He drew the attached diagram to indicate that the process of strategic choice is basically cyclic, and this makes problem solving very difficult because "speech and writing are for most people linear processes." Much

of his talk was then centered about the various headings in this diagram. At the end of his talk he discussed uncertainty, and the model which he had developed to come to grips with it, namely, to divide uncertainties into three classes: uncertainties about value; uncertainties about environment; and uncertainties about "related decisions" (that is, decisions made by others). These uncertainties lead to the need for policy guidance, for more information, and for taking the broader view, respectively, and show how strategic choice can offer a framework for the mutual exploration of uncertainties.



Friend asserted that the strategic-choice approach was to be contrasted with the systems approach, and that the latter had its origins in large-scale urban model building. It was also to be contrasted with "decision technology" (by which he meant mathematical modeling), which is relevant for decision processes concerned with the regulation of particular production or operational systems. Strategic choice is a method to help groups of people to explore their view about the structure of choices rather than to search for an optimum within some agreed problem formulation. He elaborated on Hickling's classification of uncertainty; for example, the extensive use made by planners in the 1960s of large-scale models of land-use transportation systems were well meaning attempts to reduce significant uncertainties about the environment, but failed because the most important uncertainties were really of the other two classes. Referring back to the cyclic diagram, he asserted that OR scientists have a role to play mainly in the lower reaches of the diagram, while strategic choice can be very useful in the upper reaches.

The final paper of the day was given by John Stringer, for many years at IOR but currently in Sydney, Australia, who gave a very neat and concise summary of all that had occurred that day and added a few clear-cu thoughts. He related the discussions to the "Ackoff debate," referring to the provocative and controversial articles published by Russell L. Ackoff (Univ. of Pennsylvania) in the Society's Journal at the beginning of 1979. He pointed out the developing importance of pluralism in management, with government and labor having voices as well as the nominal owners. As an example of the increase in multi-organizational settings, he described a new coal-mining project in New South Wales (Australia). It involves a number of government departments (Treasury, Natural Resources, Joint Coal Board), and a number of other industries (electricity, railways, maritime services, and the like). It was necessary to have financing from several different groups, namely from multinational companies (the ones who have the cash), from the Japanese (the ones who will be the customers), and from the Australians.

Stringer stated that two necessary conditions for the research process are access to interesting situations and an appropriately experienced scientific team. In connection with the team, he used an interesting phrase, namely, "third generation OR people." These are people who have never actually done OR and who have learned their OR from professors who never actually did OR, although presumably the latter studied under real OR people. He also referred to Bryant's x,y diagram mentioned above, in which the y-axis represented personal and organizational relations, and the x-axis skill in modeling (conventional OR). He pointed out that most problems lie on or near the line $x = y$, but that the points at which access to these problems can be negotiated (based on those in government who grant funds and the like) are typically close to one of the disciplinary axes, and he said that we should be prepared for the emergence of new modified or adapted forms of interorganizational relationships.

I talked to a number of the attendees, including people who do hard quantitative OR work in industry, and most of them felt that the day had been rewarding and fulfilling. However, with the exception of Luckman's case history and Stringer's peroration, I personally found most of the day vague and frustrating. (Robert E. Machol)

SYSTEMS RESEARCH INSTITUTE

The Systems Research Institute of the Polish Academy of Sciences, located in Warsaw, was established three years ago, shortly after a similar institute was established in the Soviet Union. This Polish Institute arose from an older organization, the Center of Applied Cybernitics and Information Science of the Institute of Organization Management and Control Sciences. It has a broadly defined charter: "mainly in the direction of development of systems analysis methods and mathematical models, operations research methods and computer optimization methods and their application to technological and socio-economic systems." The director of the Institute is Prof. Roman Kulikowski, a member of the Polish Academy of Sciences who is currently on leave of absence working at the International Institute for Applied Systems Analysis (IIASA), Vienna, Austria (*ESN* 32-2:51)

Kulikowski also heads one of the five departments of the Institute, namely the Department of Large-Scale Systems. The heads of the other four departments all have the post-doctoral European degree called "habilitation"; they are: Andrzej Straszak, Department of Control Theory; Kazimierz Maficzak, Department of Industrial Applications of Cybernetics; Stanislaw Piasecki, Department of Operations Research; and Stanislaw Walukiewicz, Department of Mathematical Programming. All but the last-named hold the title of professor, a rank awarded by the government when they feel it is due, without regard to the availability of a "chair" as is required in most European universities. While primarily a research organization rather than a university, there is some teaching done at the Institute, mainly at the doctoral level, and several doctorates are awarded each year.

The Institute has about 240 people, about 2/3 of whom are professionals. This is a larger ratio of professional to support staff than would be found in most American institutions, and represents an unsatisfactory situation in that the professionals have to do a good deal of their own clerical work. One of the scientists to whom I talked told me that this was typical of the bureaucracy's tendency to hire expensive professionals or buy expensive equipment and then balk at the minor expenses required to support them. He related that while he was working at one of the larger research institutions in the Soviet Union, their main computer was out of service for three months for lack of paper.

I talked with Piasecki through an interpreter. His department of about 40 people is divided into 5 groups, each headed by a person at the doctoral level. One of these is a woman, Dr. Barbara Mazbic-Kulma. I discovered that the position of women in science in Poland is not unlike that in the US: by law they are equal and their pay must be equal, but at the present time most of the high-ranking positions are held by men. There is an increasing flow of women into the system; for example, 30% of the students now at this Institute are women.

Mazbic-Kulma is head of the group entitled "Theory of Systems Organization," but in fact works largely on transportation and especially bus problems (another group in this department is entitled "Modeling of Transportation Processes" and is confined entirely to railroad problems). They have actually determined through computerized algorithms the schedule for all intercity buses in Poland, of which there are about 10,000. The schedules allow for maintenance, although the location of maintenance centers has been done by old fashioned methods and will be computerized at a later time. The objective function, I was told, was to maximize customer satisfaction; but it turns out that this has a specialized meaning: since there are not sufficient buses in Poland to meet the demand, they are really trying to maximize the fraction of the needs that can be met. I was told that they also attempt to minimize costs; apparently they do not use any sophisticated multicriteria techniques, but rather optimize on one criterion at a time.

Another problem being worked on in this department is location of maintenance depots for electronic equipment (such as radios and TVs) in Warsaw. This is of course a problem which would be solved by free-market forces in Ameri ca. Apparently the Poles feel that it can be more efficiently solved by planni

They also work on quality control. Here again, there seems to be little development of new theory. They have set up quality-control procedures at a factory producing light bulbs and at another producing semiconductors. (I was told that they have rather sophisticated production lines, including one for manufacturing large-scale integrated circuits).

More interesting to me was Walukiewicz's Department of Mathematical Programming. Walukiewicz is an unusually bright and dynamic young man. He received a Bachelor's degree in electric power from Moscow University, a Master's degree in computer science, and a PhD in operations research from the Polish Academy of Sciences, and the "habilitation" in mathematical programming. He has just returned from a term as Visiting Professor at the Institute of Datology atthe University of Copenhagen (*ESN* 33-10:430). His department is divided into three groups; but as explained to me by Dr. Marek Libura, head of one of these groups, the titles and charges of these groups do not bear any significant relationship to what actually happens.

The Mathematical Programming Department, unlike the Department of Operations Research, works primarily in the development of new theory. Some of the work seemed to me to be of very high caliber. They have 5-year funding as part of the government's 5-year plan, and while they write a fairly detailed proposal each year explaining what they plan to do in the next 12 months, this appears to have little to do with their funding. Walukiewicz has negotiated one external contract with the building industry, which supplies modest increases in salaries for some of his people. By his international reputation he has been able to work out close relationships not only with the University of Copenhagen, but also with the Universities of Cologne (Germany), Pisa (Italy), and Linköping (Sweden), involving exchanges of personnel and the like.

Libura is interested primarily in sensitivity analysis in mathematical programming. Sensitivity analysis is of course closely related to duality theory, or the theory of shadow prices. He is following work performed elsewhere demonstrating that shadow prices do not in general exist in integer programming problems, but that one can define appropriate shadow functions (which correspond to shadow prices if everything is continuous and linear). An analysis of these functions is useful for determining insensitivity regions—that is, regions in which the parameters of the problem may be changed without changing the optimal solution. It is well known, for example, that such insensitivity regions exist for linear programming problems in connection with the parameters of the cost function as well as with the right-hand-side constants of those constraints which are inactive at the optimum. In integer programming this may even be extended. to the right-hand-side constants of active constraints. Libura has been working on the determination of such regions using, among other things, group-theoretic approaches, and has obtained particularly interesting re sults with the knapsack problem.

Marek Trojanowski is just completing his doctorate under Walukiewicz, working on optimization problems in nonlinear networks. In particular, he is examining capacitated flows in which the cost on each arc is a concave nonlinear function; and he is taking advantage of certain special data structures involved in the network to perform more efficient search of the tree. He stressed to me that this is not just a question of how to utilize the input data, but of how to manipulate the data during the applications of the algorithm. This appears to be part of the general stress in this department on what they call the application of computer science in operations research; namely, it is not just a question of finding an optimal solution, but now they are also attempting to improve the efficiency of the computational methodology. There is a good deal of sophisticated analysis of problem complexity in this department, and stress on efficient computer methods of finding solutions to real problems.

I was thoroughly impressed with the work going on at this Institute. These scientists are thoroughly familiar with the literature not only in their own language, but also in English and Russian. Many of them seem highly competent, and the work they are doing is definitely first rate. I suspect those of us interested in operations research and systems analysis will be hearing more of the Systems Research Institute of the Polish Academy of Sciences. (Robert E. Machol)

PHYSICS

APPLIED SOLID STATE PHYSICS IN FREIBURG

In southwest Germany, on the edge of the Black Forest and about 45 minutes north of Basel, Switzerland, by train, lies the charming city of Freiburg. Since there is another city of the same name near Hamburg and a third one in Switzerland, the Freiburg near the Black Forest is usually identified by its region; i.e., it is generally known as Freiburg im Breisgau.

Freiburg i. Br. is dominated by the superbly carved medieval spire of its red sandstone cathedral, which was begun around the year 1200. I was very much impressed by this cathedral and especially by some of its humorous gargoyles. Many of the buildings in Freiburg were destroyed during WWII. Some of the more important ones have been reconstructed, and to the uninitiated they appear several hundred years old. The city has a population of almost 200,000 and a university which was founded in the 15th century. It is both a tourist center and also a manufacturing city, with products in the fields of scientific instruments, printing, electronics, chemicals and textiles.

My reason for visiting Freiburg was to spend the day at the Institut für Angewandte Festkörperphysik (IAF), the Institute for Applied Solid State Physics. For years I have met scientists from this Institute and listened to their technical papers, so I was eager to learn more about this productive organization.

My host was Prof. Dr. Adolf Goetzberger, the Director of IAF. Goetzberger is well known to many in the field of semiconductor devices. He worked at Shockley Laboratories and Bell Laboratories for a number of years, has been active in IEEE activities, and is a Fellow of IEEE. I found him a most cordial host.

IAF is one of the 25 institutes operated by the Fraunhofer-Gesellschaft, whose mission is to perform applied research. The Institute has a scientific staff of around fifty, supported by 65 technical assistants. The mission of IAF is to perform experimental and theoretical research on the solid state physics of non-metals. The main field of activities is semiconductor physics, which includes the production of prototypes and small quantities of specialized electronic devices. IAF is viewed as a link between basic research and industrial applications. Research is supported by government grants: direct research contracts with the government, the Deutsche Forschungsgemeinschaft, (the German Research Association), and industry.

The areas of research at IAF fall into six categories: (1) solid state physics, (2) solid state chemistry, (3) technology, (4) infrared physics, (5) microwave physics, and (6) display physics. The leading research programs and personnel in these areas are described in the following paragraphs.

The Department of Solid State Physics is concerned with microwave and magneto-elastic interactions and light scattering by spin waves. This department is also doing or has done work on non-linear optical mixing in I-III-VI$_2$ crystals; 10.6 μ upconversion in $AgGaS_2$; YAP:Er lasers; optical absorption by small polarons; and electrochromism of MoO_3 and WO_3, by electron spin resonance and optical spectroscopy. The Head of the Department is Prof. Dr. J. Schneider, who is well known in the US, where he worked for a number of years at Duke University with Prof. Dr. Walter Gordy, and at Texas Instruments.

The Solid State Chemistry Department, under the direction of Dr. A. Räuber, prepares and grows crystals of the binary and ternary chalcogenides and pnictides, magnetic oxides and niobates. This group is also engaged in materials assessment by optical and x-ray methods, trace analysis with spark sources, and secondary ion mass spectroscopy.

The Technology Department, headed by Dr. C. Fritzsche, engages in process development, technology service, and process controls. Specific work includes ion implantation (including superchanneling), plasma etching and deposition, high-pressure oxidation, thin-film technology, silicon technology for charge-coupled devices, scanning electron microscopy (including microanalysis) ellipsometry, and parameter control in silicon technology.

Some of the efforts in the Infrared Physics Department, under Dr. J. Baars, deal with heteroepitaxy of small bandgap semiconductors for use in atmospheric windows from 3-5 μm and 8-12 μm. In particular, the work deals with PbTe and $Pb_{1-x}Sn_xTe$ and GaAs epitaxial films by the techniques now generally known as Auger Electron Spectroscopy (AES) and Electron Spectroscopy for Chemical Analysis (ESCA, *ESN* 29-5:233), and has worked on GaAs (CsO) photocathodes.

Dr. W. Haydl's Microwaves Physics Department has been preparing III-V semiconductor devices (Schottky mixer diodes, Gunn diodes) for frequencies up to 100 GHz; has worked on molecular beam epitaxy of GaAs; has performed materials evaluations and studies on GaAs and InP; and has constructed signal-processing devices based on surface acoustic waves.

The Display Physics Department, under the joint leadership of Dr. G. Meier and Dr. G. Baur, has been performing research on electrooptic effects in liquid crystals, including studies of elastic and dielectric properties of nematic liquid crystals, the anisotropic optical absorption of doped liquid crystals, and optical properties of liquid crystal display cells. Other work has dealt with electrochromic effects in transition metal oxides, the analysis and evaluations of new display technologies, and fluorescent collectors.

It would take a 100-page volume to give even a brief description of all the interesting activities in progress at IAF. Indeed, that is about the size of IAF's Tätigkeitsbericht (annual report). I will limit myself here to discussing some of the more outstanding developments I saw during my visit. (It will probably be evident that some of the projects result in patentable devices. For that reason, it interested me to learn that, by law, the inventor receives 20% of the royalties from any item developed by him and subsequently patented.)

Among the outstanding topics of my visit were the following:

Solar energy conversion fluorescent collectors: This new type of collector consists basically of a set of transparent sheets of materials appropriately doped with fluorescent molecules. The principal of operation is shown in Fig. 1. Here an incident beam of light interacts with a dye molecule D that is suspended in a slab of material whose index of refraction if n. If this light is of the correct wavelength, it will be absorbed by D and emitted at a different wavelength, with a probability of emission equal in all directions. Part of the emitted light will leave the transparent medium (F_4); the rest, depending on n, will be reflected back into the slab because it intersects the surface at an angle of total internal reflection. Most of the emitted light can be trapped and ultimately directed to pass into a solar cell or thermal converter at the right end. With such fluorescent collectors, energy concentration ratios of 100 and more could b possible. Since quite a number of dye have fluorescence efficiencies of 100% it should be possible to construct ver efficient collectors. Moreover, by using different materials in adjacent sheets, the solar spectrum can be spli into bands of different wavelengths, with the prospect of achieving more efficient photovoltaic conversion than is possible today. Goetzberger, one o the originators of the principle, poin out that a potentially important advan tage of fluorescent collectors over ordinary concentrators is that they ar capable of concentrating diffuse sunlight.

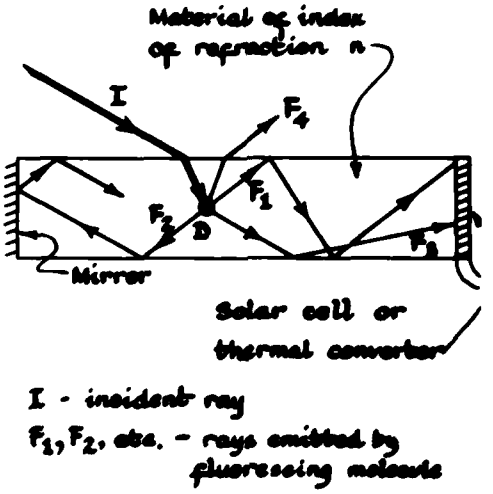


Figure 1. Principle of Fluorescent Collector

Work on this idea has been in pro gress for the past two years, and ther is great optimism for its success. Th major problems remaining are the synth sis of dyes with all the required prop erties (including the right wavelength regions), identification of inexpensiv plastic materials with high transparen (particularly in the near infrared re-gion), and the development of compound semiconductor solar cells matched to t fluorescent emission.

Fluorescence-activated liquid-crystal display: By combining a liqui crystal light valve with a plate of transparent plastic doped with a fluo-rescent dye in the manner of solar energy conversion fluorescent collecto a great intensification of brightness of the displayed digits is achievable

through the efficient use of ambient light, for in this plastic plate the ambient light is collected, guided and finally emitted at the digit segments.

Magnetic materials and phonon and and magnon investigations: IAF has developed a technique for growing large and qualitatively good crystals of iron borate ($FeBO_3$), a weak ferromagnet, and has received requests for samples of this material from laboratories all over the world. One interesting aspect of $FeBO_3$ is that because of a strong exchange interaction between acoustic waves and spinwaves (i.e., phonons and magnons) the velocity of acoustic waves can be changed by altering the intensity of an applied DC magnetic field. A change of approximately 50 gauss will change the velocity of microwave phonons by as much as 30%, as detected by Brillouin scattering techniques. There has also been considerable activity in identifying spinwave spectra of materials such as YIG.

Pictorial representation of standing acoustic surface waves on piezoelectric materials: Secondary electrons emitted because of raster scanning with an electron microscope beam (REM) are modulated by electric fields of the acoustic surface waves on a piezoelectric medium. The local REM picture contrast is therefore a measure of the high frequency amplitude of the acoustic wave on the surface. By this technique, the exponential decay of a standing surface acoustic wave inside of split reflectors with 200 aluminum stripes has been measured.

Investigation of damage in ion implanted layers by scanning electron microscopy: IAF has developed a method for determining the damage caused by ion implantation in the first 100 Å adjacent to the surface. This work is being continued with two ion implanters (150 kev and 350 kev), in particular for III-V compounds.

Electrochromic Displays: The objective of this work is to develop electrochromic displays (ECD), which may have advantages over liquid crystals displays. A basic ECD structure is shown in Fig. 2, in which a glass slide coated with transparent conducting SnO_2 and with WO_3 is shown immersed in an electrolyte, in which a conducting wire is also immersed. When a negative potential is applied to the WO_3, it turns blue. It then stays blue, even after removal of the potential. When the contacts are shorted or the voltage is reversed, the WO_3 is bleached. Problems limiting adoption of this scheme to practical devices are a deterioratio in the color switching behavior after about a million cycles, and the rather long switching time of 100 msec. Besid attempting to optimize the materials and the techniques of fabricating ECD structures, the IAF group has been studying the causes that limit performance. Among these are the influence of water trapped in the WO_3, the causes of the trapping, and the existence of diamagnetic polarons in WO_3. Research is also in progress on the possible replacement of the liquid with a solid electrolyte.

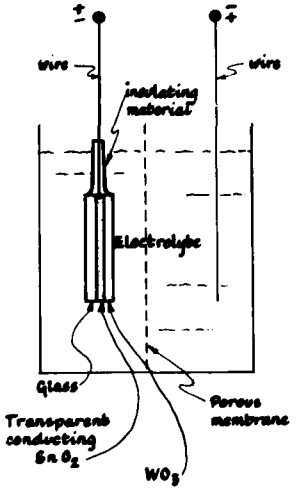


Figure 2. Principle of electrochromic display

Lithium Niobate: This material has been used for near-infrared mixing, frequence doubling, holographic storage, acoustic surface waves, and photovoltaic conversion—all areas in which IAF has worked. Among several $LiNbO_3$ topics presently under investigation is a scheme of growing periodic domains into a crystal to permit the construction of efficient ultrasonic transducers for very high frequencies.

Infrared Detectors: This has involved work on the epitaxy of $Pb_{1-x}Sn_xTe$ and related research, investigation of oxidation and the thermal desorption of $Pb_{1-x}Sn_xTe$ surfaces, passivation of PbTe surfaces by tellurium, construction and treatment of $Pb_{.8}Sn_{.2}$ diodes, integration of extrinsic silicon infrared detectors with charge-coupled devices, and others.

By now the reader should have developed an appreciation of the wide

range of activities of the Institute. I was very much impressed, and wish that there had been time to learn details of some of the work in progress. (Irving Kaufman)

LASER PHYSICS AT TECHNISCHE HOGESCHOOL TWENTE

The Netherlands' thirteen universities are divided into two categories according to the number and nature of their faculties. Seven institutions are 'complete' universities and another six have university status, the difference between the two being rather vague. The Technische Hogeschool Twente (Technological University of Twente), founded in 1961, is the newest of the second category of universities and is actually located in Enschede (instead of Twente), a few miles from the German border. The total enrollment of the thirteen universities is about 110,000, making the University at Enschede, with its 2,800 students, one of the smallest.

Last November, the author visited Enschede and was hosted by Prof. W.J. Witteman, Head of the Quantum Electronics Group, one of the eight groups in the University's Department of Applied Physics. In 1969, when this department was founded, Witteman came to Enschede from Philips Research Laboratories (Eindhoven) with the objective of developing a laser-physics research program. A quantitative indicator of Witteman's success in this endeavor is the size of his group: 6 PhDs, 5 PhD students, and 3 technicians. Another indicator, the quality of the research program, is hopefully communicated in the following paragraphs.

The research efforts of the Quantum Electronics Group have concentrated on CO, CO_2, and excimer lasers, and the phenomena intimately related to these lasers; e.g., mode locking in multi-atmosphere CO_2 lasers. This work constitutes the sole laser-physics research program in the university community of The Netherlands, and the group's primary objective is the development of lasers for plasma research and laser-induced fusion experiments. The group's efforts from 1975 through 1978 were devoted primarily to CO_2 laser problems, and a number of significant developments resulted from their work. Among their accomplishments in the area of self-sustained single-discharge CO_2 TEA lasers was the development of a novel excitation technique that resulted in high power output and large small-signal gain. The laser utilized polished aluminum electrodes shaped to provide a uniform field in the 20 mm gap between them. These electrodes had a height profile of 10.7 mm, a width of 64 mm, and a length of 40 cm, and were driven by a two-stage Marx generator characterized by a fast rise time (~15 nsec). The main feature of this laser, that is credited with the resulting large gain, etc., is the large area uv source that provides for fast, homogeneous preionization. As the design details of this unique method of uv preionization have been described in the literature, they will not be repeated here [(G.J. Ernst and A.B. Boer, Optics Co Commun. 27, 105 (1978)]. This combination of electrode configuration, fast pulsing, and large area, homogeneous uv preionization provides for a very homogeneous discharge (no streamers) which in turn provides for a high energy output beam of improved optical quality. In earlier work on TEA CO_2 lasers at Twente, in which uv preionization was provided by two wires positioned symmetrically along the length of the electrodes, the use of both a low-ionization potential seed gas (tri-*n*-propylamine) and roughened electrodes was required to obtain a stable, homogeneous discharge. However, with the fast-pulse, large-area uv preionizated laser, neither a seed gas nor roughened electrodes were required.

In the device described above, a maximum energy production of about 60 J/l and a small-signal gain of 6% were realized. In a recently evaluated 1 liter laser of similar electrode design, but having a 6 cm electrode spacing and a pulse width of 200-300 nsec, a maximum energy production of 70 J/l was observed. As all observations indicated that this laser design has good scalability, a larger device is under development. This will be a 6 liter device having a 60 cm discharge length and an electrode spacing and width of 10 cm. Should the maximum energy production scale with volume, this device should have an output in excess of 400 J/pulse.

To better understand the contributions of the usual gas additives (N_2 and He) to the pulse width of mode-locked CO_2 lasers, a study of mode-locked pulses in TEA and multi-atmospheric CO_2 lasers was conducted. In the course of this study, new analytic and experimental techniques were developed, and a brief report of two of these techniques follows. Mode locking was induced by an acoustooptic device that produced the required periodic loss

modulation. Lacking a means of direct measurement of pulse widths less than 0.7 nsec, an expression was derived that relates the pulse width to the maximum frequency detuning of the laser. The pulse width was found to be inversely proportional to the maximum frequency detuning, where this parameter is defined as the difference in frequency between that at maximum output (gain) and that at which laser action ceases. This detuning can be produced simply by changing the mirror separation, and the maximum frequency detuning (and hence the pulse width) can be expressed in terms of the maximum mirror separation change. The analytic expression for the pulse width indicated, and experimental results verified, that the pulse width is independent of the laser-discharge parameters (e.g., input energy) and is negligibly dependent on the modulation parameters (e.g., modulation depth).

Excellent agreement was found between the pulse widths as determined directly and indirectly up to laser-gas pressures of 3 atm. Above this pressure direct measurement of the pulse width was precluded because the pulse width was shorter than the time constants of the measurement equipment ($\sim$ 0.7 nsec). Helium was found to have a large effect on mode-locked pulses, and contrary to predictions deduced from absorption measurements of CO_2 laser gas mixtures under neutral conditions, it was observed that under discharge conditions the line width increased and the pulse width decreased with increasing helium percentage.

The above-described technique for determining the pulse width requires a knowledge of the laser's small-signal gain. As the use of a low-power, stabilized CO_2 laser to irradiate the system under investigation can, for a variety of reasons, yield unreliable results, a very sensitive and reproducible technique of determining the gain was developed. The essential feature of this technique is the use of an intracavity variable-loss element with which the threshold conditions of an oscillating pulsed system can be determined. The group at Twente chose to use germanium, which has a temperature-dependent absorption, as the loss element. After calibrating the germanium loss element, the absorption was increased by heating the crystal until laser threshold was reached. Accurate determination of the absorption loss at threshold, and hence the small-signal gain, was facilitated by temperature controlling circuitry capable of maintaining the crystal temperature stable to within 0.1°C.

In 1978, the Quantum Electronics Group commenced work on e-beam-pumped KrF* lasers. This effort was in addition to, rather than replacing, their work on CO_2 lasers. One of their first contributions in the excimer laser field was the observation of a dramatic increase in output power upon optimizing the diluent gas mixture. The laser system used in this optimization study had a 50 cm active length and a 4 cm diameter. The laser medium was transversely excited by a 750 kV e-beam having a 100 A/cm^2 current density, and a 30 nsec pulse duration. To date, virtually all kinetic and parametric studies of KrF* lasers have been performed on the triple mixture Kr, Ar, and either F_2 or NF_3. However, a 50% increase in output power was observed when an optimized mixture of Ar and Ne was used as the diluent. An output energy of 2.1 J (6% efficiency) was obtained from a gas mixture of 1 torr NF_3, 75 torr Kr, 1.5 atm Ar, and 5.5. atm Ne. The following explanation for the increased output was proposed. In addition to Ne acting as an important intermediate energy carrier in the formation of KrF*, an efficient production of Ne metastables (Ne*) can occur, which upon collision can ionize the Ar and Kr atoms, e.g., $Ne^* + Ar \rightarrow Ar^+ + Ne + e$. As Ar^+ and Kr^+ ions are key ingredients in the formation of KrF*, this Penning reaction can result in an enhanced production of this excimer.

During a recently completed e-beam pumped KrF* project, a comparison was made of two excitation geometries: the one-sided transversal and the coaxial (radial). To eliminate as many variables as possible, the two lasers had the same length and gain volume (50 cm and 0.63 liters), and were designed to be used with the same e-beam machine (600 kV_{max}, 60 kA, and 50 nsec). The output spectra from these lasers indicated that the energy emitted at wavelengths other than 248 nm was negligible. The optimum gas mixture for the transversal laser was 4 torr F_2, 120 torr Kr, and the balance Ar with a total pressure of 2.5 atm for maximum efficiency, or 4 atm for maximum energy. The optimum for the coaxial laser was 6 torr F_2, 200 torr Kr, and the balance Ar to a total pressure of 2.5 atm for maximum efficiency, or 4 atm for maximum energy. The maximum efficiency of the transversal laser was 8.4%, whereas that of the coaxial laser was in excess of 10%. While the increase in efficiency of the coaxial laser is not astounding, the maximum output energy of 12.8 J is nearly 4 times that of the transversal

laser. These results were obtained with laser cavities comprised of 80% and 8% reflectors. Near the close of this experiment a multi-layer dielectric mirror of 97% reflectivity became available, and an output energy of 15 24 J/l) was obtained. Some of the advantages of coaxial excitation as revealed in this experiment are: (1) the more uniform excitation resulted in a much more uniform output beam as demonstrated by burn patterns; (2) a factor of three higher input energy (as calculated from the transient pressure rise); (3) an increase in efficiency, and (4) a dramatic increase in the output energy. The superior performance of the coaxial design is attributed to the absence of a foil-support structure, a better concentration of the energy into the gain volume, and an extra contribution of electrons reflected by the potential field. The details of this experiment will appear in the literature soon.

In a soon-to-be-published analytical effort, a model was developed for obtaining the optimum performance conditions for KrF* lasers. This model is based on the relevant processes occurring in e-beam pumped lasers, and its results are supported by the experimental effort described above. The primary result is that the maximum obtainable efficiency at maximum output energy is about 8%, and that higher efficiencies can be realized at lower output powers.

The Quantum Optics Group is enthusiastic and is certainly not hampered by the lack of up-to-date equipment; e.g., they have a Maxwell Laboratories e-beam machine/laser capable of delivering output/input energies of 15 J/ 150 J in a 45-50 nsec pulse. Also, they have developed a CO_2 system comprised of an oscillator, 2 preamplifiers, and 4 amplifiers that can deliver 1000 J in a 50 nsec pulse or 50 J in a 1 nsec pulse. The laser community, especially those interested in lasers for plasma and inertial confinement research, will certainly do well to keep track of the progress at Twente. (Richard S. Hughes)

PHYSICS, ELECTRONICS AND SURFACE ANALYSIS AT YORK

In this report, which is a companion article to the one by Dr. R.S. Hughes in this issue (p. 156), I review a recent visit to the Departments of Physics and Electronics of the University of York. My principal host in Physics was Prof. M. Prutton, who heads the Surface Microscopy Group; my host in Electronics was Prof. G.G. Bloodworth.

Before addressing the technical aspects of this visit, I feel it almost my duty to sing the praise of the city of York, as perhaps others have done in this publication before me. York, located almost due north of London and reached by fast train in slight over 2 hours, was founded by the Romans It is famous for its city wall and its cathedral. Indeed, the interior of York Minster (as the cathedral is called) is certainly magnificent. In close proximity to the Minster one finds many splendid buildings that are fine examples of Medieval, Norman, Tudor, and Georgian craftsmanship. But the most unusual feature of York is the fact that the old city is nearly completely encircled by a wall which has a walkway on it. In addition, those who delight in visiting not only unusual places but also tourist shops will not be disappointed in York, for there is an abundance of fine little shops in the vicinity of the Minster.

The University of York, located a short distance out of town, in Heslington, is easily reached by city bus. To return, now, to my visit to the University, I will first discuss some of the educational aspects of the Departments of Physics and Electronics; then I will describe the research projects that I saw there.

In addition to the chair held by Prof. O.S. Heavens, who founded the Physics Department, there are two other professorial chairs in physics: Dr. M.M. Woolfson is Professor of Theoretical Physics and Dr. Martin Prutton has a "personal chair," i.e., a professorship awarded to Prutton but not normally one of the chairs of the Department.

Almost since its beginning in 1965, the Department of Physics felt that it would be extremely desirable for the University to have a Department of Electronics. This has just materialized; Electronics has commence to operate, with Dr. G.G. Bloodworth (formerly of the Univ. of Southampton) as Professor and Head of Department and with an initial class of 13 students.

As in other universities in England, courses for both physics and electronics undergraduate students cover three years. A very important aspect of both courses is the considerable emphasis placed on a third-year project.

A student entering the University is expected to have had approximately two years of intensive training in mathematics and physics. He should thus be ready for the first-year course in physics, which comprises studies of mathematical methods, differential equations, analysis, vector algebra and vector calculus, as well as mechanics, macrophysics, atomic physics, kinetic theory and analog and digital electronics. The second and third years cover statistical mechanics, numerical analysis and computing, electromagnetism, relativity, quantum statistical mechanics, nuclear and particle physics, physics of the solid state, and two optional courses, such as advanced quantum mechanics or biophysics. As in most other British universities, there is no formal course work for graduate students.

Since the Department of Electronics is new, it is only possible at this time to talk about the plans for it. First-year electronics students are scheduled to take computer fundamentals, computer programming, atomic physics, transducer physics, matrices and differential equations, waves, vector algebra and calculus, complex numbers, circuit theory and feedback, semiconductor devices and transistor circuits, analog and digital circuits, and introduction to design. The program for the second and third years lists courses in electromagnetism and solid state physics, statistics and information theory, circuit theory, computer-aided circuit design, instrumentation and signal recovery, integrated circuit design, digital-system design and computer architecture, data structure and algorithms, control theory and feedback systems, real-time computer systems and languages, RF, microwave and optical techniques, modulating and demodulating circuits, charge-transfer devices and discrete-analog systems, analog and digital communication systems, display techniques and ergonomics, and management and economics. This certainly seems to be an ambitious program, especially since a large part of the activity during the third year is taken up by design examples and projects and by the special project that is to be carried out in collaboration with the research work of the department or with industry, local hospitals, etc.

Now to the research. In Physics, Prutton heads a group of 15 individuals engaged in surface analysis. These include Dr. J.A.D. Matthew, Reader; Dr. T.E. Gallon, Senior Lecturer; Dr. A. Chambers, Lecturer; and several research fellows and students. Prutton indicate that although a number of experiments have been and are being performed, more could be accomplished, were it not for the difficulty in obtaining and keeping technicians. This problem exists because university salaries for technicians are not competitive with those paid in industry.

The objective of the work in surface analysis is principally to determine surface structure, using the techniques of low-energy electron diffraction (LEED) and high-energy electron diffraction (RHEED), and Auger-electron spectroscopy (AES) for surface chemical analysis. Some specifics of the work follow a brief review of these techniques.

LEED and RHEED are methods of determining the structure of the top layers of a surface by correlating the electron-diffraction patterns of elastically reflected electrons with patterns calculated on the basis of various assumed surface atomic structures. In LEED, a monoenergetic electron beam of, say, 500 ev or less and 1 mm diameter is shot at the surface. The electrons reflected from the surface are collected on a fluorescent screen after they have been retarded by an electric field, so that those that have lost considerable amounts of energy by inelastic collisions do not impact the screen. The display on the screen (a pattern of spots) is essentially the diffraction pattern of the electron waves reflected from the surface. The geometrical structure of the LEED spots is determined by the positions of the surface atoms; the intensity of the spots is a function of adsorbed species on the surface.

RHEED uses higher energy electrons (say, 10 Kev) at grazing incidence. It achieves essentially the same goal as LEED, with the added factors of providing information on the surface flatness (i.e., revealing atomic steps) and perhaps somewhat better sensitivity.

The goals of these techniques are to determine surface geometric structures and, possibly, surface energy band structures, to provide detailed information on how materials act in chemical reactions such as oxidation or corrosion, or as catalysts in chemical reactions, by observing how different chemical species attach themselves to a surface or alter the surface structure of a material.

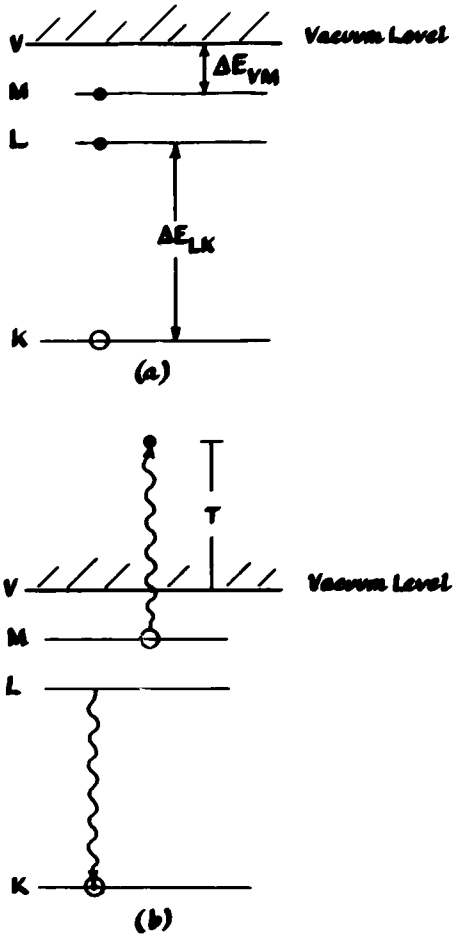
Since even in a vacuum of 10^{-6} torr a monolayer of molecules impacts a surface just about every second,

both LEED and RHEED must be performed in an ultrahigh vacuum (10^{-10} torr or better).

Whereas LEED and RHEED provide information on the geometric surface structure by observation of the results of elastic collisions, chemical information about a surface is obtained by AES, which is based on inelastic collisions, as illustrated in the figure, which shows sketches of the energy-level structure of an atom that has been struck by an electron from outside with sufficient energy to knock an electron out of, e.g., the K-shell. Part (a) shows a hole (electron vacancy) in the K-shell and electrons in the L and M-shells. In an Auger process, an electron from the L-shell drops into the K-shell, thereby releasing energy in a radiationless transition. This energy is transferred to an electron from the M-shell, which is expelled from the material. As part (b) illustrates, the kinetic energy of the expelled electron is the difference between ΔE_{LK} and ΔE_{VM}. Since (ΔE_{LK} - ΔE_{VM}) differs from material to material, a measurement of the kinetic energy distribution of emitted electrons identifies chemical species. Since the mean free path of electrons incident on a surface is on the order of 10Å, AES provides information about the chemical species on the surface, just as LEED and RHEED provide the data on the atomic geometric distribution on the surface.

Readers who are not acquainted with LEED, RHEED and AES can find more detailed descriptions in a number of articles and books of the recent literature. Examples are the article of L. Fiermans and J. Vennik, "Electron Beams as Analytical Tools in Surface Research: LEED and AES," in *Advances in Electronics and Electron Physics*, L. Marton, editor, Academic Press, Vol. 43, 1977; pp. 139-203; and the text by S. Roy Morrison entitled *The Chemical Physics of Surfaces*, Plenum Press, NY, 1977.

In Prutton's Surface Microscopy Group he following equipment is in use or under construction: (1) A manually controlled LEED system. (2) A fully computer-controlled LEED system, to be operable at the end of 1980. According to Chambers, once this system is evacuated, it can literally be operated from a computer terminal and take all the data necessary for a complete LEED picture. (3) A digital scanning AES system. (4) A RHEED system, to be used specifically for studying nucelation and epitaxy. (5) High-resolution AES equipment. (6) A general purpose, high-vacuum spectrometer for performing electron spectroscopy and measuring absorption losses (due to plasmon excitation in materials).



(a) An electron shot toward atom has created a "hole" in the K-shell. (Incident and released electron not shown.) (b) Electron from L-shell fills hole. Its energy releases an electron from M-shell into vacuum, with kinetic energy $T = \Delta E_{LK} - \Delta E_{VM}$

Prutton and colleagues pointed out that there are a number of complications in identifying surface structures. For example, the structure of the surface may be unlike that of the bulk. Instead of all lying in a plane, some of the surface atoms may be pushed above an average location and some

may be below. Impurities which are adsorbed can change the surface structure. And the fact that there is some penetration of the incident electrons below the top layer must be taken into account.

The determination of geometric structure from measurements is done on a trial-and-error basis. One assumes a certain surface configuration, mathematically matches the uniform plane electron waves outside with attenuated Bloch waves inside the surface, and then compares expected diffraction patterns with those found in experiments. This requires vast amounts of computer time; Prutton's group uses on the order of 100 hours per week. (In England there is presently no requirement yet of detailed cost-accounting for computer time used by universities.) Actually, the computers available were said not to have sufficient memory for performing calculations for diffraction by more than one layer.

Computers that have been used are the DEC-10 of York University and the Science Research Council's IBM 370/165. The group is now looking forward to using the Science Research Council's new CRAY-1 computer, which is said to be 80 times faster than the IBM 370/165 and to have twice the storage capacity.

The AES equipment is used in making certain that a surface is clean and in studies of chemical modifications of surfaces, such as by adsorption.

Among the surfaces examined by the Group to date are those of MgO (100), NiO(100), CaO(100), CoO(100), InP(110), and W(100).

In the Department of Electronics, the only staff members at the time of my visit were Bloodworth and Dr. A.C. Marvin. Bloodworth's background is in semiconductor devices and integrated circuits; Marvin's interest is electromagnetic compatability. An indication of things to come is the fact that even though the Electronics Department has just gone into business, a graduate student was already at work trying to improve and adapt into systems a novel semiconductor magnetic field sensor which produces output current pulses of a frequency proportional to the magnitude of magnetic flux density. (See M.H. Manley and G.G. Bloodworth, "The Carrier-Domain Magnetometer: A Novel Silicon Magnetic Field Sensor," *Solid State and Electron Devices*, Nov. 1978, pp. 176-184.) Bloodworth's intentions are to draw on his past experiences in semiconductor devices but to orient new work toward applications in systems. (Irving Kaufman)

WINDOW PANES AND LASER PHYSICS AT YORK

Even though petitions for the establishment of a University of York existed as early as the seventeenth century, official approval for the University was not granted until 1960, and the University's doors were not opened until 1963. The campus was established in the village of Heslington, 1.5 miles southeast of the history-filled city of York. A delightful combination of the "natural" and the "modern" is achieved by a beautiful artificial lake surrounded by terraces and contemporary-style buildings. Enrollment at the University has increased from 228 in its first year to about 3500 (including 625 graduate students) in the current session. This article, which is the result of my December (1979) visit with staff members of the Department of Physics, contains general observations about the department and highlights of four research projects.

The Chairman of the Department of Physics, Professor O.S. Heavens, was brought to York in 1964, and the department, as it exists today, is principally the result of the free hand he was given in its development. Early in the department's history, Heavens decided to avoid the extremes of a one-subject department or a department in which each staff member works independently. An effective mix of projects has been implemented resulting in a department with a few major areas of research and a number of small efforts. Mixing in another dimension also appears to be working well within the department, i.e., projects range from fundamental research to solving specific industrial and engineering problem

The number of students and staff along with the amount of research-grants support are certainly the key indicators of the magnitude of a university's research program. At York, the Department of Physics' 120 undergraduate and 22 graduate students are taught by a staff comprised of 3 professors, 4 senior lecturers, and 8 lecturers. In addition, there are 15 Research Fellows. The department has the tradition of having a celebration each time the research grant total is increased by £N/4 × 10^6, and as N is approaching 5, another party should take place soon.

The department's three major research areas are thin films and surface physics (*ESN* 33-3:100), x-ray crystallography, and laser physics and applications. Smaller programs include

organic semiconductors, theoretical solid state physics, geomagnetic pulsations, theoretical astronomy, atomic collisions and gas discharges, and medieval glass. In this article, the last shall be first, in that the discussion of research topics will begin with the medieval glass program.

Among the priceless treasures of England is the medieval glass found in its many cathedrals. Unfortunately, due to weather and atmospheric pollution, much of the medieval glass is deteriorating. Extremes in the rate of deterioration have been observed, i.e, some window panes have been corroded to the point of penetration, and some have experienced no observable damage. Heavens pointed out that because of the problems of condensation and poor air circulation often existing in cathedrals, the most severe deterioration frequently takes place on the inside. The objectives of a long-term research program in medieval glass are twofold; to understand decay mechanisms, and to devise effective methods of preservation. Auger-electron spectroscopy (AES) and x-ray fluorescence (XRF) are the principal tools used at York to identify the compositions of a variety of glasses. Because of the leaching that some glass components undergo, the composition was determined as a function of depth.

Glasses investigated include: 2nd/3rd-century (Roman) excavated from beneath York Minster, 12th-century from the York Minster, and 18th-century from Stourbridge. A piece of modern glass was also analyzed to provide a comparison. In addition to obtaining a quantitative analysis of each specimen, the limitations of the two techniques (AES and XRF) were established, and the requirements for sample preparation were determined.

XRF analyses were made on each sample after each of three stages of surface preparation: A, acetone wash; B, light polish with 6 μm diamond paste, soap/water wash, and acetone wash; C, removal of 500 μm by grinding plus B. Results indicate that the materials composing both A- and B-prepared surfaces have been chemically modified. It was verified that the composition of C-prepared surfaces is characteristic of the bulk of the specimen by obtaining the same composition on a specimen that had undergone increased surface removal. It should be pointed out that the secondary radiation from A- and B-prepared surfaces are not characteristic of either the bulk of the glass or the chemically modified surfaces. This is the result of two problems. First, the amount of secondary radiation escaping from the surface depends, in part, on the mass absorption coefficient (m.a.c.) of the glass matrix, which varies dramatically; e.g., for one sample, m.a.c.(Na Kα) = 2970 cm^2/gm and m.a.c.(Ca Kα) = 331 cm^2/gm. A second problem is introduced because the shorter wavelength components of the primary beam, which are mainly responsible for exciting the heavier elements, penetrate further into the specimen. Thus, only the x-ray intensities from C-prepared surfaces could be accurately converted into equivalent concentrations of the oxides present in the glass. Using calibration curves derived from polished, "standard" glasses, approximate concentrations of the oxides were obtained for A- and B-prepared surfaces.

The following concentration data were obtained for C-prepared surfaces. The 2nd/3rd-century glass had higher silica concentrations (70-74%) than either the 12th-century (64-69%) or 18th-century (68%) glasses. The 18th-century glass was lower in Na_2O (7%) than either the 2nd/3rd-century (19%) or the 12th-century (13-16%) glasses. The 2nd/3rd-century glass K_2O concentration (~1%) was lower than either the 12th-century (2-6%) or the 18th-century (4%) glasses. Even though it is too early in this program to draw firm conclusions, Heavens said that there is a general trend for good glass to be high in silica and Na_2O, and for glass with higher concentrations of K_2O to deteriorate more rapidly.

The laser-physics and applications program, which is led by four staff members from the Department of Physics, is composed of several distinct projects. Two of these projects are interdepartmental and the coinvestigators belong to the Departments of Biology and Chemistry. The remainder of this article contains a somewhat detailed description of one of these interdepartmental laser projects and a brief listing of the other laser-related work at York. The interdepartmental project is led by R.C. Greenhow (Physics) and D.M. Goodall (Chemistry) who are studying the ground-state repopulation (GSR) time and saturation behavior of dyes used for Q-switching and mode locking. The dye, BDN I, has been studied at York and elsewhere, and its GSR time can be varied from 25 psec to 9 nsec, depending upon the solvent. BDN I is used to Q-switch

neodymium lasers (1.06 μm) and as a mode locker for neodymium: YAG lasers. The dye under current investigation at York is BDN II, the 4-diethylaminophenyl analogue of BDN I. Its absorption band, when dissolved in a solvent containing a sulphoxide or sulphone group, is centered at 1.3 μm, and it has a 0.3 μm bandwidth. (As both the GSR time and spectral characteristics can be affected by the solvent type, it is important to specify the solvent used.) BDN II has been used as a saturable absorber for both neodymium and iodine (1.31 μm) lasers with mode locking being observed in the case of iodine.

The York group has recently used the pump-and-probe technique to obtain a direct measurement of the GSR of Eastman-Kodak BDN II dissolved in sulpholane. Single-pulse excitation (pump) was obtained from a passively mode locked neodymium: glass laser. Two photon fluorescence measurements show the pulse length to be between 5 and 7 psec, and pump energy densities up to 0.23 J/cm^2 were obtained when the beam was focused to an area of $\sim 3 \times 10^{-2}$ cm^2. The pump-to-probe delay time was provided by a simple variable optical delay, and ratios of pump-to-probe intensities as low as 5000:1 were used.

During the saturation behavior study, the pump intensity was varied by 4 orders of magnitude with the use of neutral density filters calibrated at 1.06 μm. The main results regarding saturation behavior are twofold. First, a strong residual absorption (~40%) was observed even at the highest value of pump intensity. Comparative experiments using another dye demonstrated conclusively that the residual absorption in BDN II is not an artifact. Second, excellent agreement was observed between the transmission versus pump intensity data and a curve obtained by considering a 4-level system. The 4th level of the system was the highest energy level and provided for an accounting of excited state absorption (ESA), i.e., metastable to higher excited states. Thus it appears that ESA, which would be present regardless how hard the dye was pumped, plays a limiting role in the transmission of BDN II.

A GSR time of 1.2 nsec was determined by direct measurement. This value is contrasted with a previously published value of 30 psec which was determined indirectly from an analysis of the saturation behavior of the dye/solvent system on the basis of a 2-level model, and problems regarding another assumption of the earlier work are pointed out in an upcoming issue of *Optics Communications*.

D.W. Goodwin is involved in the use of lasers in atomspheric studies and in medicine. Frequency doubled and quadrupled neodymium laser radiation (532 nm and 266 nm respectively) was used in a study of atmospheric transmissivity and turbulence in the ultraviolet (uv). The two beams were coincident and the 532-nm beam provided the "link" between the uv data and the commonly used visual range. Goodwin is using neodymium emission along with its 2nd and 4th harmonics to study the wavelength dependence of the absorption and scattering coefficients of dermis-epidermis. These data will be helpful in choosing the optimum laser (wavelength for use in laser surgery.

High-resolution, Doppler-free spectroscopic studies of the hyperfine structure and isotope shifts in a variety of materials are being carried out with the use of a tunable dye laser. Doppler broadening is eliminated by using the two-photon adsorption resulting from a sample being irradiated by two counterpropagation laser beams.

A study of the kinetics of protein association-dissociation reactions is being conducted jointly by D.J. Jacobs (Physics) and members of the Department of Biology. The reactions are followed in time by monitoring the intensity of that portion of a probe laser beam that is scattered at 90°. Changes in the 90° scattered intensity are caused by changes in the average molecular weight (hence particle size) of the reacting species. A light-scattering photometer incorporating a 50 mW He-Ne laser has been developed for use in this study. This unique apparatus provides a means of studying molecules with a wide range of molecular weights on time scales ranging from milliseconds to seconds. Current work is concentrating on hemoglobin and the key controlling enzyme of the glycolytic pathway, phosphofructokinase.

The visit to York was particularly rewarding in that there was a large overlap of research projects being pursued and the author's personal interests in physics. A description of the new Department of Electronics along with an expanded review of the Department of Physics' microscopy program are presented in the preceeding article. (Richard S. Hughes)

PSYCHOLOGY

SATISFACTION AND/OR PRODUCTIVITY IN THE WORKPLACE, A POLISH CONFERENCE

In a precise but graceful address to the Seventh Congress of the International Ergonomics Association (IEA), held in Warsaw August 27-31 1979, Roger Stansfield (Ergonomics Society, London) traced the stages and negotiations that led to the approval of its organizational articles at Oxford Univ. in April 1959. One of the hardest hurdles was cleared with the magnanimous gesture of the Ergonomics Research Society (ERS in the UK), which had already achieved eminence as an international society (one-third of its membership resided outside the UK), to cooperate fully with the development of the IEA. That action led inevitably to the foreshortening of the growth of the ERS and the rapid development of numerous groups and journals. At the present time the IEA represents the federation of some 15 societies that comprise approximately 5,000 practitioners in 30 countries.

In 1857 a Polish biologist, Wojciech Jastrzebowski (1799-1882), introduced the term "ergonomics," described the concept, and created the basis for that science in a series of articles. The Polish Ergonomics Society (PES) recently reprinted those articles in their entirety, along with an English abstract, in its journal [*Ergonomia*, 2(1), 13-29 (1979)] which was distributed to the attendees. The general title for the three articles was "Outline of ergonomics of labour science based upon the truths drawn from natural science"; its contents stress an avoidance of both inadequate and excessive demands on workers and the importance of work design that is consistent with the total needs of the person. It is clear that contemporary ergonomists could still embrace that goal as a first principle.

The PES had yet another surprise for its guests. The Polish postal service issued a special commemorative stamp of a few zlotys that many carried away as a souvenir; the stamp portrayed Jastrzebowski, noted his seminal role as a pioneer in ergonomics, and included the distinctive logo of the IEA—a globe, one half in parallels of latitude (flat world), one half in meridians of longitude (round world), encircled by a strong outline (one world). This logo is sometimes accompanied by the motto "Old world, new world, one world".

With less elan, presentors from other countries gave addresses on their pioneers in ergonomics. H. Monod (Laboratoire de Physiologie, Paris) and M. Valetin, (Société Francaise d'Historie de la Medicine, Paris) for the Société d'Ergonomie de Langue Francaise, surveyed other precursors to this discipline and reached as far back as neolithic times for evidence to improve safety, health, and ease of work in various occupations. With some humor, they noted that in the early 18th century, the strength of four English laborers was equated with one horse, but could only be matched with seven French or Dutch men. Work physiology, stressors and contaminants, fatigue, and other biomedical considerations in the workplace are numbered among the distinctive contributions from French ergonomists. The English representative, T. Singleton, (Univ. of Aston, Birmingham, UK) discoursed on the efforts of Sir Frederic C. Bartlett (1886-1953) on problem-solving behaviors, while J. O'Hare (Office of Naval Research, Arlington, VA) described Dr. F.V. Taylor (1910-1960), former head of the Engineering Psychology Branch at the Naval Research Laboratory, as an exemplar of American engineering psychology. Taylor made significant conceptual analyses toward the enhancement of operator performance in closed-loop systems.

The familiar paper-reading, parallel-session style of conference was shunned by the Polish organizers. Round-table formats that provided diverse speakers on the same theme were favored. In this multilingual setting (French, English, German, and Russian), the procedure worked well even in the discussion period, where a significant lag was introduced by translation of a given statement into Polish and then into other languages by other members of the translation team. Topics that were examined included the design of equipment, implementation of ergonomic practices, and the ever-present wish for standardization. The application settings were unusually broad and ranged from industrial/manufacturing institutions, education, forestry, and agriculture, to mining. Technical sessions on specialized topics, as well as poster sessions, nourished those who preferred those types of detailed presentations.

To an American observer, the stress on health, safety, workload, and the general satisfaction of the worker was unusual. We expect that

the goals of the employer (who pays the bills for the R&D) or the major user (e.g., military or government) are given the predominant role, and that emphasis is laid on system performance or output; efficiency, productivity, cost-benefits, and effectiveness become the watchwords of good people-machine design. The European professional in human factors or ergonomics gives considerable weight to job satisfaction. American human-factor professionals could learn a great deal from this point-of-view. Both value systems came together on sessions devoted to workload measurement (physical and cognitive) where this complex issue was thrashed around on theoretical constructs, appropriate methodology, and normative data. A satisfactory resolution of this matter, or even a clear direction for future research, escaped their definition, but a consensus was reached that this aspect of work behavior is surely in need of clarification.

Attendance was higher (563) than the planning figure. Poland, with an Ergonomics Society of over 400, provided the largest delegation (168). Some 38 countries were represented and were as scattered as Australia, Brazil, Mexico, Cuba, and Egypt. The IEA will be guided for the next three years by Dr. Jan Rosner (Central Institute for Labor Protection, Warsaw) who became its new President. Harry Davis (Eastman Kodak Co., Rochester, NY) was elected as Secretary-General and Dr. Harold Scholz (Institut für Arbeitsphysiolofie, Universitae Dortmund, FRG) was retained as Treasurer. The Eighth Congress will be hosted by the Japan Ergonomics Society and will convene in Tokyo in August 1982. The distribution of attractive brochures, and the showing of an unusually beautiful film on tourist sites, suggest that a well-organized meeting will be enjoyed at the next triennial gathering. (John J. O'Hare, Office of Naval Research, Arlington, VA)

NEWS & NOTES

PLAN FOR ELECTRONICS INDUSTRIES, EEC STUDY

In the recent summit meeting of the European Common Market (EEC), Etienne Davingnon, EEC Commissioner for Industry, presented a plan for integrating and strengthening Western Europe's electronics to assure one-third of the $1.3 trillion world market for telecommunications equipment, computers, and electronic components to European manfacturers. Among several facets proposed were: (1) Establishment of a "homogeneous" European market for telecommunications and related so-called telematic equipment, including satellite transmission facilities. The objective is to commit government-run telecommunications agencies to introduce "common, harmonized" services on new, digital networks by 1983 and to purchase for them only "harmonized" equipment starting in 1985. (2) Promotion of a European information industry by facilitating cooperation among Europe's major computer companies, particularly in joint development of such products as peripheral equipment. (3) Expanding the EEC's modest Euronet scientific data bank into a community-wide network of computers, data banks, and terminals which would link the EEC's major institutions, such as the European Parliament, the court of Justice, the Commission, and member governments.

Mr. Davingnon said that "This would help establishment us as an industry customer—promoting our industry just as American procurement policies did for the US industry. (He added also, however, that the goal is not to keep out US and Japanese competitors.) He also stated that when the idea was first proposed to government and industry officials two years ago, there was little interest in joint action. Now, however, he sensed that the majority of these individuals feel that the time has arrived for some concerted action and are asking how to implement the proposed program. (Irving Kaufman)

TRANSITION AT ORS

The major policy of address of the president of the Operations Research Society of America is made at the spring meeting of the society, immediately after he has retired and handed over the gavel to the incoming president. At the Operational Research Society (of the United Kingdom), the corresponding address is made by the incoming president, shortly after taking office, at a special meeting called in London for that sole purpose. Thus, George H. Mitchell spoke for an hour on 5 February 1980 at the Royal Aeronautical Society to more than 100 Society members, which represented 3% of the total membership, an impressive attendance at such an event. Mitchell has succeeded Rolfe Tomlinson (*ESN* 33-8:339) as head of the Coal Board—a breeding ground for ORS presidents, supplying three of the last four! Tomlinson has been at IIASA (*ESN* 32-2:51) for a couple of years, and is returning this autumn to take up the chair in OR at Warwick.

Mitchell talked about the "crisis" in OR, which has been the subject of much debate in the ORS in the past year. While it is a part of the crisis of society (Mitchell asserted), it is also largely based on the public image, and the self image, of OR. suggested that ORS should attempt to "widen" this image, specifically under four headings:

(1) OR analysts should be politically aware and competent. They should know what the employing group sees as its problems; they should not waste time on lost cuases; they should work with those empowered to take action; and they should know who makes decisions and how.

(2) The image should be responsive to the employer group. The problems on which the analysts work should be interesting to the employer; they should be soluble; they should be problems of consequence; and they should involve issues where expertise does not already exist with the client.

(3) OR should project an image of technical competence. There should be an ability to communicate backed by clarity of thought and a repository of intellectual skill. Analysts should be objective—a word difficult to define and controversial at times, but bascially understood in the sense which characterizes science. They should take the holistic (I would have said "systems") view. They must of course be competent in the tools (e.g., mathematical programming) of OR, but they must also become substantive experts in the topic under study (e.g., how coal is mined). In summary, they should be able to build an applied science.

(4) OR should be able to carry out longish research programs. That is, the OR group should have more durability and stability than is sometimes manifested.

Finally, Mitchell talked of how we should deal with OR students. We must expand their range of competence as scientists, but we must not forget to tell them how important politics is in our profession. (Robert E. Machol)

The European Physical Society has awarded the 1979 Hewlett-Packard Europhysics Prize to five individuals. The award of 20,000 Swiss Francs is shared by Eric A. Ash (Univ. College, London University), Jeffrey H. Collins (Univ. of Edinburgh), Yuri V. Gulavev (Inst. of Radio Engineering, Moscow), Kjell A. Engebrigtsen (Norwegian Institute of Technology, Trondheim), and E Edward G.S. Paige (Dept. of Engineering Science, Oxford University). This year's prize was presented for contributions to the understanding of the interaction between surface acoustic waves and electrons, and for the practical applications of the effects to a new range of devices of particular importance in information handling. (Irving Kaufman)

PERSONAL

Prof. Daniel J. Bradley, professor of optics at Imperial College, London, and head of the Physics Department, has been appointed to the chair in optical electronics at Trinity College, Dublin.

Prof. E.N. Corlett, professor of industrial ergonomics and director of the Ergonomics Information Analysis Centre, has been appointed to the Cripps chair of production engineering and production management, and headship of the Department of Production Engineering and Production Management at the University of Nottingham. He takes up his appointment 1 April 1980.

Dr. Alvin W. Nienow, senior lecturer in the Department of Chemical and Biochemical Engineering at University College, London, has been appointed to a vacant chair of chemical engineering from 1 April 1980.

Dr. A.C. Walker, associate of the Royal College of Science and Technology, reader in structural engineering at the University of London, has been appointed to the new chair in experimental mechanics in the Department of Mechanical Engineering at the University of Surrey.

OBITUARIES

Prof. E. Colin Cherry, Henry Mark Pease professor of telecommunication in the Department of Electrical Engineering, Imperial College, London, died 23 November 1979 at the age of 65. Cherry was an early researcher in the fields of carrier telegraphy and television. In later years, he was widely known for this espousal of the case for unifying information theory, phonetics, semantics, and sociology in a complete study of communication.

ONRL REPORTS

C-7-79

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

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

C-9-79

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

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

C-11-79

ELECTROSTATICS 1979 by I. Kaufman

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