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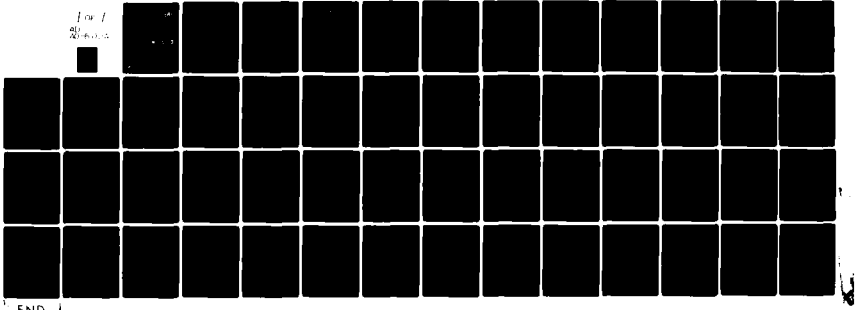

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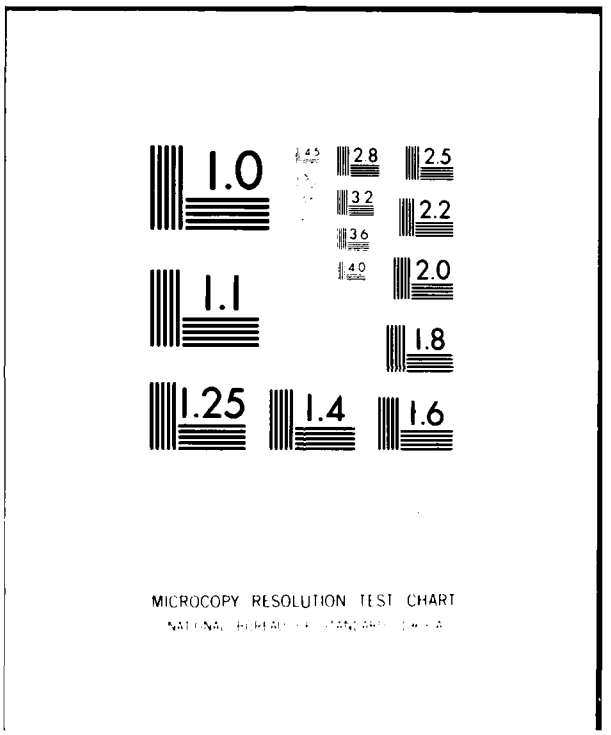
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists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

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

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

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OFFICE OF NAVAL RESEARCH
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edited by Willard D. Bascom and Don J. Peters

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SYSTEMS ANALYSIS

NEWS and NOTES

ONRL REPORTS

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F.E. SAALFELD
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Captain, USN
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CHEMISTRY

BIENNIAL CONVENTION OF THE GERMAN CHEMICAL SOCIETY

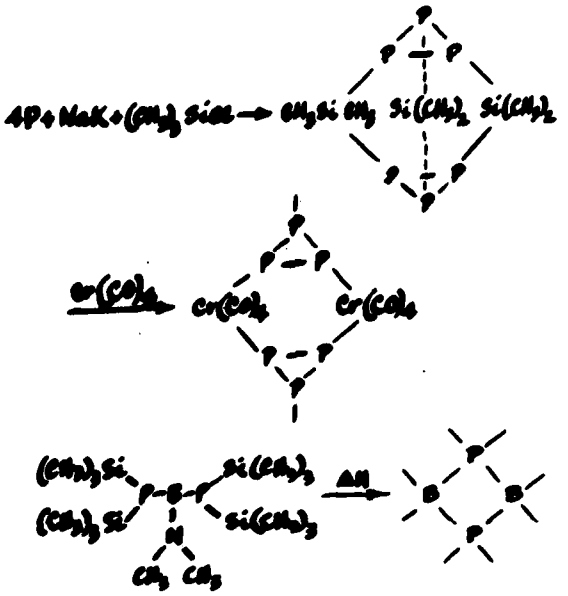
Unlike most major chemical societies, the Gesellschaft Deutscher Chemiker (GDC) meets only biennially. This year's meeting was held in West Berlin, at the Kongresshalle and in various lecture rooms of the Technical University. Some 1000 chemists were registered for the meeting which consisted of nine 1-hour plenary lectures, over fifty half-hour main lectures and an even larger number of 15-minute contributed papers. As usual, the meeting started with a "festive session" complete with a string quartet, opening remarks by a subcabinet member and welcoming speeches by a number of dignitaries. Professor R. Huisgen (Munich), H.A. Staab (Max Plank Institute, Heidelberg) and G. Manecke (Free University of Berlin) received national awards. Except for the plenary lectures, the meeting was subdivided into 20 sections which included the traditional branches of chemistry, such as organic, physical, etc., and some specialized topics such as crystallography, soap and detergent chemistry, the history of chemistry and even one on professional rights.

For those who visualize from this a meeting of mammoth proportions let me hasten to add that few of the sections had sessions every day of the week, and there were several sections (e.g., photochemistry) that settled for just one half-hour lecture and then quit! (The photochemists will have their own meeting in Göttingen, FRG in November.) It should also be mentioned that, although the GDC claims, and appears, to cover all of chemistry, its membership and activities are strongly slanted toward synthetic chemistry; the physical chemists have their own (Bunsen) society, which holds its annual meetings in May. The program of the macromolecular section was unusually brief, undoubtedly because the IUPAC (International Union of Pure & Applied Chemistry) Congress of Macromolecular Chemistry was due to be held in Mainz during the following week. (*ESN* 34-3:75)

The best lecture involving the best chemistry, "Organic Electron-Donor-Acceptor Compounds," was presented by Professor Staab (who was earlier awarded the Adolf von Baeyer Award). In this Staab and co-workers first re-examined the question of the structure of quinhydrones with the aid of newly synthesized m- and p-cyclophane quinhydrones. They found that only the p-compounds showed strong absorption in the visible region. When they observed the same behavior for the corresponding dimethyl ethers, they proved that charge-transfer (CT) interaction, not H-bonding, was all-important in the quinhydrones. When they extended this by the synthesis of "sandwich" compounds held by four (instead of two) bridges, they saw little difference. A "triple-decker" with a benzene ring between quinone and hydroquinone was found to show the CT absorption, as did a double-decker of quinone and tetramethyl-p-phenylene diamine. Pursuing this further, they synthesized a variety of p-cyclophanes containing various donor and acceptor moietics and found that some of these behaved as weak organic semiconductors.

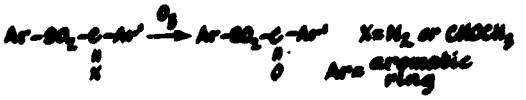
Another interesting plenary lecture was presented by Professor H. Schmidbaur (Tech. Univ. of Munich) on "New Reactions of Phosphines, Phosphine-Alkylenes, and Phosphine-Boranes." The second- and third-named types of compounds can be made by reactions of trialkylphosphines with an alkylene and borane, respectively. Methylene will undergo this reaction, but the product, R_3PCH_2, cannot be be further alkylated. On the other hand, the methylene group can be silylated. In addition, Schmidbaur also discussed some aspects of the hexamethyl diphosphoranes including their triboluminescence. Much of the synthetic chemistry he discussed has already been published. In his plenary lecture on "New Electrochemical Power Sources," Prof. Vielstich (Bonn) reviewed the state-of-the-art in this important field from the standpoint of application on a large-scale. He was of the opinion that Li-batteries and CO/H_2 fuel cells (with Ni electrodes) showed the greatest promise.

In the Inorganic Section, Prof. G. Fritz (Univ. of Karlsruhe) described work by him and his colleagues on cyclic organosilicon and organophosphorus compounds; including an adamantane analogue containing five $SiMe_2$ groups. Of special interest were these reactions depicted in the following figure:



Dr. N. Wiberg (Munich) discussed the chemistry of some very reactive Si=C and Si=N compounds. These can be obtained from suitable organosilicon precursors; they will undergo insertion reactions, -ene reactions, and cycloadditions, and dimerize readily. Prof. M.F. Lappert (Univ. of Sussex) described his recent work on transition metal complexes containing bulky alkyl-, amido-, or alkoxo-ligands. Among these are thermally stable complexes with the metals (usually Rh or Ru) exhibiting unusual valence state or coordination number. (Much of this has been published by Lappert during the past two years.)

Not everything presented at the meeting represented new work: Dr. H. Guesten (Nuclear Research Center, Karlsruhe) dusted off some 15-year old data on the effect of solvation on the cis-trans isomerization of stilbazolium salts. He and his associates find that the anion has no effect on and does not participate in the thermal isomerization. They believe that the reaction occurs via a polar transition state (also for stilbene and stilbazol) and can reproduce the observed activation energies by HMO calculations. Dr. K. Schank (Universität des Saarlandes, Saarbruecken) described a method for the preparation of α-ketosulfones for the first time by the following reactions:



Dr. H.H. Paradies (Cornell Univ., Ithaca, NY) reported on an old problem in organic chemistry: the structure of Grignard reagents. Using x-ray and synchrotron diffraction he found that OMgBr exists as a dimer solvated to one ether molecule and that it is held by Br-Br bridges. Paradies indicated that three papers on this topic will be appearing in the *Journal of the American Chemical Society*. In a paper by R. Kreher and E. Stoeldt (Technische Hochschule, Darmstadt) the synthesis and properties of triazines containing both electron donor and acceptor substituents were discussed. They are prepared from pentamethyl tetrazinium trifluorosulfonates and a suitable nucleophile (R$_3$, P, or a cyanide). They determined the activation energy of rotation about the double bond by temperature-dependent NMR spectroscopy. They also determined the structure for one such compound by means of x-ray diffraction and found that it had a trans configuration.

The last paper dealt with monomeric and polymeric phthalocyanines and represented a collaborative effort between G. Meyer and D. Wöehrle (Universität Bremen) and B. Wahl (Free University of Berlin). Their starting material was symtetracyanobenzene which reacts with Li-n-propoxide to yield either a monomeric octacyanophthalocyanine or, depending on the conditions, polymeric material. They also find that the octacyano monomer can be polymerized in quinoline, under mild conditions, using a transition metal acetate as catalyst. (The transition metal is incorporated into the product: however, when sodium acetate is used, metal-free polymer is obtained.) They also studied the conductivity and catalytic activity of the copper-containing polymer and found that its relatively low conductivity and catalytic activity could be enhanced by heat-treatment in quinoline. [George M. Wyman, US Army Research and Standardization Group (Europe)]

PHOTOCHEMISTRY AT JENA

Visits of Western scientists to university laboratories in Eastern European countries are not easy to arrange, even when the host is anxious to have the visitor. The host needs permission from government authorities, a procedure that is time consuming at best and involves the risk of disapproval, especially when the visitor is an employee of the US Department of Defense. Consequently, my visit to the Photochemistry Laboratory of the University of Jena, DDR was, in many ways, a rare treat.

My host was Professor Roland Paetzold, director of the laboratory, whom I have known (from meetings) for six years. Paetzold was originally an inorganic chemist who decided to take up organic photochemistry about ten years ago. Shortly thereafter a smallish, 65-year old building, near the center of Jena, that housed the Institute of Agricultural Chemistry became vacant and Paetzold was permitted to take it over for his research and teaching activities. The interior of this building is in reasonably good shape and the standard laboratory equipment (benches, etc.) are in about the same condition. However, it is obvious from the instrumentation available that Paetzold is a very successful "go-getter." In a country with a severe shortage of hard currency, Paetzold convinced the authorities to buy him the very best and most expensive American-made u.v.-visible spectrophotometer (Cary 17) and an equally imposing French spectrofluorimeter (Pica 55 MKII). (When I expressed surprise, Paetzold smiled and told me that, if one can convince the authorities that one needs a specific instrument to get meaningful results, one can get the foreign currency.)

Unlike most chemistry professors (in both East and West), Paetzold is primarily a manager and not a researcher. Perhaps this is because, due to the complexities of university life in a very restrictive society, he finds that managing such a program is a full time job. Paetzold has a research group of about 25 chemists (including graduate students) working on the photochemistry and excited-state chemistry of the following four types of molecules: quinones, azines, fulgides and indigoid dyes. In view of our common interest in the last-named group of compounds, our discussions were limited to these. In the course of my visit, I presented a seminar on indigoid dyes, and Paetzold also showed me around the entire institute. I learned that he holds the chair of photochemistry at the university and thus is independent of the traditional institutes of inorganic, organic and physical chemistry.

Research efforts of about six people on indigo dyes range from synthesis all the way to theoretical calculations. Their excellent instrumentation permits them to obtain measurements of the absorption and fluorescence spectra as a function of temperature. From these data they have determined activation energies of the trans-cis isomerization process and (from this and from the shapes of the fluorescence spectra) have concluded that (for isomerizable indigo dyes) the first step in the isomerization process involves a twisting of the S_1 trans molecule. This view can only be reconciled with evidence for a triplet pathway in this process, if one assumes a slight twisting, followed by crossover into the triplet manifold. In any event, I had much discussion with Paetzold's research group on this divergence of views. I should also mention that with their sensitive spectrofluorimeter they were able to measure the fluorescence spectrum of indigo and to obtain values in agreement with those determined by Dr. Sousa at the US Army Research and Development Command, Natick, MA, several years ago. They also found evidence for quenching of the strongly fluorescent indigo dyes by aromatic amines, and attribute this to electron-transfer

In closing, I should mention that the famous Zeiss optical company (now state-owned) at Jena is that city's principal employer. According to Professor Paetzold, there is no special collaborative effort between Zeiss and the university and the latter has no strong research program in optics; however, Zeiss has its own research laboratories. An interesting sidelight along these lines is about a 26-story modern cylindrical office-building that was constructed for Zeiss 3-4 years ago. When it was finished, the Zeiss management did not want it and it was turned over to the University. It currently houses most of the non-laboratory departments of the university and generates a lot of comments from the local population. [George M. Wyman, US Army Research and Standardization Group (Europe)]

COMMUNICATIONS

2-30 MHz—SOME OLD AND NEW PROBLEMS

Integrated optics may be the present glamour area in communications, but there is plenty of interesting work left even in the HF range (2-30 MHz). For the strictly engineering types, there are the very practical problems of ground-air-ground communications. For the more scientifically minded, there are problems dealing with modeling of the ionosphere and ways of optimizing communication in the presence of special ionospheric situations. And how many people just a few years ago would have thought of monitoring the wind and the ocean with a land-based radar transmitter at a distance of 1000 miles?

Then there are the very practical schemes of communicating within the tunnels of a coal mine. For, as everyone who has ever driven through a tunnel with his radio on knows, radio frequencies do not ordinarily pass through narrow tunnels. And these practical problems also have their interesting theoretical facets. Finally, there is the fascinating field of using electromagnetic waves for geophysical exploration.

All these topics were discussed at a NATO-sponsored symposium entitled "Special Topics in HF Propagation." This article is a sampling of papers presented at this meeting. (There were far too many papers to discuss them all!)

The NATO Advisory Group for Aerospace Research and Development, (AGARD) which sponsored the meeting, has a rotating administration, or "Panel." Chairman and Deputy Chariman, respectively, at the time of the conference were Dr. H.J. Albrecht (FGAN, 5307 Wachtberg-Werthoven, FRG) and Dr. J. Aarons (Air Force Geophysics Lab, L.G. Hanscom Field, MA). The technical program chairmen were C.J. Coyne (Rome Air Dev. Center, Griffis AFB, NY) and Dr. G. Lange-Hesse (Max-Planck Institut für Aeronomie, D-3411, Katlenburg-Lindau, FRG). The meeting was held at the Instituto Nacional de Meteorologia e Geofisica, Lisbon, Portugal.

Extensive HF usage dates back to the early 1920s, when Marconi demonstrated that signals at 3 MHz could be received at a great distance. Such a long history, however, does not mean all is perfect. For, while line-of-sight propagation may be easy, it is beyond the optical horizon that problems arise.

Because of the gradual decrease of the dielectric constant of the atmosphere with height, there is some refraction of waves toward the earth, thereby increasing the radio horizon slightly over the optical horizon. There is also propagation to the shadow side of a mountain and around the earth because of diffraction effects and scattering from atmospheric irregularities. In general, however, at points far beyond the horizon the power density due to scattering decreases as the 5th or 6th power of distance. While this mode of communication is used in "tropospheric scattering" propagation, it requires very-high-power transmitters and is not appropriate for 2-way communication between a ground station and an airplane. Instead, ground-air-ground communication uses the ionosphere, which can reflect useful energy to the earth for frequencies up to 25 MHz, and possibly up to 60MHz. Reflection takes place below a certain frequency, f_{crit}, which is proportional to $\sqrt{N}$, where N is the electron density in the plasma of the ionosphere. For years, information about the electron density distribution in the ionosphere, the quantity needed to predict radio propagation, has been obtained by "ionosondes," which generally transmit radar-like signals directly overhead and record the intensity and time delay of the echoes.

As it turns out, the electron density distribution in the ionosphere is such that at night for normal incidence f_{crit} is around 2-4 MHz. During the day, when the electron density is higher, f_{crit} is perhaps as high as 12 MHz. The apparent increase in the maximum usable frequency for transmission and reception (MUF) is, however, largely offset by a strong daytime ionospheric absorption. For oblique incidence of waves, the MUF is greater than for normal incidence, though generally by not more than a factor of 3 to 3.5. Since the sun controls the ionosphere, f_{crit} varies with season and latitude.

Propagation over long distances, then, occurs by reflections between ionosphere and ground. Because of the variability of the ionosphere, continuous

communication with a plane in flight, with limited amounts of power, often requires several changes of frequency. It is operational considerations of this type that were the subject of an overview paper by B. Burgess (Royal Aircraft Establishment, Farnborough, UK), whose general thesis was that HF radio will remain a prime means of beyond-line-of-sight air-ground communication. He stated that while air-ground-air communication via satellite is better than at HF (It has been tried!), at the moment the cost is too high. The principal problem, actually, is with off-route communication, where a military aircraft does not wish to transmit unless it is essential; but when it does, the response of the communication system must be rapid and highly reliable. He cited an example of an aircraft operating to the north of the UK and wishing to communicate with a base in southern England. Here because of fading, up to 8 different frequencies could be required for reliable communication. Improvements in such communications systems are needed. Other improvements needed for military aircraft are in higher speed digital transmission (up to 2.4 kb/s) and in the use of advanced modulation and coding techniques. The ionosphere as the communication link has also proved to be a limiting factor in the design of an efficient modem (modulator/demodulator). This is because multipath effects limit the serial bit rate to about 100 b/s.

A good summary of problems to be overcome in designing satisfactory links of HF communication from a ground base to small, low-flying aircraft was given by N. Maslin (Royal Aircraft Establishment, Farnborough, Hampshire, UK). Maslin stated that although HF radio communication is the principal means of beyond-line-of-sight communication to aircraft, there are particularly serious problems for the small aircraft. To achieve satisfactory results, careful consideration must be given not only to the terminal radio equipment, but also to the long-term geographic planning and the management of the frequencies to be used. The worst HF problems occur for a short-range air-ground sky-wave link at night (which requires frequencies at the low end of the HF band). Working over a longer range link increases the "optimum working frequency," thus avoiding the poor antenna efficiencies and generally reducing external noise levels. Maslin showed that good frequency management, ground antenna directivity, and the use of a number of geographically separated remote-receiving stations are vital in providing satisfactory communication reliability to the small aircraft. (As defined by Maslin, short-range means up to 280 km, medium range up to 1200 km and long range up to 2500 km.) In summary, he strongly recommended the use of links longer than 1000 km.

Since communication at one frequency entails great uncertainty, in 1972 the US Air Force began a program aimed at improving tactical HF communication. The approach involved measurement in real-time of the important unknowns (propagation, noise, and spectrum occupancy) and adapting operating frequencies in real time to the conditions measured. A potential problem with this approach is the possible harmful interference inflicted on other spectrum users. An exercise called TROPHY-DASH III was conducted, to assess the effectiveness of a particular technique that permits real-time selection of frequencies while still yielding acceptably low interference. The exercise was apparently a success. TROPHY-DASH III and the hardware associated with carrying out the functions mentioned were discussed by R.B. Fenwick (Barry Research Corp., Sunnyvale, CA) and T.J. Woodhouse, (Langley AFB, VA).

The above are samples of the types of problems of concern to Operations people. Along more scientific lines was a paper delivered in French by L.A. Mata (Instituto Nacional de Meteorologie e Geofisica, Portugal), which discussed theoretical models of the composition of the mesosphere and the lower thermosphere. Among the other papers dealing with the ionosphere, J.W. Wright and A.K. Paul (NOAA Environmental Research Labs, Boulder, CO) proposed global monitoring of the ionosphere in real time by a new network. Specifically, they suggested replacing "150-odd obsolete ionosondes now in use" with a minimum of about 90 widely spaced digital ionosonde centers. R.E. Dubroff, N. Narayana-Rao and K.C. Yeh (University of Ill., Urbana, IL) discussed methods of converting/inverting the leading edge of a back-scatter ionogram to obtain ionospheric structure. E. Harnischmacher and K. Rawer (Ionosphären-Institut, Breisach, FRG) found that a large part of the day-by-day fluctuation of ionospheric parameters seems to be due to lunar influences.

Auroral absorption is one of the special problems that has received considerable attention over the years. In the session entitled "High Latitude Ionosphere Effects," speakers discussed the special high-frequency communication problems that exist in the presence of auroral absorption. For example, V. Agy (Inst. of Telecommunication Sciences, Boulder, CO) discussed pros and cons of data obtained from the riometer, the "relative ionospheric opacity" meter, which is designed to determine the degree of absorption of high-frequency radio waves during the period of ionospheric storms. In the same session, R.W. Jenkins, E.L. Hagg and L.E. Montbriand (Comm. Res. Center, Ottawa, Canada) discussed direction and Doppler characteristics of medium and long-path HF signals within the night-time subauroral region. Specifically, they looked at different modes of ionospheric propagation and concluded that sporadic-E and skip-distance-focused ground-sidescatter modes present an opportunity for limited HF operations in the subauroral region during evening hours, when very low ionospheric MUF's would otherwise make such operation impossible.

The proceedings moved next from the polar regions to a session on irregularities. In a paper dealing with irregularities near the equator, G. Lange-Hesse and H. Lauche (Max-Planck-Institut für Aeronomie, Lindau, FRG) discussed verifying with measurements of the emission rate distribution of the oxygen line of 6300 Å in the night air glow, that irregularities of electron density in the F2 layer exhibit a nearly constant eastward drift, with an average speed of about 100 m/s. This drift had been previously identified by Röttger through studies of transequatorial HF propagation from Germany to Namibia. While the eastward drift speed found by the two methods agreed, the radio method did not permit information to be obtained about the north-south drift of the irregularities.

"HF Wavefront Irregularities Observed on a Large-Aperture Receiving Array" was the subject of a report by T.B. Jones and E.C. Thomas, (Univ. of Leicester, UK). These authors discussed results of an investigation of wavefront distortion of HF signals received on a large receiving array for a range of propagation conditions and attempts to correlate these signals with corresponding reflection conditions in the ionosphere.

Remote sensing and ocean surveillance is a discipline being actively pursued in a number of laboratories. Among these are the Université de Toulon, France; SRI International, Menlo Park, CA; NOAA/ERL/WPL, Boulder, CO; the Appleton Laboratories of the Science Res. Council, UK; and the Univ. of Birmingham, UK. Among the papers dealing with this subject is one by P. Broche (LSEET, Université de Toulon, France) entitled "Sea State Directional Spectra Observed by HF Doppler Radar." Broche stated that the back-scatter of HF radio waves by the sea surface is primarily due to coherent Bragg reflection of those wave-trains which have a wavelength equal to half the radio wavelength and are travelling toward or away from the radar. For a given operating frequency, the power spectrum of the back-scattered radio wave is essentially composed of two Bragg lines with respectively positive and negative Doppler shifts. The relative energies of these two spectral lines are characteristic both of the directional pattern of the sea-state energy and of the direction of the wind. Broche presented the results of several experiments, performed recently in the western Mediterranean, during which a ground-based HF Doppler radar was operated simultaneously at around 6 and 12 MHz. A buoy supplied direct *in situ* measurements of the main parameters of the sea surface. It was concluded that in most cases it was possible to estimate the wind direction from radio measurements at high enough frequency (12 MHz) with a precision of about ±20°.

Along the same lines, D.E. Barrick and B.J. Lipa (NOAA/ERL/WPL, Boulder, CO) discussed a radar system developed to monitor oil spillage. With this mobile system, the authors have made measurements of ocean currents at distances up to 50-60 km from the shore. The radio system here is very simple; it is the data processing (also within part of the mobile system) that is at the heart of the technique. Interested readers will find a brief description related to this work in *Science* 198, 138-144 (1977).

Finally, even more ambitious along this line is the project in progress at the Appleton Laboratory and the Univ. of Birmingham, as discussed by E.D.R. Shearman and W.A. Sandham (Univ. of Birmingham, UK) and E.N. Bramley and P.A. Bradley (Science Research Council, Appleton Laboratory, Ditton Park, Slough, UK). The groups at these institutions are presently building a system for

surveying on a routine basis a 60°-wide sector of the North Atlantic, out to 3000 km range—all with ground radar.

A number of papers were concerned with analyzing transmission properties and mode conversion in the communication technique that has been developed within the past few years for use in coal mines. Basically, the idea here is to use a 2-wire transmission line or an equivalent, loosely braided coaxial cable that can be suspended from the upper wall of the mine shaft. A transmitter placed in the vicinity of the line excites a strongly unbalanced mode that would normally propagate as a coaxial or TEM mode with relatively high attenuation. The key here is to convert this mode to a balanced mode, which is much less attenuated, because the return current flows mostly in the second wire rather than through the surrounding rock. Papers were presented on this subject by J.R. Wait, D.A. Hill, and D.B. Seidel (Univ. of Colorado, Boulder, CO), P. Delogne (Université Catholique de Louvain, Belgium), and N.A.M. Mackay, J.C. Beal, D.J. Gale and J.L. Mason (Queen's Univ., Kingston, Ontario, Canada). There were also papers dealing with VHF and UHF tunnel propagation, as well as a paper by Wait and Hill that dealt with surface wave excitation by apertures.

A very interesting paper by R.J. Lytle (Lawrence Livermore Laboratory, Livermore, CA), summarized some of the electromagnetic methods used in remote sensing of underground features. One might call these techniques "computerized geophysical axial tomography." Interested readers may wish to refer to the July 1979 issue of *Proc. IEEE*, which contains a number of articles dealing with applications of electromagnetic theory to geophysical exploration, including a paper co-authored by Lytle.

"Radio-Link Computations Optimize Pattern Shaping of Shortwave Antennas," by A. Stark, (Rohde und Schwarz, Munich, FRG), in a session entitled "Equipment Considerations," showed how statistical data can be obtained from forecast print-outs to produce frequency-dependent optimized values for the elevation angles of radiation maxima and for vertical bandwidths of transmitting and receiving antennas. The speaker maintained that horizontal logarithmic periodic antennas offer ideal possibilities here: both the elevation angle for maximum radiation plus the width of the vertical pattern were said to be accurately matchable by correct dimensioning of values dictated by the frequency. (Irving Kaufman)

FONDAZIONE UGO BORDONI, ROME—RESEARCH IN TELEPHONE COMMUNICATION

If you should find it necessary to make a long-distance phone call in an Italian city, the place to head for would be the main post office. The reason is that in Italy, as in many other countries in Europe, the telephone system is an arm of the government. It reports to the Ministry of the Post Office and Telecommunications and is managed by the Instituto Superiore Poste e Telecommunicazione (ISPT). ISPT is located in a large complex of buildings on Viale Europa in suburban Rome.

I would have expected ISPT to have a research laboratory within its structure. Actually, a lot of ISPT's research is being carried on by Fondazione Ugo Bordoni (FUB), a private, non-profit firm. Some recent telephone directories, including the one that I looked at, give an address on Viale Trastevere for FUB. No longer—it is now on Viale Europa, hidden away within ISPT. And because of its integration into the ISPT complex, FUB follows the work schedule of its host. To make an appointment for a visit, one should call between 8 a.m. and 2:30 p.m. on weekdays, or from 8 a.m. to 12:30 p.m. on Saturday. Anyone calling in the afternoon to make an appointment, as I did originally, will find the telephone unanswered.

In addition to being supported by and consulting for ISPT, FUB also receives some funds from private organizations. The sectors of FUB that consult for ISPT are groups specializing in: (1) radio communications; (2) laser and fiber optics; (3) digital and coaxial systems, and (4) network planning. Another sector, engaged in work on air traffic problems, works for another Ministry of the government. I visited the first two groups.

The host on my visit to the radiocommunications area was Dott. F. Fedi, who directs the work of this sector. Fedi, who was a Fulbright scholar at Notre Dame University in the mid-1960s, told me that his group has had two

main research projects: (1) free, unguided propagation, and (2) waveguides. Fedi has been directly involved principally with the propagation of unguided waves. Under his direction, a research installation was built in the Fucino Plain, 100 km from Rome, to gather data for predicting attenuation due to rain in the 10-40 GHz band. This work has been a part of Italy's contribution to EUROCOP-COST, the program for European cooperation and coordination in the field of scientific and technical research. This program was begun in 1967 at the request of the Ministers of Science and Technology of the then six EEC countries who had given the committee of national experts the task of "examining the possibility of European cooperation on information systems, telecommunications, transport, oceanography, meteorology, metallurgy, and pollution." In addition to the EEC nations, a number of other countries have also taken part in this study. Fedi, who was chairman of one of the committees in this program, told me that thanks to the propagation studies in the Fucino Plain, it is now possible to predict attenuation along a propagation path by measuring the rainfall intensity, at points along this path. He suggested that interested persons might wish to scan recent issues of *Alta Frequenza* for reports that treat (1) reliability of communication based on attenuation, and (2) interference, based on coupling from horizontal to vertical polarization and from the fact that terrestrial and satellite links might share the same frequency. No work has been performed yet on the latter. Fedi's group also participated in the Orbital Test Satellite program of the European Space Agency.

Fedi told me that present US satellites use 2 to 6 GHz for communications. It is envisioned that satellite communication for underdeveloped countries will be in the frequency range between 20 and 30 GHz, because of the possibility of using smaller antennas at higher frequencies.

With respect to the waveguide program, Fedi stated that this work was perfromed principally at a branch of FUB in Bologna, Italy. Here the aim was to try to develop a flexible waveguide for millimeter waves (in contrast to the solid waveguide developed by Bell Laboratories and others). The program had progressed to a field transmission over a distance of 1 km, but the project has since been shelved, because telephone traffic did not increase as rapidly as was anticipated.

Before leaving Fedi's group, I met Ing. Merlo and Ing. Barbaliscia, who work on the prediction of the attenuation and interference due to rain at 11, 18 and 30 GHZ over 10-km paths. They described two experimental setups. In one, the spacing between transmitter and receiver was 1 km, with spacing between rain gauges of 100 m. In the other, the rain gauges were separated by 1 km, while the distance between transmitter and receiver was 10 km. Their work is essentially to collect the rain data and complete a statistical analysis that yields the expected attenuation, depending on the density of "rain cells," i.e., portions of space filled with rain.

The 11 scientists and 4 technicians who work with lasers and fiber optics are headed by Prof. B. Daino, who was my host in that group. In the mid-sixties, Daino worked at Stanford Univ. in the group of Prof. A.E. Siegman. Daino told me that he and his group were engaged in studies dealing with the application of lasers to telecommunications until 1972; since then, they have worked in fiber optics. Their efforts have involved the characterization of components for fiber-optics systems, developing methods of measurement, and theoretical problems dealing with coherence properties of light propagation in multimode fibers. They have also studied the behavior of light-emitting diodes (LED) and found that there is a time delay between light emission from the edges and the center of an LED of ½ mm diameter. Daino stated, though, that for an LED feeding a fiber this was not serious, since the fiber is much less than ½ mm in diameter. He mentioned that there is also a chromatic time delay and that, if care is not taken, the two delays could add up enough to cause some difficulties. Current studies include one on the behavior of laser diodes, with particular attention to mode jump and noise.

An example of experimental work in progress in the group was that of Ing. Piccari, who was engaged in measuring the attenuation of fibers by a back scattering method. These fibers, incidentally, were obtained outside Italy, for even though a group in Florence has been fabricating fibers, (see *ESN* 30-6:262), these were not believed to be of good enough quality to be usable for actual systems.

The theoretical work in Daino's group includes that of F. Capasso (now at Bell Laboratories, Holmdel, NJ), and P. DiPorto, who claim they were the first to publish a theoretical analysis of the interplay among gain, radiation losses and mode coupling in a fiber laser-amplifier. Another very productive individual in the group is Dott. B. Crosignani, who has published, with DiPorto and others, work on coherence of electromagnetic fields in a weakly guiding fiber, statistical coupled equations in lossless optical fibers, power fluctuations in a lossless optical fiber, propagation of coherence and very high resolution measurements in optical fibers, and related subjects. Crosignani told me that for some time now he has visited the California Institute of Technology about once a year to work with Professors A. Yariv and C.H. Papas.

In summary, it is clear that the work at FUB, while of an applied nature, encompasses a rather wide spectrum of activities, from the measurement of rainfall to theoretical problems dealing with optical coherence. Since FUB is virtually hidden away in the bowels of ISPT and, for that matter, is not found in some of the published listings of Italian research organizations, it might be easily overlooked. Instead, anyone interested in telephone communication engineering should consider it a place well worth visiting. (Irving Kaufman)

ENERGY

ENERGY AND WATER IN ISRAEL

Water is the most important commodity in Israel; with it, the desert can be made to bloom, while without it the country must die. Energy is next in importance; the country has no coal, petroleum, or natural gas, and is presently importing some eight million tons of petroleum each year; even that supply is sometimes questionable because of political disaffection between Israel and most of the petroleum-exporting countries. And energy and water are intimately connected: given energy, one can prepare all the usable water one likes by desalinating the inexhaustible supplies of sea water.

Much of the background of Israel's water problems is discussed in a separate article in this issue. The available water supply in the country is about 1.5×10^9 m^3/yr, and all that is easily available is being used; this includes the surface water in rivers and lakes, and the subsurface water in aquifers which can be withdrawn from wells. Since this amount is not sufficient, it is necessary to develop the alternative sources: reclaiming used water (sewage) rather than pumping it into the Mediterranean; controlling water during heavy rains and floods rather than having it run off into the sea; desalinating salty water; and adopting political solutions such as importing water. Reclamation is discussed in the referenced article; the discussion here is about desalination efforts in Israel, as well as the related subject of energy.

A certain minimal energy is required by the laws of thermodynamics to desalinate water, given by $T\Delta S$, where T is temperature and the entropy change is $\Delta S = -R\Sigma x_i \ln x_i$ per mole, where x_i is the mole fraction (a bit less than .99 for water and a bit more than .01 for the salt) and R is the gas constant. In practice, a great deal more energy is required because of the inevitable inefficiency of the process; or rather, because of the enormous amount of capital which would be required to render the process efficient.

There are basically two ways to separate salt from water: by phase change, and by using a membrane. In a phase change, the water is frozen or boiled off; either method produces pure water and leaves the salt behind. The Israelis have thus far not investigated freezing, but there has been serious talk by some Mideastern countries of towing icebergs from the Antarctic to supply water, since there is no salt in the ice of which icebergs are formed. Distillation has been used since prehistoric times to produce pure water. The modern technology involves "multiple-effect" evaporators. As the pressure on water is reduced, its boiling point becomes lower. So salt water is heated to, say, 100°C, which is its boiling point at normal atmospheric pressure of 14.7 psi. The vapor is first used to heat another body of water to, say, 80°C and then condensed to form pure ("distilled") water; the 80° water is kept at a pressure of about 6.9 psi, at which point it boils, and this vapor is used to heat a third body of water to, say, 50°C, the boiling point at a pressure of 2.9 psi. At this last pressure the volume of the water vapor is very large, and hence the piping must be large, which increases the cost. Furthermore, as water is boiled off, the remaining salt water becomes more concentrated, and its boiling point

increases at any given pressure, while the condensation temperature of the pure vapor does not change; this increase in temperature differential increases the cost again. By the time one has protected against corrosion and provided insulation and the like, it costs at least a dollar to prepare a cubic meter of water. This is orders of magnitude higher than the cost of, say, irrigation water in the US, which is sold by the acre-foot, each acre-foot containing over 1200 cubic meters.

The membranes referred to above are "semipermeable": permeable to water molecules but not to salt molecules. They thus act like filters whose pores are of submicroscopic (molecular) dimensions. The water may be forced through the membrane (leaving concentrated salt water on one side and pure water on the other) either by electricity ("electrodialysis") or by mechanical pressure ("reverse osmosis").

Israel is now operating a reverse-osmosis plant in the south at a capacity of 1000 m^3/day, and testing various different technologies. Though the pressures required are enormous, and the engineering challenges prodigious, in the opinion of Dr. Nathan Arad of Maot Ltd. (Tel Aviv), this is surely the preferred method of desalinating brackish water, and is probably also the preferred method for sea water. Arad, who has a doctorate from George Washington University in systems engineering, and was at one time head of what is now the Ministry of Energy, also has been involved in constructing a larger desalinating plant (about 5000 m^3/day) in Eilat in the extreme south of Israel; this is a dual-purpose device, using the energy in the steam for heat or power rather than for boiling further water under reduced pressure. Arad does not now feel that this is the way to go; using reverse osmosis, it is possible to buy power from the grid for most of the day at reduced prices, and simply stop producing water during the periods of peak demand for electricity.

Arad is especially interested in peak and off-peak uses of electricity. He is an independent consultant in a small company (only one colleague and one secretary), and one of his very few contracts, with the Israel-Electric Co., is on "load management", and, in particular, how to reduce the ratio of peak loads to average loads. The fixed costs of the electric power system, including the enormous amounts of capital required to build the generating and transmitting systems, all depend only on the peak load; the marginal cost of electricity at off-peak hours is only the cost of the fuel, and while that cost has been increasing in price of late, it is still comparatively small (and in the case of hydroelectric or nuclear power, negligible). Furthermore, the electrical generating equipment tends to work at less than maximum efficiency when it is operating at peak, and so there is a fuel saving by shifting demand to the off-peak hours.

The main idea is to combine technology for local and centralized control with tariffs. By having three recorders on the electric meter, with prices varying as 4:2:1 (highest during the peak hours in early evening, lowest during the slack hours of late night), one gets the customer to do the shifting. Something like this is done in America, where certain electric devices, such as water heaters, are turned on only during the slack periods. Arad is studying the possibility of changing the timing of the three recorders from the central station (since the peak hour is later in the summer than it is during the winter), but this is apparently very expensive.

Maot Ltd. has a contract with the ministry of energy to recommend how and when coal should be introduced in Israel. Surprisingly, no coal is now being burned in Israel, although a large (1.4 GW) coal-burning power station is being constructed between Haifa and Tel Aviv and will come on line in 1981. It is difficult for individual industries to shift to coal, but Israel is planning "cogeneration" centers where coal will be burned to produce power. Israel does not have a large space-heating problem because it rarely gets very cold; but several industries use a good deal of process heat, including cement plants, phosphate plants, and the plants which produce potash from the Dead Sea, and such plants can utilize the low-grade waste heat emanating from the cogeneration plants. By such techniques, Arad hopes to save 750,000 tons of petroleum per year.

I also heard about many of the same projects from Dr. Arthur Shavit, Director of Research and Development for the Ministry of Energy (the actual title of the ministry is Ministry of Energy and Infrastructure, and it has responsibility for water, energy, minerals, and "infrastructure" as well as energy). Shavit has a doctorate from MIT and is Professor of Mechanical Engineering at the Technion. He explained to

me that the uses of energy in Israel follow a much different pattern than in the US. Only some 5% of the total energy is used for space heating, and just 10% in gasoline consumption (and less than half of that 10% is for private cars—which is why Shavit thinks that $2.50 per gallon, the present price of gasoline in Israel, is high enough although low compared to most European countries—in Israel one cannot really save very much energy by discouraging private driving). The largest single usage of energy, 38%, is for the production of electricity; 10 - 12% is consumed for diesel, kerosene, and heavy transportation fuels; 15% is used to produce industrial process heat; 5% goes for agriculture; and there are numerous smaller uses (2-3% for domestic cooking and the like).

Israel is making a significant effort to utilize solar energy. Such usage is particularly appropriate because of Israel's low latitude (Tel Aviv is at 32°), which means that the sun is relatively high in the sky, and because of its frequently cloudless skies. About 1/3 of the households in Israel now have solar heaters for their hot water; this includes urban apartment buildings, and the arrays of solar collectors on the rooftops of such buildings are characteristic sights in Israeli cities. Such heaters must have back-up, for long cloudy periods, and this back-up, usually electric, is used about 15% of the time. It is anticipated that by the second half of the 1980s, 2/3 of the households will have such solar heaters. More than 1% of Israel's total energy supply thus comes from solar sources. An even greater exploitation of such simple solar heaters is possible among the many light industries which use low-grade heat, including laundries, textile manufacturing, and electroplating plants. However, most of the industrial process heat mentioned above is required at temperatures too high for easy production directly from solar collectors.

Israel is planning many other uses for solar energy. Among these are air conditioners—an ideal use, since the sunlight is there when one needs it. (Arad, interested as he is in energy conservation, has an old-fashioned electric-powered air conditioner in his office; the Israeli summer is unbearable without it.) They have improved on the "lithium absorption machine" for this purpose. The basic refrigeration cycle is not unlike that of a gas refrigerator, which uses heat to boil ammonia out of a water-ammonia mixture, and then uses the ammonia for refrigeration. Here one uses the sun to heat a mixture of water and lithium bromide to about 85°C, boiling off some of the water, then cools this vapor and uses it for refrigeration before adding it back to the mixture.

Most exciting to me is the "solar pond", which is under intensive development. One digs a pond several meters deep, paints the bottom black, fills it with salt water, and then adds a layer of fresh water one to two meters thick which is lighter and floats on the salt water. When the sun strikes the transparent fresh water, the radiant energy goes through and is absorbed in the salt water or in the black-painted bottom of the pond. This also happens in natural ponds, but there the heated lower layer of water rises by convection and mixes with the cold water above; here, the salt water on the bottom remains heavier even when it is hot, and no mixing takes place. The pond is generally operated with the bottom at 90°C and the top at ambient temperature. The hot water at the bottom can be used for heat, or to run a turbine where Freon is the working fluid. Because there is a little mixing, however, water is occasionally drained from the middle, fresh water is added to the top layer, and salt water is added to the bottom.

Solar ponds are highly capital intensive ($2000 or more, plus the cost of the land, per kilowatt), and Israel is one of the few countries exploiting them. They have two working ponds of 1500 m^2 and one of 6500 m^2; the latter can generate 30 kW continuously, but for a short time it can generate 150 kW; and in December 1979, Israel lit a 150-kW light display from this pond as part of its Hanukkah celebration. They have a four-year, $15 million program to develop a pond of one km^2 to generate nearly 5 MW, with some help, perhaps, from the US Department of Energy (DoE).

There has been some talk of converting the Dead Sea into a massive 1000-km^2 solar pond to develop all of Israel's electricity. The idea is to build a pipe from the Mediterranean and allow the water from that sea to flow onto the surface of the Dead Sea; since the Dead Sea is 400 meters below sea level, some power could even be developed from this. While the Mediterranean is salty (like the ocean), the Dead Sea is much saltier, and so the density difference is more than

ample. This proposed project is so exotic that many of its implications are not well understood. On the one hand it might seriously harm the large industry which presently extracts potash and other chemicals from the Dead Sea. On the other hand, the extra evaporation from the enlarged and less saline surface of the new Dead Sea might modify the climate of Israel and, in particular, increase the rainfall in the Negev Desert (which occupies more than half of pre-1967 Israel).

In fact, this project almost surely would not work; the Mediterranean and Dead Seas are too far apart, there would be too much mixing due to winds, the very salty water would create too much corrosion in the piping, and so forth. Nonetheless, it may well be as realistic as some far-out US projects, such as solar power satellites or fusion devices, and it is probably worth continuing low-level study.

Finally, both Arad and Shavit are enthusiastic about "agricultural waste" as an energy source, namely the conversion of cow manure into methane, which might eventually yield nearly 1% of Israel's energy. Many countries are working on this, but Shavit told me that Israel's systems are more than twice as "efficient" as anyone else's. His definition of efficiency is the number of m^3 of methane which can be produced per day per m^3 of reactor: Israel gets about 4, while the US gets only 1.5 to 2, and China and India only .2 to .3. I queried this measure of efficiency, but Shavit assured me that it was essentially linear with cost, and therefore appropriate.

Israel is doing some research on gasohol, with partial support from the US DoE. This is not for the Israelis themselves—it takes almost a gallon of petroleum to make the fertilizer necessary to grow the corn necessary to make the alcohol necessary to save a gallon of petroleum. But Israel is working with several countries in Africa which do not use synthetic fertilizer and are desperately short of foreign exchange for buying petroleum, and it may be useful to them. Israel has no interest in "biomass"—using solar energy to grow trees which can then be burned to produce heat—because land and water are too valuable for such use. Nor are they doing any research on direct conversion of solar energy to electricity (e.g., photovoltaics or the power tower), although they are watching with interest the expensive research being done elsewhere, and might purchase photovoltaic crystals for special military uses and the like.

Israel's only fossil fuel is oil shale, of which they have appreciable deposits. They are doing some research on exploitation of this resource, but mostly they are hoping that the US will develop the technology.

In summary, Israel will eventually develop at least 3% of its energy requirements from the sun, probably 5 to 10%, conceivably as much as 15%. They will get 35% of it from coal, and they hope to get some from oil shale. The remainder will have to continue to come from petroleum or nuclear energy. As for water, they will eventually use and reuse all the water that comes naturally to Israel, and make up the remainder of their requirements by desalination. Just how expensive that will be depends on the costs of energy. For the very long term Israel, like the rest of us, may have to rely on nuclear energy. (Robert E. Machol)

ENGINEERING

FIFTH INTERNATIONAL CONFERENCE ON STRUCTURAL MECHANICS IN REACTOR TECHNOLOGY

The Fifth International Conference on Structural Mechanics Reactor Technology held in Berlin, FRG, 13-22 August 1979, was organized by the International Association for Structural Mechanics in Reactor Technology, a nonprofit organization established in Berlin in 1972. The purpose of the association, made up of about 200 members from many countries, is to promote and organize national and international scientific/engineering conferences and seminars on structural mechanics in reactor technology.

The Association and the five international conferences were the brainchild of Prof. Thomas A. Jaeger (Bundesanstalt fur Materialprufund, Berlin, FRG.) The principal emphasis remains structural mechanics and nuclear reactor technology. Over the years, in spite of many efforts to bring in a variety of engineering and materials specialists and to gain the support of various technical societies from around the world, the conferences have remained essentially independent forums on structural mechanics with a strong academic emphasis.

The conference has grown so large that it must be organized into divisions; each division, on the average, consists of seven sessions of five to seven papers each.

The conferences typically begin with a plenary lecture or series of general lectures which may be political, inspirational or organizational. The subsequent technical papers are heavily weighted toward structural mechanics and structural analysis, (really a mechanical-engineering, civil-engineering combine), while a few treat special topics such as seismic effects, steel and concrete reactor pressure vessels (where emphasis on materials is encouraged), methods of structural analysis, and fusion power plants. This latter group has grown significantly in the past few years. The conference contained approximately 600 papers but, in addition, a series of pre- and post-conference seminars gave in-depth attention to special topics.

The author's principal interest in this conference was steel reactor pressure boundary problems for the light water reactors as well as the alternative advanced nuclear systems. Accordingly, this review emphasizes the nature and content of the pertinent papers.

Since the conference took place not too long after the accident at the Three Mile Island Nuclear plant, PA, many of the participants had questions about that incident. Consequently, most of the technical sessions were directed to the topic of how to assure adequate safety margins in the design and operation of the primary system in light-water reactors.

Dr. R.W. Nichols (United Kingdom Atomic Energy Authority, Risley Nuclear Development Laboratories) and I coordinated the conference on structural analysis of steel reactor pressure vessels. Nichols is a specialist in metallurgy and mechanics for nuclear systems. A total of ten sessions were developed with a heavy emphasis on fracture mechanics. This emphasis ranged from theoretical evaluation of how fracture may be determined to the application of fracture toughness measurements to specific in-service effects such as radiation embrittlement.

The first session was an exciting, international gathering of university specialists, research workers, and representatives of the electric power industry. The result was an overview of integrity assessment which highlighted a number of problems perceived to be crucial to failure prevention and to the general safety of nuclear power plants around the world. Subsequent sessions were on the measurement of fracture toughness, the evaluation or elastic-plastic fracture mechanics, and the evaluation of component shapes or simulations of actual components of the pressure vessel, such as nozzles and other shaped regions of the vessel. A new and growing interest was apparent in the area of stable crack growth, which complicates the conventional linear elastic fracture criteria but demands solution within the fraternity of specialists if new criteria are to be established for nonelastic conditions. Another area of interest and of great value to the field was modeling to simulate component fracture, including the computational aspects of modeling to simulate fracture, initiation, crack growth and rapid crack extension. The final session involved a series of papers on stress analysis concerning unique effects in nuclear systems.

At the request of the general chairman, the author, with Dr. Darl E. Stahlkopf, (Electric Power and Research Institute, Palo Alto, CA) arranged a post-conference seminar series entitled the "First International Seminar on Assuring Structural Integrity of Steel Reactor Pressure Vessels." The objective was to review all factors which might affect structural integrity of steel reactor pressure vessels. Among the topics covered were design, materials selection, fabrication, possible problems of in-service degradation, and provisions for dealing safely with degradation. National codes, standards, and regulations which impinge upon the design, construction, and operation of nuclear power plants, especially the primary vessel, were also discussed.

Based on over twenty years of experience, the evolutionary growth of the science and technology of these topics permitted a full discussion of the factors which, at each stage of a reactor vessel's life, may influence its structural integrity. The discussion was directed specifically to potential degradation in construction and service as well as the steps now being taken to minimize chances for failure of a steel nuclear pressure vessel.

A panel discussion, drawing together experts from the various subject areas of the seminar, concentrated upon design and fabrication technology as well as experience in the operation of nuclear power plants, and how these

together permit one to project the potential for structural reliability. In addition, the recent accident in the US resulted in a focus on factors which may bring pressure for additional research as well as modification of construction and operating codes and regulations. Much of the discussion centered on probabilistic versus deterministic approaches to integrity evaluation.

Individual papers discussed the areas of design, pre-service, and in-service regulations, as well as codes and standards for future development. The strong emphasis on probabilistic analysis with a minimum of experimental backup was disappointing, as was the fact that several speakers were not able to attend. Consequently, this limited the discussion on nuclear safety, which has received so much emphasis since the Three-Mile-Island (TMI) accident.

The first session, "Design, Materials and Fabrication of Structural Integrity Assurance," was introduced by the principal speaker, Dr. Richard Ruf, spokesman for Kraftwerk Union (Erlangen FRG), a reactor constructor, who outlined the German approach to design and integrity assurance. In addition, there were several papers on the probabilistic approaches to assuring structural integrity, particularly from the German nuclear power industry, which included the utilities and their contractors, as well as the principal manufacturer, Kraftwerk Union. These were stimulating papers which provided much discussion.

The second session covered the problems associated with in-service degradation of materials. The principal speaker was the senior nuclear engineer for Commonwealth Edison, Dr. A.D. Rossin (Chicago, IL) who spoke on research needs from the operator's viewpoint. His principle theme was how to assess the properties of the structure after years of service. Rossin identified a number of specifics including neutron dosimetry, fracture mechanics development, and the integration of knowledge, past and present, to provide the utility and the regulators with a fair basis for projecting safe reactor operation. In this session there was an invited paper by Dr. Phillip Hutton (Battelle Memorial Institute, Pacific Northwest Laboratory) that reviewed the strengths and weaknesses of acoustic emission for detecting and describing flaw extension and thus aiding vessel-integrity assurance. He gave an optimistic but realistic review of this technique for use from the very earliest stages of reactor construction and fabrication to later operational life conditions. Following this presentation, two computer-based papers outlined procedures for assessing the combination of flaw-stress-temperature conditions, which are predicted to cause, or alternately, to prevent, failure.

The third and probably the most interesting session, was on codes, standards, and regulatory aspects. The principle speaker for this session was to have been Dr. Victor F. Stello, of the US Nuclear Regulatory Commission, a principal engineer from the organization that aided in the recovery operation at TMI. Unfortunately, he was subpoenaed by the Kemeny Commission (The President's Commission on the Three-Mile-Island Accident) at the last minute and could not attend the seminar but Mr. Dudley Thompson, his deputy, did an excellent job reviewing the accident and answering questions related to flaw, structures, and integrity, how best to avoid such problems, and how to identify the crucial structural mechanics problems. His detailed review indicated that the structural problems were less serious in this particular case than were instrumental or human aspects of the problem. In addition, there was a paper that discussed the contribution of the American Society of Testing and Materials to nuclear standards, as well as papers reviewing the approaches to quality assurance for reliability in FRG and in the US; the latter especially concerned radiation embrittlement.

The final session was a panel discussion, with a series of selected questions posed by the moderator for each of the panelists. The discussions dealt extensively with the questions of the research needed to assure reactor safety and structural integrity of the primary pressure boundary. The implications of new techniques of fracture mechanics and computer technology were highlighted.

Proceedings of this post-conference seminar will be published by Applied Science Publishers, Ltd. (L.E. Steele, Naval Research Laboratory, Washington D.C. 20375)

TOWED ARRAYS AND OTHER DEVICES FOR SEISMIC EXPLORATION AT PRAKLA-SEISMOS IN HANOVER (LOOK OUT YE GNOMES!)

Prakla-Seismos, GmbH, of Hanover, Germany, is a well-established seismic exploration company. It provides seismic or geological surveillance services on land, at sea, and from the air, and offers specialized related equipment to help in the search for the treasures of the inner earth. For offshore underwater surveillance, long acoustic towed arrays (streamers) are built and operated. These devices are clearly of interest in antisubmarine warfare (ASW) and the company has also been active in that area.

Originally there were two separate companies. Seismos was established in Hanover in 1922 by the Dutch Tissen group and operated as a private company. The government established Prakla in Berlin in 1936. After the war it moved to Hanover, acquired Seismos, and changed its name to Prakla-Seismos. The company is completely government owned but operates like private industry and is not averse to showing a profit. Its policy is guided by a board comprised of senior civil servants. The normal operations are determined by the director, who has come from within the company. There are three departments: commercial, operational, and scientific-technical. About 1200 people are employed, about half in Hanover and the remainder working on sites throughout the world. Most of the company's business is outside Germany. The yearly turnover is about DM 200 million ($120 million).

Seismic prospecting generates a very large amount of data which has to be processed. The results have considerable commercial value. They form the basis for estimating the potential of an area and allow best methods of attack to be formulated (Shall I drill here or there?). It is therefore very worthwhile to make the best possible assessment, using whatever computer capability may be necessary, almost independent of cost.

Offshore prospecting is carried out from survey vessels towing long arrays of hydrophones in plastic oil-filled tubes, typically 2-3 inches in diameter. The array is made neutrally buoyant so that it tows at constant depth. It can be very long. Prakla-Seismos has towed arrays as long as 14 km containing up to 200 groups of hydrophones, with the output from each group being transmitted to the ship for recording. While the towvessel proceeds on a steady course during a survey, explosive charges are set off and repeated every time that the array has travelled the distance between hydrophone groups. The sharp noise from the explosion is received by the hydrophone groups after reflection from the various layers below the bottom. The delays associated with each reflection depend on the distances involved and on the velocity of propagation of the specific path from the specific reflection point. The velocities vary with the nature of the subsurface strata. Off-line processing of the tapes is carried out for all possible assumptions for the velocity and looks for corroboration from data of the other hydrophones. Very considerable computer processing becomes necessary, therefore, to find, identify, and group the various strata. The process may be looked upon as near-field focusing of the array in an inhomogeneous medium.

On land a similar procedure is used, but it is easier to use more channels, and over 300 have been used by Prakla-Seismos. Geophones are laid along the ground and the sound sources can be either explosives or special vibrators mounted on vehicles (Vibroseis). The acoustic data from the phones is transmitted by wire to a recording station. Recently a multiplexing system was bought from Sercel in Nantes, France, and was found to operate well. At Prakla-Seismos the present trend is for 3-D processing where the phones are spread over an area rather than along a line. A similar approach will be tried offshore, using two or more linear arrays towed separately in a parallel multi-towship operation.

My host for the visit was Dr. Helmut Weichart, who is responsible for patents and for scientific-technological developments in the area of underwater acoustic towed arrays. We first visited the data-handling facility in central Hanover where the massive amount of data acquired in the field is processed. The work was described by Dr. Weimer, who is manager of the Computing Technology Department. The data center employs about 300 people, including some 50 who develop new computer programs. The data comes primarily from within the company and is gathered by two oceangoing geophysical research vessels (about 72 m, 1000 tons), three flat-bottomed shallow water survey vessels (about 27 m, 100 tons), four crews working in very shallow water (about 1 m depth) and 30 land crews.

Other data comes from customers, frequently with the location of the site a well-guarded secret. About 1,000 magnetic tapes are handled every day. The data is first pre-processed on several small computers, digitized, and brought to a standard form, as may be necessary for old data or customers' data. The main processing is then carried out on two CYBER 175 computers which are also used with time-sharing terminals. Various data-presentation systems are available, including line-by-line print-outs, CALCOMP plotters, drum-type plotting systems using electrostatic-sensitive paper, and scope displays that are photographed. This last method was developed in-house and is being offered for sale. Color is rarely used, and then only for special purposes.

Plans have been made to bring the whole company into one building, but at the moment, the manufacturing facility lies on the outskirts of town. There, Dr. R. Schulze-Gattermann, sales manager, discussed the capabilities of the company.

The company will conduct seismic or geophysical surveys, obtain data, perform analyses and evaluations, prepare maps and make recommendations; or carry out any part or combination of these tasks. It will also sell all related equipment. The most important customers are oil and coal mining companies. Prakla-Seismos will survey oil fields on land or at sea; and offer drilling rigs, sound sources in instrumented trucks, data processing systems, and plotters. They will build towed arrays for offshore work and supply them with low-noise tow-cable; and will install complete data-acquisition systems for either oceanography and marine technology, or, specially adapted, for ASW. The towed-array work itself will be described with a little more detail in a later paragraph. Air-gun arrays with up to 40 elements are being built and are available as underwater sound sources to replace environmentally unpopular explosives.

An integrated navigation system, "INDAS V," has been developed which uses satellite position fixes, doppler sonar, gyrocompass and/or land-based radio navigation to give accurate coordinates for offshore measurements. The system can be used to provide automatic ship steering. A US-built, high-precision, radio-navigation system is also being offered for sale and service. In another system, hydrographical data can be recorded as a function of location.

For coal mines, the main interest is to determine the extent of seams and the location of faults. The new 3-D seismic survey and data processing technique is specially useful for this work. One such survey covered an area of about 6 km × 3 km. After thorough initial preparations, it took about 2 weeks in the field to complete, at a cost of approximately half a million dollars.

Underground cavities in salt formations, frequently used for storage, may contain air compressed for energy storage, or gas or oil, and thus need to be surveyed and checked periodically. A special small-diameter probe has been developed by Prakla-Seismos that measures the 3-D shape of cavities using acoustics or lasers. It can also provide photographic records of the cavity or borehole.

Aerial surveys are carried out for which a precision doppler navigation system has been developed. The surveys are for radioactive minerals and use airborne gamma-ray spectrometry from which contour maps are made. Magnetic surveys can be carried out at the same time.

Prakla-Seismos participates in present international efforts of exploring the Antarctic through the "Antarctic Club" and performs surveys in that region.

Underwater towed arrays are built in substantially standard seismic form using a plastic hose 2-3 inches in diameter and having three internal steel-cable strength members. The hydrophones used are either "Multidyne" from the Seismic Engineering Corp. (SEC) in Dallas, Texas, or from Ateliers Mécaniques de Saint-Gaudens (AMG) in Saint-Gaudens, France. The hydrophones are connected together in groups, each group coupled by transformer to a pair of twisted wires, and thus brought to the towship for amplification and recording. Recently, charge-coupled amplifiers have been used onboard, without transformers in the array. This system was bought from SEC and performs well and reliably. There is continuous pressure from customers for surveys with higher resolution which implies the use of higher frequencies. This in turn means more phone groups with closer spacing, more wire pairs, and more processing. New arrays are now planned with 200 groups of phones having an inter-group spacing of 12.5 m. The total length of the array would then be 2.5 km, and the highest ambiguity-free frequency would be 120 Hz (half-wavelength inter-group spacing).

Quick-disconnect couplers have been designed and can easily accommodate 200 or more pairs of wires to carry signals, power supplies, connections to depth sensors, etc. They are normally made of brass, but lightweight versions have been built from titanium. Pre-amplifiers are not normally fitted in the array but can be for special purposes. The preferred mode of operation uses the SEC system having neither pre-amplifiers nor transformers in the array, but rather, the outputs are brought to charge-coupled devices on the ship.

Accurate depth control is necessary in shallow waters. It is achieved with "birds" which are perhaps a foot or two long and fit around the array. Each bird has wings that provide a small upward or downward force until the correct depth is indicated by a pressure sensor.

The array modules are assembled in a long corridor suspended from the ceiling. The array itself is finally inserted in the hose using positive air pressure to drive it.

The company seemed aggressively interested in the development of advanced technology. The visit was interesting and instructive. (T.C. Cheston)

MATERIALS SCIENCE

BIENNIAL UK CONFERENCE ON THE PHYSICAL ASPECTS OF POLYMER SCIENCE

Since 1963, physicists and chemists with common interests in polymer science from British universities, government establishments and industries have met and exchanged viewpoints at a biennial conference organized by the Polymer Physics Group. This group is comprised of members from both the Institute of Physics and the Chemical Society. The Chairman is Prof. A. Keller (Univ. of Bristol).

For many years, the conference was held at the Royal Military College of Science at Shrivenham. This year, however, the meeting was held at the National College of Food Technology at Weybridge, 10-12 September. The title of the meeting was "Physical Aspects of Polymer Science."

The first invited paper was given by Prof. M. Gordon (Univ. of Essex) who reviewed and compared theories of phase equilibrium in polymer solutions. The capacity of various theoretical models to account for the sensitivity of phase equilibria to small changes in polydispersity was considered. Theoretical approaches based on scaling methods appear unable to deal with this problem at the present time. Several papers in the first session were concerned with studies of various polymer solution systems.

The second invited paper was given by Dr. W.R. Thomas (Xerox Webster Research Center, Rochester, NY) who reviewed recent research on the polyacetylenes and photo-emission spectra. Undoped polyacetylene, as well as AsF_5 and iodine-doped polyacetylene were considered and compared. At a doping level near the saturation of electrical conductivity (11% AsF_5) the As:F ratio is 1:5 and the arsenic-fluoride moieties are localized near the surface of the polyacetylene fibrils. The C_{1s} core-level spectra indicate a charge transfer of one electron per AsF_5 molecule. Ultraviolet Photoelectron Spectroscopy, X-ray-induced Auger spectra, and CNDO calculations suggest, however, that the AsF_5 moities are not simple AF radical ions. The relation between the electrical conductivity and core level information for various levels of doping were considered.

In the session that followed, several papers dealt with crystal morphology and structure. N.A.H. Halim and C.J.E. Kempster (Univ. of Manchester Inst. of Science and Technology) discussed various morphologies encountered in a study of bi-constituent fibers spun from a mixture of isotactic polypropylene and nylon 11. Bimodal crystallization of the polypropylene was observed with molecules both parallel and perpendicular to the fiber axis. In blends containing more than 50% nylon 11 a third mode was observed, α-phase crystallites oriented with molecules inclined at 50° to the well oriented nylon molecules. Wide-angle and small-angle x-ray studies combined with scanning-electron micrographs of annealed biomodal blend fibers showed that recrystallization of the polypropylene into the third mode orientation took place. The orientation of the polypropylene crystallites was discussed in terms of an epitaxial relationship.

A critical review of the use of Raman spectroscopy for measurements of lamellar thickness was given by G.V. Fraser (Univ. of Bristol). The significance of Raman spectroscopy as a routine method of measuring "absolute" lamellar thickness and the quantitative effect of various corrections used for background, frequency, and temperature on conclusions reached about lamellar structure was considered.

A very careful and systematic study of the influence of growth rate on spherulitic texture in high density polyethylene was reported by M.S. Rahman and D. Vesely (Brunel Univ., Uxbridge). Morphological changes were interpreted in terms of a change in growth kinetics arising from sudden changes in interfacial free energy of molecular folds.

D.C. Bassett and R.H. Olley, (Univ. of Reading) reported on a study of high pressure crystallization and annealing of branched polyethylenes. Differential scanning calorimetry (DSC), nitration-gel permeation chromatography, and optical and electron microscopy of samples annealed or crystallized at high pressures revealed fractionation; partly by molecular weight, but also by branch content. The studies supported the hypothesis of a local melting/recrystallization mechanism for annealing. Only the methyl-branched polymer reached lamellar thicknesses in excess of 1000 Å; ethyl and butyl branches were excluded even from the less dense hexagonal phase. Bassett and A.M. Hodge reported on a morphological characterization of uniaxial drawing in polyethylene utilizing chlorosulphoration and permanganic etching (*ESN* 33-3:96). After yield, the c-axis was inclined by an angle δ to the draw direction. δ was found to decrease with draw ratio (α) to $\sim$15° when α = 5:1. By studying polymers crystallized at high pressures (when extended lamellae were produced) it was possible to separate rotations of lamellae originally present from lamellae formed during deformation (chain folded lamellae).

The results of an infrared study of uniaxially drawn polyethylene terephthalate film subject to constant strain were presented by I.J. Hutchinson and I.M. Ward (University of Leeds) and H.A. Willis and V. Zichy (Imperial Chemical Industries Ltd, Welwyn Garden City, UK). Up to yield, the elastic strains were taken up chiefly in the glycol residues. After yield, conformational changes occurred which permitted stress and orientation to decrease, a higher degree of overall orientation being achieved by orientation of terephthalate residues.

An interesting collaborative study was made by D.J. Blundell (Imperial Chemical Industries, Ltd, Welwyn Garden City, UK) and J. Tunnicliffe and A.H. Windle, (Univ. of Cambridge) on the retraction of polypropylene tape at elevated temperatures. The retraction could be separated into two components: an instantaneous retraction which DSC analysis showed to arise from a partial melting out of crystallites, and a time-dependent retraction which resulted from a thermally activated crystal process.

The last invited paper was given by Dr. M.R. Mackley, (Univ. of Sussex) who reviewed methods of obtaining large polymer chain extension in flowing systems. Solution and melt states were examined from a theoretical viewpoint. The surface growth processing techniques developed by both Zwijnenburg and Pennings for intrinsically flexible molecules and the flow of mesormorphic polymer systems were considered.

In the session that followed, an important paper given by M.J. Folkes, D.A.M. Russell (Brunel Univ.) and R.J. Crowson (GKN Group Technological Centre, Wolverhampton) discussed the results obtained from a careful study of the relation of fiber orientation to injection speed given in the injection molding process. During component fabrication of short-fiber-filled thermoplastics, complex patterns of fiber orientation developed which are responsible for significant degrees of mechanical anisotropy. The injection speed was found to have a major effect on the orientation of fibers in the mold core; slow speeds give fiber orientation parallel to flow and fast injection gives fiber orientation perpendicular to flow. The variation in polymer molecular orientation was also studied using birefringence measurements and related to fiber orientation and fiber concentration.

A paper by A. Unger and A. Keller, (Univ. of Bristol) reported the results of an investigation of the effects of irradiation on the crystal lattice of polyethylene and n-paraffins. Catastrophic destruction of the crystal lattices occurred at 2 M rads. Crystals irradiated at lower doses showed an orthorhombic-hexagonal phase transition at a critical dose which depended on crystal thickness. The transition temperature was lower for higher doses. Separate experiments on paraffins provided evidence that the crystals are especially susceptible to irradiation when in the hexagonal state. Heat of transition measurements on polyethylene revealed that the radiation-promoted hexagonal phase represented a state of order intermediate to the rotary phase in paraffins and the hexagonal phase in unirradiated polyethylenes induced by application of high pressures at elevated temperatures.

A poster session consisting of 20 papers was also included as part of the conference. The papers were left on display for a 24-hour time period, during part of which the authors were required to be present to answer questions. Various papers on physical aspects of polymer science were presented, at least ten concerned with crystal morphology and related physical properties. Two papers treated the relation of the piezoelectric properties of poly (vinylidene fluoride) to crystal structure.

A.A.L. Challis (Science Research Council) spoke at the conference banquet. He dwelt at length on the lack of engineering studies in polymer science (*ESN* 33-5:189). According to Challis, the plastics industries are extremely large and their growth during the past 30 years has been sustained and has usually exceeded 10% annually. In academic institutions, polymers are studied in the main by physicists or chemists; however, information directly useful to industry is usually obtained by in-house research and is not widely distributed to the scientific community. Challis also remarked that there is a lack of understanding in academia of the engineering aspects of processes and applications involving polymers. The physical and chemical properties of a fabricated plastic component result from its physical and chemical structure. Many physicists and chemists are interested in this problem. However, the relation of physical and chemical structure to initial processing is a problem not generally considered in great detail by the scientific community.

Challis concluded by exhorting physicists and chemists to begin to tackle many of the important engineering problems that exist in the general field of polymer science. (B.A. Newman, College of Engineering, Rutgers)

RAPRA

The Rubber and Plastics Research Association, known throughout the polymer world simply as RAPRA, began in 1919 as a cooperative effort of the British rubber and tire industry and the government (Dept. of Scientific and Industrial Research) to establish a group specifically devoted to R&D for the rubber industry. It was the British government that initiated the venture in 1919 because the experiences of WWI had taught that the British industry in general had inadequate research back-up. Today, there are 46 associations like RAPRA giving research support to UK industry.

RAPRA's beginnings were very modest. It started as the British Tyre and Rubber Institute with a director and a research staff of two. It was located at University College in London and funding from member companies was matched one-for-one by the government. The mission of the fledgling Association was to conduct research as prescribed by industry or government. Gradual enlargement of the group forced it to move in 1921 to facilities in Croydon, south of London, and in 1929 it was renamed the Research Association of British Rubber Manufacturers. Firmly established as a quality polymer R&D center, the Association moved in 1954 to its present location in Shawbury, just north of Shrewsbury, Salop and was renamed RAPRA in 1958.

The Association is governed by a council made up of representatives from industry, government, and academia, with industry predominating. The present Council makeup consists of 33 people from industry, two from academia and only one from government. Dr. J.P. Berry, who succeeded Dr. W.F. Watson, C.B.E., in 1976 as Director, has a technical staff of about 75.

RAPRA provides three categories of service: information gathering and dissemination, technical R&D supported by members' fees, and separately funded contract research. An abstract service published every two weeks and covering over 500 journals, patents, and company reports is offered by RAPRA. Association members receive these biweekly abstracts and can obtain literature/data searches and surveys at no cost, and nonmembers can subscribe to the abstracts and purchase computer searches and surveys. The abstracts, along with technical and marketing data, are computer stored for later use in searches and surveys. Product evaluations are also made available to member companies.

The technical staff serves as expert consultants to the industry, and the consultations may be in the form of either a conference session at RAPRA or an on-site visit lasting from a day up to many weeks.

The technical R&D program supported by members' fees is aimed at basic and applied problems pertinent to the industry and also directed toward developing and maintaining the technical expertise of the staff. In 1979 the total expenditure was £520,000, and involved nearly 40 professional man-

years. Currently, they are working on process technology, product design, specification standards, quality assurance (for raw materials and end products), health and safety of plant environments and of plastic products when they reach the consumer (fire hazard, toxicity), and the conservation of resources with emphasis on the efficient use of raw materials and energy. In selecting a research or development project, RAPRA demands a clear justification based on industry need and/or market opportunities, and the objectives of the program must be spelled out in great detail. Also, they involve themselves in the implementation of the results. Each project team submits a 6-month progress report to which the member companies have access. Member companies also receive the final report in advance of it being made available to the general public. Much of the research is eventually published in the open scientific literature.

RAPRA also surveys and conducts R&D projects on a contractual basis for government and industry (including nonmembers), these efforts often being conducted on a confidential basis. During 1979, funds from contract research amounted to 49% of the RAPRA budget.

Some of the work being done under the technical program supported by members' fees includes a study of the degree of cure of rubber products. The work is motivated, first, by the trend in the industry to shorter cure cycles for higher production rates and, second, by rubber being used increasingly in precision engineering applications which means tighter specifications. They are also looking into the problems associated with powdered rubber technology, which promises to increase automation of production and the use of conventional mixing processes in place of the traditional hot-roller blending methods. In another aspect of rubber technology, they are trying to improve mold design techniques and to develop cheaper molds. The emphasis of the design work is to predict the temperature distribution in the mold and its variation with time based on the temperature at the mold cavity surface and the thermal properties of the rubber.

In the area of standards and quality assurance, RAPRA staff members are on a number of international and national polymer standards committees. Because of their long history of involvement in standards setting and their strong technical reputation, the RAPRA people on these committees are highly respected and highly influential. They back up their committee efforts with laboratory work and with test equipment evaluation and development. Also, they are very active in evaluating the properties of new polymeric materials. The principal reason for this activity is that the industry is reluctant to use new materials until good property and processing data are available. Therefore, newly developed polymers are only slowly applied to best advantage.

Quality assurance (QA) during production and of the end item in the plastics and rubber industry has taken on considerable importance in recent years partly because of the use of polymeric materials in structures and in precision engineering applications. Equally important is the increased public awareness of product reliability and its effect on sales and consumer protection legislation. RAPRA's efforts are primarily aimed at assessing the industry to determine the extent of QA, surveying current practice, highlighting unique and effective QA practices, and advising individual companies on QA technology. They are also evaluating QA techniques with an emphasis on determining the state of the art.

In an area RAPRA calls, "community responsibility," they are concerned with the flammability and burning characteristics of plastics, and the air and noise pollution produced by the polymer industry. This group of tasks also includes their Polymer Supply and Characterization Centre (PSCC). In the past, the work on the reaction of plastics to fire concentrated on ease of ignition, and smoke and toxic gas evolution from specific plastic products such as chairs, fabrics, ceiling panels, etc. Currently, they are investigating what happens when a collection of plastic items burns, for instance, when the living room of a home or a school auditorium is on fire. They find that the burning characteristics of a stack of molded plastic chairs are quite different from what one would expect from the burning behavior of a single chair. The burning plastic softens and may flow, thereby propagating the fire more than wooden items.

Due to pressure from government and unions, and as a result of their own initiative, the polymer industry is acting to decrease the hazard of toxic chemicals to the industry's work force and the communities

surrounding polymer plants. RAPRA has singled out for itself the problem of toxic emissions from the processing of major tonnage materials, as in the production of plastic pipe or plastic film. In small scale production the release of dust and the vaporization of toxic chemicals that are present in the formulation as minor constituents do not pose a major problem. However, in large tonnage operations the dust and volatiles can create an unacceptable hazard. RAPRA is sampling and testing industrial environments to determine the magnitude of the problem. Also, they are developing low cost devices for the continuous monitoring of plant environments. In a related area, RAPRA has developed expertise in using polymers for mechanical vibration damping under Ministry of Defence contracts. They are now using this expertise to reduce machinery noise. They have developed foam core panels for sound insulation.

The PSCC was established at RAPRA by the Science Research Council (the UK equivalent of NSF) as a source of standard, well defined polymers and to provide a polymer characterization service. These functions of the PSCC are intended to be an aid to polymer research in universities, but can also be utilized by industrial and government laboratories, and these services are used internationally. Polymer samples, usually a few kg in weight, are drawn from large stockpiles which have been put aside by PSCC over the past decade and longer. They are kept stored under carefully controlled conditions. In this way samples of a given polymer are taken from a single source over a long period of time. The polymer stockpiles are not special preparations but are taken directly from industrial production. Nonetheless, the stockpile materials are well characterized both by PSCC and by their customers who are required to report to PSCC any test data they obtain on the samples they purchase. The tests which PSCC performs on their standards and under their characterization service include gel permeation chromatography, osmometry, viscosity determination, calorimetry, chemical analysis, and electrical and mechanical testing.

Energy conservation is a critical issue in the plastics industry as it is everywhere else. RAPRA is trying to help the industry to improve its utilization of heat, specifically in molding operations. Field studies have determined that there is an incredible loss of heat in, for example, injection molding. Therefore RAPRA has been experimenting in the field and in their laboratories with insulation schemes, enclosures, and recovering heat from ventilated air and from cooling water.

I had an opportunity to talk with three members of RAPRA's staff, Mr. Paul G. Howgate, Head of the Plant and Dynamic Engineering Division, Dr. D.C. Wright, Head of the Product Design and Process Development Division, and Mr. K.V. Gotham, a senior staff member in Wright's Division. Howgate is currently concerned with impact energy adsorption of plastics and rubbers, vibration isolation and damping, and what he calls quasistatic design. Impact absorption is of prime importance for plastic materials used inside automobiles, and for toys and playground equipment. Howgate stated that efforts to design for impact energy absorption often go astray because of misconceptions about the impact event itself. The critical time is in the first few milliseconds of contact because, after that, the object being struck, whether it is the head of a child being hit by a swing seat, or electronic equipment being dropped, will be dissipating the energy itself. He described the case of the swing seat which can be made safe if along the edges of the seat there is a strip of highly compliant rubber. During the first few milliseconds the child's head is compressing the compliant rubber. After that, the motion of the head is taking up the shock.

Howgate's work on vibration isolation and damping has been in designing systems to reduce noise in helicopters for the RAF. Currently, he is trying to formulate rubbers which have damping characteristics with less temperature sensitivity than presently available materials. In his quasistatic design work he is concerned with the creep and stress relaxation behavior of rubber diaphrams and engine mounts.

Wright described the work at RAPRA on glass reinforced plastic (GRP) pipe which began about two years ago when the Imperial Chemical Industries (ICI) became concerned about the reliability of GRP pipe used in chemical processing equipment. ICI realized that there are no failure criteria, no design codes, and no information on the effect of point loadings. ICI organized a consortium of GRP pipe users, materials suppliers, fabricators, the government (Polymer Engineering Directorate), and academia (Univ. of Liverpool

and Univ. of Manchester Institute of Science and Technology). RAPRA was contracted by this consortium to develop design criteria for bend sections of GRP pipe. (The National Engineering Laboratory, East Kilbride, Scotland, was assigned pipe tee sections.) RAPRA is developing finite element analysis for stress distribution and is collecting from the fabricators GRP materials with different fiber contents and fiber orientations. GRP will be subjected to a variety of tests including fracture as Wright expects the material to be notch sensitive. He further pointed out that GRP pipe is a low technology item and also that the composite has a relatively high resin content. Both these factors conspire to a poor uniformity in fiber distribution making it almost impossible to design to a realistic unit load/glass content. Wright does not see any easy way out of this problem since it is probably uneconomical to fabricate to a uniform glass distribution.

Gotham is working on the brittle failure of thermoplastics, specifically, polyvinylchloride (PVC) and polypropylene (PP). He has come upon a dilemma which is beginning to worry other people working on polymer fracture. As previously reported (*ESN* 33-1:14, 33-2:41, 33-9:388), many polymer and polymer composite fracture studies are often justified by claiming that the results relate to the reliability of structures fabricated from these materials. In most of the fracture work, the tests are made using notched specimens, hence the quantity being measured is the stress or energy required to propagate a deliberate notch. Gotham has found in comparing the test results of notched and unnotched specimens that the latter are more discriminating in distinguishing between low and high strength PVC or PP. For example, specimens cut from two apparently identical sheets of PVC gave identical results when tested with deliberate notches, but quite different results were obtained using unnotched samples. Gotham claims that failure is being controlled by crack initiation and not propagation, and that the two PVC sheets differ in the number or type of some flaw initiating defect, such as a bubble or inclusion. He has some microscopic evidence to support this thesis. As Gotham feels that failure criteria based on flaw initiation and growth would be more realistic than one based on flaw propagation (notch tests), he is investigating flaw initiation in PVC and PP.

RAPRA has long held an excellent international reputation in both basic polymer science and in polymer technology. The variety of activities I was shown during my visit indicated that this reputation is well deserved. (Willard D. Bascom)

MEDICINE

ONR FUNDED SCHISTOSOMIASIS PROJECT IN EGYPT

Schistosomiasis, caused by infection with a blood fluke, is one of the world's most serious medical problems. There are more than 200 million people infected with one of three species of schistosomes. In Egypt 20 million people, or half the population, are infected with either *Schistosoma mansoni, S. haematobium,* or both species. The complications of *S. mansoni* infections are usually gastrointestinal and hepatic: diarrhea, intestinal polyps, enlarged liver with fibrosis, enlarged spleen, ascites (excessive fluid in the abdomen) and hemorrhage from the upper gastrointestinal tract (hematemesis). The complications of *S. haematobium* infection usually involve the urinary tract: bladder, ureter and kidney obstruction, pyelonephritis (kidney infection), polyps, calcification, fibrosis, stricture of the bladder and possibly cancer of the bladder.

Dr. Mohamed Farid Abdel-Wahab, Professor of Tropical Medicine at the University of Cairo Faculty of Medicine, has an ONR-funded research project to study the morbidity from and the methods used in the control of *schistosomiasis mansoni* in Egyptian villages. He and his colleagues have concentrated their efforts in three villages about 80 km north of Cairo in the center of the Nile delta. Many of the people in these villages are heavily infected with the species (*S. mansoni*) which causes liver fibrosis.

In a paper published recently in the medical journal *Lancet*, Dr. Abdel-Wahab and his colleagues reported that there has been a complete reversal in the predominant species in one of these villages since 1935. In an earlier study 70% of the villagers were infected with *S. haematobium* while 3% had *S. mansoni* infections. Investigation in 1979 showed that the prevalence of the two species had reversed. Other data suggested that these changes were

rather recent, and that they are associated with a change in the numbers of the intermediate-host snails in the canals nearby. The snail species required to complete the life cycle for *S. mansoni* is much more common than that required for *S. haematobium*, this finding being opposite that reported by earlier workers. If this increased prevalence of infection with the species causing gastrointestinal and liver pathology is occurring elsewhere in Egypt (as some think it may be), it could have serious consequences since it is the more difficult of the two species to cure and probably causes greater clinical illness.

Dr. Abdel-Wahab's group has studied another village of 900 inhabitants in great detail over a 2-year period, and last November they reported that two-thirds of the villagers were excreting *S. mansoni* eggs in their stools. The group with the highest prevalence of infection (85%) were boys between the ages of 10 and 19. The children excreting large numbers of eggs (assumed to be also heavily infected with adult worms) had a larger proportion of enlarged livers and spleens than other villagers, and a history of bloody diarrhea. Sixteen people in this small village have had their spleens removed because of complications from schistosomiasis.

These studies show that schistosomiasis is causing considerable morbidity in Egyptian villages. As yet, however, no one has found a good way to control transmission of the infection or the morbidity it causes. Killing the snails with chemicals has been unsuccessful, as have been attempts at breaking the cycle of transmission by employing methods to prevent people from defecating or urinating into the water. The infected eggs release a larval stage (miricidium) which then infects the specific snail species. Following maturation, another larval stage (cercarae) escapes from the snail and swims in the water, infecting humans by penetrating the skin.

As yet, we do not know if drug treatment of villagers who are continuously exposed to reinfection reduces morbidity and transmission. In a nearby village school, Dr. Abdel-Wahab is in the second year of a study to prove the efficacy of systematic drug therapy. He has shown that a full dose of the drug oxamniquine cures 80% of the children and reduces worm burden (egg excretion) by 95%. However, preliminary study results suggest that one year later, following a summer season working in the fields, almost all children are reinfected and many still have enlarged livers and palpable spleens. This study will require prolonged follow-up and repeated evaluation to determine if drug therapy is an effective way to control schistosomiasis in a community with heavy transmission of infection.

ONR has supported several research projects in Egypt, some relating to schistosomiasis. Dr. Abdel-Wahab's research is particularly worthy of detailed reporting because of the practical significance of the questions they are addressing. (G. Thomas Strickland, Department of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD 20014)

OCEANOGRAPHY

MARINE SCIENCE IN PARADISE

The marine biological laboratory, Laboratoire Arago, is located in the seaside resort of Banyuls-sur-Mer. The resort is on the southernmost tip of France near the Spanish border on the "Costa Brava" where the Pyrenees mountains drop precipitously into the Mediterranean Sea. Jewel-like white resort villages, including Banyuls-sur-Mer, with tiny blue harbors are located in each valley. The valleys are separated by tremendous headlands with backdrops of sunny terraced vineyards on all but the steepest slopes.

The Laboratory was founded 99 years ago by the illustrious zoologist Henri de Lacaze-Duthiers, although it was not officially opened until a year later in 1882. He had first tried to establish a marine laboratory on the north coast of France, but the staff objected to the bad weather there. During his search for a more suitable location, the mayor of Banyuls-sur-Mer offered free land for the Laboratory, which Lacaze-Duthiers accepted. Although the laboratory site is about as far removed from Paris as it can be and still be in France, it does enjoy fast and frequent access to Paris by train. The fast trains from Barcelona to Paris pass through miles of tunnels all along the Costa Brava.

The present Director, Prof. Jacques Soyer, was in Paris on the day I visited the Laboratory, so I talked to several staff members. The Arago Laboratory

was affiliated with the Sorbonne until the late 1960s when its affiliation was transferred to the Department of Zoology of the then-new Pierre and Marie Curie University in Paris (*ESN* 33-8:333). Funding for the Laboratory is shared by the University, CNRS (the French equivalent of our National Science Foundation), and CNEXO (the National Center for the Exploitation of the Oceans). The latter supports "semi" applied research.

An interesting firm division of duties was pointed out to me. The senior staff members, paid by CNRS, are not allowed to teach or have any administrative duties, they only do research. The staff members, paid by the University, must have all three duties; each is in charge of the administration of some function or functions of the Laboratory as a whole.

The Laboratory is well equipped for marine biological research with all the basic equipment, including an electron microscope and computer. The physical oceanographers have reversing thermometers and water bottles and some *in situ* marine optical instruments. The laboratory operates three vessels, each under 20 m in length; their small size restricts "sea time" to fair weather. They have plans to obtain a new, more seaworthy 24-m vessel in the near future. All publicly owned research vessels longer than 24 m automatically are part of the CNEXO pool and individual laboratories lose control of them.

Banyuls-sur-Mer is on the direct route to London from the Spanish and Portuguese marine laboratories that I visited in November 1979, so I stopped there to visit the two physical oceanographers stationed at the Arago Laboratory. Most of the remainder of this article will be about their research programs, along with a brief outline of the marine biological research that is underway.

The senior physical oceanographer, Prof. B. Saint-Guily, works under unique conditions. He is a professor at the Physical Oceanographic Laboratory of the Museum of Natural History in Paris (*ESN* 33-5:178). He explained to me that he became tired of living in the hustle and bustle of Paris twelve years ago. Since that time he has spent alternate two-week periods teaching and working with his students in Paris and carrying out his research in seclusion at the Arago Laboratory.

Saint-Guily is mainly interested in the physical oceanography of the Gulf of Lions in the northwest corner of the Mediterranean. He is studying the various processes in which deep water is formed at the surface in the Mediterranean (*ESN* 33-5:178). One process occurs in winter when the surface water is cooled over the shallow continental shelf. The cold water sinks to the bottom and then cascades down canyons near the edge of the shelf and on into deeper water. During a cold winter the cooled shelf water may sink to depths of 800 m or more where it spreads out.

Saint-Guily, in cooperation with researchers from other laboratories, has made a large number of current measurements in the Gulf of Lions on the continental shelf between the Spanish border and Marseilles as part of a study of summer upwelling. This upwelling is caused by very strong, short-duration (one to three days) local winds called Mistral and Tramontane. This type of upwelling is restricted to coastal regions northeast of Banyuls-sur-Mer. Serial infrared satellite photographs of the temperature of the water surface shows that cold upwelled water at the surface usually occurs at fixed points along the coast. This indicates that, in addition to the wind, the upwelling is influenced by coastal contours and bottom topography (*ESN* 33-4:168). Strong upwelling regularly occurs off Marseille, Camague, and Narbonne. Two weaker upwelling regions occur between the above areas. Mathematical models of localized fixed-point upwelling are being constructed by a student, Miss B. Lin Hua (*ESN* 33-5:178), at the Museum of Natural History in Paris. The current measurement studies have shown that the return countercurrents associated with upwelling in summer near shore are not as simple and regular as countercurrents of other well-studied upwelling regions, such as that off the Oregon coast.

Another subject of interest to Saint-Guily is that of planetary waves on the continental shelf. He has recently developed a nonlinear mathematical model of these waves which takes into account the density stratification of the water column. A strong thermocline at an average depth of 30 m usually occurs over the local shelf in summer. The model indicates that with stratification the baroclinic and barotropic modes of the shelf waves are coupled.

The other physical oceanographer at the Arago Laboratory, Eng. M. Panouse, is a member of the team studying primary

productivity (photoplankton development). He received his training in optical oceanography under Prof. Ivanoff at the Pierre and Marie Curie University in Paris (*ESN* 33-8:333). During primary productivity cruises he measures and records the distribution of temperature, salinity, and subsurface solar radiation for the use of the biologists. He is working on mathematical models relating the distribution of light with depth and photosynthesis. He has found that waters of the Gulf of Lions are relatively unproductive except during and after upwelling when the upwelling has replenished the nutrients in the surface layer. One of the strongest upwelling periods occurs in the spring, usually in March. It results in very strong mixing over the shelf from the surface to the bottom and results in major plankton blooms.

Panouse worked on several cruises in the Indian Ocean over a two-year period. The cruises extended from Reunion Island south past the Kerguelen Islands almost to the Antarctic ice pack. The resupply vessel for the Kerguelen Islands which comes several times a year is used for the research. According to Panouse, the lonely Kerguelen Islands' principal use is for biological, geological, and geophysical research. In the southern summer, all of the factors between the Kerguelen Islands and the Antarctic seem to be right for high primary productivity, but it does not occur. The reason for the low productivity is not as yet understood. As of November 1979, the next cruise to the Antarctic was scheduled for February 1980.

Panouse's personal research is the development of mathematical models for the penetration of light in the sea. In keeping with most of the other experts in marine optics, he feels that better instruments are needed. He is trying to develop his own instrument to measure most of the optical properties of interest *in situ* and independent of the distribution of solar radiation.

Historically, the primary interest at the Arago Laboratory is in all phases of marine biology. The twelve-person, plankton-production team is led by Dr. C. Razouls. Its general objective is to study the structure and operation of planktonic ecosystems in regions of upwelling. They are also carrying out experiments on the efficiency of energy transfer from the milieu to phytoplankton to copepods. In cooperation with other French plankton-production teams they have formed a "Groupe Mediprod" to study primary production. They have been running sections between 43°S to 61°S (see Panouse's work described above) in the Indian Ocean.

Other studies underway include: (1) Pelagic production in a number of places in the oceans; (2) Bioenergetics of phytoplankton photosynthesis; (3) Fixation of CO_2 in phytoplankton; (4) The global budget of the exchange of carbon between the milieu and phytoplankton; and (5) Morphological and physiological adaptations of mesoplankton to the environment.

The benthic ecosystem team is by far the largest team in the Laboratory with 17 members including the Director, Prof. Jacques Soyer. The head of the team is Dr. Aline Fiala. Its primary interest is in energetics of the coastal benthic ecosystem. Research *in situ* and in the Laboratory are carried on simultaneously. Field work consists of obtaining data on the seasonal cycle of nutrients available to the benthic community, determining the populations of bacteria, and studying the biological cycles and population dynamics of important species. As far as possible for certain organisms, studies are made in different climatic regions: subarctic, temperate, and tropical. Laboratory experiments are carried out on the absorption, assimilation, and excretion of organic matter in various forms by representative species at different trophic levels.

The cellular biology team of seven persons is headed by Dr. Marie-Odile Soyer. The principal subject of research is the study of the composition of dinoflagellates. They are studying the structure of their chromosomes, their cell chemistry, and making biochemical analyses of their chromosomic nucleofilaments (DNA proteins).

Other smaller groups as well as individuals are studying the biology of a number of different individual species of marine organisms.

If I were a marine biologist looking forward to a sabbatical, I would certainly consider the Arago Laboratory because of its well-equipped research facilities, normally fine weather, and beautiful surroundings. I was impressed by the *esprit de corps* of the scientists that I talked to. (Wayne V. Burt)

OCEANOGRAPHY IN THE HYDROGRAPHIC INSTITUTE OF THE SPANISH NAVY

An oceanographic research program was started at the Instituto Hidrografico de la Marina (Hydrographic Institute of the Spanish Navy) in 1968 by two Spanish naval officers who had completed a six month course at the US Naval Oceanographic Office in Suitland, Maryland. The Institute, located in the interesting and historic seaport of Cadiz in southern Spain is composed of three divisions; (1) The Nautical Division with departments of Cartography, Navigation, and Nautical Instruments; (2) The Hydrography Division with departments of Geodesy, Geophysics, and Planning; and (3) The Oceanography Division with departments of Physical Oceanography, Chemical and Biological Oceanography, and Geological Oceanography.

I spoke with Rear Admiral Vincente Gandaries, the Director of the Institute, with Captain S.S. Lopez, head of the Oceanography Division, and with LCDR Francisco Nuche Benito, head of the Planning Department. The latter spoke perfect English and interpreted for the others. I find that working through an interpreter is surprisingly efficient for this type of interviewing. While interviewees are discussing each question, one can ignore them and have time to write down the answer to the previous question completely and accurately.

The Institute, with a total complement of 250 persons, operates two 1,000-ton vessels and four 400-ton vessels. One vessel in each class is outfitted for oceanographic research and is engaged part time in that endeavor. The ships have a wide variety of echo sounders including a French-made EGNG side scanner sonar for shallow water, a Kelvin-Hughes echo-sounder for shallow water work, an Atlas DeSoto Model Piso 10, and a Raytheon sounder for deep water work.

In cooperation with CDR Manuel Catalán of the Spanish Naval Observatory the Institute is building a prototype proton magnetometer for measuring declination in shallow water. Their highest priority is a complete new depth survey in the shallow waters surrounding Spain and her navigable rivers and harbors. Their master computer is an IBM 370/115. In addition, they have a number of smaller Hewlett-Packard 2100X computers for hydrographic data reduction both at sea and ashore. There is no DECCA navigation chain available but they use a short range Raydist DRS-4 in a system integrated sounder-Raydist computer package. For shallow water work very close to shore and in bays and harbors, they have a second system for more accurate positioning. This system's integrated package consists of the sounder and computer hooked up to a Motorola Mini Ranger III radio position finder. In depths of 40 m or less the computer print-out is in tenths of meters. I was astounded to examine a large computer print-out with many zero crossing errors and average crossing errors of only one or two tenths of a meter, despite the fact that sounding lines making up the crossings were made at different times and stages of the tide. All contouring, however, is done by hand because they believe that the results are better than any computer generated product, particularly when the bottom is bumpy or pitted.

CDR J.M. Garcia Moretón has his degree in oceanography from the University of Washington. He is head of the Nautical Division at Naval Headquarters in Madrid and acts as a liaison scientist between the Navy's Oceanographic Department and other marine science programs in Spain. Two other officers are currently working on their MS degrees at the US Naval Post Graduate School in Monterey, California. The Hydrographic Division has two in-house instructional programs. One trains enlisted men to be petty-officer technicians. The other is for officers who, after two years at sea on hydrographic ships, return to the Institute to complete a two-year course of study for the degree of Hydrographic Engineer.

The primary emphasis in the Oceanography Division is on determining the distribution of temperature and salinity for underwater sound path predictions. The observations are made with a STD, Salinity-Temperature-Depth recorder. The distribution of dissolved oxygen is also studied as part of their research on circulation and mixing.

The most important program at this Institute is, of course, hydrography. However, the oceanography program appears to be gaining in importance. Two signs of its strength are the fact that a new oceanographic building is to be built shortly and the two master's degree candidates now at Monterey will be the first two officers to be assigned permanently to the Oceanography Division. Previous to this time officers had been temporarily assigned to the Division. (Wayne V. Burt)

THE SPANISH INSTITUTE OF OCEANOGRAPHY REVISITED

Previous ONR London Reports and articles in *ESN* give the history of the Instituto de Español de Oceanografia (Tech. Repts. 10-55, 72,61, 14-66, and *ESN* 27-7:182). In 1955 and 1961 the Institute was under the jurisdiction of the Ministry of the Navy. By 1966 it had been shifted to the Ministry of Commerce. Then it reverted back to the Navy in 1973. Now it is in the sub-section for Fisheries and Merchant Marine of the Ministry of Transport and Communication.

The Institute of Oceanography is relatively large compared to other oceanographic institutions in Europe with a total complement of 214, 92 of whom are classed as "cientificos." Just over a quarter of the staff are based in an office building in downtown Madrid. The remainder are stationed in branch laboratories at Malaga on the south coast, east of Gibraltar (Director, Dr. N. Cãno); at Mar Menor on the southeast coast (Director, Dr. A. Rodriguez de Leon); at Palma on the island of Mallorca (Director, Dr. M. Duran); at Santander on the north coast (Director, Dr. O. Cendraco); at La Coruña on the northwest tip (Director, M. Torre); at Vigo on the west coast (Director, Dr. R.R. Robles); and at Santa Cruz de Tenerife in the Canary Islands (Director, Dr. R.C. Garcia). These branch laboratories are used as bases of operation for researchers from the main laboratory in Madrid, and teams may be drawn from several laboratories to work on a research problem near one of the laboratories.

I visited the Headquarters Laboratory in Madrid and the Malaga Laboratory during November 1979 and had previously visited the Vigo Laboratory in 1973.

The Headquarters Laboratory has the following Departments: (1) Geology, with programs in mineralogy, prospecting, and sedimentology; (2) Marine Biology, with programs in planktonology, productivity, and ecology; (3) The Spanish Center for Oceanographic Data that archives all types of oceanographic data and collaborates with other national and international data centers; (4) Contamination, with programs to survey Spanish coastal waters, bays, and estuaries for pollutants and to study methods for protecting marine structures from pollutants and sea water; (5) Fisheries Technology and Biology, with programs to improve the technology of catching fish, fisheries biology, and research on how to obtain the maximum sustained production in the various fisheries; (6) the new Department of Aquaculture, whose purpose is to develop aquaculture programs in Spain's numerous bays and estuaries to replace some of the seafood products that are no longer available to Spain with the advent of the 200-mile economic and fisheries zone limitation; and (7) Physical Oceanography, which will be discussed below.

Dr. José M. Turnay, Director, and Mr. Julian Gomez, Head of the Physical Oceanography Department, were away the day that I visited the Institute. I talked with two senior members of the Department of Physical Oceanography: Gregorio Parrilla, who had spent a year at Woods Hole Oceanographic Institution (WHOI) eleven years ago, and Fedrico Fernandez, who worked for several years in a C.I.R.S.O. Laboratory in Australia. In addition, I was told that some staff members had had training at the University of Liverpool (*ESN* 33-10:425).

The principal field program of the Department of Physical Oceanography is a comprehensive study of water masses and currents of the Straits of Gibraltar and the Alboran Sea, between southern Spain and north Africa, east of Gibraltar. This study is largely supported by a subcontract with Woods Hole Oceanographic Institution (WHOI) in the US. Mr. Arthur R. Miller is principal investigator of the WHOI contract with the US National Oceanic and Atmospheric Administration (NOAA) for the research on the Alboran Sea. The contract is now in its second year. The program consists of a study of the hydrographic conditions in the sea: how Atlantic water enters the Straits of Gibraltar and flows into the Mediterranean Sea; how the Atlantic water is then distributed; how it mixed with Mediterranean water; and what currents and eddies are associated with it. Cruises, which are made in all four seasons of the year, will continue for several years, depending on the extent of funding from the US.

The interest in the Alboran Sea studies is not only theoretical, but also has a number of applied aspects. Acousticians want to know the depths of sound channels and shadow zones which can be computed from the temperature-salinity-depth data. Marine biologists need to know the hydrographic conditions in their study of the adaptation and development of marine animals and plants, including reproduction, growth, and

migration. They are particularly interested in the conditions fostering phytoplankton blooms in the relatively unproductive Mediterranean Sea. They are also interested in wind-induced and orographic upwelling (*ESN* 33-4:168), occurring in the northeast part of the Alboran Sea, that brings nutrient-rich water to the surface and is one of the factors producing phytoplankton blooms.

The circulation of the Alboran Sea near the Spanish coast depends primarily on the tides and the inflowing Atlantic water and is complicated by a large antecyclonic gyre east of Gibraltar. Data from current studies are being used to predict the distribution and dispersion of pollutants that may be introduced into the Alboran Sea. The Institute is also interested in the effects of water temperature on the microclimate along the south coast of Spain. Also of interest are the internal waves that form on the interface between inflowing Atlantic water near the surface and the outflowing Mediterranean water below it.

The Institute carries out multidisciplinary pollution studies under contracts with private companies. These have included a nuclear power-plant site on the coast south of Barcelona. In the past each department of the Institute acted independently. Parrilla is leading a move to remove some of the barriers between departments to set up the interdisciplinary teams necessary to solve complicated practical problems.

Parrilla wants to modernize the techniques used in the Physical Oceanography Program. He hopes to hire an American specialist in geophysical-fluid dynamic modeling for some months to develop mathematical models of features in the Alboran Sea, including the upwelling in the northern part of the Sea, and a frontal zone (divider between two water masses) and the gyre (large circular eddy) that are sometimes found in the upwelling area.

The civilian marine scientists in Spain, both from the Spanish Institute of Oceanography and in the laboratories of the Institute of Fisheries Research (which will be described in a later *ESN*), share the 50-m, 1000-ton oceanographic research vessel *CORNIDE DE SA SAAVERA*. It was designed as an oceanographic and fisheries research vessel and was put into service in 1971. It is based in Vigo on the northwest coast of Spain. Smaller vessels are frequently chartered for work close to the various coastal and island laboratories.

None of the universities in Spain teach oceanography on a regular basis. The Institute occasionally offers a 6-month formal course in oceanography at one of its branch laboratories with instructors brought in from Madrid and the other branch laboratories. The Instituto Cooperacion Ibero-Americano gives fellowships to Latin-American students to come to one of the Spanish Institute of Oceanography laboratories for 1-2-year, on-the-job training programs. Occasionally UNESCO grants money to students and research workers in Spain and Latin America to come to the laboratory at Mar Menor for 1-month courses in marine pollution. Up to 20 students at a time attend these courses at Mar Menor.

The Institute's only continuing publication is the *Boletin Del Instituto Español De Oceanografia*, which appears at irregular intervals. The two issues that I was given were about 150 pages long and contained papers by in-house scientists. All the papers were in Spanish.

The branch laboratory at Malaga is housed in part of a very pleasant building belonging to the Navy. It is located on the waterfront near the city's main park. A new building is scheduled to be built for the laboratory on the coast a few miles west of Malaga.

The Director, Dr. Natalio Caño, is a physical oceanographer. The laboratory's eight "cientificas" are divided into four sections: physical oceanography, icthyoplankton, mollusks, and fisheries statistics. About half the staff are in the fisheries statistics section.

Caño, in cooperation with Parrila's group from Madrid (who use the Malaga Laboratory as a base of operation), has been studying currents, water masses, upwelling, and the acoustics in the Alboran Sea for many years. There is no instructional program and no students are in residence at the Laboratory. They do some cooperative work with the Ecology Department of the University of Malaga. Caño expects to have a 24-m research vessel for the Laboratory in the near future.

The newest laboratory of the Institute is Mar Menor on the coast northeast of Malaga near the city of Cartagena. Mar Menor (Little Sea) is a large coastal lagoon with restricted connections to the Mediterranean Sea. This makes it ideal for aquaculture research, and is the reason why the new laboratory was located there.

The head of the Mar Menor Laboratory is a marine chemist, Dr. A. Rodriguez de Leon. In addition to aquaculture, the Laboratory carries out research in: (1) the toxicity of detergents and pesticides in marine organisms and sediments, (2) accumulation of Zn^{65} in marine organisms, and (3) bacteriological and pollution surveys of Mar Menor and the nearby coastline.

The branch laboratory at Palma on Mallorca Island is officially called the Laboratorio Oceanografia de Baleares. Its major research projects are: (1) Hydrobiology of the coastal waters around Mallorca; (2) the study of heavy metals in sediments; (3) impact of sewage in local waters; and (4) the dynamics of local fisheries populations.

The Santander Laboratory is primarily interested in fisheries biology and pollution. At present the Laboratory is concentrating on base-line studies of the large bay of Santander—studies that are partially supported by the local city government. The industrial complex around the bay is expanding. Scientists from the central laboratory in Madrid make quarterly cruises in Santander Bay to assist the local laboratory.

The studies underway include: an inventory of marine life that is present; mapping the distribution of temperature salinity and oxygen; and a study of the current patterns in the bay.

The northwest coast of Spain has the largest fishing ports in the country and very large aquaculture projects growing mussels on rafts in the local bays. For this reason, the laboratories at Vigo and La Coruña concentrate on the chemistry of the bays and the biology of shellfish. The central laboratory made a massive base-line study for a proposed pulp mill on Pontevedra Bay north of Vigo, which resulted in six large, Sears catalogue-size volumes of data.

The laboratory at Santa Cruz de Tenerife in the Canary Islands is more broadly based than most of the other regional laboratories, with interests in ichthyology, physical and chemical oceanography, and planktonology. The upwelling area between the Canary Islands and Africa is a region of good fishing. The two physical oceanographers have been concentrating on the physics and chemistry of this area. The US Naval Base at Rota, Spain, provides the Institute with Expendable Bathythermographs (XBTs) to run lines between Spanish ports and the Canaries. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH IN AGRICULTURE AND WATER RESOURCES

ORAGWA, the International Conference on Operations Research (OR) in Agriculture and Water Resources, was held in Jerusalem 25-29 November 1979. A specialized conference of the International Federation of Operational Research Societies (IFORS), it was organized by the Operations Research Society of Israel (ORSIS), sponsored by the Israel Academy of Sciences and Humanities, and held in the Van Leer Jerusalem Foundation Building of that Academy. Registration was held on 25 November; the technical sessions were all held 26-28, with tours of Israeli facilities on the 29th.

At the opening ceremonies, the chairman of the Program Committee, Dan Yaron (Hebrew Univ., Jerusalem) welcomed the guests and asserted that Israel was an appropriate venue because of its limited resources, especially with respect to water. He then quoted from the old testament: "The wilderness and the parched land shall be glad and the desert shall rejoice and blossom as the rose" (Isaiah 35-1). Greetings were also given by Meir Ben Meir, Israeli water commissioner, who pointed out that scientific ingenuity is essential to solve Israel's water problems: there is little water; it occurs in the wrong place (in the north, while it is needed in the south); at the wrong time (in the winter, while it is needed in the summer); and it is irregular, some years being wetter than others. And finally much of the water is found at very low levels, and a lot of energy is required to lift it to where it is needed. Y. Birk (Hebrew Univ.) welcomed the delegates on behalf of the seven institutions of higher education in Israel, B.P. Banerjee (Calcutta, India) on behalf of IFORS, and A. Boneh (Technion, Haifa) on behalf of ORSIS, a society of 300 members, surprisingly large considering the size of the country.

Thereafter there were five plenary sessions, and several sets of simultaneous (two or three at a time) technical sessions.

My favorite plenary lecture was given by R. Weitz, head of the Land Settlement Department. He was a poli-

tician rather than a scientist, but a man with much technical knowledge and boundless enthusiasm. He talked about the evolution of farming, from subsistence farming to modern specialized and automated farming; his principal message was that there is an intermediate "transitional" stage which cannot be skipped, and that attempts to skip it are doomed to catastrophic failure. The table (p-195) condensed from one of his charts, gives the gist of his concept. The data were taken from a World Bank study, and the prices are all in 1978 US dollars; some of these prices have already increased significantly—for example, the value added per work day for automated farms has already increased, Weitz told us, to more than $50. The bottom rows in the table are crucial—the infrastructure and community support are essential.

Is Israel a reasonable model for the underdeveloped countries? "In part", was Weitz' answer. The Israeli kibbutz (collective farm) is unique and nonexportable, though it is in Israel to stay. But the common assertion that enormous infusions of external capital render Israel unique is invalid. Israel did indeed have such infusions, and they enabled it to go all the way from the left-hand to the right-hand column of the table in 1½ generations, which is unusually fast. But the principal function of outside capital is to help generate capital from within, and more than 75% of Israel's capital was indeed internally generated. Israel's success in developing its rural system is no more startling, Weitz asserted, than its failure in developing its urban system.

Weitz presented some experimental and futuristic types of farms in which the progressions of numbers in the table are extrapolated even further. He admitted that his optimistic projections were based on unlimited cheap energy (and the unlimited water that can be obtained by desalination if cheap energy is available). For those interested in Weitz' ideas, he has expatiated on them in a recent book: *From Peasant to Farmer*.

This was a conference on OR, and Prof. G.C. Rausser (Univ. of California, Berkeley) spoke pessimistically in another plenary session on prospects and limitations of OR in agriculture. He discussed the demand for government intervention, and the propensity of governments to respond affirmatively to such demands; he talked about inventories of buffer stocks, export subsidies, import controls, price controls, and other tools available to governments as solutions to the problems of agriculture, and concluded that while such policies might be good in the short term, they were bound to have long-term deleterious effects.

Among the technical papers which I found interesting was one by Dr. Dan Dvoskin of the Inter-Kibbutz Unit for Management Services, Tel Aviv, on the uses of linear programming (LP—a computerized procedure for allocating scarce resources optimally under constraints) in Israeli agriculture. I was surprised to hear him say that LP has become a standard tool for the kibbutz economy, and that LP terminology (activities, constraints, shadow prices, optimal solutions) is common language among managerial personnel in the kibbutzim.

Dvoskin's study was based on some 100 users of LP during the previous three years, of whom 40 submitted responses to his questionnaire which were sufficiently complete to be used in the statistical analysis. He found that LP was being used less and less in overall short-term planning of economic activities for the yearly master plan, and more and more for short-term planning of field crops, or of field crops together with livestock operations. In the latter, typical constraints apply to land, water, daily nutrition requirements, labor availability, and production quotas; activities include cash crops, feed crops, orchards, livestock, water supply, and water storage. Most of the users indicated a high degree of satisfaction in using LP. The LP results had a considerable influence on decision-making; there was always some degree of utilization of the LP findings; and in more than half the cases, economic performance increased by 10-30% as a result of using LP.

L.G. Anderson and A. Ben-Israel, both of the University of Delaware (the latter was visiting professor at the University of Tel Aviv at the time of this conference) gave a brilliant paper on fisheries management (the definition of agriculture was broad!). Ben-Israel presented both a simulation model and an optimization model. The former has an economic sector and a biological sector, linked by the fishing effort. The biological sector contains fisheries which are interdependent biologically (competing for food and/or habitat or having a predator-prey relationship) and/or

Stages of Economic Development and Structure of the Individual Farm Unit

Characteristics	Development Stage			
	Subsistence	Transitional	Specialized	Automated
1. The National Economy				
Per Capita GNP ($)*	120 - 450	600 - 2800	2800 - 5000	Over 6500
Employment - %				
Agriculture	50 - 80	20 - 45	8 - 18	5 - 10
Industry	5 - 20	20 - 35	35 - 40	40 - 45
Services	15 - 30	40 - 50	45 - 50	50 - 60
2. The Individual Farm				
Farm Type Product Destination	Subsistence Home Consumption	Diversified Marketing + Home Consumption	Specialized Marketing + Processing	Automated Mainly Processing
Output Value $	300 - 1000	2000 - 6000	10,000 - 30,000	Over 50,000
Ratio: Value Added/ Output %	90 - 60	50 - 40	35 - 25	25 and less
Investment per work day $	2 - 6	15 - 35	50 - 85	350 - 500
Value Added per work day $	2 - 4	5 - 15	15 - 30	Over 35
Annual Work Schedule	Seasonal (Underemployment)	Balanced	Depends on Farm Type	Mostly Seasonal
3. The Supporting System				
Dependence Upon Community Organization	Insignificant	Complete	Partial	Insignificant
Dependence upon Regional and National Organizations	Insignificant	Partial	Complete	Essential

technologically (harvest of one species necessarily involves harvest of the other), leading to great complexities. The optimization model is even more complex; it first uses dynamic programming (DP) to determine the optimal harvest, and then uses LP to allocate this harvest among the various vessels.

Prof. S.B. Harsh (Michigan State Univ.) discussed the application of OR tools to agriculture in connection with TELPLAN, a computer system developed over the past dozen years. The earliest computer systems, c. 1960, were not useful in agriculture because they supplied only descriptive information (answering "What is ...?" types of questions). TELPLAN goes on to give predictive information ("What if ...?") and even prescriptive information ("What should be done?") It has been widely and successfully applied, not only throughout Michigan but more recently in many other states, by agricultural extension agents who are not technically trained, using small portable terminals and a large central computer. The sophistication of this system is impressive, considering the lack of technical background of both the customers (farmers) and the agents. For example, a farmer might wish to know what size of cropping equipment best fits his farming operation. Assuming each of several alternative machinery systems, the agent might then determine the most profitable mix (say of corn, soybeans, etc.) given expected prices, production costs, machine performance rates, field time, storage facilities, land and labor availability, and other related factors. The outputs would include measures of probabilities and/or risk which the farmer can then take into consideration in determining the optimal size of machinery for his farm.

B. Espildora, E. Brown, and J. Castillo (Dept. of Civil Engineering, Univ. of Chile) described a simulation model for a reservoir and associated irrigation system in the Loa River in the Atacama Desert in Chile. While it has not been possible to use this model for optimization of the releases from the reservoir as originally desired—because errors in the input data are of the same order of magnitude as the differences between alternative policies—it is of some interest to note that this type of computer model is apparently operational worldwide.

M. Avron & A. Mercado of TAHAL (Water Planning for Israel, Tel Aviv) spoke on an optimization model concerning salinity in the aquifers of the coastal plain of Israel. This plain, while only some 20 km wide, is the locale of much of Israel's agriculture. Water from the hills of central Israel flows westward through the aquifer, and supplies the wells which are a source of irrigation water. However, the salinity in the aquifer is increasing at a rate of at least 2 ppm per year, which is unacceptable; for example, above a threshold of 200 ppm of chloride, each additional 50 ppm of chloride reduces the yield of oranges by about 4 tons per hectare. Some crops, such as cotton, are more tolerant, while others, including avocados (a crop which yields exceptionally high monetary value per hectare) are even more sensitive. One unusual property of this aquifer is that the chloridity decreases in the direction of the flow, because there is more rainfall near the coast, which dilutes the water which has come through the aquifer. So one solution is to pump the purer water from the sand dunes on the coast, where there is little demand, and carry it inland on the surface to where the demand is. Avron and Mercado have developed an optimization model: the activities are the amounts pumped from various wells at different locations; the constraints represent the maximum permissible chloridity at different points of application; and the objective function is to minimize cost. In the question period it was made clear that this model does not account for intrusion of sea water, which will result if too much fresh water is pumped from wells near the coast (see below); nor does it account for the inevitable long-term increase in salinity if the water is continually reused—by being applied to the crops, draining into the aquifer while leaching salt from the soil, and then being pumped up for reuse.

"Optimal Allocation of Irrigation Water on a Farm during Peak Seasons" was presented by D. Yaron (see above) and represented work done by his student, A. Dinar, at Hebrew University. Much previous work has been reported using DP to optimize irrigation schedules, or LP to allocate water at a given time to competing uses. The present paper combines the two, using the shadow prices arising from the LP solution as inputs to the DP model, which in turn consists of two submodels: a soil-moisture model which related soil moisture to irrigation decisions; and a crop-response model which relates crop yields to soil moisture.

Space does not permit description of many other fascinating papers, but the reader by now will have concluded that OR is being applied effectively throughout the world to many problems in agriculture and water resources; and that in Israel in particular, where water is an exceptionally scarce resource, OR is being applied very generally and most effectively, and is one of the factors leading to the extraordinary success of Israeli agriculture.

Friday, 29 November, the last day of the conference, was devoted to tours of facilities where many of the techniques of which we had heard were being put into practice. Our first stop was the Dan Region Sewage Reclamation Project in Rishon-le-Zion, in the sand-dune region south of Tel Aviv. At the present time it is processing more than 20 million cubic meters (mcm) per year, arriving in an 84-inch gravity pipe from the southern suburbs of Tel Aviv, some 10 km away. This represents about one sixth of Tel Aviv's sewage and ultimately this plant will process all of it. The objective is to reclaim this water, which represents a significant fraction of the 1500 mcm which is Israel's annual water supply. The reclamation produces water which is basically of potable quality, but which is not used directly; it is allowed to drain into the aquifer, from which it is withdrawn, one or more kilometers away, after percolating through the aquifer for some hundreds of days, for use in agriculture. The basic treatment method is biological, which requires a lot of area (some 200 hectares for the present 20 mcm/yr) but comparatively little capital. Additional land is not available, so the expanded plant will use primarily chemical methods which are more capital-intensive.

After all of the available surface and subsurface water has been used, Israel must go to reclamation or to desalination; the latter, which is discussed below and in another article in this issue, is far more expensive.

Our next stop was the Saad Kibbutz in the southwest corner of Israel 10 km north of Gaza, where we examined their automated irrigation system. The original motivation for this system was security: a man going out at night to turn a valve might be killed, so it was desirable to turn the valve on and off remotely. But the principal benefits have been economic, and the total $100,000 cost of the system (solenoids to operate the valves, electric lines, controls, and the computer), was recouped in less than five years. Specifically, with the computer there is no need for extra pressure as a safety factor to ensure that the farthest sprinkler operates efficiently; failures from spillage are eliminated (e.g., if a tractor breaks a pipe, this is sensed automatically and the appropriate valve is closed); and the entire fertilizing operation can be made more efficient, with the ground being wet with just the right amount of pure water before water containing the proper amounts of fertilizer are fed to a particular crop at a particular stage in its development.

An interesting bonus of the automated irrigation arises from the fact that this particular Kibbutz is very orthodox, and orthodox Jews are not permitted to work on the Sabbath, which means that they may not even open or close a valve. However, Saad's computer is under no such restraints, and merrily continues the optimal irrigation schedule throughout the week.

The computer system, developed for Saad by Motorola, is now a commercial item used in many places. It does not, as yet, have a lot of logic built into it; that is, it does not do many of the fancy things described at the conference, but only opens and closes valves according to a predetermined schedule, together with printing out instantaneous and cumulative values of interesting parameters (such as total water usage month to date—crucial during the summer, when there is an absolute ban on exceeding the monthly quota of water, and it is undesirable to run out several days before the end of the month). But the instruments for measuring such things as temperature and soil moisture are there, and it is surely only a matter of time before the computer will be taking the inputs from these instruments and computing optimal watering and fertilizing schedules.

Mekorot, the national water company of Israel, divides Israel into five regions for administrative purposes, and our final stop was at the headquarters of their Central Region, located in Ramla (between Jerusalem and Tel Aviv). This company operates the national water carrier, the remarkable engineering achievement, completed in 1964, which brings water from the Sea of Galilee in the north, more than 200 meters below sea level, and pumps it through a 108-inch pipe to distribute it throughout Israel, including the Negev Desert in the south. There

are three pumps to lift the water, and when they all operate, they pump 65,000 cubic meters per hour. Just to get the water up over the hills between Galilee and Tel Aviv requires 2 kwh per cubic meter, so the energy cost is high. Because some of the inlets to this Sea were brackish, the chloridity used to be very high (384 ppm), so they built a canal around the Sea to carry this brackish water to the Jordan River, and now there are only 230 ppm chloride, so that the water is usable in most agriculture.

Mekorot also operates the country's desalination plants, notably the large reverse-osmosis plant in Eilat (in the south, using Red Sea water) which produces 1,000 cubic meters per day of fresh water, some of which is mixed with local brackish water, and which supplies more than half of all the water used in the Eilat region. It now appears that reverse osmosis may be more promising than the classical method of distilling the water in multiple-effect evaporators.

Mekorot uses a number of analytical techniques in managing these facilities. One especially interesting one which was described to us concerned preventing intrusion of sea water into the coastal aquifer. Such intrusion is exacerbated by the withdrawal of water from the aquifer through wells near the coast. What their analysis has shown is that the water table can be drawn down very far at distances from the coast exceeding one km, provided that plenty of fresh water is pumped into the aquifer about one km from the coast. The remarkable conclusion of this study is that this same fresh water can be pumped out again half a km from the coast, after it has done its job, so that there is no net loss of fresh water.

This tour convinced us that the OR techniques discussed at the ORAGWA conference are being applied successfully—at least in Israel, and apparently also in many other places. And while there were some papers presented at the conference by substantive experts who didn't really understand OR, and by OR experts who didn't have sufficient knowledge of agriculture or water resources, the conference was on the whole very stimulating, and I suspect very useful. (Robert E. Machol)

PHYSICS

CAMBRIDGE UNIVERSITY—LASERS & CHEMISTRY

In January I had a delightful and informative visit with Dr. Ian W.M. Smith at the University Chemical Laboratories, Cambridge. Smith and his group have not only made extensive use of lasers in chemistry research, but have also developed their own lasers when the "right" laser was either unaffordable or unavailable. Before describing Smith's research projects, I would like to make a few comments about Cambridge University, Christ's College, and the University Chemical Laboratories.

Cambridge University came into existence in the early thirteenth century "with the arrival of a group of fugitives from Oxford," as one writer put it. The University has 24 undergraduate colleges with 7 admitting men only, 2 admitting women only, and the remainder being co-educational. The undergraduate students, just over 12,000 in number, are instructed by 1,300 teachers and 125 professors. Each college is autonomous in that it has its own rules and regulations, elects its own Fellows, a admits its own undergraduates, and provides academic, sporting, and social facilities for its members. One rule surprisingly still on the books forbids undergraduates to have cars and as one might expect, the streets and paths are crowded with bicycles. The University, in its umbrella relationship to the colleges, has among its functions the organization of examinations, the awarding of degrees, and the enforcement of those aspects of discipline which lie outside the competence of the individual colleges. One university-wide rule permits the use of electronic calculators in the Cambridge Colleges' Examinations provided that the calculators are hand-held, silent, and battery operated. Spare batteries can be brought into the examinations; however, magnetic cards for storing programs are prohibited. With the rapid increase of hand-held calculator capability, these rules will undoubtedly have to be modified before long.

Christ's College, from which Smith graduated and in which he is a Teaching Fellow, was originally founded in 1437 under the name of "God's House." In 1505, some 60 years after the college was forced to move to another site in Cambridge, Lady Margaret Beaufort, mother of King Henry VII, undertook to "augment, finish and establish" the

college, which was from that time called Christ's College. John Milton and Charles Darwin are among the notables to have attended Christ's College.

The University Chemical Laboratories, which are independent from all undergraduate colleges, house both the Chemistry and Physical Chemistry Departments and are dedicated to research and graduate student training. Even though they are in the same building, these departments have separate staffs, budgets, and space. Three of the 15 staff members of the Physical Chemistry Department use lasers; Smith uses them more extensively than the others. Dr. P.B. Davies uses tunable semiconductor injection lasers and ir laser magnetic resonance to determine the structures of gaseous free radicals and other transient molecules. Professor B.S. Thrush, who holds one of the department's two chairs, uses far ir, ir, and visible laser spectroscopy to study free-radical reactions of atmospheric importance. Like Davies, he uses laser magnetic resonance spectroscopy to study free radicals.

Most of Smith's research revolves around the quest for a better understanding of the kinetics of diatomic and triatomic gaseous molecules. The process of major concern is vibrational energy transfer and the species studied are chosen because they are of fundamental interest and have practical importance; e.g., atmospheric constituents and laser media (CO, CO_2). Vibrationally exited molecules can be produced in a number of ways: through an intermediate by vibrational-vibrational (V-V) or electronic-vibrational (E-V) energy transfer; by chemical reaction; by passing a gas through an electric discharge; by heating the gas; or by direct photon absorption. Usually the kinetic analysis of the last method is less complex and the interpretation of the results involves fewer assumptions.

The technique used by Smith to get a handle on the decay constants is laser induced ir fluorescence. In this technique a laser is used to excite (either directly or indirectly) the species of interest, and the rate constants are deduced from time-resolved measurements of the ir fluorescence emitted by this species. This fluorescence can result from self-relaxation, but in most relaxation studies it results from energy transfer to the other constituent of a binary mixture.

Until the advent of tunable lasers, direct laser excitation could only be achieved when there was a coincidence between a laser line and an absorption line of the species under investigation. Smith recently performed the first experiment in which vibrational relaxation of HCN was observed following direct optical excitation [*J. Chem. Phys.* 71, 3346 (1979)]. He reported on the utilization of tunable ir radiation obtained by stimulated electronic Raman scattering (SERS) in cesium vapor to determine the rate constants for:
$HCN(001) + M \rightarrow HCN(mno) + M + \Delta E$ where M = HCN, Ar, N_2, CO, and CO_2. The third harmonic of a Nd:YAG laser was used to pump a tunable dye laser, and the output from this dye laser was tuned to near resonance with the cesium 7^2P-6^2S transition. When this pump wave is of sufficient intensity and is near resonance, stimulated Raman scattering occurs with an efficient shift to shorter wavelength. (Smith obtained a dye laser/SERS photon conversion efficiency of 15%.) In this case, the dye laser was tuned so that the SERS output coicided with the 3.05 μm absorption line of HCN. For more details on the SERS process the reader is referred to the first paper on this topic [*IEEE J. Quant. Elect.* 9, 227 (1973)]. The rate constants for the five reactions indicated above were found to be in reasonably good agreement with the results of previous work. The results of this and previous work are compared in the *J. Chem. Phys.* paper mentioned above.

Smith and J.S. Robertshaw have recently used the output resulting from frequency doubling the output from a flashlamp pumped dye laser to produce $O(^1D)$ from the direct dissociation of O_3. E-V energy transfer from the $O(^1D)$ was used to generate non-Boltzmann v vibrational distributions in the following molecules: CO, N_2, CO_2, N_2O, and OCS. By measuring the variation of ir fluorescence with time and gas composition, the rate constants for vibrational relaxation of CO(v=1), N_2(v=1), CO_2(001), N_2O(001), and OCS(001) by O_3 were determined. Because N_2 does not emit ir fluorescence, N_2† could not be observed directly by the ir fluorescence technique. In this case the relaxation rates for N_2(v=1) were deduced by observing the ir fluorescence from CO(v=1) following photolysis of O_3 in mixtures of CO and N_2. The relaxation processes in CO_2 and N_2O are of interest because in the CO_2 and N_2O chemical transfer lasers, these molecules are excited by energy transfer from OH† or OD†

generated in reactions that are initiated by flash photolysis of O_3. It was concluded that the most probable mechanism for the relaxation of these 5 molecules to O_3 is V-V energy exchange, rather than vibrational-rotational, translational (V-R,T). A detailed discussion of this experiment and a complete presentation of the results will appear in an upcoming issue of *J. Chem., Soc. Faraday Trans. II (GB)*.

In an experiment to be published in *Chem. Phys. Lett.*, Smith and D.J. Wrigley report on the first application of a new technique for obtaining the relaxation rates of molecules in high vibrational levels. Chemical reaction is used to generate the excited species; however, in this case the reaction is initiated by pulsed photolysis and the time-resolved vibrational chemiluminescence was observed. The excited species generated in this study was $HF(v \leq v_{max}=3)$ produced according to $F + HCl \rightarrow HF + Cl$ where the F atoms were produced by photolyzing F_2 with the frequency quadrupled output of a Nd:YAG oscillator-amplifier laser system. The energy transfer rates for HF(v=3) as determined in this investigation confirm those obtained by workers using other techniques, e.g., optical pumping. It was concluded that this new method can be used to provide molecules in even higher levels of excitation. To this end a series of experiments in which HCl is replaced by HBr or HI are underway in Smith's laboratory.

As a result of his undergraduate lecturing on bimolecular reactions, Smith could not help but note the glaring shortcomings of simple collision theory. In simple collision theory, the reagents are assumed to be structureless and hard. The latter assumption means that in a "collision" no reaction occurs until the reagents' separation is equal to the sum of their hard sphere radii. The most widely recognized shortcoming of the simple collision theory is a result of the assumed structurelessness which results in the probability of reaction upon "collision" being orientation independent. To provide for an improved theory of bimolecular reaction that is appropriate for the undergraduate classroom ("not too easy nor too difficult"), Smith has developed a new modified simple-collision theory. (A paper describing this theory has been submitted to *J. Chem. Educ.*) The key modification involves taking into account the angle between the bond which has to be broken and the line joining the centers-of-mass of the reagents "at impact". This new theory, like any other, has limitations, one being that no predictions can be made about the product characteristics, e.g., the distribution of scattering angles on energies among the products' degrees of freedom. Smith pointed out that in teaching, the new model should fill the gap between the crude simple collision theory and complex full-scale scattering calculations.

Smith is highly regarded for his research in kinetics of gas reactions and for his knowledge in the area of chemical lasers. His contribution to the "Workshop on Tunable Laser Spectroscopy" (*ESN* 33-6:247) and a review paper on chemical lasers to be published soon (*Optics and Laser Technology*) attest in a small way to this recognition. Smith's research leadership ability and his concern for the educational process of his undergraduate students certainly make him a valuable asset to Cambridge University. (Richard S. Hughes)

THE INTERNATIONAL CONFERENCE ON NUCLEAR PHYSICS WITH ELECTROMAGNETIC INTERACTIONS

The International Conference on Nuclear Physics with Electromagnetic Interactions took place in Mainz, FRG, on 5-9 June 1979. Over 300 scientists participated, mostly nuclear physicists from 24 countries. The program was undoubtedly one of the most comprehensive presented in this field. The field itself is of central importance in nuclear physics since the lion's share of knowledge we have in the structure of nuclei has come from investigations with electromagnetic probes.

The conference was organized into 19 sessions: 15 sessions of invited papers, 2 of contributed papers, and 2 of both types (Sessions 7 and 8). The contributed papers were presented in parallel session except for sessions 7 and 8, where the contributions were given parallel to the invited addresses. The topics covered at the conference included nuclear structure, electron scattering, photonuclear reactions, new accelerators, instrumentation, and relativistic and mesonic effects. The distinguishing mark of this conference involved the linking of the new accelerators, such as those at Bates-M.I.T., Saclay (Gif-sur-Yvette, France) and IKO (Amsterdam), to the theoretical advances in relativistic and mesonic aspects of nuclei. This is, in fact, a rather even-handed affair with cases of theoretical advances motivating accelerator

development and vice versa. On the whole, however, most of the challenges are still with the theorists to explain even the current experimental data, especially at high momentum transfer, to within the experimental accuracy.

The importance of the field of electromagnetic interactions in nuclear physics has mainly to do with the probe used to study the nucleus. These are usually electrons or photons, and they may be accelerated toward the target nucleus and detected after the reaction. Their main virtues are that the electromagnetic interactions are for the most part known, and they are weak—weak, that is, compared to the forces inside the nucleus between the constituent neutrons and protons. The ratio of the strengths of the electromagnetic forces to the stronger nuclear forces is roughly determined by the fine structure constant ($e^2/hc \approx 1/137$) times the charge of the nucleus. Hence, perturbation theory, and usually the Born approximation, can be used reliably to analyze the experiments (at least with light nuclei). In elastic electron scattering, for example, the charge and magnetic structure of the target nucleus can be rather clearly extracted, while corresponding information on excited states and continuum states can be extracted from inelastic scattering and reactions. The extraction of such information from purely nuclear reactions is much more difficult because of the internal excitations and rescatterings caused by the strongly interacting projectile nucleus when it penetrates the target nucleus. (This is not to say that such reactions are not rich in information if correctly analyzed.) One of the main goals in the study of either type of process (electromagnetic or nuclear interactions with nuclei) is to employ the extracted information on nuclear states to tell us something about the underlying nuclear interactions.

This being said, the caveat must be added that at high energies (i.e., as the center of the nucleus is being probed, or as relativistic components of the nucleus' momentum distribution are being probed) the electromagnetic interaction with the nucleus is not completely known. A well-grounded theory of calculating nuclear-wave functions in the relativistic domain still does not exist. Also, from relativistic field theory, processes contribute that involve in a complex way both the nuclear and electromagnetic interactions simultaneously and cannot be accounted for simply in terms of a nuclear potential and static electromagnetic (Coulomb and vector) potentials. An example of this is the simultaneous propagation of a photon (which carries the e.m. field) and a pion (which partially carries the nuclear force field). These processes are usually referred to as meson-exchange currents (MEC). While these effects are a complication, only their understanding will help us to understand in detail the internucleon dynamics and its relation to particle physics. Investigations in the energy region where these mesonic and relativistic effects start to become important define what is called "intermediate energy physics" or "meson-nuclear physics". Developments in this field have produced the "meson factories" at Los Alamos (LAMPF), Vancouver (TRIUMF), and in Switzerland (SIN), for the study of nuclear reactions, and have motivated the development of higher-energy electron accelerators at Cambridge (Bates-M.I.T.), IKO, Saclay, and elsewhere to study nuclear interactions by electromagnetic probes.

At Mainz, important advances were reported in both the traditional "low-energy" domain and in the newer "intermediate-energy" field. In both, the higher-precision data available from various reactions as well as from the new dispersion-matching techniques in electron scattering have challenged the theorists to refine their descriptions of nuclei, a challenge they are beginning to meet. The extreme precision of the data in the low-energy regime (including static properties such as charge and magnetic radii and magnetic moments of nuclei) has shown small, but significant, deviations from theory. This is a region where standard nuclear theory (e.g., the shell model) has been fairly successful in the past in describing the data. Now there are theoretical efforts to see how the "intermediate-energy" components of the nuclear wave functions may help resolve the remaining discrepancies. For large momentum transfer (i.e., the "intermediate energy" regime) large discrepancies between theory and experiment have existed in the past, and still do, although significant progress in understanding them was reported at Mainz, at least in light nuclei. Some of the experiments planned, at Bates for instance, are specifically aimed at resolving some theoretical uncertainties, such as in the understanding of MEC.

The above description of the Mainz conference is rather general; the following paragraphs discuss topics covered in the conference along with the highlights of the invited sessions.

The opening session dealt with the mesonic presence in nuclei and their influence on electromagnetic (mainly magnetic) properties of nuclei. Two additional sessions covered nuclear structure information, mainly charge and magnetic distributions, obtained from high and low energy, elastic and inelastic, electron scattering and also from muonic x-ray measurements. There was also a report on very high energy electron-scattering experiments on the A = 2 and 3 systems.

The second day's session dealt mostly with new accelerators and the experiments performed or that could be performed on them. In addition, the subjects of photoneutron cross-sections, photoabsorption sum rules and electromagnetic sum rules were discussed.

Some traditional nuclear-physics topics—collective motion, giant resonances, fission barrier studies, etc.—dominated the third day. Most of the fourth day's talks dealt with photonuclear or pion-photonuclear physics. In addition, there was a talk on coincidence experiments at the Bonn cyclotron, while Y.E. Kim (Purdue Univ.) spoke on the theory of light nuclei.

The last day of the conference dealt with relativistic effects, including MEC and isobar propagation. In the final session there were presentations on parity violation in deep inelastic electron scattering and on future prospects in this field.

The main theoretical contribution of the conference was the detailed consideration of the mesonic degrees of freedom in nuclei (remember, pions and other bosons carry the nuclear force field). In the opening talk G.E. Brown (State University of NY, Stonybrook) indicated that the dominance of the pion presence in nuclei (these give the largest MEC contributions) in the intermediate energy region can be attributed to a small quark "bag" of about .5 fermis (dubbed the "little Brown bag") which suppresses the MEC of heavier bosons. This dominance is evidenced by (among other things) the extreme success that these MEC's have in describing the back-angle deuteron electrodisintegration data for 200-600 MeV electrons—a fact which was also reported in other contributions. Brown's remarks can also be taken to define the upper limit of the "intermediate energy region" as the energy where one just begins to penetrate the "bag". This upper limit is about 1.5 GeV.

For years experimentalists and theorists have questioned why electron-scattering form factors at large momentum transfers are so much greater in magnitude than expected. This has motivated much of the work on MEC, relativistic effects and isobar propagation—but still the discrepancies are not fully resolved. It now appears that a better theoretical understanding of these processes is necessary, and not just to explain the form factors at large momentum transfer. The experimental precision of nuclear charge and magnetic densities (and other properties), well described in the lectures on low energy inelastic and elastic scattering by A. Richter (Technische Hochschule, Damstadt, FRG) and L. Lapikas (IKO) respectively, and in high energy scattering by J. Heisenberg (Univ. of New Hampshire), B. Frois (CEN de Saclay) and H.D. Wohlfahrt (Los Alamos Scientific Laboratory), indicates the necessity for refinements in theories of the "mesonic degrees of freedom." Especially dramatic was the precision to which the central density of ^{40}Ca can be calculated, given the experimental data including recently measured electron scattering measurements (up to momentum transfer 3.6 fm^{-1}) at Saclay, which was the subject of the talk by D. Gogny (Centre d'Etudes de Bruyeres-le-Chatel, France).

While most of the contributions considered "low" and "intermediate" energy phenomenon, the talk by R.G. Arnold (Standford Linear Accelerator Center, Standford, CA) touched on measurements of electron-scattering cross-sections on light nuclei at such a high momentum transfer that it was hoped the quark structure of the nuclei could be probed. Arnold claimed that at the large momentum transfer end, the region in which he took data, the curves describing the data in ^{2}H, ^{3}He, and ^{4}He were starting to obtain the shape one expects from quark theory—which would help confirm the quark theory of hadrons providing he could actually get "asymptotia" in momentum transfer. Actually his talk also emphasized two other important points relevant to the "intermediate energy" region: First, the drastic disagreement persists between theory and experiment in the ^{3}He form factor at the point of the second maximum, even when MEC effects are included; second, not all the experimental possibilities of using elec-

tron scattering to determine the deuteron wave function have been exploited (mainly, measuring polarizations). These light nuclei are important testing grounds for nuclear force models and of the "mesonic" presence because the Schroedinger equation can be exactly solved, by computer, for such systems and hence can be related more clearly to the internucleon dynamics. Two possible explanations were advanced for the disagreement in ^{3}He: M. Fabre de LaRipelle (Institut de Physique Nucleaire, Olsay, France) proposed that a three-body force that becomes repulsive when there is one obtuse angle in the triangle formed by the three nucleons, forms a hole in the charge distribution that enhances the form factor toward the experimental value (this was also mentioned in the talk by Kim on light nuclei); an alternative explanation was offered by D. Drechsel, Arenhövel and their coworkers, namely, that the protons obtain a quadrupole moment in ^{3}He from the admixture of spin 3/2 isobar states and this also enhances the form factor. There is important information on nuclear forces in this disagreement in ^{3}He (which occurs in other nuclei as well), and one or both of these hypotheses may really help advance the understanding of the large momentum transfer electron scattering data and of the nuclear force.

In the photonuclear realm, Dr. J. Matthews (MIT) pointed out the general success in analyzing (γ,p) and (γ,n) reactions in terms of single particle processes, at least below 100 MeV. Above 100 MeV, two particle effects are important, and MEC and isobar processes also contribute but give too large a contribution to explain the data. Again this presents a challenge to refine the theoretical description. E.L. Tomusiak (Univ. of Saskatchewan, Canada) pointed out the need to better understand the 0° deuteron photo-disintegration data. Currently no standard nuclear force model explains the low energy data even when corrected with MEC, isobars or relativistic effects. Moreover this is a very simple system, the two nucleon system, in which we should be able to understand the wave function and interaction. This is indeed a mystery and its resolution should prove very interesting.

In the most colorful talk of the conference J.L. Friar (Los Alamos Scientific Laboratory) spoke on relativistic effects in nuclear electromagnetic interaction. He emphasized the need to treat the electromagnetic and nuclear forces in a consistent manner starting from the reduction of relativistic equations (99 times out of 100 this is not done). Without this approach, he claimed, some of the concepts dealt within non-relativistic potential theory like the D-state probability of the deuteron, become ill-defined with respect to their "measurement" by an electromagnetic probe. To illustrate his point, he inflated a balloon labelled "P_D" (the symbol for the D-state probability), released it, and naturally, it shrank to almost nothing. This was visual proof that one could not determine whether "P_D" was large or small.

In view of increased experimental precision and the availability of higher energy data, the main trend indicated by the Mainz meeting is to view more seriously the mesonic presence in nuclei. On the whole, the conference also demonstrated a clear trend toward cohesiveness among the various experimental branches of the field, e.g., electron scattering, pion capture and scattering, and photonuclear reactions. (Michael I. Haftel, Naval Research Laboratory, Washington D.C. 20375 and Lawrence W. Fagg, Catholic University of America, Washington D.C. 20064)

PHYSICS AT HERIOT-WATT UNIVERSITY

The Riccarton campus of Heriot-Watt University is located in the village of Currie, a western suburb of Edinburgh, Scotland. The Physics Department, located on this campus, was "born" some ten years ago and its growth continues under the leadership of Prof. S.D. Smith, the department's founder and current chairman. The department's growth and evolution involves more than numbers (25 faculty, 10 research associates [post doctorals], 18 PhD students, and an annual budget of about $1.2M), for in the past two years the department has been diversifying its research program. For several years, the majority of the department's effort was in the development of spin-flip Raman lasers, and many of their contributions in this area have been described by V.O. Smiley (*ESN* 32-4:145). Among the several areas now being pursued at Heriot-Watt are: visible and far ir lasers; experimental and theoretical solid state physics; energy conversion (solar cells & alternative energy sources); and space, environmental, and device physics.

Heriot-Watt University was founded in 1821 as the Edinburgh School of Arts, and the Department of Physics is indeed working in harmony with the original school's objective of providing "for the better education of the mechanics of Edinburgh in such Branches of Physical Science as are of Practical Application in their Several Trades." This is evidenced by Edinburgh Instruments Ltd., a high-technology company producing CO, CO_2, and far ir lasers, and a variety of optical instruments and components. As with the Physics Department, the company was founded and is chaired by Prof. S.D. Smith. Edinburgh Instruments' location, in the Industrial Research Park on the Riccarton campus, is convenient for the company and for those members of the department consulting for the company. The company has 20 employees, and its gross income for fiscal year 1980 is expected to reach $900k. One of their new products, a tunable, optogalvanic-stabilized, 50-watt/line CO_2 laser, can operate with either a flowing gas or with a closed, refillable tube. The company is proud of the record power levels obtained from its far ir lasers, and of its worldwide market which includes customers in the USA, the USSR, The Federal Republic of Germany, and France.

While on sabbatical leave with the Projektgruppe fur Laserforschung der Max-Planck Gesellschaft (Garching, FRG), Prof. S.D. Smith commenced a study of the infrared absorption of SF_6. This was an experimental effort in which an injection-locked, single-mode CO_2 TEA laser was used to determine the time and intensity dependence of infrared absorption by this molecule. The time resolution was <1 nsec and the intensity was varied from 10 kW/cm^2 to 2 MW/cm^2. The absorption cross section was observed to drop to ∿1% of its small-signal value during the first 40 nsec. As evidence indicates that the observed absorption continues (including the quasi-steady state which is reached after 40 nsec) in the three to four lowest vibrational levels, it is conjectured that the major reduction in the effective absorption cross section is due to population changes rather than a change in the nature of the absorption itself.

The development of efficient, large-area, stable, and cheap photovoltaic cells for solar energy conversion is the ultimate objective of a team at Heriot-Watt led by J.I.B. Wilson. This group feels that the key ingredient of solar cells having these characteristics is amorphous silicon (a-Si), and their study of this material involves both thin-film research and device fabrication. Comments follow below on their work in the areas of a-Si films, solar-cell-fabrication techniques, and device efficiency.

a-Si films produced by rf glow discharge decomposition of mono-silane (SiH) contain several atomic percent of hydrogen, and the presence of this hydrogen has a strong effect on the electrical properties of the films. By bonding to the Si, the hydrogen removes the dangling bonds in the amorphous network, and the density of states in the band gap is reduced. Wilson's group is collaborating with members of the university's Chemistry Department in an investigation of the role of hydrogen in a-Si films. Studies conducted at Heriot-Watt and elsewhere on the thermal decompostion of hydrogenated a-Si films indicate that hydrogen loss occurs at two distinct temperatures, ∿350°C and ∿550°C. One of the objectives of Smith's study was to determine the nature of the molecular processes involved in this hydrogen loss. While maintaining the a-Si films in a vacuum ($<10^{-6}$ torr), infrared absorption measurements were made, and the data thus obtained enabled the molecular percentage of SiH and SiH_2 present in the films to be calculated. After this study was conducted as a function of film temperature, the following dehydrogenation mechanisms were proposed. The low-temperature (∿330°C to 370°C) process results from the scission of Si-H bonds and the simultaneous formation of H-H bonds (molecular hydrogen). For this to occur, the hydrogen atoms must have been in close proximity; and could have been in SiH_2 groups, $(SiH_2)n$ chains, or in neighboring [SiH_2, SiH] or [SiH, SiH] groupings. The absorption data and calculations indicate that after low-temperature dehydrogenation has taken place, the residual hydrogen is mainly incorporated in isolated SiH and SiH_2 units. Therefore, it was suggested that the high-temperature dehydrogenation process involves a rupture of the Si-H bonds and a subsequent combination of hydrogen atoms to form molecular hydrogen. The understanding gained in this study and in related work in other laboratories should be useful in producing a-Si cells having improved electrical characteristics and increased long-term stability.

In 1978, Wilson reported an efficiency of 4.8% from an a-Si metal-insulating-semiconductor (MIS) solar cell.

(J.I.B. Wilson, et al., *Nature* 272, 152 (1978)]. This efficiency is greater than any reported for p-n junction amorphous cells of a-Si. This MIS cell with its nickel-barrier contact was designed and fabricated at Heriot-Watt, the metal and insulating films being deposited on a 1 μm thick film of undoped a-Si produced by Prof. W. Spear's group at Dundee University. The optimum thickness of the insulating TiO_x layer was between 1.5 and 2.5 nm. The efficiency measurements were made with simulated sunlight @ 60 mW/cm^2, and the cell not being anti-reflection coated.

The most recent work of Wilson's group involves a determination of the optimum donor doping for the barrier region. Schottky barrier diodes of gold on n-type a-Si were used in this study, and the growth conditions for the best diode films are as follows:

surface temperature	220°C
pressure	0.1 torr
pure silane flow rate	15 std. cm^3/min
rf power (13.56 MHz)	20 W

The films thus deposited contained less than 10% bonded hydrogen, and no secondary- or tertiary-bonded hydrogen (SiH_2 or SiH_3) was detected from infrared absorption data. The 1-2 μm thick films were doped with phosphine and were composed of two layers: a 35-350 nm thick heavily doped layer deposited on 316 stainless steel substrates, and a thicker, lightly doped layer which contained the barrier region. The following conclusions and suggestion resulted from this work. The best Schottky solar cells require an undoped layer next to the barrier metal to provide as wide a built-in field as possible. This result agrees with the following intuitive argument. Since the lifetime of holes in n-type a-Si is short, essentially only those carriers created within the space-charge region are collected by the metal contact. Hence the need for a wide built-in field. It was found that the dark current of gold/a-Si junctions is controlled by majority carrier, and hence does not decrease as the doping is increased. To increase the photocurrent collection outside the field region (and to improve both the series and shunt resistances as well) it was suggested that a drift field be added to the cell by a doping gradient.

Based upon the progress in basic understanding and device development being realized at Heriot-Watt and elsewhere, I feel that Wilson was not overly optimistic when he said that "the time is rapidly approaching when amorphous silicon MIS solar cells will be a commercial proposition."

R.G. Harrison has developed a high-power optically pumped ammonia (NH_3) laser (12.812 μm), and he has collaborated with C.R. Pidgen and R.H. Wood in the frequency shifting of both this laser and its CO_2 pump laser. (Harrison, Pidgon, and Wood are affiliated with Edinburgh Instruments Ltd. as well as with Heriot-Watt Univ.) The NH_3 was resonantly pumped by the 5 MW, 9.294 μm output of a pulsed CO_2 TEA laser. A 4% efficiency and a peak power of about 200 kW were obtained for an NH_3 pressure of the order of 10 torr. Frequency-doubled output (14 kW, 6.4 μm) was obtained from NH_3 laser-pumped tellurium with an internal conversion efficiency of 24%. The generation of 16 μm radiation by non-degenerate four-wave of CO_2 and NH_3 laser radiation in germanium was first reported by this group. In non-degenerate four-wave mixing, $\nu_4 = \nu_2-(\nu_1-\nu_1')$, where ν_4 is the output resulting from mixing (in this case) $\nu^2 = 781$ cm^{-1} (12.8 μm) of the NH_3 laser, and ν_1 and ν_1' are the many CO_2 laser lines near 1087 cm^{-1} (9.2 μm) and 935 cm^{-1} (10.7 μm) respectively. Because of the large number of CO_2 laser lines, it is possible to realize stepwise (<0.2 cm^{-1} intervals) tunable radiation near 16 μm over the range 624-626 cm^{-1}. The research results of these investigators are being used by Edinburgh Instruments, Ltd.

M.J. Colles is continuing to use cw dye laser spectroscopy as a tool in photolysis and molecular spectroscopy research. His use of dye lasers in a "triple spectroscopy" (simultaneous measurement of absorption, fluorescence, and optoacoustic spectra) study of iodine predissociation was reported by V.O. Smiley (*ESN* 32-4:147). Colles' more recent work resulted in the first report of spectroscopic evidence for the formation of nitrosomethane (CH_3NO) in the photolysis of nitromethane (CH_3NO_2). The quantum yield of CH_3NO, and the rate constants of some of the oxidation reactions were also determined. This effort is being followed by a study of the short-lived radical HCO, produced in the photolysis of acetaldhyde. A xenon arc monochromator is being used as the photolyzing source, and the HCO, which absorbs at 614 nm, is detected via cw dye laser optoacoustic spectroscopy.

D.A.B. Miller, while working on his doctorate at Heriot-Watt, and co-workers reported the first observation of optical bistability (OB) in a semiconductor crystal. Even though his work was reported recently in an article dedicated to OB (*ESN* 33-12:535), a brief summary follows. The physical origin of OB in Fabry-Perot resonator devices is the nonlinear increase (with respect to the input intensity) in the optical path length of the material within the resonator. Miller reported on OB in InSb, which has a very large intensity-dependent refractive index. When used in the "optical transistor" mode, a differential gain of 6 was observed. If a bandgap resonant mechanism as proposed at Heriot-Watt is indeed responsible for the optical path length increase in InSb, it may be possible to produce bistable devices that can be switched in times of the order of 10^{-12} seconds. A determination of the switching speed of such a device will be made at Heriot-Watt in the near future. As the experiments with InSb required that the sample be maintained at cryogenic temperatures (~5 K), the potential for OB in semi-conductors at higher temperatures is being determined.

The few projects described above do not indicate the full depth of research in the Physics Department. However, since space does not permit a review of each program the following list is provided of their other activities:

(1) cw spin-flip Raman laser spectroscopy.
(2) Time-resolved spectroscopy with spin-flip lasers.
(3) Energy transfer processes in molecules.
(4) Generation & detection of short-pulse infrared radiation.
(5) Interaction of laser radiation with solids.
(6) Far-infrared laser spectroscopy of solids.
(7) Remote sounding of planetary atmospheres.
(8) Theoretical studies in solid-state physics, nonlinear optics, and photo-excitation of molecules.

Regarding future trends of the department, Smith said that four areas will be emphasized: (1) experimental low-power nonlinear optics (e.g., optical bistability in semiconductors, and nonlinear magnetoopics), and the achievement of an improved understanding of microscopic effects in nonlinear optics; (2) amorphous thin-film solar cells; (3) theoretical and experimental work on high power excitation of molecules; and (4) the development of high-power, short-pulse ir lasers.

I would like to close this article with a few observations. Even though Heriot-Watt University is somewhat isolated geographically, it is not isolated when it comes to intellectual stimulation. By holding conferences each year at Heriot-Watt, the Physics Department is providing a vehicle for the exchange of ideas. The department is also fostering such stimulation by encouraging its staff to spend one-or two-year periods on leave of absence in overseas laboratories. The interchange of ideas during such assignments is of great value to all parties involved. I would characterize the Physics Department as being energetic, well led, well equipped, progressive, and productive. (The department's output of some 40 papers per year is just one measure of its productivity.) (Richard S. Hughes)

SIGNAL PROCESSING

ULTRASONICS, COAL MINES, AND NONDESTRUCTIVE TESTING

Signal processing related to mapping using sonics and ultrasonics is a topic that has been of interest for a relatively long time. One needs only to look at any one of the many articles on earthquake detection, oil exploration, underwater mapping or, more recently, nondestructive testing (NDT) and medical ultrasonics to note the international participation and the variety of schemes that have been evolving. In virtually all of these situations the objective is to obtain a three-dimensional representation of the contents of the volume under investigation. The calculations are very complicated if the medium is inhomogeneous. But even with homogeneous media there are problems yet to be solved. It was therefore no suprise to us to find an announcement by the Institution of Electrical Engineers (IEE) about a colloquium entitled "Signal Processing in Ultrasonics," scheduled for 17 January 1980. What did suprise us was that there were only about 40-45 participants.

This is a brief report on the 6 papers presented at the IEE colloquium. It seems reasonable that these papers are a sampling of current work in this field in England.

The first paper, "B-Scan Viewing Using Backward Wave Propagation" by

S. Sepehr and S.O. Harrold (Department of Electrical and Electronic Engineering, Portsmouth Polytechnic, UK) dealt with a program that uses a computer to process the sampled acoustic diffraction field data created by a radiating or reradiating target. The objective was to reconstruct in one dimension the field intensity in the plane of that target. A backward-wave-propagation technique was employed and simplified by the very special and very limiting assumptions that all the radiating or re-radiating sources are in the plane of the target and in phase.

This paper was followed by "Sonoscan: A Real-Time Microprocessor-Based Imaging System," by P.D. Hanstead (Central Electricity Generating Board, Bristol, and a Senior Visiting Research Fellow at The City University, London). The term "Sonoscan" has no connection with a system by that name found in the US. His report dealt with the problem of very rapid inspection (for NDT) of a volume of solid material that could have internal flaws.

According to Hanstead, there are at least two other methods available for producing a cross-sectional image. One of these, the B-scan technique, where the display shows a brightness-modulated plot of Range vs Angle, has the disadvantage that the transverse resolution is limited to approximately 10 mm at 5 MHz, this frequency being roughly the highest frequency at which material attenuation is not yet serious. The other technique, acoustic holography, was said to be limited to a longitudinal resolution of about 10 wavelengths, or, again, 10 mm in steel at 5 MHz.

The technique described by Hanstead and published recently in the *British Journal of Nondestructive Testing*, July 1979, pp 212-213, is a development of acoustic holography but uses pulsed ultrasound to improve resolution. The speaker stated that this system displays the best features of B-scan and acoustic holography and is capable of displaying flaw position with a resolution of about one wavelength. He explained that the technique is essentially single pulse echo holography and could be thought of as holography with a source of wide bandwidth (because of very short pulse duration). Hanstead's approach uses a microprocessor with simple arithmetic and logic operations (rather than complex number manipulation) and is therefore very fast, with processing time per cross-section of about 3 seconds. The speaker stated that his scheme has been demonstrated satisfactorily in the laboratory.

A system that is expected to have applications in automated, high-resolution sizing of defects and in the inspection of austenitic stainless steel welds was described by C.E. Fernando (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Southampton), in his presentation entitled "A 4-Probe Array." Fernando replaced the manual method that uses a single transmit/receive transducer combination with four co-planar transducers. A transmitting transducer is in the center, and three transducers forming a receiving array are located about it symmetrically. Fernando stated that this system is sufficient to locate a point reflector, such as a flaw in a weld, with a resolution of $m\lambda z/R$, where $m\lambda$ is the minimum detectable path difference in the system, z is the range, and R the radius of the array. Since the resolution is linearly proportional to wavelength λ, it would appear to be advantageous to use as short a wavelength, i.e., as high a frequency as possible. However, acoustic attenuation in the material increases as frequency is increased, so that the signal-to-noise ratio worsens. Fernando appears to have found an optimum frequency (higher than expected) by improving the signal-to-noise ratio with a signal-averaging technique. Alternatively, with this system he can use a smaller array size than normal, a consideration likely to be relevant when inspecting curved surfaces, such as pipes.

Fernando complements his high resolution system with a "rougher" system having a search beam with which the whole volume may be searched rapidly. This is done by broadening the time of arrival of echos at the transducer by $\pm \Delta T$, where $\Delta T \simeq 2\,SR/v^2T$. Here S is the radius of the cylindrical search beam, T is the time-of-flight to the transducer, and v the velocity of sound. The same raw data can thus be used for the broad-area search and for the fine beam. The system includes a PDP11/05 computer, with analog echo signals multiplexed on to a 100 MHz Biomation 8100 digitizer. Fast signal averaging is carried out in an external interface that has low power Schottky logic, and a read/modify/write sequence is used to communicate with the computer. To simplify use of the system in production testing, the calculated range data is voiced via digital voice synthesizer. Preliminary tests in steel specimens suggest a resolution of the order of 0.5 mm at a range of 80 mm. The advantages

over a manually operated system were said to be (1) the removal of the variability found for different manual operators, and (2) an improvement in resolution. The automatic system was also said to be cost-effective.

An application of signal processing related to sonic waves and relevant to the energy crisis was discussed in "Fault Location by Underground Seismic Surveys," by I.M. Mason, G. Beresford-Smith, and T.L. Szabo (Department of Engineering Science, Univ. of Oxford). This work, which started about five years years ago, deals with the location of faults in coal seams (i.e., layers) that are a considerable distance (say, 500 m) below the surface. Such faults could be split seams, throws (vertical displacements), or washouts (complete absence of coal in a pocket). Since coal mining is an expensive business, optimal utilization of a mine is very important. The location of such faults is therefore greatly needed.

According to the speaker, while it would be desirable to use surface seismography to find such faults, the large seam depths, along with such sonic artifacts as multiple reflections within rock layers, do not permit the use of this technique. Mason and his colleagues have therefore been investigating fault mapping in coal seams by the use of channel waves, i.e., they have made use of the fact that the coal seams themselves guide sonic energy. (The problem was thus reduced to two dimensions.) This was accomplished by placing sonic exciters (e.g., explosive charges) and sonic detectors (geophones) along the subterranean roadways that form two of the boundaries of the seam that is to be cut away (mined).

A wealth of data processing techniques have been developed for surface seismology, such as double Fourier transforming, compression by spectral warping, mapping by an ellipse-lag-sum technique, migration by Fourier transforms, and Huygens-Kirchhoff migration. Mason and colleagues have adopted these techniques to their problem. From results of work with an actual coal seam, they have concluded that the velocity dispersion of channel waves has presented no real obstacle to the high-resolution imaging of structural features underground. For example, they have been able to locate a fault with a throw of about 1 m in a sufficiently homogeneous 3 m seam, at a range of 250 m, using a wavelength of 33 m at a center frequency of 110 Hz.

Mason also reported on the mapping of a 425 m × 850 m rectangular block of coal into a profile of velocity inhomogeneities in the seam. The input data were derived by static correction from handpicked arrival times of sonic pulses. The reduction itself was effected by the use of an algorithm which accomodated underground site access restrictions. The reconstructed velocity field suggested that the coal panel was bisected by a ridge for which the sound velocity was higher than average. The ridge was found to follow the general line of a system of pillars left in place during the mining of a lower-lying stratum. Based on this result, Mason concluded that channel waves may be used to map underground subsidence into old workings.

In response to a question, Mason estimated that a 500 m × 1000 m area could be surveyed in about two weeks, at a cost of about $30,000.

Next in the program was "Compact Sonar System Design Using Charge-Coupled Devices," by J.W. Widdowson, J.F. Dix, and N. Dean (Admiralty Underwater Weapons Establishment, Portland, Dorset). Widdowson, who presented the paper, discussed two areas where charge-coupled devices (CCDs) have significant applicability for sonar systems. In the first of these, long pulses are transmitted and are used with a pulse compression system as a means not only of reducing reverberation, but also of generating high pulse power to overcome background noise without encountering cavitation. The second is related to problems of beam forming and beam steering. Widdowson pointed to the significant simplifications that can be obtained if CCDs are used to accomplish these two functions for small sonars and arrays.

A CCD accepts analog signal samples directly for matched filtering and performs the necessary operational and storage functions at speeds in excess of those required for sonar. In addition, the use of CCDs provides for simplicity, economy, and low power consumption. Beam steering can also be achieved by a CCD device, for beam steering in a phased array requires the introduction of delay elements between each transducer. This can be accomplished simply by varying a clock frequency governing the speed of charge transfer through a CCD device.

In what seemed to be an attempt to point out some of the important conclusions from already published

literature, D. Saxon (Sigma Consultants, Hampton, Middlesex, UK) in "Pulse Compression Techniques" discussed such techniques as applied to sonar ranging systems. He discussed linear-frequency and linear-period modulation, and the choices of weighting functions to reduce sidelobe levels. (This is a problem that we have met in antenna work.) He also examined the implications of baseband processing and quadrature channels, as well as sampling criteria.

Weighting functions, of course, are put into systems to reduce side lobes and therefore improve system dynamic range. Particular examples of the weighting functions considered by Saxon were triangular (Barlett), cosine^2 (Hanning), cosine^2 with pedestal (Hamming) and cosine^4. Saxon pointed out that because of the large percentage Doppler shifts possible in sonar, linear-period modulation is superior to linear-frequency modulation in pulse compression systems. He concluded that nature discovered this long ago, for the signals emitted by bats also sweep from high to low frequency. However, in agreement with Kroszczynski ["Pulse Compression by Means of Linear Period Modulation," *Proc. IEEE*, 57, 1260-1266 (1969)], Saxon stated that the asymmetry of the weighting used by the bat was not optimal and that his experimental results bore this out. "Perhaps," he said, "nature has not yet arrived at the optimal solution." (Irving Kaufman and T.C. Cheston).

SYSTEMS ANALYSIS

INTERPROGRAMMA

Interprogramma is the alternative name for the Soviet-Bulgarian Research Institute in Sofia, Bulgaria. The Director of the Institute is Vladimir Bunakov, a Russian who is in Sofia on contract for a period of a few years; the Deputy Director, Veselin Spiridonov, and most of the workers, are Bulgarians, to be expected of a "Soviet-Bulgarian" organization located in Bulgaria.

The Institute is only 2 years old. It has about 300 people, of whom about 160 are "specialists" (i.e., technically trained), and of these about 100 are mathematicians. Such a majority in the US would probably imply a strong leaning toward theory, but this Institute is highly applied. In fact, neither Bunakov nor Spiridonov has gone beyond the Master's degree. Both were trained in mathematics, but in "computing mathematics," Spiridonov at the University of Sofia and Bunakov at the University of Leningrad. When I met with these two men, they indicated very strongly that one could not use pure mathematics, or even a mathematical approach, for solving the kinds of problems which were of interest to this Institute. Bunakov stipulated that this was only his own philosophy, but then added that it was also the philosophy of the Institute.

Interprogramma works on two basic types of problems: to write applied software, and to help create management systems. In order to understand the latter it is necessary to be familiar with the Russian acronym ASU, which stands for Automatic System for Control (the word for control in Russian, Bulgarian, and other Slavic languages is *upravlenia*, and this acronym is used throughout the socialist countries). While it refers to both an information system and a control system, the emphasis is very much on the latter, that is, it is totally unlike what is referred to in American as an MIS (Management Information System), although it has some similarities to what we call a production information and control system. It is specifically not designed to control a process, but to control an entire enterprise. It is based partly on obtaining information, but largely on optimization techniques. Interprogramma is very interested in ASU and in developing new theory for ASU as well as for developing ASU for particular industries in Bulgaria and writing and applying the necessary software. Their first applications will be to electronics factories and factories building machinery. Bunakov thought that ASU might be somewhat similar in approach to system dynamics, since it is frequently run as a discrete simulation in which a typical equation would be of the form $x_{n+1} = x_n + a_n - b_n - q_n$ where x is what systems dynamicists would call a level, a is the amount coming from sources, b is the amount going to output, and q represents losses.

I attach here two diagrams which Bunakov drew for me. In Figure 1 we have a feasible region, and a starting point A. We would like to go along the gradient, in the direction AB, but we do not know this gradient, and therefore the next best thing is to attempt to reach a constraint line (as at point C) on the second step. For this one needs not rigorous algorithms but heuristics, and Bunakov stressed that they develop

heuristic algorithms. He pointed out that 10 years ago in the Soviet Union they were very optimistic about theory but today he feels that they are less so, and certainly he is less so. He also pointed out the importance of thinking of the system as a man-machine system, which implies developing man-machine algorithms first and computer algorithms later. He stated: "The main mistake of many authors is to think about computers from the beginning."

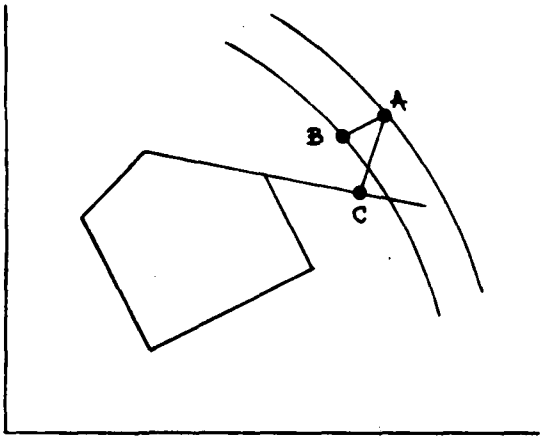


Fig. 1.

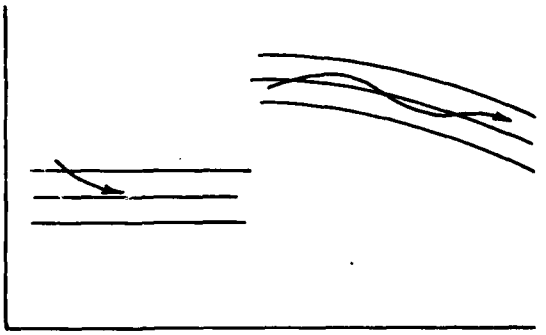


Fig. 2.

The point of Figure 2 is to emphasize that knowledge of an optimal plan is not sufficient. One must also determine a trajectory for getting to and staying as close as possible to this plan. On the left we have the situation of a constant plan which is approached in an overdamped way, but this is an uncommon luxury. On the right we have a dynamic plan and a trajectory which oscillates about it, necessarily involving underdamping. This is clearly a problem in automatic control.

One more quotation will illustrate the remarkably antitheoretic (one might almost say anti-intellectual) attitude of this Institute. They told me that the accuracy of linear programming may be adequate at the Ministry level, but it is not adequate at the enterprise level. Workers at this institute may write a sophisticated mathematical model, say an operations research model with nonlinear constraints, stochastic objective functions, and the like, but then they decompose it and use heuristic algorithms to solve it. They call this "using mathematical theory in an applied way." Finally, Bunakov said to me: "We must be optimists."

They have used two IBM programs, namely PICS (Production Information and Control System) and CAPOSS (Capacity Planning and Operations Sequence Scheduling). These are software systems with heuristic algorithms fitting in well with their philosophy. They intended originally to modify these programs but eventually decided they had to start from scratch (perhaps in part because of the problem of adapting software to domestic computers). However, they have used much of the systems concept from these software systems, which are based on mathematical understanding of production management.

Because of the youth of this organization, there have not yet been any applications of their ideas. These should be in full force within the next year or two. It would be fun to go back to Sofia to see how well this kind of approach works. (Robert E. Machol)

NEWS and NOTES

TRAINING ENGINEERS IN BRITAIN—THE CURRENT DEBATE

In his maiden speech in the House of Lords, Lord Scanlon, the former president of the Engineering Union in the UK, and now chairman of the Engineering Industry Training Board, stressed the importance of regenerating the UK's manufacturing base and of improving industry's competitiveness through better training and better deployment of engineers, and upgrading their status and remuneration. In this he joins a number of others, such as Prof. John Brown, president of the Institution of Electrical Engineers, in backing a report recently prepared by a Committee of Inquiry headed by Sir Monty Finniston. The Finniston Report suggests the establishment of a £10M/yr engineering authority funded by the government which would handle education qualification, and registration of professional engineers.

A point made by Lord Scanlon was that too many very-well-qualified engineers spend their time in research and development and not in the practical application of their knowledge. As a specific remedy he advocated cash incentives to employers who undertook training of their young engineers to ready them for more effective jobs in their industry.

Prof. Brown, who is head of the Electronics Section of Electrical Engineering at Imperial College of the Univ. of London, while agreeing to the need for improving productivity of engineers suggests that while industry must do its share, the training would, perhaps, be better carried out by altering the undergraduate curriculum of engineering students from one designed to train researchers to two separate curricula. One of these, would aim at the diploma engineers, who would continue somewhat in the vein of present studies. The other, which would encompass the majority of students, would result in "qualified engineers." A large part of training of the latter would be carried out by engineering teachers who would come from industry. In an article in *Electronics and Power*, Jan. 1980, Prof. Brown states, "Were I able to wield a magic wand, I would express the wish that at least 50% of all the engineering teachers of 1990 shared their time equally between teaching and work in industry."

The January 1980 issue of this journal, incidentally, carries not only Prof. Brown's discourse on engineering education in the 1980s, but also an a assessment by leaders of British industry and government of events and progress in the 1980s of various fields associated with electrical engineering. (Irving Kaufman)

Semiconductors Conference Papers Published

The Institute of Physics, Techno House, Redcliffe Way, Bristol BS1 6NX, UK, has just published a collection of the papers presented at the First European Insulating Films on Semiconductors Conference, which was organized by the Institute and held at the University of Durham, Durham, UK, on 2-4 July 1979. The US Office of Naval Research, London and the US Army Research and Standardization Group (Europe) were among the sponsors of this conference. Chariman of the organizing committee was Prof. G.C. Roberts of the University of Durham.

Except for an invited paper by Prof. R.A. Stradling (Univ. of St. Andrews, UK) entitled "The Physics of Space-Charge Layers" which dealt with the electronic properties of the semiconductor layer in MOS structures, the papers dealt with various aspects of the insulating layers in semiconductor structures. For example, among the papers in the chapter of the text entitled "Silicon Oxide Films on Silicon," there are reports dealing with the mechanism of thermal growth of vitreous oxide layers on silicon, electron trapping, and diffusion of sodium ions. Other chapters are entitled "Silicon-Silicon Oxide Interface States," "MOS and MNOS Tunnelling Structures," and "Insulating Films on Group III-V Semiconductors."

Although a few of the contributors to the conference were from the US or Canada, nearly all the material presented describes work performed in Europe. Moreover, a number of the papers treat work disclosed for the first time at this conference. (Irving Kaufman)

Dental Scientists Develop Improved Bone-Sampling Method

An improved method of obtaining samples of bone and hard tissue for medical testing has been developed by scientists in the Oral Pathology Division of the Hebrew University-Hadassah School of Dental Medicine. It makes it possible to obtain thin slices of hard bone for biopsies and other histological examination without first decalcifying the sample.

Previously, in order to examine bony tissue microscopically, it was necessary first to soften it by decalcification—removing the calcium and other minerals and leaving only the organic components behind. Even then, the sample obtained was a slice nearly 7 microns thick.

With the new method, the bone tissue is included in a hard medium and, with a diamond or glass knife, a slice 1 to 2 microns thick is cut from it in its original, hard state, mineral content intact. This gives the examining physician a much clearer picture of the tissue and makes it easier for him to identify changes in it, and to diagnose the disease.

PERSONAL

Dr. John B. Harris, senior lecturer in experimental neurophysiology in the Univ. of Newcastle-upon-Tyne and visiting associate research professor of the University of California, has been appointed to the Action Research Fund chair of experimental neurology.

Dr. Brian F. Scott has been appointed to the James Watt chair of mechanical engineering at Glasgow Univ. Dr. Scott is at present head of the postgraduate schools at Birmingham Univ. and will take up his appointment by 1 October.

The title of professor of postgraduate medical education at the Univ. of Southampton has been conferred on Dr. Philip Rhodes, regional postgraduate dean of medicine.

Dr. Paul Broda has been appointed UMIST's first professor of applied molecular biology from September 1980.

At a ceremony on 19 March, Miss Theodora Cooper became the first woman in the history of Oxford Univ. to become a proctor.

Dr. David Ingram, principal of Chelsea College, London has been appointed vice-chancellor of Kent Univ. in succession to Dr. Geoffrey Templeman, the university's first vice-chancellor. Dr. Ingram will take up his post on October.

Prof. John Houghton became director (Appleton) in the combined Appleton and Rutherford Laboratories on 1 September 1979 following the retirement of Dr. Fred Horner on 31 August. Houghton is on a 5-year "detached service" leave from Oxford Univ. where he has been professor of atomspheric physics since 1976.

OBITUARIES

Prof. Dudley M. Newitt, NC, FRS, Professor Emeritus of Chemical Engineering in the Univ. of London, died on 14 March. He was 85.

Mr. R.L. Smith-Rose, CBE, FCGI, FIEE, FIRE, FIC, who was director of Radio Research at the Department of Scientific and Industrial Research, from 1948 to 1960, died on 19 March at the age of 85.

ONRL REPORTS

R-5-79

Current Perspectives in Hyperbaric Physiology, Ultrasonic Doppler Bubble Detection, and Mass Spectrometry by R.F. Goad

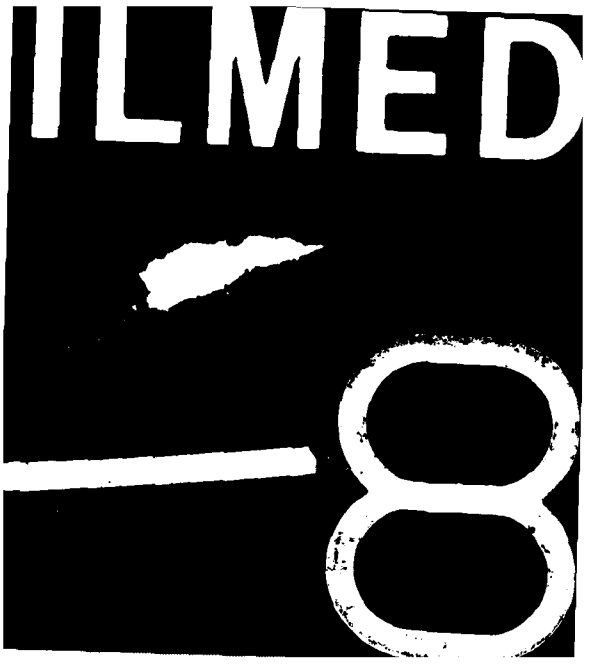
Two important analytical techniques in biomedical research have been increasingly utilized in hyperbaric physiology over the past 12 years. Doppler ultrasonic bubble detection on the one hand and mass spectrometry on the other have been used to demonstrate responses to both elevated pressure and decompression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

C-12-79

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

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

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