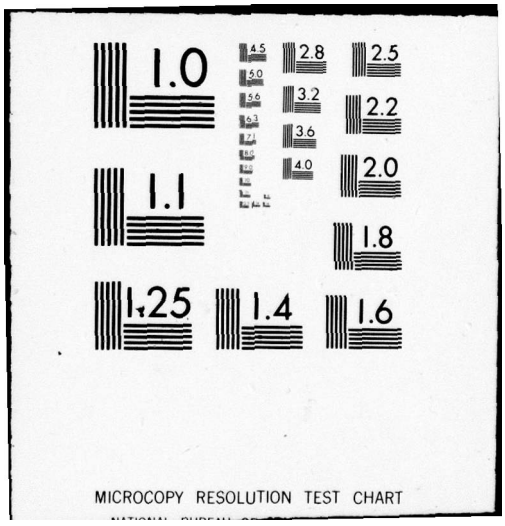
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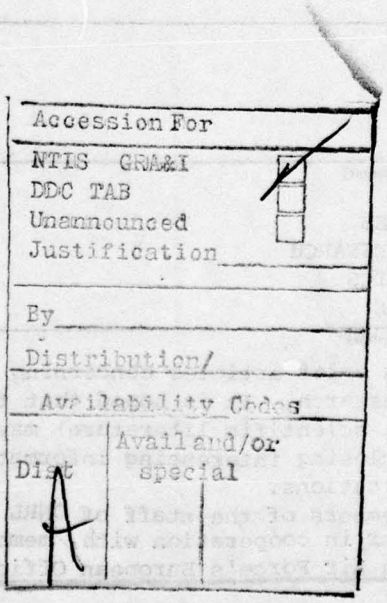
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OFFICE OF NAVAL RESEARCH
LONDON

R.E. Machol and Victoria S. Hewitson

31 October Volume 33, No. 10

AVIATION	Navigation Over the North Atlantic Ocean	R.E. Machol	399
ELECTRONICS	Philips at Redhill	I. Kaufman	401
ENERGY	Future Energy Concepts	C.H. Spikes	405
	Systems Analysis in Jülich	R.E. Machol	409
ENGINEERING	Thermodynamics and Heat Transfer at the University of Glasgow	M. Lessen	413
MATERIAL SCIENCES	Physical Metallurgy Research in Portugal	J. Perkins	415
	Second International Symposium on Magnetic Resonance in Colloid and Interface Science	H.A. Resing	417
MEDICINE	The IAEA Advisory Group Meeting on Nuclear Methodology and Techniques in the Study of Parasitic Diseases of Humans	G.T. Strickland	418
	The Fleischner Society Symposium	I.M. Freundlich	420
OCEAN SCIENCES	IOS Bidston I: Research	W. Burt	423
	Department of Oceanography, University of Liverpool	W. Burt	425
	The Foaming Main and Other Chaotic Phenomena	H. Medwin	429
OPERATIONS RESEARCH	The Danish-Polish Mathemathical Programming Seminar and Operations Research in Denmark	R.E. Machol	430
	The 1979 International Symposium on Information Theory	J.E. Shore	432

OPTICAL PHYSICS	Electro-Optics Research in Israel—Part I	R.S. Hughes	433
SPACE SCIENCE	An Overview of Space Science and Technology in West Germany	R.W. Rostron	436
NEWS & NOTES	High-Energy Collisions at Cern	R.E. Machol	440
	CHIPS Research	I. Kaufman	440
ONRL REPORTS	New		441
	Index of 1978 Reports		

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AVIATION

NAVIGATION OVER THE NORTH ATLANTIC OCEAN

During the 1960s there was a serious conflict concerning navigation standards for aircraft over the North Atlantic Ocean (NAT), which I have documented in *Management Science* 21, 1089-1101 (1975). At that time, planes flying over NAT were assigned to tracks 120 nautical miles, or two degrees of latitude, apart laterally (i.e., in a direction perpendicular to their E-W flight paths), 15 minutes apart longitudinally (i.e., along the flight path), and 2000 feet apart vertically. The airline owners, through their organization, the International Air Transport Association (IATA), suggested that this was overly conservative, and wanted to reduce the separations. The airline pilots, through their organization, the International Federation of AirLine Pilots Associations (IFALPA), responded that any reduction in separation would make the situation unsafe. The Federal Aviation Agency (FAA) of the USA initially sided with IATA, but subsequently reversed that opinion. The International Civil Aviation Organization (ICAO), which has to make the actual rules, eventually came up with a new arrangement called "composite" or "staggered" separation, in which each plane has neighbors that are separated by 120 miles laterally, or by 2000 feet vertically, or by 60 miles laterally and 1000 feet vertically or by 60 miles laterally and 1000 feet vertically. This turned out to be as safe as the original system, and much more convenient, so that the pilots received as much safety as they had originally demanded and the operators avoided deviations from the desired track as they had originally demanded.

A lot has happened since that time, and it is the intention here to bring the situation up-to-date, and in particular to report on the surprising widespread acceptance of a quantitative assessment technique. I find it refreshing to see operating people who formerly shunned mathematics discussing not only probabilities of errors, but the standard deviations of errors!

There are more aircraft flying NAT now than a decade ago; there are different kinds of aircraft with different speeds (747s fly faster than 707s for example); there are more operators; there are more different kinds of operators (including private jets); and there are more routes, including crossing routes (e.g., Montreal to Spain and Dallas to London)

In addition to the situation in NAT, which is under continuous study by a group called the North Atlantic Systems Planning Group (SPG) under the aegis of ICAO, ICAO established an RGCS (Review of the General Concept of Separation) Panel that has also been continuous operation for several years to determine what should be safe and efficient standards for separating aircraft all over the world. These standards are, of course, very different over land, where positions can be easily determined, than over the oceans, where navigation is much more difficult. One result of this study was the extension of a couple of years ago of the concept of composite separation to the Central Eastern Pacific, which essentially means flights between Hawaii and California.

ICAO, and in particular the NAT SPG, have been under a good deal of pressure, especially from IATA, to reduce the separations again, in view of the much improved navigational performance of most aircraft. The reduced separations will not matter much in the established track system. But south of this system, which is

ACRONYMS IN THIS ARTICLE

CAA	Civil Aviation Authority
DORA	Directorate of Operational Research and Analysis
FAA	Federal Aviation Association
IATA	Int'l Air Transport Association
ICAO	Int'l Civil Aviation Organization
IFALPA	Int'l Federation of AirLine Pilots Associations
MNPS	Minimum Navigation Performance Specifications
NAT	North Atlantic (Ocean)
NLR	Nat'l Aerospace Lab. (Netherlands)
RGCS	Review of the General Concept of Separation
SPG	Systems Planning Group

very heavily travelled (e.g. by planes to and from the Caribbean), 120 miles separation (no composite) is now required, and reduction to 60 miles will make a significant difference to the operators.

In response to this desire for reduced separation, the SPG has suggested, and the ICAO and its member nations have accepted, a new concept called MNPS (Minimum Navigation Performance Specifications). The SPG has established a stringent target level of safety, based on the same collision model that was previously used, of 0.2 accidents (0.1 collisions) per ten million flying hours due to collision with aircraft flying on an adjacent track. They have determined that this level of safety could be achieved even with 60 miles of lateral separation (not composite) if the following specifications were met: standard deviation of lateral errors not greater than 6.3 miles; probability of "gross error" not greater than 1/1900; probability of "60-mile error," not greater than 1/8000. A gross error has been variously defined as one of more than about 25-30 miles—the idea being that if all errors are less than this, 60 miles is a safe separation. The "60-mile errors" are, obviously, especially dangerous; they are defined to be those of more than 50 and less than 70 miles, which puts the aircraft precisely into the adjacent track. Errors between 110 and 130 miles are also included in this count.

The original idea was that after the MNPS had been achieved by aircraft in general, only those that could meet those specifications (by carrying INS—inertial navigation system—or OMEGA, an electronic navigation system) would be permitted in MNPS airspace. Other aircraft would be required to fly below or above the 29,000-39,000 foot altitude band or north or south of the desirable tracks of the MNPS system. It was essential to have some new system anyhow, since the navigation environment was being drastically altered at the end of 1977 by turning off the LORAN A long-range navigation transmitters that had been a significant part of that environment for many years.

Data were collected starting in December 1977, and by the middle of 1978 data had been collected on 58,000 flights. The standard deviation requirement was more than met, but the other two were not. The model permitted 31 gross errors and 39 occurred; the model permitted eight 60-miles errors, and 15 occurred. The 120-mile (60-mile composite) standards were then maintained while more data were collected. At its March 1979 meeting at ICAO headquarters in Paris, the SPG again decided that the target level of safety could not be met by 60-mile separation. This decision, while nominally made by the SPG to whom the responsibility had been given by ICAO, was in fact made by three people: Peter Brooker of DORA in the British CAA (see *ESN* 33-4:133); Allen Busch of NAFEC (US FAA); and Anthony Pool of NLR (National Lucht-en Ruimtevaartlaboratorium, the National Aerospace Laboratory of the Netherlands) (see *ESN* 32-11:398). That the conclusions of these three scientists are generally accepted by all the interested parties surprised and pleased me; the bitterness and suspicion that characterized similar discussions ten years ago appear to have disappeared.

I talked to Capt. Laurie Taylor, the Executive Secretary of IFALPA, together with Capts. V. King, of Air Traffic Services, H. Gallagher, Regional Vice President for NAT, and D. Dobie, in charge of Regional Activities, at their headquarters in Egham, Surrey. They are ready to fly at the reduced separation if SPG says it is OK. I talked to Lincoln Lee, who represents IATA to the SPG, at their headquarters in London. He raises a number of objections to the SPG procedure for MNPS, based on what he considers to be their excessive conservatism; he is willing to wait, though impatiently, until the reduced separations are approved, after which he will press for 30-mile composite separation. I talked with Paul Berger, who represents the ICAO secretariat at their headquarters in Paris. He told me that ICAO is willing to follow whatever recommendation the SPG gives; although Berger is now personally pessimistic that the MNPS will ever be met, if SPG says MNPS has been met, ICAO will implement 60-mile separation. I talked to Pool in Amsterdam. He is more optimistic about meeting MNPS in the near future, but realizes that this depends heavily on certain subjective interpretations of the data,

and feels the responsibility heavily. I talked to F.A. White, the British representative on the SPG and Brooker's boss, at his office at CAA headquarters in London. He is convinced that when the MNPS is met (and he thinks this will be in the near future) then 60-mile separation will be completely safe.

The difficulty is that some 0.02% of all the traffic on NAT is causing the errors that determine where the other 99.98% will fly. Over the years, IATA carriers have made 3/4 of all flights over NAT and only 1/4 of the major errors. Three of the 39 blunders mentioned above were caused by a non-IATA Latin American airline which, when called on the carpet, claimed never to have heard of MNPS and promised not to do it again. Some were caused by East European countries who also pleaded ignorance. One was caused by a private jet based on a Caribbean island, whose owner-pilot told ICAO afterwards that he would fly where he pleased and they couldn't do anything about it (he discovered that he was wrong). And one was caused by an improperly equipped aircraft that should never have been in MNPS airspace, but a controller put him in during a nonbusy period—because the sky was empty. There had been no risk—but his error showed up in the statistics nonetheless.

There seem to have been no errors caused by hardware failures of the INS, which has shown a remarkable record of accuracy and reliability. There seem to have been some errors caused by failure of the OMEGA navigational device. And there seem to have been others due to human errors, either ATC (air traffic control) loop errors in which the controller and the pilot have some communication failure, or insertion errors, in which the aircrew insert the wrong data into their INS. These are the ones that are likely to lead to errors of exactly 60 miles (or some multiple thereof) and that are therefore the most dangerous.

Whatever decisions are finally made, their implementations will only operate for a few more years—apparently by the 1990s navigational satellites will be available that will enable all appropriately equipped aircraft to determine their positions within a small fraction of a mile. In the interim, however, it seems clear that the lives of those of us who fly NAT are in the hands of people who are dedicated to protecting us, and that flying over this region is considerably safer than being in the terminal area at the end of the flight, which in turn is safer than getting into an automobile to complete the trip. (Robert E. Machol)

ELECTRONICS

PHILIPS AT REDHILL

(Key Words: Alphanumeric Displays, Cadmium Mercury Telluride, Deep Level Spectroscopy, Ferrites, Ferroelectrics, Fine Line Lithography, Fuel Valve, Imaging, Image Intensifiers, Impurity Levels in Semiconductors, Infrared Detection, Interface State Density, Mercury Cadmium Telluride, Mixer Diodes, Molecular Beam Epitaxy, Plasma Panels, Powder Semiconductors, Solid State Image Converters, X-ray Imaging.)

Most individuals engaged in research in the physical sciences are aware of Philips as a manufacturer of scientific equipment and as a center of research. Relatively few persons in the US, however, are aware of the extent of this giant corporation. Philips, with headquarters in Eindhoven, the Netherlands, was founded in 1891. It is a highly integrated multinational organization whose products fall into 13 main industry groups. The company has branches in about 65 countries and manufacturing operations in 50 of these. There are on the order of 400,000 employees, of whom three fourths are employed in Europe. Jane's *Major Companies of Europe 1979-80* lists a total turnover for 1977 of 31,164.3 million fl., or approximately $15 billion. (Net sales of the General Electric Co. for that year were $17.5 billion.)

Since the company's success is based on leadership in highly technical fields, research is an important concern. Although the best known research laboratory of Philips is the one in Eindhoven, there are actually five other main research establishments in various parts of Western Europe, with close coordination. In addition, according to a company brochure, "a cordial relationship also exists with the Philips Briarcliff Laboratories." (The latter are the laboratories of North American Philips, a US associated

company.) Since Philips has recently acquired Signetics, in California, the research activity there can now also be counted into the general company research effort.

Readers of these Notes may recall a report by W.J. Condell entitled "Mullard of Redhill," written about seven years ago (*ESN* 26-3:85), which describes the Mullard Research Laboratories. Some time ago the name of these laboratories was changed to Philips Research Laboratories (Redhill). The present article, in which the Laboratories will be referred to as PRLR, is therefore an update of this earlier one.

My visit to PRLR, with two colleagues, was arranged by Mr. George Weston, head of the Gas Discharge Group of PRLR, whom I had met at an IEE colloquium on Engineering Aspects of Gas Lasers. Weston may be known to readers as the author of the recent informative survey article "Alphanumeric Displays" [*IEE Reviews* 125, 1077-1099 (1978)].

In our introduction to PRLR we found out that although PRLR coordinates its work closely with the rest of Philips, the principal function is to support the activities in the UK of such Philips organizations as the MEL Equipment Co. Ltd., Mullard Ltd., Philips Electrical Ltd., and the Pye of Cambridge Group. Since we had heard that some work at PRLR was of a military nature, we wondered whether there was also feedback to Eindhoven on this. We were assured by our hosts that the results of any work carried out under contract to the British government would not leave the UK unless so authorized.

PRLR was founded in 1946. The Laboratories now occupy a floor space of 17,640 m^2 and are located on a 24-acre site in semi-rural surroundings south of Redhill, about a half hour train ride from London. As reported in 1972, the personnel complement remains at about 500 to 600, of whom about 200 have doctorates or "equivalent postgraduate experience."

The Laboratory Director is N.E. Goddard; Deputy Director is Prof. J.C. Walling, MBE, who was also one of our hosts. There are five divisions, with Directors as follows: Solid State Electronics (Prof. Walling); Applied Physics (Dr. P. Schagen, OBE); Systems (K.L. Fuller); Circuit Physics (L.G. Cripps) and Engineering (P.B. Bunn).

In the rest of this report I shall first briefly list the functions of these Divisions and the various departments in these Divisions as they are given on the organization chart. This is followed by a report of our visit and some details of specific items.

The Solid State Electronics Division has the mission to prepare and study solid state materials that are of immediate and potential application in devices and circuits. This includes techniques for device fabrication. The majority of the work at this time seems to be in the field of semiconductors. The following groups are listed: Physics of Solids (Dr. R.F. Pearson); Physics of Semiconductor Devices (Dr. J.M. Shannon); Silicon ICs and Techniques (Dr. P.J. Daniel); Materials (E.J. Millet, with Chemical Analysis the responsibility of J.A. Roberts).

The Applied Physics Division encompasses several disciplines. For example, there is the Electron Lithography Group (H.N.G. King), which has the mission of developing ultra-fine-line lithography using electron beams. Dr. J.W. Orton's Powder Semiconductors Group deals principally with powder semiconductors for the use in solid state image intensifiers for medical x-ray applications. The Gas Discharge Group (G.F. Weston) has been engaged in work on alphanumeric displays.

For some years, PRLR has been working on image tubes both for viewing infrared as well as x-ray images. Indeed, there is an Image Tubes Group, headed by A.W. Woodhead. Finally, in this division we find a group labeled Special Problems (A.A. Turnbull), whose current missions were not disclosed to us.

As its name implies, the Systems Division is primarily concerned with developing electronic systems to fit specific operational requirements for applications in industrial, military, or specialized professional work. Activities here range from the proposal of concepts to the development of the actual hardware and include problems dealing with radar; information processing; methods of extracting signals from noise; studies of the transmission, reception, and measurement of electromagnetic radiation; sensing and imaging; and the display of data. The various groups in this Division are: Communications (J.S. Palfreeman), Electronics (C.H. Braybrook), Microwave Systems (R.N. Alcock), Microwave Techniques (Dr. R. Davies), and Instrumentation (V.A. Evans).

The Circuit Physics Division, which includes the Computer Department, performs research into the properties and applications of electronic devices in anticipation of the needs of users. The various groups listed here are Telephone Techniques (E.S. Eilley), Linear Circuits and Display (R.N. Jackson), Ferrites and Piezoelectrics (E.C. Snelling), Computer Applications (J.A. Weaver), and the Computer Department (W.A. Crossley).

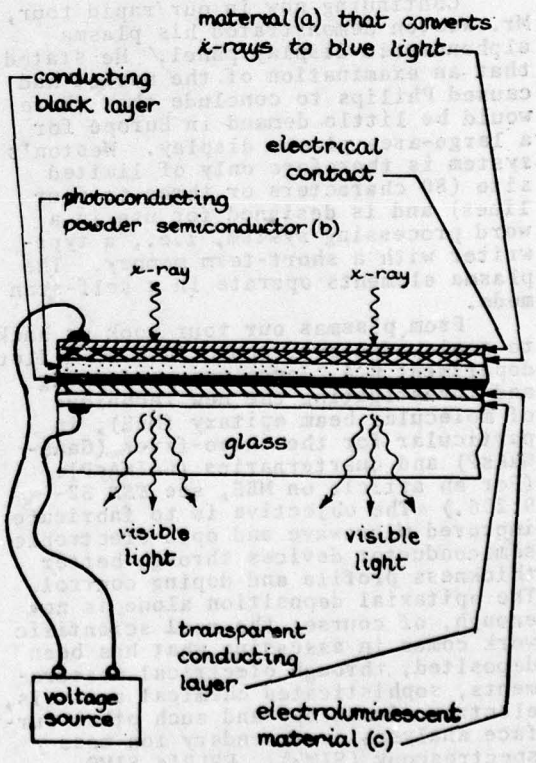
The function of the Engineering Division is to provide support to the other divisions (e.g., drafting and fabrication), and to improve design and manufacturing technologies and establish new ones. Examples of the work here are the application of computer techniques to mechanical design problems and the development of a process for producing replicated aspheric optical components of high quality.

Now for some details of our visit: Our first stop was at the Powder Semiconductor Group, where seven individuals are involved in studies on powder semiconductors, four others were said to be performing Auger spectroscopy on glasses, but no details were given. As explained by Dr. B.J. Goldsmith and Dr. J. Ralph, the ultimate objective of this work is *imaging* and, in particular, conversion of an x-ray image into a visible one, with solid state image intensification achieved by coupling a powder semiconductor to an electroluminescent material. We were informed that this work started as a follow-up to the Kazan Panel, first demonstrated by Dr. B. Kazan of the US.

The principle of a solid state x-ray imaging unit—really a display unit—is illustrated in the Figure.

Here x-rays strike layer *a*, where a small amount of visible light is produced. This, in turn, activates the photoconductor *b* and lowers its resistance locally, thus permitting a current to pass through it in series with the black layer and the light emitter *c*. The light emitted by the latter is much greater than that from the x-ray-to-light converter.

According to Ralph, until recently the long decay time of high gain photoconductors had limited this system to virtually stationary images. There had also been a problem of sensitivity because of the excessive dark currents. The contribution of the Philips group has been to alter time constants of the photoconductor from hours to milliseconds as well as to reduce dark currents, by proper powder preparation and by the judicious application of voltage pulses to interdigital electrodes. (Not shown in the Figure, but see British Patent Specification 1,533,657, published 11/29/78). The behavior of the photoconducting powders is thought to be similar to the action of a junction field effect transistor operating in a charge storage mode, in that the grain-to-grain conductivity is reduced to very low values by the application of the voltage pulses, so that a small amount of carrier creation by the light causes a large change in conductivity. Powders that have been under investigation are PbO, n-ZnO with absorbed oxygen and dyes, n-ZnO grains coated with p-ZnTe, and others. [See J.E. Ralph and M.J. Plummer, "Charge storage and photoconductivity of PbO powder layers." *Appl. Phys. Lett.* 32, 744-746 (1978).]



Solid State Image Intensifier Layer Structure for X-ray Imaging. (The positions of the top electrical contact and layer *a* could be interchanged.)

The group is now confident of the principle of operation and is trying to make reliable devices that can operate at rates of a few frames per second.

In the laboratory devoted to fine-line lithography we were shown ½-micron lines and heard of work on pattern shaping. We also saw an apparatus that is being tested for use in the exposure of photoresists on silicon wafers. As briefly explained to us, here one first fabricates a mask by ultra-fine electron beam technology. The mask is then used in a manner analogous to an optical shadow mask, except in this case it is not light that passes through the mask but electrons. The screen here is the photoresist on the silicon chip, and there is no image magnification. To ensure high resolution, electron trajectories are forced to be rectilinear and parallel by immersion of the entire system in a strong axial magnetic field whose uniformity is a few parts in 10^5. The individuals performing this work were Drs. P. Daniel and H.N.G. King.

Continuing now in our rapid tour, Mr. Weston demonstrated his plasma alphanumeric display panel. He stated that an examination of the market had caused Philips to conclude that there would be little demand in Europe for a large-area plasma display. Weston's system is therefore only of limited size (80 characters or three to four lines) and is designed for use in a word processing system, i.e., a typewriter with a short-term memory. The plasma elements operate in a self-scan mode.

From plasmas our tour took us back to semiconductors, where in E.J. Millett's department B.A. Joyce was performing and investigating the new technique of molecular beam epitaxy (MBE), in particular for the three-fives (GaAs-GaAsP) and quarternaries (GaInAsP). (For an article on MBE, see *ESN* 32-9:296.) The objective is to fabricate improved microwave and opto-electronic semiconductor devices through better thickness profile and doping control. The epitaxial deposition alone is not enough, of course; the real scientific work comes in assessing what has been deposited, through electrical measurements, sophisticated chemical analysis, electron microscopy and such other surface analyses as secondary ion mass spectroscopy (SIMS). PRLR's SIMS facility uses an Atomika (Munich) apparatus. Joyce stated that MBE-deposited layers are somewhat more difficult to dope than those obtained by other processes; especially for n-type dopants. An example is found with tellurium which, instead of doping GaAs films, forms the surface compound GaTe.

Besides yielding new scientific information, MBE has already resulted in some improved devices. For example, PRL has made an improved low-noise mixer diode for 115 GHz ("better than Bell Labs") and a varactor whose ideality factor does not increase as the temperature is lowered.

Another very active area in PRLR deals with studies of impurity levels in semiconductors. This work is being carried on by S.D. Brotherton and colleagues. The aim here is to improve semiconductor device performance, as, for example, the switching speed in power devices. Several techniques of deep level spectroscopy (DLS) have been investigated for measuring such parameters as energy levels, concentration, capture cross section, and recombination lifetimes. [See, for example, S.D. Brotherton and J. Bicknell, "The electron capture cross section and energy level of the gold acceptor in silicon." *J. Appl. Phys.* 49, 667-671 (1978).] Prof. Walling stated that he felt the PRLR facilities for carrying on this work were not exceeded by any other laboratory in the world.

Closely related to DLS are the investigations of R. Pratt, in Pearson's group, on Cadmium Mercury Telluride, or CMT, the well known infrared-sensitive material. (Others prefer to call it Mercury Cadmium Telluride.) Pratt has been measuring the density of interface states (which have a great influence on lifetime, sensitivity and noise) by making CV-plots of MOS-CMT structures at various temperatures.

The last event of the day was a brief visit to the area of E. Snelling and Ian Flynn, who work on engineering aspects of ceramics, specifically of ferrites and ferroelectrics. Snelling's domain is magnetic; his work aims at industrial applications of soft Mn-Sn ferrite cores and encompasses anything from the physics of magnetism to the use of these materials for telephony filters. The ferrite cores are fabricated either in England or in the Netherlands; it is Snelling's work,

together with the fabricating groups, to arrive at materials whose permeability is stable to ± 0.05% for a twenty-year period.

An example of Flynn's work is a study of high power effects in the lead zirconate titanates, the well-known piezoelectric ceramics, with samples fabricated in the Netherlands. Possible applications are in underwater sound and for such industrial uses as a piezoelectric fast-acting valve for automobile fuel metering (See PRLR Philips Technical Note 036.) and piezoelectric bleepers for smoke detectors.

The impression left after the day's visit to Philips-Redhill is that this organization comes up to the general high quality that Europeans have come to expect from Philips. The surroundings are pleasant, the laboratories are clean and orderly, and the research is of high quality and very much up to date. Philips is indeed one company that realized long ago that good research equipment and the atmosphere conducive to good research are necessary ingredients for continued success in high-technology fields. (Irving Kaufman).

ENERGY

FUTURE ENERGY CONCEPTS

As reported in *ESN* 33-5:180, this follow-on article will cover the sessions on *Waves and Tides* and *Wind Power* held at the "Future Energy Concepts" conference earlier this year.

Because tidal schemes have already proven to be technologically feasible (and with OPEC's current rate of price increases, they soon may be economically viable too), they will be covered first.

Tidal Power. The two most popular methods of extracting energy from tides are barrages across a river or harbor entrance and turbine rotors operating in the tidal current. The best approach to barrages appears to be the utilization of caissons floated into place by tugs, a skill advanced considerably by North Sea oil-platform work. This is about 25% less expensive than the earlier method of constructing cofferdams to facilitate *in situ* construction of the barrage, sluices, and turbine units. Most experts agree that, as of this writing, the Sulzer Straflo Turbine (see Fig. 1) is potentially the best of the many candidates, but it is also almost unanimously accepted that several further stages of development are required before barrage tidal power is clearly an economically feasible investment on a large scale.

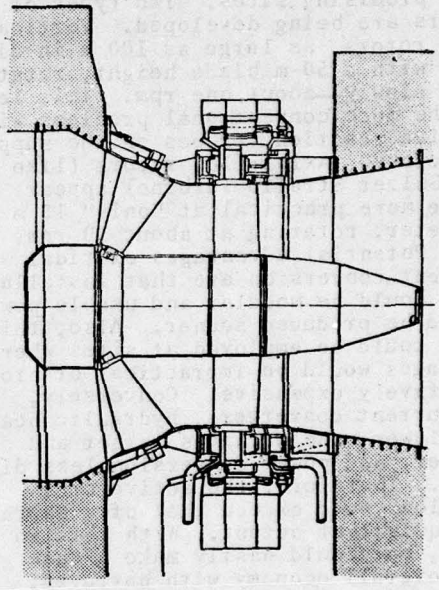


Figure 1

On the irksome problem of energy storage, several recent proposals contain built-in systems using pumps, turbines, and multiple basins. One grandiose scheme calls for underground pumped hydroelectric/compressed-air storage. Of course, the barrage itself could be built such that it would contain the necessary reservoirs. This idea has prompted development of a fully reversible axial pump-turbine. Indian scientists claim a scaled efficiency of 85% in each direction through the utilization of fixed runner vanes. At any rate, ideas for storage schemes will continue to proliferate and ultimately should pose minimal difficulty in matching whatever barrage plan is adopted—assuming one eventually is.

Turning to the alternative approach, turbine rotors placed directly in the tidal current, the technology for implementation of the massive structures for machine support and water containment has been around for a long time. Present estimates show that approximately 30% of the kinetic energy of the free stream crossing the rotor-swept area can be extracted, which could yield upwards of 10 GW at the most promising sites. Two types of rotors are being developed. Vertical-axis rotors, as large as 100 m in diameter with a 50-m blade height, rotate very slowly—about one rpm. This leads to the more conventional problems with massive reaction torques on the support structure. Axial-flow rotors (like the Sulzer Straflo Turbine) appear to be more practical at "only" 15 m diameter, rotating at about 50 rpm.

Potential advantages of tidal current conversion are that installation could be modular and usable power could be produced sooner. Also, this plan could be employed at sites where barrages would be impractical or prohibitively expensive. Conversely, in current converters, hydraulic heads are lower, the machines larger and slower, and power conversion less direct. Therefore, the active cross section could exceed that of a barrage of equivalent output. With this in mind, one could easily make a case for overall economy with barrages, especially when access for maintenance and component availability are considered.

It remains to be seen whether tides will eventually prove to be one of the answers to the growing energy dilemma. We know that they work, for it has been proven at certain favorable sites capable of significant energy production (La Rance, France; Kislaya Guba, Russia). Although not currently comparable economically to coal, petroleum, or nuclear power, the margin is decreasing. Many Europeans feel that even if the initial expense is difficult to justify, a working tidal power plant would be welcome.

Wave Power. As previously stated, tidal energy is here and now—albeit expensive for the time being. By contrast, wave energy is at a stage of development comparable to the Wright brothers and aeronautics at the turn of the century. Considerable progress has been made in understanding the physics of wave energy conversion and in optimizing the design principles of the four basic devices under review in the UK's Wave Energy Research Programme: Salter's Ducks, Cockerell's Rafts, the National Engineering Laboratory (NEL) Oscillating Water Column (OWC), and the Hydraulics Research Station (HRS) Rectifier (see *ESN* 31-8;302; 32-4:124; 33-3:86). Present estimates of more than $0.50/kWh certainly compare unfavorably with typical costs of $0.05/kWh from conventional (coal or nuclear) power stations. The high estimated cost of delivered energy results from the following factors:

(1) realistic estimate of available energy (down from 80 kW/m of wave front to 25-35 kW/m);

(2) wave directionality (decrease in available energy by a correction factor of 0.5 - 0.75);

(3) device spacing limitations imposed by moorings and ship navigation requirements;

(4) variability in sea conditions;

(5) system down-time for maintenance or component failure, which the operating environment makes inevitable.

There is a widespread feeling that further improvements on this rather gloomy outlook rest in a combination of the following: (1) concentrating on simple, direct conversion systems (e.g., air turbines, medium-head water turbines); (2) combining the best features of existing designs to build new devices with lower structural costs; and (3) designing for minimum down-time through good component reliability, maintenance accessibility, and redundancy in critical areas.

Salter and his duck are the best known team in wave energy today, yet this device is furthest from engineering realization. The "brick wall" that proponents of this system have run up against is the enigma of power conversion: how to produce high-speed directional rotation of an electrical generator from the low velocity nod of the ducks. Enthusiasts claim that the recent inclusion of internal gyroscopes should solve this problem. However, since the gyro function is restricted to relatively small angular displacements of the frame and a speed increase remains essential to drive the required hydraulic pumps, it would appear that the gear design problem is, if anything, worsened.

Nevertheless, Salter must go down as the pacesetter in wave power devices; much useful data as well as material and structural breakthroughs can be attributed to his scientific endeavors. One-tenth scale field trials of his ducks at Loch Ness showed that conclusions from tests on the spine may be applied to any floating structure of similar overall dimensions. Mooring forces and bending moments do reach a definite limit and are much lower than originally estimated. This is one of the few bright spots, and would suggest that any potential floating wave-power device should have a length of approximately 500 m at full scale. Based on this data, calculations (especially correlation analysis) have yielded the actual overall motional response of a structure this large, which in turn is giving the construction community the first believable inputs to operational specifications for moorings and flexible cable connections.

Some UK scientists continue to caution their colleagues on full-scale system assessments. The consequences of device performance, scale, and power-limiting on output are apparent in calculations that wave-power devices may be capable of only a 30% maximum overall energy conversion (even before secondary conversion, transmission and reliability-based losses are taken into account), which corresponds to approximately 25 kW/m energy output possible off the Hebrides, at this time considered to be one of the prime placement areas. Carrying this premise one step further, a 50-m-wide raft would only generate about 1.25 MW. So, the size of the resource available is rather less than originally imagined. However, opmistic predictions indicate future design improvements could help, giving an annual power supply from the maximum feasible number of devices around the UK of 20-60 TWh compared with the current overall UK requirement of 250 TWh per year. So, even with the inevitable pitfalls, wave energy could well be worthwhile by the turn of the century.

One of the most promising UK schemes of late is the air-turbine-based system. Recently proven analytical techniques have advanced the theory that only three levels of Coulomb damping are required to maintain overall conversion to within 70-80% of the ideal. Initial designs for a single air turbine coupled with each OWC gave relatively small outputs (about 2 MW) and were rated for peaks. Now, planners can put a number of rectified OWC cells into a common main, which means larger units rated at closer to the mean power level. This should lead to improvements in reliability that ought to offset the original 20% loss in efficiency. Larger generating units in the 15-20 MW range will also bring monetary advantages to the currently favored transmission plan—flexible connection of devices to series-connected transformer/rectifier modules and HVDC transmission to shore—by reducing the number of flexible cables, underwater joints,and required offshore components.

The only really new device presented at this conference was the Farley Triplate Wave Energy Converter (see Fig. 2), a fascinatingly different contrivance. The idea is to convert incoming wave power to high-pressure hydraulic flow. In principle, plates 2 and 3, oriented parallel to the wave crests half a wavelength apart, cause a standing wave to form between the plates which opposes any horizontal system motion. That old bugaboo, conversion, is no problem—the pumped hydraulic fluid can be used to drive a turbine directly, at about 50% efficiency. Although test results on scale models have validated the concept, it may prove extremely difficult to engineer at full scale by virtue of the half-wave-length spacing of the rear plates and the extra-long ramrod required for the power takeoff. Nevertheless, this embodies an important lesson: that it is possible to replace expensive structures with the *in situ* element and still come up with high conversion efficiencies. This is definitely the type of approach to follow if wave energy economics are to be significantly improved; more such ideas are urgently needed.

Today wave power is in that phase of technological innovation where the problems loom larger than the possible solutions, but the subject is much better understood, the total potential for energy remains large, and promising new devices may be just around the corner.

Wind Power. In the UK, the Department of Energy (DoE) is funding studies of "aerogenerators" (a windmill

by any other name...) through their Energy Technology Support Unit (ETSU). The Central Electricity Generating Board (CEGB), civil engineering industry, and aerospace industry are also involved. There are two basic types: horizontal or vertical-axis machines; each may be large or small, and sea- or land-based. All eight combinations of these possibilities were covered during this conference.

A standing opinion in the UK and on the continent is that even low-cost high-efficiency machines can only be economically feasible if the mean wind speed is greater than 8 m/sec (as petroleum prices increase, this cutoff point should move downward). But by utilizing aerogenerators in conjunction with hydropumped storage schemes, they show promise of being competitive with coal-fired plants because of the value of the on-call power obtained from the storage system. Wind energy might also be utilized to produce liquid fuels that could replace gasoline, and hydrogen fuel obtained from electrolysis fed with aerogenerator electrical power might be competitive with liquid coal-derived fuels.

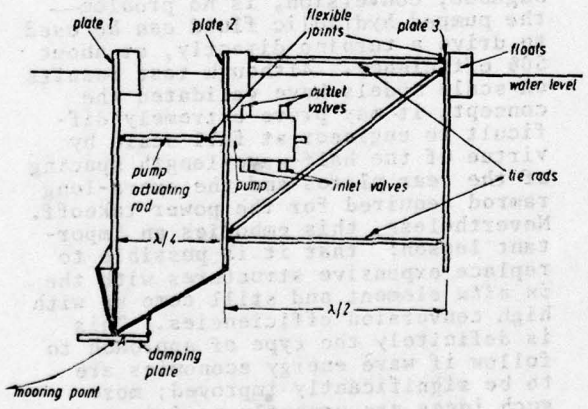


Figure 2

Darrieus patented a vertical axis aerogenerator in 1929, but little work was carried out until recently when it was realized that such machines may be more economical than conventional horizontal axis designs. Their greatest advantage is, of course, the fact that wind velocities from any direction are accepted without the usual requirement for orientation, and there are no problems of yawing and associated gyroscopic torques. Inherent drawbacks, by no means insuperable, include possible blade stalling under heavy loads, lack of self-starting capabilities, the possible requirement for air brakes in very high winds, and a means of furling the blades.

Proponents of offshore systems argue that up to 6 GW of aerogenerator capacity could be installed on the UK's broad eastern continental shelf off Lincolnshire and Norfolk in depths less than 20 m. Adding other prime sites, an output equivalent to 25% of the UK's present electrical needs could be satisfied. Furthermore, optimizing machine size could bring capital costs down to about $1000 per kW, which makes this a not altogether unattractive option.

The selection of wind-speed factors to use in designing a particular aerogenerator is crucially important, and not everyone agrees with the "8 m/sec rule." In fact, some scientists argue against using the highest rated wind speeds in attempting to maximize annual energy output; instead, they say, the "load factor" should be the vital design criterion. Aerogenerators optimized for maximum output have load factors around 25%, but factors up to 37% can be achieved when machines are rated closer to the areal mean wind speed. Also, when lower design-rated speeds are used, there is less wind depletion behind the turbines, so more machines can be placed in closer proximity on an individual site. Even though these complex technical and economic differences must be clarified through further R&D, the subject of placement and site location bears further discussion.

If clusters of aerogenerators were placed over an extensive area of shallow water or on land, the numbers would necessarily have to be large to yield a significant contribution to the national energy grid. Unfortunately, the greater surface drag associated with such large arrays would alter boundary-layer conditions, thereby reducing downstream wind speed. Therefore, the problems of optimizing positions and spacing between individual units (be they of the horizontal- or vertical-axis type) are obviously very important in assessing the

economics and feasibility of large-scale power production from wind. The benchmark against which aerogenerator schemes are measured in the UK today is the "power density per square kilometer of site area"; preliminary investigation indicates up to 20 MW/km^2 should be achievable.

Recent data analyses have indicated that an array of fixed aerogenerators, accepting the wind from only one general direction, can collect just 57-66% of the available energy. The cost of power from such machines would be some 50-75% higher than from their omnidirectional counterparts—quite a strong case for vertical-axis machines.

Differences of opinion exist with respect to the smaller systems that could be put to domestic use. Based purely on cost considerations, some scientists argue that, at this time, application of a wind generator to a self-sufficient house project with the associated storage that would be required is not a prudent venture. This verdict does not even take into account other crucially important disadvantages of such aerogenerators, namely noise, vibration, aesthetics, safety, and reliability. On the other side of the ledger, a 5-kW Darrieus machine has been developed for unattended operation at exposed rural sites. Mounting a Savonius-type rotor on the common shaft gets around the self-starting nemesis. The machine has operated safely in 82-knot wind gusts, and the designers are confident that their project has proved that wind energy extraction on this scale is practicable.

Finally, some Imperial College professors (L.L. Freris et al.) have shown, through a working prototype, that a horizontal-axis aerogenerator with a 7-m-diam. rotor coupled to an 8-kW generator should provide around 14 MWh per year at a location where the mean wind speed is 5 m/sec. One difficulty with such proposed residential system is that householders rarely invest in energy-saving devices that do not offer a quick payback.

In retrospect, while many technologists agree that wind power is an undeveloped though proven source of high-grade electrical energy, there still exists the need to establish technical reliability and feasibility of aerogenerators (particularly the MW-size machines) and, above all, to reduce capital costs. Although, if petroleum prices continue to increase, it may not be too long before we reach the crossover point on the "OPEC oil price vs wind energy cost" graph.

Conclusion. Most energy experts, at least in the UK, do not foresee renewable energy sources (tides, waves, wind, etc.) being implemented on a large scale before the turn of the century. The West Germans are more optimistic. They will have a 270-kW aerogenerator (or "wind energy plant" as they call it) in operation later this year and should have a 2 MW system on-line sometime next year. Five smaller plants, each with an output of 10 kW, are also planned for near-term operation. Who was it that said, "He who hesitates..."? (LCDR Clay Spikes)

SYSTEMS ANALYSIS IN JULICH

The KFA (Kernforschungsanlage, or nuclear research establishment) is one of two atomic research centers in West Germany, the other being at Karlsruhe. Each has almost 4000 workers The KFA was established in a lovely rural setting in the little old village of Jülich, more or less midway between Düsseldorf, Cologne, Bonn, and Aachen in the western edge of the country, in 1956. Since 1968 it has been a GmbH (Limited-liability corporation) owned 90% by the federal government and 10% by the state government of Westphalia. The name "nuclear" is somewhat misleading, since the center actually has a wide variety of research activities beyond the nuclear area. In addition to nuclear studies and associated activities in physics, there are extensive studies in biotechnology, alternative forms of energy, and systems analysis, among others.

There is no classified research at KFA—and indeed there is by treaty no nuclear weapons research in West Germany. In addition to some fusion research based on magnetic containment, the principal nuclear activities at KFA center around the High-Temperature Gas-cooled Reactor (HTGR) (see *ESN* 29-8:350 and 30-11:522). Unlike the Light Water Reactors (LWR) that generate most of the nuclear power

around the world and have maximum temperatures available in the working fluid of 300 to 350°C, the HTGR is cooled by helium, which can reach temperatures of 900 to 1000°C. This high temperature not only allows more efficient electricity generation (because of Carnot's principle), but also permits certain high-temperature chemical reactions, such as the gasification of coal or various thermochemical cycles for the production of hydrogen. The Germans, who are very optimistic about the HTGR, also stress its safety. The fuel is inside a graphite "pebble bead," a 6-cm sphere (about the size of a tennis ball). The reactor core consists of a pile of some 200,000 of these beads. Because of the low energy density and the high specific heat of graphite, even with complete loss of coolant the reactor would not overheat dangerously for more than a day.

The Germans have no petroleum, little coal, and large amounts of "brown coal" or lignite. It is anticipated that by high-temperature treatment this lignite can be gasified or liquefied, i.e., turned into synthetic natural gas or synthetic gasoline. Systems analysts at KFA are also studying underground gasification of lignite—for the very deep deposits, say more than 1500 m, this is probably the only feasible method of exploitation for the foreseeable future. Just a mile from KFA is a huge lignite deposit that is just now being exploited. The lignite is at a depth of 500 m, and the overburden is being removed to develop an open-pit mining operation; the first product is expected in 1983.

All of this obviously leads to a wide variety of questions about environment and pollution, economics, energy demand and supply, and the like. These are among the subjects being studied at the Systemforschung und Technologische Entwicklung (STE) or systems research and technological development, one of some dozen institutes within KFA. It is headed by Dr.-Ing. Alfred Voss who, like so many fine systems analysts, was trained not in this field but in engineering; having studied nuclear engineering at the University of Aachen, he started working at KFA in 1971. There he became interested in the question of how one integrates an HTGR into a community. This led him to systems analysis and eventually he wrote his doctoral thesis (again at Aachen) on a system-dynamics-type world energy model which he developed for KFA.

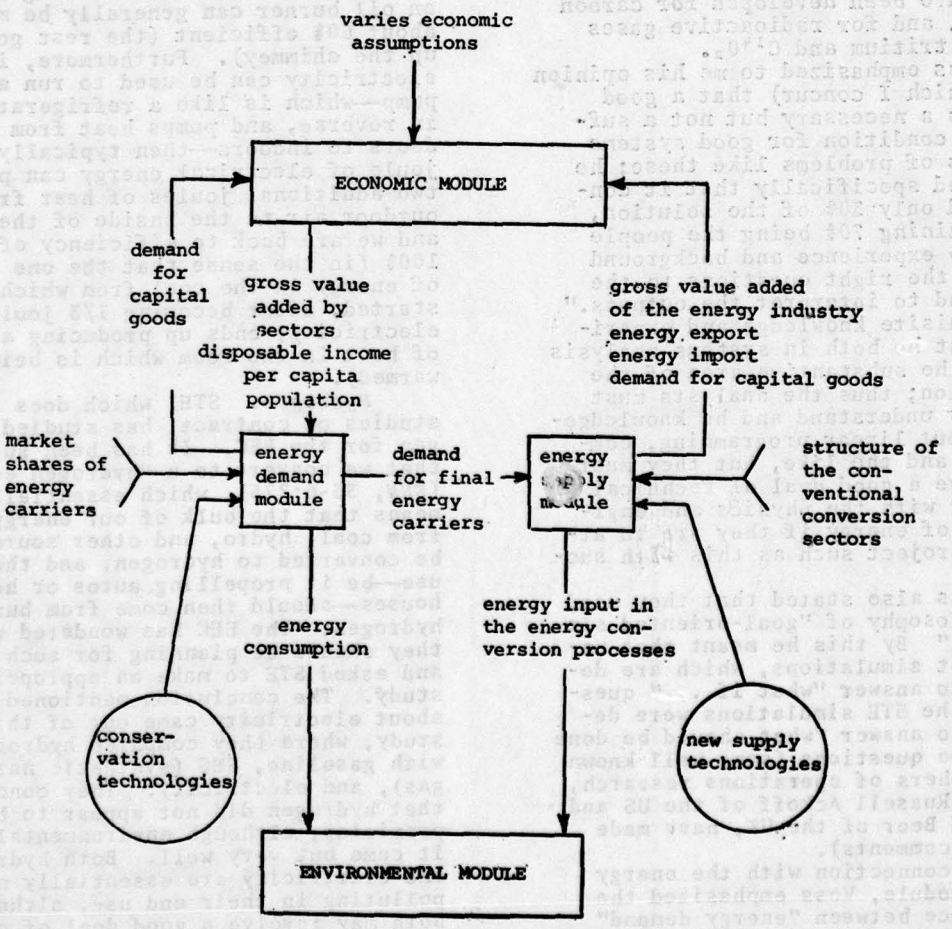
The STE was set up in 1973, with Voss as its head, just two weeks before OPEC pulled the rug out from under the western world. The resultant "energy crisis" immediately led to greatly increased interest in many of the problems which STE was beginning to tackle, and the group has prospered ever since. There follow a few paragraphs on some of their activities.

Nuclear long distance energy. STE is studying the implications of a fascinating new technological development at KFA which is code-named "Adam and Eve" (*ESN* 29-6:264). Originally this was called the Einzel Versuchsrohrspalt Anlage, for which the acronym is EVA, the German equivalent of the biblical name Eve; Adam was subsequently added gratuitously. In this system, an equimolecular mixture of methane and water is heated to about 900°C, at which point it is converted endothermically into hydrogen and carbon monoxide. Through a countercurrent heat exchanger this mixture is cooled while preheating the incoming gases, so that the energy conversion (from the enthalpy of the helium to the chemical energy in the H_2-CO) is highly efficient. This mixture may then be transported arbitrary distances without loss (except for the cost of pumping) to the consumer where, by passing it over a suitable catalyst, it is converted back to methane plus water at a temperature of 400°-500°C.

Implementation of the HTGR. The technical, economic, and environmental effects of the HTGR and the economic implications of electricity generation by the HTGR are being studied by a wide variety of techniques. One of these is "net energy analysis," usually known in the US as "energy cost of energy." For example, if a solar energy system uses a great deal of aluminum, and it takes a lot of energy to produce that aluminum, the net energy analysis may show small or even zero negative energy production by that system; alternatively, one might show that the "cost" in joules of the aluminum is greater than the energy production of the system over its useful lifetime; from still another viewpoint, the "payback time" for the energy may exceed its useful lifetime. The HTGR comes out rather well in this kind of analysis because the materials of which it is constructed are not highly energy intensive.

Simulation models. The attached block diagram shows the Long-term Energy Simulation System (LESS), which in turn becomes one block in a larger diagram where this is combined with an economic impact model, an input-output model, some optimization routines, various historical data bases, and miscellaneous sub-routines for curve fitting, regression, and the like, to simulate either the FRG (Federal Republic of Germany) or the entire world over a period of about 50 years. With the help of this model system, alternative developments in energy demand and supply can be investigated and their effects consistently represented.

There are some interesting aspects to some of these sub-models. The economic impact model is a Leontieff type (input-output) model which was originally developed by the Siberian Power Institute. Voss spent a year recently at the International Institute for Applied Systems Analysis (IIASA) (*ESN* 33-5:173) where he worked closely with a Soviet scientist from whom he obtained the model that has been modified for use at STE-KFA. There are two optimization routines, with acronyms MARKAL and MESSAGE, that are basically linear programming models specially modified for use in this connection; the objective functions are minimization of



LONG-TERM ENERGY SIMULATION SYSTEM (LESS)

total discounted costs over a fixed time horizon (of course such models are undesirably sensitive to the discount rate chosen). The MARKAL model, as implemented on the 370/168 (a large IBM computer), can handle up to 2500 rows (constraints) and 3000 columns (variables). The matrix must then, of course, be very sparse, and it turns out that it is—in fact, it has the typical form which usually leads to use of the Wolfe decomposition algorithm, although they have not yet bothered to apply that here because the machine seems to work quickly enough using a conventional revised simplex algorithm. In addition to these energy models, similar models (for the entire world, or for Germany only) have been developed for carbon dioxide, and for radioactive gases such as tritium and $C^{14}O_2$.

Voss emphasized to me his opinion (with which I concur) that a good model is a necessary but not a sufficient condition for good systems analyses of problems like these; he suggested specifically that it constituted only 30% of the solution, the remaining 70% being the people with the experience and background "to put the right questions to the model and to interpret the outputs." The requisite knowledge and experience must be both in systems analysis and in the substantive area of the simulation; thus the analysts must not only understand and be knowledgeable about linear programming, computers, and the like, but they must also have a good deal of technical facility with the physics and engineering of energy if they are to attack a project such as this with success.

Voss also stated that they used the philosophy of "goal-oriented simulation." By this he meant that unlike most simulations, which are designed to answer "what if ..." questions, the STE simulations were designed to answer "what should be done ..." type questions (some well known philosophers of operations research, notably Russell Ackoff of the US and Stafford Beer of the UK, have made similar comments).

In connection with the energy demand module, Voss emphasized the difference between "energy demand" and "useful energy demand." If the cost of energy is sufficiently low, as it has been (and perhaps still is) in the US a lot of "useless" demand (as for propelling gargantuan autos) is generated.

Comparative Energy Study. Voss told me of a study done by STE which showed, surprisingly, that electricity was not bad as a source of energy for such things as heating houses. This is surprising because everyone knows that in converting the chemical energy of coal or petroleum to electricity, one cannot avoid losing two thirds of the energy to useless heat. One tends to forget, however, that the conversion of that electricity back to useful heat can be done with efficiency of essentially 100%, whereas something like an oil burner can generally be made only about 60% efficient (the rest going up the chimmey). Furthermore, if the electricity can be used to run a heat pump—which is like a refrigerator run in reverse, and pumps heat from outdoors to indoors—then typically each joule of electrical energy can pump two additional joules of heat from the outdoor air to the inside of the room, and we are back to efficiency of about 100% (in the sense that the one joule of energy in the coal from which we started, after becoming 1/3 joule of electricity, ends up producing a joule of heat in the room which is being warmed).

Hydrogen. STE, which does some studies on contract, has studied hydrogen for the EEC. It has been suggested that we convert to a "hydrogen economy" (*ESN*, 33-6:225), which essentially means that the bulk of our energy (as from coal, hydro, and other sources) be converted to hydrogen, and the end use—be it propelling autos or heating houses—should then come from burning hydrogen. The EEC has wondered whether they should be planning for such use, and asked STE to make an appropriate study. The conclusion mentioned above about electricity came out of this study, where they compared hydrogen with gasoline, SNG (synthetic natural gas), and electricity. They concluded that hydrogen did not appear to be promising, although environmentally it came out very well. Both hydrogen and electricity are essentially nonpolluting in their end use, although both may involve a good deal of pollution in their generation. It should

be pointed out in this connection that the assertion that electricity comes out of the study looking good depends on the assumption of sophisticated end-use technologies (such as heat pumps). Without such technologies, it is hard to recover from the typical 33% efficiency of generating electricity from coal or petroleum.

Risk Study. Related to the above is a fascinating study done by a man named Inhaber, a Canadian, on the total risks associated with gas, coal, nuclear energy, and solar energy. Most people would probably guess that nuclear would be most risky, but Inhaber's study found that coal was most risky—in terms of the total expected harm done during the generation (in this case mining) and use of the energy form. This takes into account the accidents in coal mines and the black-lung disease of miners, as well as the inevitable pollution by sulfur dioxide caused by the burning of high-sulfur coals. KFA is involved through contracts with the International Energy Agency, and the STE is following up on this study.

INFCE. The International Fuel Cycle Evaluation Program was set up in 50 countries in response to an initiative by Jimmy Carter, who was anxious to control the proliferation of nuclear material that might be diverted to bombs. In particular, Carter wished to prevent any breeder reactors (which generate more nuclear fuel than they consume) from being built in the world, and stopped development work on America's breeder. He also wanted to avoid reprocessing, in which the radioactive wastes coming from nuclear energy plants are treated in such a way that the nuclear fuel can be recovered and recycled into other nuclear plants (or perhaps into bombs). It is to be hoped that within a year or two there will be a concensus on whether the world does indeed need breeders and/or reprocessing. Meanwhile STE's contribution is a study on the HTGR. They are looking at a Thorium High Temperature Reactor (THTR) which utilizes thorium (in place of uranium) as fuel, and converts 70% of it to U^{233}, which (like U^{235} or plutonium) is a useful nuclear fuel; there is also a version which is a "near breeder" and converts 95%.

The KFA in general and the STE in particular have good relationships with the local universities and with industry in the nearby cities (to as far away as Essen in the Ruhr Valley). People tend to come to STE, work for a few years, write a dissertation, get a doctorate, and then go out to a job with industry at a pay level that the KFA cannot match. Nonetheless, during the several years that this process requires, Voss has the services of a number of bright and dedicated young men, so that the output from this rather small group—the KFA has only about 50 people, of whom about 25 are professional—is of unusually high quality. (Robert E. Machol)

ENGINEERING

THERMODYNAMICS AND HEAT TRANSFER AT THE UNIVERSITY OF GLASGOW

The Mechanical Engineering Department of the Univ. of Glasgow has been headed for some years by Prof. R.S. Silver, whose chair was named in honor of James Watt, the inventor of the modern steam engine. It is significant that James Watt neither had a college degree nor was he of professorial rank at the Univ. of Glasgow many years ago, but rather served as a highly skilled instrument technician. Silver has just retired, and the acting chairman is Dr. N.R.L. Maccallum.

Silver's interests are in thermodynamics and phase-change processes particularly as applied to desalination. Silver contributed in a fundamental way to this area by inventing the multi-flash distillation process in the early 1960s. At present a large research program in desalination at Glasgow is being supported by the Science Research Council, and by Wier-Westgarth Ltd., the largest British manufacturer of desalination equipment.

A number of processes, including distillation, reverse osmosis, electrodialysis, and freezing can be used to desalinate sea water. The distillation and freezing processes selectively boil or freeze out the fresh-water component of sea water. In reverse osmosis a pressure difference forces water, but not the salts,

through a semi-permeable membrane. Of course the pressure difference must exceed the osmotic pressure, which is generally in the range 27 to 100 atm. In electrodialysis, water is driven through the membrane by a potential difference across the membrane. If there are two ion-permeable membranes with the salt water between them, a potential difference across both membranes will cause anions to migrate in one direction and cations in the other, leaving purer water between. If the membranes are respectively anion and cation impermeable, the liquid between them becomes saltier by virtue of losing the pure water that passes through them.

The research effort in desalination at Glasgow is under the direction of Dr. Willis T. Hamburg, and is based mainly on the multi-flash distillation process. In this process flash distillation occurs at a number of different pressure levels such that latent heat of condensation at one level is utilized in vaporization at the next level; "flash" implies near-instaneous vaporization following sudden reduction in pressure. Examples of problems that are being studied are nucleation in flash boiling, flashing flow in nozzles, condensation and the role of non-condensable gases that were dissolved in the salt water before the distillation process, heat transfer in tube banks, scaling, corrosion owing to exposure to hot brine (particularly at welds between stainless steel nozzles and mild steel nozzle mountings), and a solar heat source for desalination distillation. A greenhouse-type collector (rather than a concentrating reflector-type collector) is used to collect the solar energy.

In the reverse osmosis process, the membrane must be very thin, hence not very strong, but must still withstand high pressure. I was shown an apparatus in which the membrane was in the form of small-diameter hollow fibers, which can withstand a very high pressure difference. High-pressure saline outside the hollow fibers yields fresh water inside the fibers. It is necessary to prefilter the salt water and to add a scaling inhibiter. Turbulence outside the fiber is stimulated, since it cuts down the concentration of saline at the membrane and thereby promotes the flow of fresh water through it.

Dr. Samir Aly, who is also involved in the desalination program, is studying heat and mass transfer at a tube boundary by simulating the mass transfer in a homogeneous fluid via injection into the main flow through a porous wall. Aly is particularly interested in heat transfer at the point of separation of the flow on the tube boundary. Of course, it is difficult for many researchers to agree on what constitutes the point of separation of the flow from a boundary, but if one uses the definition that the point of separation occurs where the velocity gradient at the boundary is zero, this then denotes the point where momentum transport at the boundary ceases. Since the mechanism of momentum transport differs from that for heat and mass, the two last-named do not necessarily cease at the point of separation as defined by zero momentum transport, as Aly has confirmed in his researches.

Maccallum's work on vane-swirled flames in furnaces comprises experimental studies and theoretical modeling of the aerodynamics and mixing of vane-swirled isothermal and combusting flows. In this work, various degrees of swirl have been studied along with concomitant effects on flow patterns. Maccallum also has on-going research in such diverse areas as thermal influences in gas-turbine transients; the effect of transverse injection on the flow through turbine cascades; and the effect of boundary layer changes caused by transient heat transfer on the performance of axial flow compressers.

Other activities of the thermodynamics group are the use of heat pumps for greenhouses (directed by Dr. S.K. Nisbet), creep and corrosion of solid materials (Mr. W.W. Mackie), and properties of turbulent transport in single-phase and two-phase flows (Mr. J.R. Tyldesley).

The small group in thermodynamics and heat transfer at the Univ. of Glasgow is doing significant work. Predominance in the area of desalination is maintained through a special Master of Engineering degree course in desalination technology. This course is full time over a 12-month period and includes provision for candidates to spend periods of up to three months in industry and government organizations. All candidates are required to prepare and submit a dissertation on some desalination topic for their degree. (Martin Lessen)

MATERIAL SCIENCES

PHYSICAL METALLURGY RESEARCH IN PORTUGAL

Research prior to my trip to Portugal had suggested that there were only two institutions that I should visit in order to assess the state of work in physical metallurgy. These were the National Laboratory of Engineering and Industrial Technology, near Lisbon, and the Engineering School of the University of Minho, located in Guimaraes, in the north.

As is well known, Portugal has recently undergone significant political changes. This has also brought about economic and social changes as well as some perturbations in the state of Science. Nevertheless, the period of relative stability since 1974 has allowed some progress to be made, and one can hope that things will continue to get better.

Under the auspices of the Ministry of Industry and Energy, the "Instituto Nacional de Investigacao Industrial" (National Institute of Industrial Investigation) and the "Laboratorio de Fisica e Engenharia Nucleares" (Laboratory of Nuclear Physics and Engineering) were recently amalgamated into the "Laboratatorio Nacional de Engenharia e Tecnologia Industrial" (LNETI-National Laboratory of Engineering and Industrial Technology), with the two separate sites maintained in the Lisbon area. I visited the second lab mentioned above, which is located in Sacavem, 6 km east of Lisbon. I regret to have to state that although I was told that this is the best-equipped physical metallurgy lab in Portugal, by US standards the facilities are only marginal. Much of the equipment is 15 or 20 years old, with the best pieces being an Instron machine and some modern equipment for powder characterization. I was informed that there are no electron microscopes in Portugal dedicated to materials research, and that although there are about 15 transmission electron microscopes (TEMs) in the country, it is virtually impossible to convince the biologists and medical people who have these to share them.

The Head of the Metallurgy Department at Sacavem is Dr. A. d'Oliveira Sampaio, but my hosts during my visit were Eng. Carlos Pacheco da Silva, whose main research area at present is powder metallurgy (P/M), and Eng. Maria Manuela Oliveira, who has worked recently in high temperature gaseous oxidation (of Fe-Cr-Al alloys, in a joint program with the Central Institute for Industrial Research in Oslo, Norway) but is beginning work in foundry metallurgy problems. One of the more sophisticated research apparatus I saw was a very nice high temperature thermobalance used in the oxidation work, which ironically is now virtually inactive. My hosts explained that beginning in about 1970, the research at Sacavem began to have a decided industrial flavor, whereas prior to that time mostly basic studies were conducted.

As in Spain, where much of the metallurgical research is keyed to the particular mineral reserves of the country, so in Portugal, where the resources include uranium-, tungsten-, and iron-bearing ores. Currently, industrial interests being emphasized include the foundry industry, tungsten carbide manufacturing, uranium ore extraction, powder metallurgy ferrites for the electronics industry, etc. There is actually very little work on nuclear materials, in spite of the fact that this was until recently called the "Laboratory of Nuclear Physics and Engineering."

A modest P/M research effort is underway. The incentive for this program is not only to provide support for Portuguese industry but also to develop industry further. Portugal has significant tungsten reserves, but at present there is only one firm in Portugal that produces tungsten carbide. There is also a desire to build up a ferrous P/M industry as well, since there is no activity in this area at all. Therefore, workers at Sacavem have initiated studies intended to answer various pragmatic questions concerning P/M processing and the properties of P/M materials. Other project areas include alloy development in Fe-Cr stainless alloys, P/M ceramic microstructures, and Mn-Zn ferrites.

The province of Minho is located in the north of Portugal. It is a very picturesque, hilly region, where the grapes for the vinho verde (the characteristic "green" wine) grow on vines as high as 15 ft above the ground. There is so much ground water that it springs from every hill in miniature

waterfalls. One frequently sees women, dressed in very unbecoming black or dark outfits, cluster in some of the larger streams to do their laundry in an age-old fashion, carrying the baskets away on their heads. In this region, the rate of progress one can expect by auto is about 25 miles an hour, and the condition of the roads is exemplified by the fact that at one point I got 2 flat tires at once.

Braga, an expanding light industrial city, is the setting for the main center of the University of Minho, the newest of Portuguese universities. (Another center, for engineering studies, is located 15 km away in Guimaraes.) The head of the program in Science and Technology of Materials is Associate Prof. F.D.S. Marques, who guided me on a tour of the laboratory spaces. The word "spaces" is appropriate because there is more of that than equipment, and what equipment exists is very rudimentary. In fact, the most developed materials-oriented research in the University of Minho is on textiles, which is a national industry with no export market because the manufacturing processes are too expensive. There are independent groups in this field at both Braga and Guimaraes, and they have assembled a reasonable array of equipment for practical studies.

There has never been a PhD metallurgist produced in Portugal. The current practice is for PhD candidates to be sent abroad. For example, Marques took his degree from Imperial College of Science and Technology in London and worked in Denmark and Norway in the years between the revolution and counter-revolution before returning to Portugal. Sampaio, of LNETI, studied at Stuttgart, FRG. I got the impression that the returning PhD is supposed to take up a position in a university, to teach undergraduates working for their five-year degrees. With respect to research, however, those that return have so far found their goals very elusive. There are a handful of other PhD metallurgists in Portugal, but all have understandably found it difficult to maintain viable research activities and so have drifted into administrative posts or limited their activities at universities to teaching. There is virtually no pressure to conduct physical metal lurgy research at the universities and, in fact, almost a negative incentive to do so, since faculty tend to be rewarded for other uses of their time.

Marques hopes to change this and is attempting to start a PhD program at Guimaraes. This is no mean undertaking, in view of the dearth of students, funds, and equipment. Currently, because of the lack of "world-class" equipment for physical metallurgy studies in Guimaraes, Marques has to take his research act "on the road," since electron microscopy and sophisticated mechanical tests are essential to his research goals. So he packs his valise with thin foils and tensile samples and takes off, usually at his own expense, to the laboratories of friends in Britain and Europe, comes back with the necessary data, and writes another paper. Using this method, he has managed to participate in a remarkably large number of international conferences in the last few years. Unfortunately, such dedication goes virtually unnoticed within Portugal itself, and Marques is still a long way from one of his main ambitions, namely to establish a materials-oriented electron microscopy center in the north of Portugal.

Marques' recent research interests have centered on phase transformations in zirconium and titanium alloys, including martensitic transformations and dispersion-strengthening (by natural transformation of intermetallic compounds). He has investigated such aspects as the effect of cooling rate on transformation mechanisms, at morphology and substructure of transformation products, and at the strength of the alloys, and would like to extend this work to study the effect of stress on transformations. He also plans to begin work at Guimaraes on lead-based bearing materials and to develop superplastic aluminum alloys, but the "activation barriers" described above are yet to be overcome.

The conclusion from my tour of Portugal is that modern physical metallurgy research is in a nucleating state. There are few centers of research, and the best of these are modestly equipped and staffed. The type of work favored at present is of a practical, industrial-support nature. Fundamental work is not funded at all, but if the current

practical work has its intended (indirect) effect on the industrial economy, this could change in the future.

Currently, there are only a few metallurgy PhDs in the whole country, and the great proportion of these do not pursue research actively. In the universities, there is virtually no pressure to publish, and throughout the country, the crying need for modern research equipment is not currently acknowledged by anyone with the influence to direct funds to this purpose. Probably none of these shortcomings should be considered suprising, in view of the recent political and economic crises in the country, and if the scientific situation is viewed in comparison with that of just a few years ago, things are actually improving rapidly. While there are a few outstanding individual researchers, there is a very long way to go before Portugal, as a whole, makes any significant impact on the worldwide physical metallurgy research community. (Jeff Perkins)

SECOND INTERNATIONAL SYMPOSIUM ON MAGNETIC RESONANCE IN COLLOID AND INTERFACE SCIENCE

It is patently unfair to plunk oneself down in one of the world's prime vacation areas and leave the wife and kiddies at home. Nevertheless, the NATO Summer School on Magnetic Resonance in Colloid and Interface Science, in conjunction with the 2nd international symposium on that topic, was held in Menton on the French Riviera—25 June to 6 July 1979—to the great benefit of all 130 participants. The venue was excellent, not only for the scenic wonders, but especially for the facilities of the Palais d'Europe, which offered well equipped meeting rooms of appropriate sizes, spacious foyers for poster sessions and informal discussions, and a general feeling of pampered contentment. Menton is reached from Nice International Airport by a half hour bus ride along the basse corniche (of the via Aurelia) which displays all the touristic wonders as it deposits passengers in Nice, Monte Carlo, and Cape Martin. The only activity available in Menton after 1900 hours is dinner on the terrace of a randomly chosen restaurant; this displayed all the symposium participants and allowed one to wander through old Menton and select one's intellectual companions for the evening at will. Have your conference in Menton!

This conference was truly a school, with a lecture program designed to show the applicability of nuclear magnetic resonance (NMR), electron paramagnetic resonance (EPR), and Mössbauer spectroscopy to the panoply of catalytic, two-dimensional, bilayer, and micellar phenomena of which colloid and interface science is composed. Director Jacques Fraissard (Professor of Chemistry, Université Pierre et Marie Curie, Paris) requested and obtained lectures ranging from introductory presentations to coverage of latest results, and this from a panel of world's experts including one from the Eastern bloc. Publication of the lecture summaries and posters is to be by Reidel, the Netherlands. Highlights follow.

Professor Harry Pfeifer (Karl Marx Universität, Leipzig, DDR) presented the results of extensive NMR diffusion studies of hydrocarbons in zeolite catalysts. They have shown that diffusion in the interior of the catalysts is much faster than would be expected on the basis of the more classic "rate of adsorption" measurements. The implication is that there is a surface reaction step that limits the reaction rates on zeolite catalysts. Pfeifer leads a group of at least twenty scientists devoted to the use of NMR in solving basic and applied problems in zeolite science, the largest NMR-surface science group in the world. Because of intense coupling with industry, this group is very effective.

Jacques Conard (Centre National de la Recherche Scientifique, Orleans, France) presented his ^{13}C NMR spectra for graphite intercalated with the do donors Li, K, and Cs. From the ^{13}C Knight shifts he was able to deduce carrier densities for the graphite layers and to compare these with calculations of changes in the density of states at the Fermi level owing to the presence of donors. This difficult experiment has been under development by Conard for many years; Fourier transform NMR spectroscopy allows the necessary long signal averaging periods. Conard represents the Centre de Recherche sur les Solids à Organisation Crystalline Imparfaite (CRSOCI), a group of about thirty, which employs a broad range of techniques in addition to magnetic resonance on a wide variety

of basic and applied problems of surface chemical interest. Said Prof. Jose Fripait, Directeur de CRSOCI, for example, "Draw the hysteresis loop for a magnetic oxide, and I can make an oxide with the property. If you want to make a virgin (noise free) magnetic tape in outer space, I can make you one there." Not exactly NMR, but an example of what one learns in informal discussions.

Prof. Robert Vaughan (Cal Tech), who was killed in the DC-10 crash at Chicago, was working as an ONR contractor to apply the so-called solid-state NMR techniques to problems in heterogeneous catalysis. His lab represented perhaps the largest group in the US active in NMR of interfacial systems. In his absence his former associates (Gerstein, Iowa State U. and Nicol, CRSOCI) displayed his experimental techniques and older results. It was clear that the solid-state NMR techniques are about to flower in the US, if not worldwide. Thus unfortunately, the only applications of these presented were by myself (NRL), who showed how to use ^{13}C NMR of solids to: a) find the orientations of adsorbed molecules on oriented surfaces; b) perform qualitative analysis of chemisorbed species; and c) perform quantitative analysis of adsorbed species.

Prof. Jack Lunsford (Texas A&M) showed the utility of EPR in the search for catalysts useful in the photoreduction of water. He was able to follow redox activity in ruthenium bipyridyl complexes in zeolite 13-X. Prof. Bernard Cabane (Université d'Aix-Marseille) showed via NMR studies with shift reagents that the long-chain hydrocarbon part of aqueous amphiphile micelle spends much of its time in a U-shape rather than extended configuration. This, of course, solves the problem of molecular packing in the micellar interior. In his review Prof. Lovatt Rees (Imperial College) remarked how Mössbauer spectroscopy had been useful a) in disclosing changes in beryllium bearings as a result of ion implantation of iron, and b) showing the formation of austenite in surface layers as steel is machined; the relatively new technique of ^{57}Fe conversion electron spectroscopy was used.

In the words of Mme. V. Cohen of the NATO office: this symposium represented a summer school run the way it should be run. Prof. Edward W. Merrill, of the Dept. of Chemical Engineering at MIT asked why there is not more research on magnetic resonance in surface science going on in the US. Prof. Marco Villa of the Univ. of Pavia said "Art (and science) only flowers under the constraint of being useful." I agree with all of these comments! (Henry A. Resing, Naval Research Laboratory, Washington D.C. 20375)

MEDICINE

THE IAEA ADVISORY GROUP MEETING ON NUCLEAR METHODOLOGY AND TECHNIQUES IN THE STUDY OF PARASITIC DISEASES OF HUMANS

The International Atomic Energy Agency (IAEA) has an "Advisory Group on Nuclear Methodology and Techniques in the Study of Parasitic Diseases in Humans." This group met at the London School of Hygiene and Tropical Medicine (LSHTM) on 2-5 July 1979. The meeting was attended by some 60 experts, mostly biomedical scientists, from 15 countries, both developed and developing. The chairpersons were Profs. George S. Nelson of LSHTM and Ruth Nussenzweig of New York University School of Medicine, NYC. The rapporteurs were Drs. Martin G. Taylor of LSHTM and G. Thomas Strickland of the Uniformed Services University of the Health Sciences in Bethesda, Maryland.

The IAEA Advisory Group recognizes the importance of the application of radiation and isotopic techniques in understanding host-parasite relationships and in developing practical control measures in human parasitic diseases. The nuclear technology exists and is being expanded primarily in the developed countries, while the needs for its application are in underdeveloped areas where the diseases are endemic. The two major goals of the new IAEA program in human parasitic diseases are to identify the nuclear and related technology needed and to transfer the technology and skills to the endemic areas.

Following invited papers and discussions on the subject, the Advisory Group considered the needs and the goals of the program, with

special reference to malaria, schistosomiasis, filariasis, and hookworm. Evidence was presented that irradiated parasites are often more effective in producing protective immunity (when used as vaccines) than are nonirradiated organisms. The needs and goals of the program include the use of nuclear technology to study: (1) the maturation and migration of the parasite in the intermediate and definitive hosts; (2) the effect of irradiation of the parasite on its development and localization in the host; (3) the biological properties of irradiated parasites which potentiate their immunogenicity; (4) the assessment of immunity to parasitic diseases; (5) the metabolism of parasites (using *in vitro* techniques); (6) the pathogenicity of parasites; (7) the pharmacodynamics of antiparasitic agents; and (8) the utilization of nuclear and related technology in the diagnosis of parasitic diseases.

The goals of the program are to build competence in the endemic areas and to perform as much of the work as possible in these regions. To facilitate this, the program will develop strong links between institutions. It will support cooperative research programs, strengthen institutions, expedite the exchange of scientists, and train at appropriate levels. The coordination and cooperation with the United Nations Development Program (UNDP)/World Bank/World Health Organization (WHO) Special Program for Research and Training in Tropical Diseases will continue. The meeting was useful, not only by assisting in planning the new program, but in bringing together scientists from different disciplines to focus attention on the advantages of nuclear technology for the understanding and control of human parasitic diseases.

The authors and the titles of their papers are as follows: R. Nussenzweig: The use of radiation-attenuated sporozoites in immuno-prophylaxis of malaria; M.G. Taylor: Progress in the development of irradiation-attenuated vaccines for schistosomiasis; D. Denham: Vaccination against filarial worms using radiation-attenuated vaccines; R.L. Beaudoin: Production of radiation-attenuated vaccines against malaria and schistosomiasis; E. James: Production and cryopreservation of schistosomula; G.T. Strickland: The use of immuno-potentiators in malaria; M. Suzuki: Host response induced in mice by a radiation-attenuated *P. berghei* malaria parasite; J.P. Verhave: The role of macrophages in the sporozoite-host interplay; A. Voller: The use of solid phase isotopic and non-isotopic immuno-assays in parasitic diseases; S.M. Phillips: *Schistosoma mansoni*: immune response to normal and irradiated cercerial or soluble stage-specific surface immunogens; J.P. Dessaint: Contributions of radioisotopic techniques to the evaluation of immunity in human and experimental schistosomiasis; A. Omer: Patterns of red cell survival and sites of sequestration in patients with splenomegaly in the Sudan with special reference to schistosomiasis; and V. Houba: Panel discussion: Criteria for identification of resistance and the immune capacity of the host.

The scientific papers and discussions are scheduled to be published in the *International Journal of Nuclear Medicine* early in 1980. Therefore, only a brief summary will be given. Drs. Nussenzweig, Taylor, and Denham (LSHTM) gave the present state of the art and reviewed the progress to date on malarial, schistosomal, and filarial vaccines, particularly stressing the vaccines using irradiation-attenuation of the invasive stages of the parasites. Dr. Beaudoin (NMRI, Bethesda, MD) reviewed the progress in the US Navy's irradiation-attenuated antisporozoite malaria and anticercarial schistosomal vaccine programs. Dr. James viewed the progress made by the LSHTM's schistosomiasis program in the production and cryopreservation of schistosomula. Dr. Strickland discussed the protective effects of immunostimulating agents in malaria and presented results of research performed at the US Naval Medical Research Institute on the use of BCG in rodent malaria and the immunostimulating drug levamisole in both rodent and monkey malaria.

The second day's session started with Prof. Suzuki (Japan) describing studies in which immunization was obtained using an attenuated strain of a virulent rodent malaria *Plasmodium berghei*. This was followed by Dr. J.P. Verhave (Nijmegen, the Netherlands), who reported progress in assessing the role of macrophages in protection against malarial sporozoites (the

infectious stage from the mosquito) and the development of the exoerythrocytic stage in the liver. Drs. Voller and DiSavinany (LSHTM) gave excellent talks on the use of radioisotopic and related assays in the diagnosis of human parasitic diseases. Drs. Phillips (Univ. of Pennsylvania) and Dessaint (Lille, France), reviewed various *in vivo* and *in vitro* techniques for tracing the fate of irradiation-attenuated schistosomal cercariae and for evaluating immunity to schistosomiasis. Dr. Omer (Univ. of Khartoum, Sudan) showed results of physiological studies using radioisotopes in human and cattle schistosomiasis.

The morning of the third day consisted of a panel discussion chaired by Dr. V. Houba of the UNDP/World Bank/WHO Special Program for Research and Training in Tropical Diseases. Participation was excellent, and numerous examples were given on how the use of radionucleotides could improve the understanding and help lead to the control of human parasitic diseases.

Anyone wishing more information about this IAEA Consultants Meeting or the new IAEA Program on the use of Nuclear Technology and Techniques in the Study of Parasitic Diseases of Humans should contact:

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ONAL REPORTS

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

THE FLEISCHNER SOCIETY SYMPOSIUM

"Dedicated to advancing knowledge of the normal and diseased chest" is the creed of the Fleischner Society, which held its 9th annual symposium in Stockholm, Sweden, 11-13 June 1979.

The Society was formed ten years ago following the death of Felix Fleischner, an outstanding radiologist, whose primary interest was in pulmonary problems. Although the Fleischner Society consists mainly of radiologists, a multidisciplinary approach to diseases of the chest is stressed, and many of the speakers were from medical disciplines other than radiology. This broadly based approach to thoracic disorders gave the symposium medical depth that is often lacking in meetings limited to a single medical discipline. The symposium consisted of 21 papers and 34 refresher courses. Six of the papers are described in some detail in this note. Several additional papers and courses are described.

A paper delivered by Marvin A. Sackner (Univ. of Miami, Florida), describing mucociliary clearance in asthma, was a good example of the multidisciplinary approach to the problems of chest disease common to Fleischner symposia. The work described is not directly related to chest radiology but is basic to pulmonary physiology and the understanding of asthma. The mucociliary apparatus of the airways removes inhaled particles from the mucosa of the trachea and bronchi. There is an optimum interaction between cilia and mucous with the result that surface transport velocity appears to increase from the peripheral towards the central airways. Asthmatics typically demonstrate mucous gland hypertrophy and increased secretions, in addition to denuded ciliated epithelium.

Sackner used radio-opaque Teflon discs in intact dogs and followed their movement by fluoroscopy and video tape. An asthmatic reaction was induced in the dogs by an extract of ascaris. In the animals that responded to the antigenic challenge with bronchospasm, tracheal mucous velocity decreased and was still significantly decreased after the bronchospasm was no longer detectable.

The possible involvement of a chemical mediator of anaphylaxis was evaluated by bronchial provocation

with histamine and acetylcholine solutions that induced bronchospasm comparable to that observed in the antigen challenged dogs. There was, however, no effect on tracheal mucous velocity. Therefore, Sackner concluded that 1) tracheal mucous transport is impaired after inhalation of a specific antigen in allergic dogs, 2) mucociliary dysfunction is unrelated to the presence of bronchospasm, and 3) abnormal mucous transport may be related to the release of slow reactive substance (SRS-A). Sackner then went on to describe recent experiments in six young asthmatic patients during spontaneous acute asthmatic attacks. As in the canine experiments, the human studies suggested that in antigen-induced bronchospasm; patients with allergic bronchial asthma demonstrated a rapid decrease in mucous transport independent of bronchospasm and presumably related to the release of chemical medicators during the asthmatic response.

The Fleischner Memorial Lecture was delivered by Ewald Weibel (Chairman, Department of Anatomy, Univ. of Bern, Switzerland), whose subject was "Looking into the lung: What can it tell us?" The main theme of this lecture was the relationship between the microstructure of the lung and pulmonary physiology. He made three points initially upon which he elaborated throughout his talk. These were that 1) normal pulmonary gas exchange must be rapid, 2) a large contact surface must be available, and 3) the supporting tissue for the lung must represent a very thin barrier for normal gas exchange to take place. He then described the supporting structures, which are peripheral to the lung and connect the lung to the pleura or are axial through the pulmonary lobules with connecting fibers between the two systems.

Electron microscopy of the alveolar-capillary membrane reveals supporting interstitial tissue on one side only while the other side is the very thin two-cell layer alveolar-capillary interface for gas exchange. This alveolar-capillary interface is continuously bathed in a fluid containing a phospholipid, surfactant, that lowers the surface tension almost to zero. Surface tension must remain very low for the thin-walled alveolar spaces to remain open. A reduction in surfactant leads to atelectasis. Therefore, small amounts of fluid can collect in the interstition without affecting gas exchange as long as the surfactant mechanism is intact. On the thin side the two-cell layer consists of the capillary endothelium and the epithelium on the alveolar side. The cells are either type 1 with cytoplasmic extensions through which gas exchange takes place or type 2 cells which are secretory and responsible for elaborating the surfactant.

Weibel then turned to a common clinical situation, that of the adult respiratory-distress syndrome. He described an exudative phase of one to four days during which the cells are damaged and a proliferative phase after the first four days during which cell repair takes place. The ability of the alveolar-capillary membrane to exchange gas is lost rapidly under conditions of the adult respiratory-distress syndrome and only regained slowly. Type 1 cells are destroyed to a much greater extent than type 2 cells. This leads to the deposition of blood products in the alveolar spaces and along the alveolar-capillary membrane. Fibrin deposition leads to the well-known hyaline membranes. In the proliferate phase gas exchange is inhibited by the replacement of the type 1 cells by large, cuboidal type 2 cells. The type 2 cells not only suffer considerably less damage than type 1 but divide by mitosis and proliferate more rapidly. It is, therefore, the biological property of the cells that determines the course of events. The adult respiratory-distress syndrome histologically is "monotonously the same" independent of the etiology of the disease state.

In the final portion of his talk Weibel analyzed the correlation of morphometric and physiologic parameters in evaluating diffusing capacity. The correlation is not perfect but is reasonable because the physiologic estimate, usually made at the basal state, must be corrected for work and the morphometric estimate must be corrected for over expansion owing to fixation and infolding of the alveolar-capillary surface. Throughout his talk Weibel illustrated his points with beautiful photoelectron micrographs. In his summation he stated that at the microstructure level morphometry is closely related to physiologic function tests. In Weibel's view the definitions of a anatomy by electron microscopy and by physiology have drawn very close together as a better understanding of the ultrastructure of the lung is achieved.

Pulmonary blood flow was discussed by two authors, Morris Simon (Harvard Univ. and Beth Israel Hospital, Boston) and Eric Milne (Univ. of California, Irvine). Both of these investigators have spent many years relating the physical laws of flow and pressure to pulmonary physiology and the chest radiograph. It is well known that in the erect human, pulmonary arterial and venous pressure is greater at the lung base than at the lung apex, but Simon reminded the audience that the difference is much larger than one expects. If the diameter of the upper lobe vessels is only one third that of the lower, the ratio of cross-sectional areas is one to nine and of lumenal areas is one to thirty, so that normally flow through the lower lobes is considerably greater than through the upper lobes. Simon went on to state that blood flow in pulmonary vessels tend to follow Poiseuille's law. For clinical radiology this can be simplified into the statement that flow is proportional to the pressure and to the fourth power of the diameter of the vessel. Velocity will remain constant in the pulmonary vascular system, but the size of the vessels adjust to compensate for differences in flow. This is independent of pulmonary arterial pressure. Clearly in the larger vessels the velocity will be much greater than in the capillary bed. In the capillary bed, because of its vast area, the flow is much slower in spite of the markedly decreased resistance.

Milne's discussion of cardio-pulmonary hemodynamics was similar. His major point was that pulmonary blood flow and pulmonary vascular bed capacity do not have a fixed relationship. The potential capacity of the pulmonary vascular bed is considerably greater than the flow during ordinary life and work. For the entire capacity of the pulmonary vascular bed to be utilized, the organism must be exercised to the point of exhaustion. This concept is to Milne a unifying one that allows him to explain changes in blood flow distribution as observed on the chest radiograph.

Milne made another major point related to pulmonary alveolar pressure. In a number of diseases it is necessary to ventilate the lungs with positive pressure in order to provide sufficient oxygenation. Increased alveolar pressure due to positive pressure ventilation may actually diminish pulmonary capillary blood flow. The increased alveolar pressure, artificially induced, may indeed increase capillary pressure sufficiently to cause right heart failure.

John B. West (Univ. of California, San Diego) discussed regional differences of function within the lungs. West, who is undoubtedly one of the world's leading pulmonary physiologists, first led the audience through the basic pressure relationships among the alveolar gas, the pulmonary arteries, and the pulmonary veins and then described new work in which he is currently engaged. In the upper third of the lung, commonly known as the lung apex, it is possible for pulmonary alveolar pressure to exceed pulmonary arterial pressure, which in turn exceeds pulmonary venous pressure. Under these abnormal conditions, there would be no flow in the pulmonary vascular system. One condition that can produce such a state is shock, with pulmonary arterial hypotension and an increase in pulmonary alveolar pressure due to positive-pressure respiratory therapy. In the mid-portion of the lung under ordinary conditions, pulmonary arterial pressure exceeds pulmonary alveolar pressure, which in turn exceeds pulmonary venous pressure. It is of considerable clinical interest that in this section of the lung, in contrast to the base, pulmonary venous pressure does not determine blood flow. In the basal or bottom third of the lung pulmonary arterial pressure exceeds pulmonary venous pressure, which in turn exceeds pulmonary alveolar pressure. The reason for these pressure differences is that in the erect adult gravity causes greater pressure at the bases in both the pulmonary arteries and veins and less pressure at the apex by approximately 15 cm of water in each case.

As far as ventilation is concerned, West indicated that ventilation is also greater in the base than in the apex, but the difference between the two is not as marked as the difference in perfusion. West also reminded the audience that intrapleural pressure is more negative at the top of the thorax than at the bottom. This phenomenon occurs because the base of the lung has a smaller expanding pressure than the apex and the base a greater change in volume per unit resting

volume than in the apex. The ratio of ventilation to blood flow is low at the lung base and high at the apex, which translates to a higher partial pressure of oxygen and a lower partial pressure of CO_2 at the apex. Since the lung base has a smaller expanding pressure, it was assumed that the size of each alveolus would be considerably greater at the apex. Pathologists have not found this condition, but of course the assumption is true only in the live animal. West and his group proved the point with whole lung sections made from upright frozen dogs. The alveoli were four times as large at the apex as at the base. Because the lung is suspended in the erect human, the stresses are much greater at the apex than at the base, which he related to the development of centrilobular emphysema, that is much more common at the apex.

West's current interests lie in two directions. He is trying to assess gas exchange in the lung at the height of the summit of Mt. Everest. His initial conclusion is that at times barometric pressure at this altitude is considerably greater than initially assumed, and in other respects the atmosphere on the mountain may differ from air elsewhere at the same altitude. However, this will depend to a large degree on the weather and wind conditions at the summit on any specific day. Therefore, the possibility of ascending to the summit of Mt. Everest without oxygen, accomplished recently by two Germans, would vary from day to day.

The other line of current research West has undertaken is related to pulmonary blood flow and ventilation during weightlessness. When the space shuttle is launched, experiments on this topic will be carried out. As pilot study, the distribution of ventilation was tested in a Lear Jet, which can achieve weightlessness for its passengers for about 25 sec by an appropriate maneuver. By using a single-breath argon-oxygen mixture, ventilation was evaluated at weightlessness. As expected, it became uniform throughout the lung instead of being greater at the base than the apex as it is under the influence of gravity. As is always the case with John West, he has the unique ability to present complex material in a lucid fashion, and the talk given to the Fleischner Society Symposium was no exception. (Irwin M. Freundlich)

OCEAN SCIENCES

IOS BIDSTON I: RESEARCH

The Natural Environment Research Council (NERC) took over the funding of the Liverpool Tidal Institute of the University of Liverpool in 1969 and renamed it the Institute of Coastal Oceanography and Tides. Later in 1973 it became a part of the British Institute of Oceanographic Sciences (IOS), the tidal research program at the principal IOS Laboratory at Wormley south of London was moved there, and the enlarged institute was renamed IOS Bidston after the small town where it is located, across the Mersey River Estuary from Liverpool. Dr. David Cartwright, formerly head of the tidal research program at IOS Wormley, became an assistant director of all of IOS and head of IOS Bidston. The present article covers the research programs at IOS Bidston. A following article in the November issue of *ESN* concerns the public service functions of the Laboratory.

In 1969 Cartwright's team at Wormley was successful in developing a sea-floor tide gauge and began studies on the continental shelf around Great Britain. With 16 shelf stations recording pressure and currents, he was able to do a budget of tidal energy coming into the North Sea and to compute the dissipation of energy over the continental shelf caused by tidal friction on the bottom.

Cartwright now has about 50 good deep-sea tidal records. He is running a latitudinal line of tide stations across the North Atlantic at 53 1/2° N and is boxing off the North Atlantic in 20° squares to study the deep ocean tides. His latest measurements came from seven gauges that were placed on the bottom along a line from Sierra Leone Africa through St. Paul's rocks near the Equator to stations off the coast of Brazil.

Dr. David Pugh is studying tides and sea-level changes in the Indian Ocean. This includes a study of anomalous tidal features off the Somali Coast, the tides near amphidromic points, and the persistent 10 to 100 cm, 45 min seiche in

lagoons in the Chagos Island area. Next year he plans to study the tides with a number of gauges around a 1000 km triangle south of the Chagos Islands.

The dynamic modeling group, headed by Dr. N.S. Heaps, is concerned with developing numerical and mathematical models of the British continental shelf seas, the North Sea, and the adjacent oceans. Heaps and his assistant, Mr. J.E. Jones, are presently working on a 3D model of the currents in the Irish Sea. Heaps also supervises two PhD candidates who are at Bidston on NERC fellowships. Mr. A. Owens is working on tide and surge modeling in the British Channel and the Celtic Sea to the west of Cornwall with applications to possible tidal power schemes. The very high tides in the study area make it an attractive place for erecting barriers for the purpose of generating electricity from tidal flow. Heaps' second student, Mr. R. Proctor, is making a current circulation study of the Northern Irish Sea.

Over the past 15 years, Heaps has been studying storm surges (nontidal sea-level changes caused by storms), attempting to forecast them, or at least to determine the probability of a storm surge exceeding a given height in various locations around the British Isles. While major storm surges are rare, damage when they do occur could be extremely high in some locations (including London). Sea level is slowly rising in the Thames River estuary area, increasing the possibility of flooding. The problem has become so acute that a storm surge barrier is being constructed across the Thames River at Woolwich, 17 km below the Tower Bridge, at a cost of about $1,000,000,000.00. The barrier will consist of large gates which are designed to remain open most of the time to allow free passage of ships and tides, but can be closed to prevent flooding.

Storm surges that affect the Thames River estuary are of two types: internal and external (to the North Sea). The latter are set up by slowly moving or nearly stationary storms over the shallow continental shelf west of Scotland. They then move as progressive shallow water waves around the northern tip of Scotland and down the east coast of England. Their southward passage is monitored by six tide gauges located between the north tip of Scotland (Wick) and the mouth of the Thames. Accurate methods have been developed to forecast these surges from prognostic air pressure charts of the generating area from which the surface wind field is derived. The accuracy of these forecasts is currently limited by the accuracy of the prognostic charts.

Fortunately the external surges that affect the Thames area appear to undergo nonlinear interactions with the dominant M_2 semi-diurnal lunar tidal component in such a way that the two waves are usually out of phase when they move up the Thames River estuary. Thus, only a few times a year will the external surges be large enough in themselves to require the closing of the Woolwich barrier after it has been completed.

Forecasting storm surge components internal to the North Sea is more difficult than forecasting external surges. Usually the warning time is relatively short compared to that required to close the Thames' barrier. If the internal surges are in phase with either the external surges or M_2 tides, they may raise the water level in the Thames at London to dangerous flooding levels. The key to the successful use of the Thames barrier will lie in learning to forecast internal surges far enough in advance of their arrival at Woolwich to allow the barrier gates to be closed.

Dr. R.A. Flather and Dr. A. Davies collaborate on the 2D nonlinear shelf-sea model which is directly geared to the UK Meteorological Office numerical forecasts for surface atmospheric pressure and surface wind. The model was used operationally to forecast storm surges by the Met. Office for the first time during the 1978/79 winter. Flather is also developing a tidal model covering the shelf around the UK and Ireland and part of the Atlantic Ocean. Davies is investigating a 3D model for currents and a fine-mesh 2D model of the North Sea.

Dr. D. Prandle has been working on the use of a nonlinear model of the southern North Sea/Dover Strait area to investigate surge tide interaction, residual flows, and coastal mean sea level. Mrs. J. Wolf is combining Prandle's model with one of the Thames estuary for forecasting surge heights in the vicinity of the Woolwich barrier.

The instrument section under Mr. Joseph Rae is unique in that the same teams of technicians not only design and construct most of the equipment, but also get the equipment ready to go to sea, organize the cruise, deploy the equipment at sea, and recover it and make it for the next cruise. Finally, they translate the magnetic data tapes into computer-compatible form and check the data. They have found that this system works very well and no one can pass the buck onto someone else in case of errors. They have a field station at Holyhead, Wales, for checking coastal equipment under field conditions.

The geophysics group under Dr. T.F. Baker have two Lacoste-Romberg instruments to measure earth tides. These are tested in the virgin-rock basement of the old observatory building. Because of their location between the Mersey and Dee estuaries, the tide loading caused by changing depths of water over the bottom is comparatively large. The tide loading signal is about one fourth the magnitude of the earth tide signal.

Baker's group has recently begun a program of measuring the earth's tidal tilt at a site in Cumbria with Askania bore-hole pendulums. The resulting signals showed excursions of over 100 m/sec that were correlated with atmospheric pressure, temperature, and rainfall. However, the strongest correlations were with ground water level through some undefined complex interaction process. One of his goals is to use the bore-hole pendulum in an inverse process to determine oceanic tides.

Dr. John Huthnance is continuing his research on coastal trapped waves in a stratified ocean. This is a continuation of his research on waves trapped over Rockall Plateau, a submerged sub-continental land mass west of Scotland. These waves have exceptionally long periods and show up as surface elevation changes in tidal records as well as modifications of shelf currents.

Huthnance is also carrying out a long-term theoretical study stimulated by some odd characteristics of the diurnal tidal components in the Atlantic Ocean. One would expect that the phase angles of O_1 and K_1 would be about the same. This is true on the east coast of the US where the difference in phase angles varies from 30° down to 0°. The phase angles of O_1 and K_1 are quite different all around the UK, and the difference may be as large as 120°. This is not a local effect but prevails along the eastern North Atlantic Ocean with phase angle differences of 100° off Northwest Africa, growing to 130° to 140° off Norway.

He describes his model as "rather tortuous." However, he does have it in the computer and working, and a paper on the subject is in draft form. His basic conclusion is that tidal energy flows northward from the South Atlantic Ocean into the North Atlantic where the two oceans join. This effect goes all the way to Norway and the Arctic Ocean. His reasoning is based on the different nature of the co-tidal lines in the two oceans, causing interactions where the two oceans join.

Dr. I. D. James has been concerned mainly with frontal systems, the near-surface thermal structure, heat budgets, and mixing in shallow seas.

Mr. G.A. Alcock is working with Cartwright on "SeaSat" altimetry. He is calculating the deformation of local sea areas due to tides and weather, for all relevant "SeaSat" passes. When this has been done, they plan to confer with geodesists for an exchange of oceanographic, geodetic, orbital, and altimetric data in order to determine whether they can make a significant reduction of residual variance when oceanographic data is added to the altimetric equation. If the above proves to be successful, they plan to use "SeaSat" data in other areas for the determination of tides where they are little known.

Another article on Bidston will appear next month in *ESN*. For a more complete and historical report on Bidston, see ONRL Report R-4-79. (Wayne V. Burt)

DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF LIVERPOOL

The University of Liverpool houses the oldest and largest of the three university departments of oceanography in the United Kingdom; the other two are located at the University of Southampton and at the Menai Bridge (Bangor, Wales) Laboratory of the

University College of North Wales. Dr. K.F. Bowden, a physicist who had joined the Liverpool staff in 1945, became chairman of the Department in 1954.

At the present time the efforts of the Department are divided almost equally between physical and chemical oceanography. In past years the Department has gained international repute for training marine analytical chemists. More recently, it has expanded its training program in physical oceanography. A full-range of courses is taught in both physical and chemical oceanography, ranging from introductory curricula in marine dynamics and pollution chemistry to analytical chemistry as applied to oceanography. About a dozen undergraduate students are working toward a BS Honours degree in oceanography. They take one or two introductory courses in oceanography beginning in their sophomore year, along with a large dose of mathematics, physics, and chemistry. Most of the courses in the last year are in oceanography

There are currently 17 postgraduate or research students in the department. The majority work in chemical oceanography. If they lack an Honours BS degree in oceanography, they must take appropriate remedial courses.

In addition to the regular degree programs, there is a six-month short course leading to a Diploma in Marine Pollution Chemistry. About a dozen students are normally enrolled, all from developing countries, most with training in chemistry or biology or both. During this course, they receive lectures from marine pollution experts, and student visits are made to various laboratories around England working in fields such as regulatory pollution analysis One important aspect of this training is that students learn not only the correct questions to be asked, but where and to whom they should go for answers. This course is sponsored largely by the British Ministry of Overseas Development as part of the British contribution to the Intergovernmental Oceanographic Commission, with some additional financial support from UNESCO.

The Department receives about 60% of its support from the University and 40% from government agencies. The bulk of the latter comes from the Natural Environment Research Council (NERC), while some funds are received from a separate branch of government, the Department of Environment (DoE), for work on specific pollution problems. Most of the ship time used by the Oceanography Department here comes from the NERC fleet of research vessels, an arrangement that is most satisfactory to the staff at Liverpool.

Bowden's personal research program has covered a number of different topics in physical oceanography. Recently he and his graduate students have published papers on circulation, mixing, and diffusion in estuaries, and on work ranging from a sophisticated mathematical model of estuaries to field studies of the Mersey Estuary, a part of which forms the Liverpool harbor. He has also worked on heat budget considerations in a study of upwelling (see below) off the northwest coast of Africa. Salinity distribution and net heat gain in the surface waters can be used to trace the source and movements of upwelled water and to estimate the rate of the upwelling.

Currently Bowden and one of his students, R.S. Ferguson, are completing a study of the dependence of turbulence on height above the bottom in a shallow-water (30-m depth) tidally induced boundary layer. Velocity fluctuations (as a measure of turbulence) were observed in the bottom boundary layer in the eastern Irish Sea near Liverpool. The sensors were two- and three-component electromagnetic flow meters with a frequency response extending up to 2 Hz. Signals from three sensors at fixed heights of 50, 100, and 200-210 cm above the seabed have been analyzed to observe possible variations with height in the turbulent structure.

Let u, v, and w denote the velocity components in the x, y, and z directions where x is the direction of the mean horizontal current, y is horizontal and perpendicular to the x direction, and z is vertical. U, V, and W are the average velocity components and u', v', and w' denote the turbulent random fluctuations around the average state (such that $\overline{u'} = 0$, $\overline{v'} = 0$, and $\overline{w'} = 0$). Near the bottom boundary W = 0 and by definition V = 0.

The variations with height above the bottom of the u component $|\overline{u'}|$ were generally insignificant, but the variations with height of the w component, $|\overline{w'}|$ tended to increase slightly with height above the sea floor. The mean product $\overline{u'w'}$ correlated well with the square of mean horizontal velocity U^2 at each height. The energy density spectra of u, v, and w had similar forms throughout the ebb portion of the tidal cycle, differing only in their general level with the systematic changes in the mean velocity. No systematic variations of any of the turbulence parameters could be correlated with tidal phase.

Drs. M.R. Howe and R.I. Tait have been working together for a number of years on the characteristics and movements of the Mediterranean water (MW) mass or "type" that flows out into the Atlantic over the sill at the Strait of Gibralter. They have discovered that as the MW spreads out at depth in the Atlantic, step layering beneath its core is a permanent feature. Twenty or more steps between 1200 m and 1800 m depth extend as continuous laminae for distances of over 50 km. They have also studied the processes by which the MW core is eroded and mixed with water masses of different characteristics above and below. Tait has also done extensive research on the water mass chacteristics and microstructure in the Mediterranean itself.

Recently Howe, in cooperation with R.I. Amber from the Univ. of Lisbon, has made a thorough study of the MW core from its Atlantic entry to and around Portugal's Cape St. Vincent. They used 18 closely spaced conductivity/temperature/depth (CTD) cross sections through the core that had been recently made by the UK research ships *SHACKLETON* and *DISCOVERY*. The MW actually splits into two distinct horizontal layers fairly close to the sill at about 7°W, which then hug the continental shelf off southern Portugal. The center of the upper core (Mu) is about 700 m deep and that of the lower core (M1) is at about 1000 m. Mu, thinner, with less volume transport, is always about 1°C warmer than M1 and is always inshore of M1. The separation into two cores is not influenced by any distinct bottom topographical features. Further downstream the cores pass over several submarine canyons which cause more vigorous offshore spreading. These meanders are related to conservation of vorticity and to obstructions in the bottom topography. At 9°W Mu turns northward around Cape St. Vincent as it hugs the continental shelf, while M1 continues westward at depth as it moves away from shore out into the Atlantic, no longer influenced by bottom topography.

The previously sparse data base indicated patchiness in the MW cores as if the water moved in pulses, but now it appears that this phenomenon is caused by lateral meandering of relatively steadily flowing cores.

An analysis of the dissolved nutrients in the upper core indicates that its source is at a depth of approximately 100 m in the Mediterranean; the lower core originates at a somewhat greater depth.

Dr. Peter Hughes has studied upwelling for the past decade. A joint upwelling expedition was made off northwest Africa between 21°N and 26°N from 27 Jan to 4 March 1975. Participants were from the Department of Oceanography of the Univ. of Liverpool and the Institut für Meerskunke an der Universität Kiel. The Germans used the research vessel *METEOR* while the British, headed by Hughes, used *DISCOVERY*. In addition to measurements made from the ships, moored current meters were established in three lines of CTD stations, each perpendicular to the coastline. These yielded a continuous three-dimensional picture of the upwelling process. Hughes was particularly interested in the frontal structures between North and South Atlantic central water masses, the coastal jet current and the countercurrent which runs beneath it. At present he is conducting further studies of the subsurface features of the frontal zones.

Prof. J.P. Riley is world-renowned on the one hand for the large number of marine analytical chemists he has trained, and on the other for the new improved techniques in marine analytical chemistry developed in his laboratories with the help of generations of graduate students. He has made a number of chemical oceanographic cruises during the past 15 years to the Atlantic and Indian Oceans, the Mediterranean Sea, the Skagerrak, and the Norwegian fjords. Much of his research has been on trace-element chemistry of sea water, but he intends to devote most of his future time to the organic chemistry of fresh water.

During a tour of the laboratories, Riley pointed out the following: (1) a homemade high-performance liquid chromotography instrument for studying phytoplankton pigments, (2) a quantitative method under development for determining mercury in fresh and salt water, (3) the development of a method for determining antimony in fresh and salt waters, (4) a seagoing automatic titration apparatus for dissolved CO_2, (5) an ion exchange column used to separate dissolved humic acids into their several components, (6) an ultrafiltration system for separating humic acids and other dissolved organic compounds, and (7) a system under development for determining chlorophyll in sea water.

M.J. Scoullos is nearing the completion of a three-year postdoctoral fellowship in the Department. He teaches chemical oceanography in the Chemistry Department at the Univ. of Athens, has written a book on the subject in Greek, and hopes to set up a chemical oceanography program at his University.

Scoullos is just completing a monumental study of Elefsis Bay, a few miles west of Athens. He has conducted approximately 20,000 individual chemical analyses of water, suspended solids, and bottom sediments. The study covers water circulation, oxygen, nutrients, chlorophyll, trace metals, and magnetic monitoring. The last-named has been applied in a marine environment for the first time in this case. The Bay is badly polluted from the effluents of some 40 industries, including two crude oil refineries, large steel mills, shipyards, etc. In spite of all this, the western part of the Bay remains a popular resort area. The study objectives are to determine the amount, nature, and eventual fate of the pollutants from each plant, information which could be used in future planning to clean up the bay.

For the past 15 years, Dr. R. Chester has been working in deep-sea geochemistry, specifically the mineralogy, chemical composition, size distributions, and biological components of aeolian dust in the atmosphere, particulate matter suspended in water, and ocean bottom sediments.

Dr. E. Joanna Sharples, a marine botanist who assists Chester in his research work, has recently completed a study of the area in Liverpool Bay (actually 25 miles west of Liverpool) where large amounts of human and industrial sewage sludge have been dumped for many years. She has found that the sludge might contribe to the abundant growth of *Phaeocystis pouchetti*, a phytoplankton that sometimes forms malodorous gelatinous masses when washed up on beaches. Since there were no other negative results, she concluded that the amount of sludge being dumped could be materially increased without permanent damage.

M.R. Preston, who directs the Marine Pollution Chemistry course, has just completed his doctoral research on the organic chemistry of estuaries. He has studied the humic and fulvic acids present in water samples and sediments. Gel filtration was used to determine molecular size fractions of the humic acids and other organic compounds in the samples, and the chemical characteristics of these components were studied. Some oceanographers who have studied the optical properties of ocean water masses have reported the effects of dissolved "yellow substances," and suggested that they are derived from terrestrial humic acids. However, Preston does not concur with this thesis based on his observations of rapid precipitation of humic acids in estuaries.

Several marine programs outside the Department of Oceanography at the Univ. of Liverpool are underway in the various biology departments on campus, one of which also operates a marine biological station on the Isle of Man. Some oceanographic research is being carried out by the Department of Applied Mathematics and Theoretical Physics. Dr. Philip Chatwin, a specialist in the theory of turbulent diffusion, has done research on turbulence and diffusion in estuaries and wind-driven circulation in lakes. Catherine Allen, who recently completed her PhD degree in the Department of Physical Oceanography at the University College of North Wales, has joined this Department and is working on the three-dimensional time-dependent structure of fronts in the Irish Sea.

Although the oceanography building is overcrowded and almost 20 years old, it is light and airy, neat and pleasant, and lacks the equipment-crowded hallways that are the hallmark of many oceanography buildings. There is

a busy air of confidence and competence about the Oceanography Department and the educational program and research appear to be excellent. It should continue to grow and most likely will eventually branch out into other oceanographic disciplines. For a more complete description of the Department and list of publications see ONR London Report R-1-79. (Wayne V. Burt)

THE FOAMING MAIN AND OTHER CHAOTIC PHENOMENA

"Bubble, bubble, toil and trouble; fire burn and cauldron bubble,"* could well have been the theme of the "International Congress on Cavitation and Inhomogeneities in Underwater Acoustics" held at the 3rd Physical Institute, University of Göttingen, West Germany, 9-11 July 1979.

The brew concocted by Prof. W. Lauterborn of Göttingen, with the assistance of Prof. L. Bjørnø of Denmark, sustained some 40 participants through 34 lectures and a concluding round table discussion ranging from single bubble dynamics and laser-initiated cavitation, through acoustical and optical microbubble spectrometry to fluctuations in acoustic propagation caused by the spatial and temporal variability of ocean temperature.

There were several fine summary invited papers that helped to integrate the diverse efforts, e.g., "Propagation of sound and shock waves in bubbly liquids," L. van Wijngaarden (Netherlands); "Inhomogeneities in underwater acoustics," L. Bjørnø (Denmark); "Sound propagation in inhomogeneous ocean," R.H. Mellen (USA); "Acoustic fluctuations in the ocean," Y.J.F. Desaubies (USA); and "Cavitation and coherent optics," W. Lauterborn (West Germany).

A very impressive optical experimental capability, applicable to the study of bubble dynamics, was revealed by the several presentations by Lauterborn's group (R. Timm, E. Cramer, K.J. Ebeling, W. Hentschel, G. Haussmann). For example, the Göttingen laboratory is now capable of photographing rapidly changing holographic images of bubble cavitation, over a depth of field of several meters, at 10^8 frames/sec. It can also form vapor cavities of computer-generated predesignated numbers (up to 5), size (down to several microns), and position, by laser vaporization holography.

Acoustical techniques for "counting" bubbles of radius 20 to 200 μm were reviewed by myself and updated by F. Schippers (Netherlands) and A. Løvik (Norway). The acoustical methods take advantage of the high Q of a resonant bubble that results in scattering and extinction cross sections which exceed the geometrical cross sections by factors on the order of 10^3 at synchronous frequencies that are inversely proportional to the bubble radius. Since the only other present technique for bubble counting at sea involves the tedious use of bubble catchers and photography with incoherent light, acoustical measurements appear to have little competition at this time. To date these experiments have revealed the quantitative dependence of bubble numbers on radius, distance below the sea surface, water depth, wind speed, time of day, season, and the presence of sea slicks or windrows. In coastal waters typical densities, within a 1-μm radius increment, range from *about 100 to 1000 per* m^3 for bubbles of radius 200 to 20 μm, respectively.

A competing coherent optical technique with computer identification of the contrasting light at the circular boundary of the bubble seems to be out of the running as a bubble "counter" except for small bubble densities. This is because of the excessive computer times now required, namely about two bubbles counted per minute of high-speed computer time.

To provide the flavor of the meeting a few other presentations may be mentioned: Amplification of modulated acoustic waves in air-liquid mixtures, F.H. Fenton (USA); Dynamics of nonspherical bubbles, Prosperetti (Italy); Acoustic emission from bubbles, E. Cramer (Germany); oscillation near a two-liquid interface, G.L. Chahine (France); Free and forced bubble oscillations, H.J. Rath (Germany); Bubble dynamics due to a tension wave, R.A. Wentzell (Canada); Collapse of bubble clusters, K. March (Denmark); Polarization effects, G. Gimnez (France); Cylindrical cavities, V. Kendrinskij (USSR); Air bubble persistence, A. Evans (England); A quantitative model of cavitation, L. Crum (USA); Cavitation threshold prediction, R. Apfel (USA); Cavitation

*Shakespeare; Macbeth, Act IV, Scene 1.

or megahertz frequencies, P.W. Vaughn (England); Mesoscale inhomogeneities, P.D. Scully-Power (USA); Effects of stochastic speed variations in shallow-water propagation, H.G. Schneider (West Germany); Acoustic scattering from near-surface bubble layers, P.A. Crowther (England); Inverse backscattering, S. Leeman (England); Nonlinear scattering, P.M. Tilmann (West Germany); Dynamics of bubbles, N.V. Malykh (USSR); Self-transparency during intense propagation in a bubbly liquid, L.A. Ostrovsky (USSR).

In terms of national representations, an interesting situation appears to be developing. In the past we have come to expect the nonappearance of scheduled speakers from the USSR. This continuing political fact of international science has now been supplemented by an economic fact, namely the absence of significant numbers of scheduled speakers from the USA, who presumably found the disadvantageous exchange rate inhibiting to international travel.

Plans are being made for a similar meeting concentrating on bubble dynamics to be held in Pasadena, California, in 1981. With the accelerating efforts in acoustical and optical techniques, one can probably look forward to substantial progress in these two years, particularly in terms of the details of numbers and actions of bubbles of radii less than 20 μm.

The proceedings of this conference will be published by Springer Verlag as one of their series on "Electrophysics." (H. Medwin, Naval Postgraduate School, Monterey, CA)

OPERATIONS RESEARCH

THE DANISH-POLISH MATHEMATICAL PROGRAMMING SEMINAR AND OPERATIONS RESEARCH IN DENMARK

The annual meeting of the Danish Operations Research Society (DORS) was held on Tuesday, 22 May 1979, in conjunction with DAPS-79, the Second Danish-Polish Mathematical Programming Seminar, which was held on the other four days of that week. Both were held at Rolighed (a Danish word meaning "tranquility"), a charming hotel-cum-conference-center in Skodsberg, a suburb of Copenhagen, which was reserved exclusively for the conference. It was a mile by foot or irregular bus to a commuter train and then 30 minutes south into the center of the city, so except for planned excursions on two afternoons and two evenings, the participants were generally isolated together day and night for five days—which makes for excellent social as well as technical interchange.

There were about two dozen Danish participants in the Seminar, more than half of whom were from DIKU, which is described below. There were about a dozen Polish participants, all from the Systems Research Institute of the Polish Academy of Sciences, which will be the subject of a subsequent article in *ESN*. There were also one or two participants each from Britain, West Germany, Hungary, the Netherlands, Switzerland, and the US. The Co-chairmen of the conference were Jakob Krarup (pronounced Yah´kub Krah´rupp) of DIKU and Stanislaw Walukiewicz (pronounced Valookay´vich) of the Systems Research Institute who was just completing a term as visiting professor at DIKU.

The first DAPS was held in Zaborów in May 1978, and the third will probably be held in May 1980 in Budapest under the sponsorship of the Computer and Automation Institute of the Hungarian Academy of Sciences. (If that should be the venue, the name will presumably be changed, perhaps to DAPHS.)

Twenty-six papers on mathematical programming were presented at the DAPS meeting, in addition, nine papers were presented on Tuesday at the combined DORS-DAPS meeting, several of which were related to mathematical programming. All sessions were plenary, and almost all papers were allotted 30 minutes each. The exceptions were four 40-minute papers given by foreign invitees during the Tuesday meeting, including my own and the following: Frank Harary (Univ. of Michigan) spoke on his recent researches in graph theory and managed to make highly esoteric results in generalized Ramsey theory for graphs seem intriguing. He developed a number of theorems which should allow any alert listener to make a fortune in bars with games played on graphs—those in which, for example, each participant tries to be the first (or last) to complete

some geometric figure. Tic-tac-toe is an elementary example of such a game. (Some of these results have recently appeared in a Martin Gardner column in *Scientific American*, April 1979, pp 18 ff.) C. Bernhard Tilanus (Univ. of Eindhoven) spoke on models, and why there are more people sowing methodologies than there are reaping the fruits thereof. He defined an "application" as something that makes money, which provoked spirited discussion from some of the Danish socialists in the audience. And Susan Powell (London School of Economics) talked on solving mixed integer programming problems with branch-and-bound algorithms, with emphasis on the exact way in which the computer must remove subproblems from being considered (bounding) and select subproblems to be explored (branching) and on computer codes available for doing these things.

Although many of the technical papers were given by younger research workers and even by students at DIKU, there was a surprisingly high level of sophistication. My favorite paper was by Jens Clausen, who teaches at DIKU. He referred to a famous paper by Klee and Minty published in 1971 that proved that there exist linear programming problems for which it is possible to traverse every one of the feasible basic solutions while always increasing the objective function, and always visiting an adjacent extreme point (i.e., changing only one vector at a time in the basis). However, if the simplex algorithm in its usual form is applied to this problem, most of these iterations are not required. Clausen has developed a modification of this problem where the constraint set is

$$\sum_{j=1}^{n} a_{ij}x_j \le 5^{i-1} \qquad i = 1,\ldots,n$$

$$\text{where } a_{ij} = \begin{cases} 0 & \text{if } i < j \\ 1 & \text{if } i = j \\ 5^{i-j}2^{2(j-i)+1} & \text{if } i > j \end{cases}$$

The objective function is

$$\max \sum_{j=1}^{n} 4^{j-n}\, 5^{1-j}\, x_j$$

After putting in the slack variables, this problem has n rows and 2n columns, and 2^n basic feasible solutions; namely, a basic solution is feasible if and only if for every j, exactly one of the two variables x_j and x_{n+j} is in the basis. Applying the ordinary form of the simplex algorithm to this problem results in $2^n - 1$ iterations. This naturally leads to the question of why this kind of thing does not happen in practice (it is well known that the simplex algorithm usually converges very rapidly), but Clausen had nothing to contribute to that question.

Among the other papers Dominique de Werra (Swiss Federal Institute of Technology, Lausanne) spoke on graph-theoretic models applied to scheduling problems, and the ways in which linear programming and network flow algorithms deal with such problems. Piroska Sz. Turchányi (to nonHungarians it may not be clear that the name, pronounced Peeroash´ka, is feminine) spoke on optimization problems in computer networks. The network consists of computers and terminals, with capability of storing messages when a channel or computer is busy. The optimization problem consists of minimizing some measure of the waiting time.

Most of the attendees were deeply immersed in research on mathematical programming, and so several of the papers which I found too technical and difficult to follow were very well received. Further details of the conference, including the titles and abstracts of all papers, and full texts of most of them, can be obtained from Krarup at DIKU.

DIKU (Sigurdsgade 41, DK-2200 København N) stands for Datalogisk Institut, Københavns Universitet, which is officially translated as Institute of Datalogy. I do not know whether the word Datalogisk exists in Danish—certainly the word Datalogy is new to me in English—but the meaning seems clear enough. They have apparently chosen this name because they want to be a bit more than a Department of Computer Science, and wish to emphasize operations research in general and mathematical programming in particular. They are part of the Faculty of Science of Copenhagen University, and are housed by themselves. Financing is basically from the state, and the Institute is involved in both teaching and research. It has a professorial staff (assistant, associate, and full) of 15. Hundreds of students take their courses in the first three years, and

some 60 of these each year go on to do graduate studies. Most of these are part-time students, who also work, and take several years to complete their degrees. There seems to be no trouble in placing the graduates of this course—quite the opposite, many are recruited into full-time jobs before they complete their degrees. Many of the students study essentially only computer science, but a large number also do operations research. Besides the members of the staff, half a dozen DIKU students presented papers at the seminar, and Krarup told me that this was one of his principal motivations in organizing the seminar—to give the students this experience, especially presenting technical papers in English.

Denmark is a small country, and its operations research establishment would be expected to be correspondingly small, but the Danish Operations Research Society has some 250 members. They hold meetings once a month during the fall and spring; these tend to be all-day affairs at which several technical papers are presented. Because of the size of the country, most of the members can easily attend any meeting, and 50 is a typical attendance. The attendance at the annual meeting was considerably smaller, having been purposely restricted because of the limited capacity at Rolighed.

Operations research is taught at all of the few universities in the country. Prof. Arne Jensen, who holds the chair in Operations Research at IMSOR (Institute of Mathematics, Statistics, and Operations Research) at the Technical University of Denmark in Lyngby, north of Copenhagen, is especially well known internationally, and was president of the International Federation of Operations Research Societies for three years, 1970-73. The chair in OR at Aarhus Univ. in Jutland is held by Prof. S. Fredens, who works in stochastic processes, queuing theory, and inventory control theory. There are two professors of OR at the University of Odense. At DIKU, while there are chairs in computer science, the senior man there in OR is Krarup, who holds the rank of Associate Professor. Operations research is also taught in business schools in Aarhus and Copenhagen (independent of the respective universities mentioned above) and at the new university in Aalborg at the northern end of Denmark.

There is not enough OR being done in Denmark to absorb the graduates of all these courses. There are OR sections in a few of the larger organizations and government departments, and the country supports a few OR consultants, but most of these graduates take on other positions. This is, of course, similar to business school graduates in the US, many of whom study operations research, but almost none of whom actually become practicing analysts. Nonetheless, most of them feel that the OR instructional background has been invaluable for their later professional careers, and this also appears to be the case in Denmark. (Robert E. Machol)

THE 1979 INTERNATIONAL SYMPOSIUM ON INFORMATION THEORY

The 1979 International Symposium on Information Theory took place at Grignano, Italy, during 25-29 June. There were approximately 250 attendees from many countries, including 3 from the Peoples Republic of China. Papers were presented at 5 concurrent sessions and at several plenary sessions. There were sessions on multiple-access communications; measures of information and certainty, estimation and filtering, pattern recognition; Shannon theory; stochastic processes; coding theory; convolutional coding theory; block coding theory; image processing; complexity of computations; data compression; algorithms for estimation; bandwidth-efficient digital modulation; computer-communications networks; detection; stochastic systems; complexity and cryptography; decoder implementation for algebraic codes; analysis of communications systems performance; performance of coded communications systems; decoding theory and techniques; adaptive and robust applications; radar systems; and detection, synchronization, and equalization for data communications. There follow summaries of the first four plenary sessions.

Prof. James Massey (UCLA) gave an invited lecture entitled "Convolutional Codes—Theory Lagging Practice." Massey reviewed the applications of convolutional codes and discussed a variety of remaining theoretical problems, including appropriate distance measures, algebraic structures, classes of codes, error bounds, and the pairwise-independence question.

Suguru Arimoto and Takeshi Hashimoto (Osaka University) gave an invited lecture on "The Complexity of Decoding for Tree Codes and Convolutional Codes." The authors presented solutions to the problems of finiteness of computational moments, tight bounds on buffer overflow probablities, and tight bounds on the deficient decoding probabilities.

Prof. Robert Gallager (MIT) gave an invited lecture entitled "Distributed Algorithms and *Network Routing*." Gallager presented several examples of distributed algorithms and discussed the information theoretic aspects of the exchanged information, questions of termination and deadlock, and robustness of algorithms.

Aaron Wyner (Bell Labs) gave an invited lecture entitled "An Analog Scrambling Scheme which does not Expand Bandwidth." Wyner contrasted analog and digital methods of voice scrambling and pointed out that, although voice quality can be made very high with analog scrambling schemes, the level of immunity to cryptological attacks is usually no more than moderate. He *then outlined a new, basically analog* encryption technique that may make feasible both high security and high voice quality.

At the same session, Prof. Jack Wolfowitz, (U. South Florida) presented this year's Shannon Lecture, entitled "On the Rate Distortion Function for Source Coding with Side Information at the Decoder." Wolfowitz extended the work of Wyner and Ziv, who obtained the rate distortion function for source coding with complete side information, and presented a method for obtaining sharp upper and lower bounds on the rate distortion function when the side information is only partial.

The abstracts of all papers presented at the Symposium are available from the IEEE (IEEE Catalog Number 79 CH 1452-2 IT). (John E. Shore, Naval Research Laboratory, Washington D.C. 20375)

ONAL REPORTS

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

OPTICAL PHYSICS

ELECTRO-OPTICS RESEARCH IN ISRAEL — PART I

This two-part article presents the highlights of basic and applied electro-optics (EO) research programs that are being conducted in Israel. These efforts fall in one of the following categories: the processes of generating and manipulating light; the interaction of light with matter; or optical materials. Five universities and institutes were visited; Ben Gurion University of the Negev (Beer Sheva), The Hebrew University (Jerusalem), and the Technion-Israel Institute of Technology (Haifa) are reported on here. Tel-Aviv University (Ramot-Aviv) and Weizmann Institute of Science (Rehovot) will be covered next month.

Nineteen investigators and several graduate students in both the physics and electrical engineering departments of these schools were interviewed, and tours were made of the experimentalists' laboratories. Even though a thorough survey of the field was attempted, this report cannot claim to be complete because of oversights.

Ben-Gurion University of the Negev - Beer Sheva is located on the northern edge of the Negev, the large desert region in the south of Israel. The city has its old and new sections, with the University's campus as well as its "downtown campus" located in the new part. Staff of the Departments of Physics and Electrical Engineering were visited. Both Departments have active graduate programs and are accredited through the MSc degree. Even though the accreditation for the PhD degree in both Departments is pending, each has several students working on dissertation projects.

The Faculty of Engineering Sciences was established in 1960 to help provide qualified engineers, who were in critical shortage. The Department of Electrical Engineering has 20 full-time technical and administrative staff members, 9 part-time lecturers, almost 400 undergraduate

students, and approximately 20 graduate students. The EO projects within the Department are directed by Professor Dan Censor, currently the Department Chairman, and Dr. Jonathan Molcho.

Since receiving his doctorate from the Univ. of Illinois in 1968, Censor has published heavily in the areas of propagation and scattering in moving media (1968-1974) and more recently in ray tracing in nonlinear and absorbing media (1975-present). In one of his recent publications he has unified the theories of ray tracing in nonlinear media and in absorbing media. [Dan Censor, "Ray Propagation and Self-focusing in Nonlinear Absorbing Media:, *Phys. Rev. A* 18, 2614 (1978).] This unified theory can be used to describe media that are dispersive, absorbing, anisotropic, inhomogeneous, and time varying. In absorbing media the dispersion equation is complex, and the group velocity is usually treated as complex, but Censor has shown that wave packets and ray tracing can be consistently defined while using only the real part of the group velocity.

Since receiving his doctorate at the Univ. of Washington, Molcho has been "combining bioengineering and elect-optics." Motivated by the need to determine the effects of transplants and burns on blood flow to the skin, Molcho is developing a laser Doppler technique with which the velocity of the capillary blood flow can be measured. At present the signal/noise ratio of the apparatus is being optimized with fluid flowing in a tube. Molcho is also working on an exciting problem involving light propagation in scattering, absorbing, and fluorescing media: The development of an optical method for determining when a fetus is under stress. The substance meconium is present in the gastro-intestinal tract of fetuses and is not normally present, except in trace quantities, in amniotic fluid. However, when a fetus is under stress, meconium is expelled into the amniotic fluid and alters its optical properties. It is planned to expose amniotic fluid to light and to measure the return signal, both fluorescence and scattered light, and determine the effects of the presence of meconium on this return signal.

The Department of Physics (at the main campus) has 25 senior academic staff members who are responsible for teaching physics to students of natural science, technology, and medicine in addition to physicists. Among the Department's experimental efforts are researches on ultrasonics and magnetism, lasers, NMR, liquids and glasses, radiation physics, biophysics, semiconductors, and nuclear physics. Also, a laboratory for the study of gas discharges (low-temperature plasmas) will soon be developed on campus. The theoretical programs include astrophysics and gravitation, nuclear physics, and condensed matter physics. The Department has 14 students working on their MSc and 12 working on their PhD degrees.

Reuben Shuker holds MSc degrees from both the Hewbrew Univ. and the Univ. of Rochester (Optics) and received his PhD degree from the Catholic Univ., Washington, D.C. Some 9 publications resulted from his dissertation work on Raman scattering in solids and viscous liquids. Upon his return to Israel in 1971, and until 1976, Shuker investigated energy transfer between atoms of noble gases, e.g., He/Xe^+. During this period he utilized a fast electrical discharge (40 nsec) to study the spectroscopy of XeCl. In this discharge system, strong emission resulting from energy transfer in molecular He/CO^+ at 200 nm was observed. Shuker feels that this medium should lase if excited at pressures of the order of 1 atm.

While at the Joint Institute for Laboratory Astrophysics, Boulder, Co. (1975-1978), Shuker developed models of Na-Xe dischagres. Upon returning to Israel for the second time, he assumed the position of senior lecturer at Ben-Gurion Univ., and he is currently planning to develop a fast-discharge capability with which good candidate laser materials can be tested. Candidates include mixtures of about 1 torr of Ca or Mg in a few atmospheres of a noble gas.

A rather thorough description of several research projects underway in 1977 within both the Physics and EE Departments at Ben Gurion Univ. is included in a previous article (*ESN* 31-6:226) that also contains an excellent description of Beer-Sheva and the Negev.

The Hebrew University of Jerusalem - Upon its opening in 1925, The Hebrew University of Jerusalem had one institute, three faculty members, one

small building, and over 100 applicants for admission. That beginning can be contrasted with the University's current 7 faculties and 10 Schools/Centers, approximately 2,400 faculty members, 4 campuses; and over 14,000 students of whom 1/3 are working on advanced degrees. EO studies are carried out on the Givat Ram campus of the University by members of the Racah Institute of Physics and the Graduate School of Applied Science and Technology.

Professor Shaul Yatsiv is one of the six staff members of the Magnetic Resonance and Laser Physics Section, one of the nine sections of The Racah Institute of Physics. Three of the Institute's 35 graduate students are working under Yatsiv on laser or laser related research. One of these research efforts involves a study of the kinetics of chemiexcitation of metastable excited atomic states. Their work on lead has been published [A. Gabai et al., "Chemiexcitation of the ^3P Metastable States in Lead Atoms," *Jour. Chem. Phys.* 67, 2284 (1977)], and one of their current goals is to produce chemiexcited atomic sulfur and selenium. Yatsiv feels that research on chemical lasers is very important because of the large energy storage density inherent in these lasers. He pointed out that typical chemical energy storage densities (10-40 J/cm^3) are much grea greater than those obtainable in capacitor storage ($\sim$ 0.1 J/cm^3).

In addition to his research efforts, Yatsiv is involved in a number of "technology" studies, one of which the author found particularly interesting. This effort may be described as a study of the materials properties of nonconventional compounds of earth. It was observed that CO_2-laser irradiation of common soil (a mixture primarily of silicates and carbonates) dramatically changes the surface of this "building" material. The surface became hard and appears to the eye to be potentially durable. The obvious question is, is it feasible to make an earthen covered structure that can be rendered durable by exposing it to intense laser radiation?

In addition to the above projects, Yatsiv is also investigating kinetic studies facilitated by the use of an e-beam pumped laser, mercury halides and their excitation processes, and the physics of solar ponds.

The School of Applied Science and Technology provides graduate training with the objective of preparing scientists for work in Israel's industrial laboratories. The School's Applied Physics Division was started by Dr. Nissim Ben-Yosef in 1971, and the current areas of emphasis in this Division are optics, electro-optics, electromagnetic propagation, and microwave electronics. Approximately 60% of Ben-Yosef's research time is devoted to investigations of atmospheric effects on the propagation of light, and he is assisted by four graduate students and two staff members in this work.

As a result of the analysis of atmospheric-transmission data collected over a two-year period at the University, the effects of atmospheric turbulence close to ground level (5-100 m) in a nonmarine environment can be predicted. In a paper accepted recently for publication in the *Journal of the Optical Society of America* Ben-Yosef has shown that the effects of day turbulence are dependent on the height above ground level in a manner consistent with Tatarskii's convection model (V.J. Tatarskii, *Wave Propagation in a Turbulent Medium*, McGraw-Hill Book Co., New York, 1961).

This group has also developed a predictive model that, upon being provided the pertinent physical data, can project atmospheric effects on optical transmission up to six hours. This model works 70% of the time, and its failure to handle changes in relative humidity appears to be responsible for its failure the remaining 30%. Other interests of Ben-Yosef's group include nonreal-time digital image processing, linear IR detector arrays, and image stabilization.

Dror Sarid joined the Applied Physics Division in late 1978 after spending four years with the Xerox Corporation at the Webster, NY. He is establishing a new group that will concentrate on integrated optics. Sarid's recent investigations focus on theoretical and experimental aspects of efficient coupling of laser emission into and out of Ti-$LiNbO_3$ diffused waveguides. They have reported an input coupling efficiency of 94% that compares well with the calculated value of 95%. A paper containing a detailed analysis of the high efficiency input-output prism coupler used in their experiments is being submitted for publication.

Technion-Israel Institute of Technology - The Technion was opened for instruction in 1924 and is Israel's oldest institution of higher learning. The main campus, known as Technion City, is located on a 300-acre site on Mount Carmel overlooking Haifa. Instruction by 3000 staff members is limited to courses in engineering, architecture, and the exact sciences. The Technion has played an important role in the development of Israel's industrial and economic potential; two thirds of the engineers, architects, and technologists in Israel are graduates of the Technion. Thirty percent of the 10,000 students currently enrolled at the Technion are working on advanced degrees.

Most of the EO projects at the Technion are carried out by or under the direction of Dr. J. Shamir of the Faculty of Electrical Engineering. Shamir and his graduate students (currently 6 full time) have made recent noteworthy contributions in both experimental and theoretical EO. In a combined theoretical/experimental effort, his group has developed a new interferometric technique for determining the optical parameters of partially transmitting thin films. The parameters of interest are the thickness, refractive index, and absorption coefficient. The new technique has the advantages over those previously used of being simpler, less expensive, and instead of measuring absolute quantities (e.g., light intensity), only relative quantities (e.g., the intensity ratio) are required. His group has extended their previously described technique to include the determination of the optical parameters of very weakly absorbing thin films. [Y. Demner and J. Shamir, "Weakly Absorbing Layers: Interferometric Determination of Their Optical Parameters," *Appl. Opt.* 17, 3738 (1978)]. This is an important capability, as such measurement is a difficult task.

High-resolution detection of defects is another of Shamir's areas of interest. By carrying out a detailed theoretical analysis, his group has determined the capabilities of a one-dimensional filtering method for the detection of defects in periodic structures. The examination of electronic microcircuitry, which frequently contains periodic structures, would be an ideal application of this development. The theoretical analysis was followed by a demonstration of the ability to detect defects less than 2μm in size. Shamir pointed out that the detection capability was limited by the available test mask and not by the detection system. A paper on this work should appear soon.

Among the theoretical contributions of Shamir's group is the development of an operator algebra which permitted the description of Fourier optics in a simple, compact manner. In this algebra, the Fresnel-Kirchhoff integral, lens transfer function, and other operations are replaced by operators. This approach works because all of the complicated expressions contained in the integral calculus of Fourier optics can be decomposed into three basic operations: multiplication by a quadratic phase factor, two-dimensional Fourier transformation, and scaling. It has been shown that aberration effects and Gaussian beam illumination can also be treated by an extension of this theory. Very recently, Shamir has extended this operator algebra by introducing some new operators that he then applied to the synthesis of optical processing systems. Papers on this operator algebra and its extension, including applications, have been submitted for publication.

Other EO projects under way in Shamir's group include nondestructive testing using holographic interferometry, visual accommodation as determined by speckle, and magnetic field switching of the polarization of lasers. (Richard S. Hughes)

SPACE SCIENCE

AN OVERVIEW OF SPACE SCIENCE AND TECHNOLOGY IN WEST GERMANY

Although the Federal Republic of Germany is the second largest contributor in the European Space Agency (ESA), it has, as with the smaller members, limited its aims in the area of space research. The broader aerospace science discipline has an old established tradition in Germany through research at the universities and Max Planck Institutes. In 1962, space research began to receive

public funds in the FRG through German participation in what is now ESA. In 1969 the Deutshe Forschungs- und Ver Versuchsanstalt für Luft- und Raumfahrt (German Aerospace Research Establishment), commonly known as the DFVLR, was established with headquarters in Porz-Wahn by the amalgamation of three aerospace research institutions: (1) Aerodynamic Testing Institution; (2) German Testing Establishment for Aviation and Spaceflight; and (3) German Research Institution for Aviation and Spaceflight. The DFVLR is an association registered under public law governed by a General Assembly, a Supervisory Board, and an Executive Board, the chairman of which is the Chief Executive Officer of the Establishment. About 82% of the funding for the Establishment was provided by the Federal Government last year, 8% by state governments, and 10% through earned income via contracts and consulting work.

DFVLR comprises five main research centers located at Braunschweig (aircraft dynamics), Göttingen (aerodynamics), Porz-Wahn (structures), Stuttgart (propulsion), and Oberpfaffenhofen (satellites). These five research centers are in turn comprised of 30 research institutes, and for the most part a good deal of cooperation exists between them. The DFVLR, which is the largest research establishment dealing with the engineering sciences in the FRG, has three basic goals. The first is to sponsor and conduct applied research in the areas of transportation and communications (transportation being interpreted to also include that of information). DFVLR has for example been investigating advanced public transportation systems. The second broad goal is the system studies of the application of applied research to public needs such as solving energy problems. The final goal is implementing projects of importance to public interest.

A great deal of space-related research is also carried out in the sister field of meteorology, primarily by the Deutscher Wetterdienst (German Weather Service). Much of this research is accomplished through funding university programs which actively utilize satellite data. Prominent problems being funded include weather forecasting for large areas; energy balance and dynamic behavior of air layers; meterological instrumentation; and agricultural meteorology.

The total staff of the DFVLR is about 3200 of whom about half are R&D personnel. Some 60% of the annual DM 250 million is spent on sal aries with 15% being invested in capital equipment and 25% utilized for operational costs. The capital equipment consists of aircraft for flight testing and airborne labs; space simulation laboratories for environmental testing; flight instrumentation and trajectory test labs; devices to measure the effects of flight (both space and atmospheric) on people and equipment; wind tunnels in the sub-, trans-, super-, and hypersonic ranges; test facilities for structures and materials; engine test stands for gas turbines and ramjet and rocket engines; operation facilities for spacecraft, sounding rocket launches, and computers; and electrical and mechanical workshops. Three types of R&D are sponsored by DFVLR. Phenomenon-oriented R&D of the basic research nature is primarily contracted to the universities and Max Planck Institutes, while system-oriented R&D is undertaken by the DFVLR research departments and under contract to the Association of Major Research Centers (AGF). Product-oriented R&D is contracted to industry. Aircraft and space technology comprise about 54% of the total budget, with transportation and communications systems 10%, remote-sensing technology 10%, and energetics and propulsion systems 14%. The remaining 12% of the program budget involves future studies, program management, and support activities.

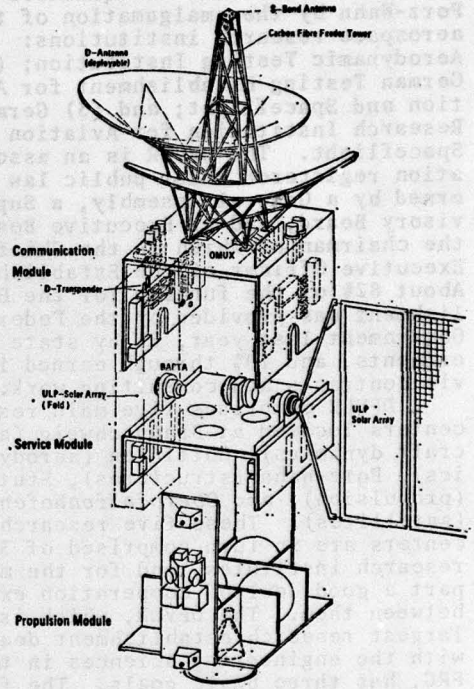
The DFVLR represents the FRG in ESA and acts as coordinating a agent with other international space organizations as well as in bilateral programs. Working with the French Space Agency (CNES), they developed the first European communications satellite SYMPHONIE and are continuing what now will probably be a Franco-German direct broadcast television satellite. In late 1978 a feasibility study for such a satellite was completed under the sponsorship of the DFVLR by the German firm Messerschmitt-Bolkow-Blohm (MBB), the largest aerospace company in Germany. Virtually every other German aerospace company was involved as a subcontractor in this study,

comprising a team of over 70 scientists. Several different payload and spacecraft versions were examined with the preferred system consisting of three broadcast channels for Germany and two for other countries (it now appears that France will be the only other country). The goal of the study was the technical definition of a television direct broadcast satellite, its development planning, and the cost estimate with particular emphasis on reducing the current high cost of TV program distribution via the ground networks. A minimum cost concept was applied using existing proven components or those under development with good promise of success while still sustaining an advanced spacecraft concept with growth capability.

The satellite design for this new generation spacecraft is based on a simple box-type structure and a subdivision into three functional modules (see figure). The communications module will include the repeater and antenna system; the service module the spacecraft subsystems; and the propulsion module, which will include as a new feature in operational communication satellites ion engines as the thrusters used for station keeping. This feature is estimated to increase satellite bus lifetime from six to ten years. The satellite is designed so it can be launched by either the ESA ARIANE expendable launcher or the NASA Space Shuttle. Another innovation of the spacecraft is the partially external mounting of the 235-W traveling wave tubes for direct heat dissipation into space. Heat pipes will also be used for equalizing heat distribution.

The communication module consists of a simple U-shaped structure conceived by MBB for the Arab communications satellite (which never materialized) and subsequently implemented on the ESA European Communications Satellite (ECS) and INTELSAT V. The advantage is a maximum assembly and radiation area for the transponder equipment. The single conversion repeater has five channels with triple redundancy ensuring an operational reliability of 0.935 for five years. The antenna system comprises two equal-sized elliptical reflectors (260 × 160 cm) which would be folded for an ARIANE launch.

Spacecraft Conceptual Design



The service module comprises the normal spacecraft subsystems for satellite operation such as thermal control, attitude control and measurement, prime power system, and the telemetry, tracking and command system (TT&C). The antenna measurement and control system is designed to allow a pointing accuracy of 0.1° or better. It comprises a double-gimballed momentum wheel, redundant gyro reference package, a set of six digital sun sensors, and the data processing electronics. The solar array is the type already built and tested under contract to DFVLR and INTELSAT and has been flight qualified. It is lightweight design with carbon fiber frames and a pretensioned blanket which is a first in solar-array technology. It is envisioned that the solar cells incorporated in the array will be improved high-efficiency nuclear-radiation resistant cells developed

by AEG-Telefunken. The power subsystem will operate at 50 V with dedicated power converters as part of the repeater and other power users. Batteries will be utilized only for telemetry during eclipse and orbit injection periods as a weight-saving measure; the eclipse periods will be short and occur during the early hours of the morning when the satellite will not be operating. The TT&C subsystem will incorporate separate redundant S-band transponders. Only a tracking beacon will operate in the television broadcast (12.5 GHz) band. Data handling will be performed by an SEL system comprising a central unit and subsystem terminals. There are 256 different commands and 309 telemetry data channels.

Launch of the first preoperational television direct broadcast satellite is expected in 1983. However, in the last several months, as reported in previous *ESN* articles, certain interesting political factors have entered the arena. The first of these is that MBB has designed, independently of DFVLR, a direct broadcast satellite for the Peoples Republic of China. A contract was signed which would result in the FRG building three operational satellites for the PRC, and these satellites would be financed by the PRC with the stipulation that PRC engineers will take an active part in the program, and technology transfer will be maximized allowing the PRC to build their own subsequent satellites. The latest word is that the contract has been revised to MBB construction of one of the above satellites and an unknown number to be built later in the PRC. The second political note is that the Germans and French have tentatively agreed not only to build a TV direct broadcast satellite jointly but also to join with several other European countries to organize an ARIANE launch vehicle company as a quasi-commercial venture. This action is certainly partially triggered by OTRAG (*ESN* 33-4:169) and partially by the interest in assuring the survival of ARIANE.

Although the FRG's aerospace research was essentially completely curtailed for many years after World War II, they are definitely back in the business today through DFVLR sponsorship. The first space research was in astronomy and began in Germany at the same time as Kepler was carrying out his research at the University of Prague in the early seventeenth century. Optical astronomy research has matured to very advanced techniques, including radioastronomy, with almost all of the old German universities having some sort of optical observatory and the new ones having either observatories or astrophysics institutes or both, with one of the world's finest radiotelescopes situated in the FRG. (Robert W. Rostron)

NEWS & NOTES

ONRL NEWS

It is the end of an era for readers of *European Scientific Notes* as we have said farewell to our administrative editor, Mrs. Victoria Hewitson. "Vicki," as so many of us have come to know her, retired in September after a long and dedicated career of over 35 years with the Federal Service and more than 21 as librarian and writer-editor with the Office of Naval Research in London. Her extensive editorial and writing skills coupled with much tact and diplomacy have not only given excellence to these pages but have also enhanced the reputation of each command under which she served.

We are sure that all of our readers, former Liaison Scientists, Chief Scientists, Naval Officers, Commanding Officers and friends will join us here in London in wishing Vicki smooth sailing, health, and happiness in her new home and new life in Florida.

NOTES

HIGH-ENERGY COLLISIONS AT CERN

Physicists at the Centre Europeenne pour la Recherche Nucleaire (CERN) in Geneva are planning beam-beam collisions of protons and antiprotons which will represent the hightest-energy collisions ever seen by physicists. Antiprotons will be generated by the collision of 30-GeV protons with fixed targets. These antiprotons occupy a large region of phase space and so cannot form a good beam. However, a new project, code-named ICE, will cool these antiprotons either by electron cooling or stochastic cooling, condensing them into a tiny region of phase space so that they become a true beam. This beam of low-energy antiprotons will then be accelerated to 30 GeV. In the first experiment they will be injected into the ISR (interesting storage rings) where they will be interacted with 30-GeV protons. Subsequently they will be put into the large (400 GeV) machine, with both protons and antiprotons accelerated to 200 or 250 GeV. The experiments in ICE are now going on and are highly successful. The first such collisions in the ISR are expected in February 1981, with experiments in the main ring later in that year. A collision between a 200-GeV proton and a 200-GeV antiproton is equivalent to the collision of 100-TeV proton with a stationary antiproton. With these incredible energies, it is hoped to create an intermediate vector boson. (R.E. Machol)

CHIPS RESEARCH

A Science Research Council grant worth a quarter of a million pounds has been awarded to a team of UMIST, the University of Manchester Institute of Science and Technology, to take the next step forward in the microprocessor revolution.

The team is led jointly by Professor David Aspinall of the Department of Computation, and Dr. Erik Daglass of the Department of Electrical Engineering and Electronics, and is investigating the design of systems based upon the use of many microprocessor components.

The outline programme of work involves the use of a unique research vehicle which has 16 interconnected microprocessors with the aim of designing and building systems in which many microprocessors co-operate to achieve a given task in a way which offers more flexibility, higher reliability and performance than could be achieved by a single microcomputer.

The multi-microcomputer research vehicle is known as CYBA after the Welsh initials for the University College of Swansea, where the early studies were carried out. It is supported by extensive software to provide an environment for three main investigations:

1. The design of a multimicroprocessor system.
2. The design of suitable software support tools.
3. The development of application studies.

The address of UMIST is P.O. Box 88, Manchester M60 1QD, UK (I. Kaufman)

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

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

C-5-79 THE FLEISCHNER SOCIETY CHEST SYMPOSIUM by I.M. Freundlich

The annual Symposium of the Fleischner Society is the major event of the year in chest radiology. The society's multidisciplinary approach is conducive to important papers and symposia concerning chest disease that may bear only indirectly on the practive of radiology. While there was no single unifying theme, the meeting was highlighted by Sackner's review of his work on the mucociliarv transport mechanism in asthma, Weibel's impressive lecture on the microstructure of the lung and its relationship to pulmonary physiology, and West's plans for future experiments during weightlessness.

ESN 33-10

INDEX OF ONRL TECHNICAL AND CONFERENCE REPORTS, 1978

Now that all ONRL Technical and Conference Reports published during 1978 have been accessioned by the Defense Documentation Center, we are pleased to provide this index. Copies of these reports may be obtained from either the Defense Documentation Center, Cameron Station, Alexandria, VA 22314 or the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, by using the listed AD number.

BIOLOGICAL SCIENCES

ONRL C-3-78	J.E. SIPPEL	Symposium on Functions of Microbial Membranes, Tübingen, Germany 5-7 September 1977 (AD-A057432)
ONRL R-5-78	J.B. BATEMAN	A Biologically Active Combination of Modulated Magnetic and Microwave Fields: The Priore Machine (AD-A060988)

COMPUTERS

ONRL R-7-78	D.C. RUMMLER P.A. SANTONI H.G. STEUBING R.J. PARISEAU	Systems Design and Software Engineering Methodologies in Europe (Distribution Limited to U.S. Government Agencies only) (AD-B035695L)
ONRL R-11-78	H. WHITTED J. SILVA A.K. NEDOLUHA D.C. RUMMLER	Flat Panel Display Technology in Europe (AD-A065302)

EARTH SCIENCES

ONRL C-11-78	E.C. HADERLIE	Fourth International Biodeterioration Symposium, Berlin, West Germany, 28 Aug-1 Sep 1978 (AD-A064307)

ELECTRONICS

ONRL C-2-78	V.N. SMILEY	Quantum Electronics—A National Conference at Southampton (AD-A057431)
ONRL C-5-78	B.D. McCOMBE	The Second International Conference on the "Electronic Properties of 2-Dimensional Systems" (AD-A054419)

ONRL R-8-78	D.K. CHENG	An Overview of Electronics Education in Poland and Romania (AD-A064241)

ENGINEERING

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MATERIALS

ONRL C-1-78	I.M. BERNSTEIN	The 45th Meeting of the Structures and Materials Panel of the Advisory Group for Aerospace Research and Development (AGARD) (AD-A052877)
ONRL C-10-78	J. Perkins	Third International Conference on Rapidly Quenched Metals (AD-A061776)
ONRL C-13-78	S.N.B. MURTHY I. GLASSMAN J.R. PATTON	The Seventeenth International Symposium on Combustion (AD-A065454)

MEDICINE

ONRL C-8-78	R. GOAD	European Undersea Biomedical Society 4th Annual Scientific Meeting (AD-A065401)
ONRL C-12-78	J.C. LAROQUE	Progress in Cardiology (AD-A064885)
ONRL R-9-78	P.F.D. VAN PEENEN	National Health Service and Military Medicine in Great Britain (AD-A064242)

PHYSICAL SCIENCES

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ONRL C-7-78	R.R. SMARDZEWSKI	First International Conference on Matrix Isolation Spectroscopy (AD-A053579)
ONRL R-1-78	F.C. ESSIG	Superconducting Microwave Cavity Research at Siemens (AD-A057414)
ONRL R-2-78	R. BRACKETT	Underwater Inspection and Nondestructive Testing of Offshore Structures (AD-A057425)
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PSYCHOLOGICAL SCIENCES

ONRL C-6-78	M.J. FARR C.R.J. LAFLEUR	The 13th International Symposium on Applied Military Psychology (AD-A053578)
ONRL C-9-78	J.A. ADAMS	Fourteenth International Symposium on Applied Military Psychology (AD-A061819)