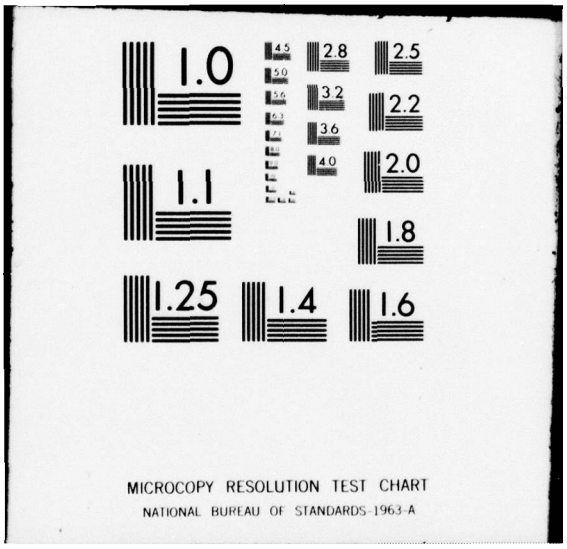
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This is a monthly publication presenting brief articles concerning recent developments in European scientific research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

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

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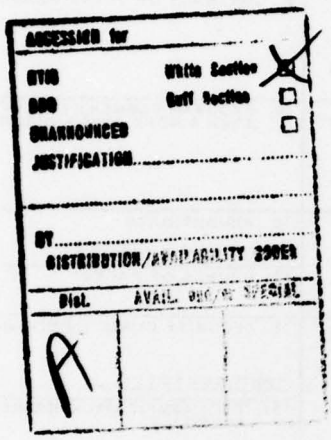
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OFFICE OF NAVAL RESEARCH
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ENGINEERING

Video Discs: Yet Another Use for Your TV Set	N.M. Blachman	481
Information Theory in Hungary	N.M. Blachman	482
Panel Displays	C.C. Klick & A.W. Pryce	485

MATERIAL SCIENCES

Sheffield International Conference on Solidification and Casting	J.D. Ayers	486
A Conundrum: Improvement in the Properties of Beryllium Is Not Mirrored by Increased Use	I.M. Bernstein	489
A Fatiguing Experience: An AGARD Conference on Inspection of Aircraft Components	A.W. Thompson & I.M. Bernstein	493
Material Preparation at RSRE—Towards a More Perfect Crystal	C.C. Klick	494
9th Annual British Mass Spectrometry Meeting, University College of Swansea, Wales	F.E. Saalfeld & J.J. DeCorpo	497

MECHANICS

Aeronautics at the Polytechnium of Torino	M. Lessen	498
The Institute of Aerodynamics at the University of Naples	M. Lessen	500

OCEAN SCIENCES

Application of Remote Sensing to Ocean Surveillance—AGARD Lecture Series	R.W. Rostron	502
NATO Air-Sea Interaction Symposium	E. Mollo-Christensen & P.F. Twitchell	504

PHYSICAL SCIENCES

A Max-Planck Laser Institute in Garching—Maybe?	J. Gorrell & V. Smiley	506
Lasers and Magnetic Resonance	C.C. Klick	508
Probing the Stratosphere with Lasers at Verrières-le-Buisson	V. Smiley	510

PSYCHOLOGICAL SCIENCES

The Simulator Instructor: A Neglected Dimension of Flight Training	J.A. Adams	512
Human Factors and Modern Communication Technology	J.A. Adams	513

SPACE TECHNOLOGY

Satellite Heal Thyself	R.W. Rostron	514

NEWS & NOTES 516

ONRL REPORTS

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ENGINEERING

VIDEO DISCS: YET ANOTHER USE FOR YOUR TV SET

Color TV sets can be used not only to receive Teletext pages from British TV transmitters (*ESN* 31-2:72), to display Viewdata pages received interactively over the telephone line (*ESN* 31-2:72), to provide a field in which to play games, to project tape-cassette recordings, and to show photographic slides, but also to exhibit moving pictures recorded with stereophonic or bilingual sound on discs. This last application was the subject of the Video Disc '77 Conference held 8-9 November at the British Academy of Film and Television Arts (BAFTA) at 195 Piccadilly, London, which was attended by nearly 200 people from the UK, France, Benelux, West Germany, Scandinavia, and the US.

Although a cooperative effort between Telefunken of Germany and Decca of Britain has produced the only discs and players to be marketed commercially (mainly in Germany) so far, this consortium was not represented in the Conference program, and their project was described by one speaker as a commercial flop. Their players were reported as still in use, however, by German travel agents for showing vacation spots and by a medical service for keeping doctors up to date on new techniques, despite the fact that each disc provides only 10 minutes of information on a 21-cm disc, 0.1 mm thick. In Japan similar systems are being marketed to provide English lessons, entertainment, golf instruction, etc. The method of recording is hill-and-dale, produced mechanically on the master disc at 1/25 or 1/5 of the playback speed. A diamond stylus attached to a piezoelectric transducer reproduces the combined monophonic audio and video waveform by mechanically following the groove with the assistance of a drive geared to the rotation of the disc, which rides on an air cushion. When properly handled the discs are apparently not subject to wear, but they are easily damaged. In large-volume production these discs cost less than 15¢ each for the material and pressing.

Two other video-disc developments, however, were very much in evidence at the Conference. Both that of Philips (Netherlands) and MCA (US) and that of Thomson-CSF (France) were demonstrated as well as discussed by their own representatives. These two are very similar in most respects, the principal difference being that the Thomson disc is transparent and is read by a laser beam transmitted through the disc, while the Philips-MCA disc has an aluminum coating and is read by reflection of the beam from a 1-mW He-Ne laser. The "grooves" consist of a sequence of pits whose lengths and spacing along the "groove" vary so as to yield a frequency-modulated squarewave with carrier frequency 7.8 MHz for Thomson-CSF and 9.5 MHz for Philips-MCA carrying the full video bandwidth. Thus, the "micropits" have dimensions of the order of a μm (1/25,000 inch).

These discs, like that of Telefunken-Decca, record one frame per revolution, but they hold 30 minutes of material on each side, the back side of the Thomson-CSF disc being readable (at least in principle) without turning the disc over—simply by focusing the objective lens on the opposite side of the 0.006-inch-thick flexible disc. The Philips-MCA disc is 2 mm thick and is stiff, being coated with pvc so as to yield a smooth surface on which fingerprints and dust are said to be out of focus and cause no trouble.

The designs take into account both NTSC and PAL-SECAM color-TV standards (*ESN* 31-11:445), which involve 30 frames/sec in the US and 25 in most other countries. Thus, the discs turn 1800 or 1500 rpm, and they include up to 54,000 or 45,000 frames on each side, each frame being numbered. The frame number is stored on the disc in one of the two vertical retracing intervals (when the TV beam is shut off), and it can be displayed, if desired, in the corner of the screen. Provisions are included, for selecting any particular frame or sequence of frames for repeated display; and slow, fast, and reverse motion can also be selected. There is, in addition, a browsing mode that is equivalent to glancing in turn at the top of each page of a book. Recording is done photographically in real time on the master disc by a laser beam, the spacing between "grooves" being less than 2 μm, which yields a beautiful rainbow-colored diffraction pattern when a spot of light strikes the disc (particularly the reflecting disc).

Like phonograph discs, these two video discs are 12 inches in diameter, but their information-storage density is about 500 times as great, and there has been some discussion of using the same techniques to put a few hundred hours of sound alone on a disc or even to provide several billion bits of fixed information or programs for computers, but the Conference concentrated on the video applications. For teaching and training the possibility of looking at a single frame or a sequence in slow motion can be extremely valuable, greatly increasing the amount of material that can usefully be compressed into a one-hour recording. In addition, video discs are proposed for such applications as explaining new legislation or safety procedures, for distributing information on the use and servicing of new products, for recruiting and training new employees, for storing catalogues and encyclopedias, and for accompanying journals and reports as well as for documentaries and entertainment.

Video Disc '77 took place during Britain's electrical power workers' strike, and it began with some uncertainty as to whether the Piccadilly area would find its power shut off in the course of the somewhat random sharing of the power shortage. This uncertainty ended at 4:45 on the first afternoon, when the nicely appointed BAFTA auditorium (with 224 duly labeled endowed seats and 8 large TV monitors) went dark. The Conference continued, however, in the lobby with the aid of gas lights and a battery-powered amplifier. Pocket flashlights, which many people had learned to carry, solved the problem of the unlighted cloakroom when the session ended.

A compilation for the Conference by David Fisher, editor of *Screen Digest* (37 Gower St., London WC1E 6HH), describes 25 different video-disc developments, of which only 5 survive as independent efforts. Of these, 4 now appear to be competing—including the RCA system on which little up-to-date information is available except for its aim of getting one hour on each side and reducing the cost of the player. [Also see D. Mennie, "Television on a Silver Platter," *IEEE Spectrum* 12, 34-39 (Aug. 1975).] To be successful the manufacturers feel a price under $500 for the domestic player is necessary, with discs selling for between $2 and $10. Industrial models will cost more and may include such features as a cordless remote control and a hard copier. The Philips-MCA laser is intended to cost only $10 in large-volume production and to last 5000 hours, with replacement by the user requiring no adjustments.

It seems that the problems delaying video discs are not technical but result from video tape-cartridge recorders' having preempted the (US) market (albeit at a price of the order of $1000) and from the vicious circle that requires the availability of a wide variety of programs on discs before disc players become attractive and a large number of the latter in use before such discs can be produced economically. It was announced, nonetheless, that 1000 Thomson-CSF players made in Brittany will be offered for sale late in 1978. Since in the UK 63% of the color-TV sets are rented, renting was suggested as a method of circumventing the uncertainty about video discs. Still another hang-up is the problem of guaranteeing writers, performers, musicians, and directors reasonable compensation for the not yet authorized new use of their work (cf. *ESN* 31-7:269), especially if video discs should be rented. Divergent views were expressed at the Conference as to whether video discs (on which few users can afford to record their own programs) will catch on. But it is interesting to consider that they may be the vehicle by which lasers are brought into the home and office along with servo systems that enable the optics to track the recorded information within a micrometer. (*Nelson M. Blachman*)

INFORMATION THEORY IN HUNGARY

In the course of a recent trip to Budapest I visited the Mathematical Institute of the Hungarian Academy of Sciences and managed to include half a day at the Institute for Communication Electronics of the Technical University of Budapest. At these Institutes I also met a few people from other organizations in Budapest where research on information theory and statistical communication theory apparently is also carried out—the

Telecommunications Research Institute and the Fine Mechanical Works. These four, I was told, are the principal centers of Hungarian research in this area, though some individuals elsewhere are also contributing to the field.

Since the time of Josef Jauch's visit to the Mathematical Institute a decade ago (ONRL-R-56-67), living conditions in Hungary have improved considerably, and Hungarians are enjoying much more contact with the West. The shops in Budapest seem well stocked and are selling domestic goods at prices comparable with those abroad except that food is relatively inexpensive. On the other hand, wages are only about a third of those in Britain, which pays perhaps 40% as much as the US, but incomes are augmented by extra jobs in Hungary, such as consulting or translating. This situation may be more the result of Hungary's still being largely agrarian than its being a Soviet satellite, though some aspects of the latter status persist.

At the Mathematical Institute the wage scale is somewhat reduced to compensate for the attractive working conditions. The director, László Fejes Tóth, is continuing the policy of Alfréd Rényi, his predecessor and the founder of the Institute, that each of the 70 mathematicians there should be free to choose his own lines of investigation. The Institute is divided into ten Groups, the three known as the "Stochastic Groups" being: Probability headed by Pál Révesz, Statistics headed by István Vincze, and Information Theory headed by Imre Csiszár. These men also have half-time appointments at the Eötvös University of Science in Budapest, which is the source of many of their Group members, such as János Körner.

Körner is a frequent collaborator of Csiszár's, and the Academic Press will shortly publish the first of their two volumes in English on information theory *à la* Shannon in the discrete case, exploiting the power of "typical sequences" in obtaining exponential error bounds, etc. The second volume, dealing with the continuous case, seems to be some years off yet. Along with some of their colleagues, such as Miss Katalin Marton, they have also been working on such topics as multiuser channels with correlated sources, reliability at rates above the channel capacity, source coding, and information measures (including the Kullback-Leibler information divergence) as well as applications to probability and statistics. Others in the Information Theory Group have also been working on problems of statistical physics, combinatorics, and graph theory.

A recent paper by Csiszár and Körner, "Source Networks with Unauthorized Users" [*J. Combinatorics, Information and System Sciences* 1, 25-40 (1976)] considers separate coding of the output of each of two correlated sources. One source is treated as a "helper," and its coded form is made available to the destination in order to reduce the information rate required for coding the other source. The authors found that (regardless of the coding of the helper) the latter rate is independent of whether the user knows the coding of the helper or he does not (his use of the helper is "unauthorized"); however, the coding required for the other source is more complicated in that case.

The Institute receives around 70 foreign visitors per year for various periods of time, and some of the resulting collaboration with Prof. Giuseppe Longo (Univ. of Trieste) has been mentioned earlier (*ESN* 31-6:229). Members of the Institute also have had many opportunities to travel and work abroad themselves. In one respect, however, the Institute remains somewhat narrow, as all of its members are mathematicians by training, and there are no engineers or physicists to introduce a practical point of view, though informal contacts exist with engineers located elsewhere.

Vincze, head of the Statistics Group, published an Academic Press book *Mathematical Methods of Statistical Quality Control* in 1974 with Károly Sarkadi (a member of his Group) as coauthor, and he has also investigated the interrelationship between information theory and statistics as well as its application to statistical physics. The work of his Group concerns statistics and its applications, including the fitting of models and of probability distributions. The Probability Group's interests tend toward limit theorems, strong convergence, and stochastic approximation.

With 1700 faculty members and well over 10,000 students, the Technical University of Budapest is by far the largest institution of university standing in Hungary. Its Faculty of

Electrical Engineering has a staff exceeding 400 and a student body of over 3,000. Within this Faculty, the Institute of Communication Electronics, headed by Prof. Sandor Csibi, is responsible for teaching and research in the fields of its six Departments: Computers, Circuits, Broadcasting, Telephone Exchanges, Wired Transmission and Data Processing, and Acoustics—each with a dozen to 15 staff members.

Approximately 200 students of telecommunication enter the five-year diploma program each year. This degree requires a thesis and examination as does the advanced degree "candidate," which is equivalent to the PhD and is translated as "doctor." There is also a higher doctorate awarded later after some years of research and the submission of a dissertation to an institute affiliated with the Academy of Sciences. Corresponding members of the Academy are selected from among these higher doctorates.

Csibi had previously worked at the Telecommunications Research Institute (TKI) in Budapest, which is not affiliated with the Technical University. TKI is primarily concerned with the development of telephone microwave relay-system designs and prototypes, but Csibi also worked there on automatic recognition of abnormal patterns in electroencephalograms, and he brought this interest as well as some of the TKI personnel with him to the Institute for Communication Electronics.

Dr. Géza Gordos, who heads the Institute's Department of Wire Communication and Data Processing, has studied loading problems connected with frequency-division-multiplexed (FDM) telephone transmission. In the USSR, where many different channels may be carrying the same facsimile signal (an on-off-keyed tone) to different towns for use in producing their local newspapers, the usual approach to loading based on independent signals in the channels would not be applicable; it would lead to overloading and, hence to distortion and intermodulation.

Gordos is a consultant to Budavox, a Hungarian telephone manufacturer selling a good deal of equipment to the USSR; for this company he has also developed a random-waveform generator whose output has both the spectrum and the probability distribution of the human-voice waveform for use in testing telephone systems. In addition, Gordos has written books in Hungarian on filters and on data transmission and data processing as well as doing some book translation, and he has investigated pattern recognition as applied to voice waveforms for speaker identification and other applications.

Dr. Ivan Schmideg, the man I met from the Fine Mechanical Works, is currently simulating the heat flow in a cabinet housing a microwave transmitter. I was very glad to meet him as I had made use of some of his thesis work ["Note on the Evaluation of Fourier Coefficients of Power-Law Devices," *Proc. IEEE* 56, 1383-1384 (Aug. 1968)] in determining what nonlinearity will have a prescribed effect on any harmonic of a sinusoid as a function of the amplitude of its input. Although I do not know what research in communication theory is being done at the Fine Mechanical Works (if any), I was impressed by the amount of work that is being done in this field in a poor country of only ten million people, and especially so by the output of Mathematical Institute. It is also impressive that at least seven mathematical journals are published in this small country in languages other than Hungarian, albeit for the purpose of obtaining foreign journals through direct exchanges as well as facilitating the communication of research work.

Visitors to Hungary will find that, once they are officially invited, they are made very welcome. Affiliation with the US government, however, is occasionally an impediment, and contact with each institution seems to need formal arrangement. Despite many difficulties, it appears that Hungary is able to keep abreast of research in the rest of the world. Further details are to be found in my forthcoming report ONRL-R-11-77. (Nelson M. Blachman)

ONRL REPORTS

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

PANEL DISPLAYS

The Royal Signals and Radar Establishment (RSRE) at Malvern, Worcs., UK, previously the Royal Radar Establishment (RRE), took its new name following recent incorporation with the Services Electronic Research Laboratory (SERL) at Baldock, Herts., and the Signals Research and Development Establishment (SRDE) at Christchurch, Hants. (*ESN* 30-11:524). Another index of change in the laboratory is the pattern of its financial support. Once there was support only from the Ministry of Defence (MoD), and this continues to be the largest source of funds for the organization. More recently however, the Department of Industry (DoI) has begun to fund research and development in the electronics area, and RSRE has been quick to extend its expertise into areas of concern to DoI.

A case in point is the RSRE display-development work described below which is equally supported by MoD and DoI. This broadening base of support brings with it some interesting complexities. As the major British electronics laboratory, RSRE is often asked to send its experts to sit on advisory panels making recommendations to MoD concerning contract proposals by industry. The symmetry is reversed in the DoI relationship. There the advisory panels are populated by industrial experts who review RSRE proposals to be sure that they are sound and meet major industrial needs. This reversal of the roles of claimant and referee in the MoD and the DoI relationships tends to be reminiscent of checks and balances characteristic of the US Constitution.

Panel display development is under the overall guidance of Dr. Cyril Hilsum, one of the most senior and well-known scientists at RSRE. John Kirton is the immediate leader of the group which consists of about six technical people. The overall guiding principle in the program is one of making large-area displays to be seen by an individual. A resulting goal is that the speed of the display must be sufficient for the human eye. Another is that it should be made—or be able to be made—in 1-ft square panels. Two kinds of display panels are being studied: electroluminescent and liquid crystal.

The material used in the electroluminescent panel is ZnS:Mn,Cu. Rather than imbed the phosphor particles in a dielectric, the RSRE approach is to coat them thinly with some copper, use a small amount of binder to hold the particles rigidly, and mount them between a transparent electrode, such as tin oxide, and an aluminum backplate. In this way the particles make direct contact with the electrodes. The application of a dc potential causes electroluminescence with a comfortable yellow color. The electroluminescence response is a strong function of voltage so that a crossed grid system may be used to produce light at the intersections when voltages of opposing polarity are applied. By properly activating portions of the vertical and horizontal grids, patterns may be produced. In addition to dc supplies, pulsed voltage supplies are used with a duty cycle of 1/200, which improve the lifetime of the devices for reasons that are not very clear. The basic yellow color can be made green or red by using filters.

This system has advanced to the point where an electroluminescent display is being considered by the British Post Office for use by telephone operators. This particular display would have four lines of letters and numbers—each with 20 characters—and could be used for giving operators dialing codes, routing information, and similar simple working information. This type of display is also being considered as a way of presenting an eyecatching oscillating yellow-arrow warning to helicopter pilots in connection with radar for avoiding power lines. A cooperating industrial group is also understood to have developed a control-panel display using the RSRE system for an automobile.

A second major RSRE approach to panel displays is the development of a liquid-crystal color switch. In this system the source may be a monochrome one such as a cathode-ray tube (CRT) that presents the information to be viewed. A liquid-crystal transmission cell is placed over the face of the CRT to transmit in successive frames either red or green light. The CRT display changes each frame, of course, to present the appropriate part of the overall picture corresponding to the color being transmitted. By transmitting both red and green a third color, yellow, can be formed in part of the viewed picture by eye integration.

As this use of liquid crystals appears to be novel, a brief analysis will be given of its operation. An extensive review may be found in an article entitled "Multicolour Displays Using a Liquid Crystal Colour Switch" by Ian A. Shanks in *AGARD* CP167, pp. 18-1, 1975.

The liquid-crystal cell employed uses the "Twisted Nematic Effect." Nematic liquid crystals have asymmetric molecules that do not normally have long-range order. Ordering, in liquid crystals, means only that the orientation of all the molecules is parallel—there is no translational symmetry as in ordinary crystals. They can be given long-range order in several ways; one is to apply an electric field of about 10^4 V/cm or more. Depending on the liquid-crystal material, the molecules will align parallel or antiparallel; for simplicity we will assume in the discussions here that the long molecular axis aligns parallel to the electric field. The cells used at RSRE are typically 6 to 40 μm thick so that voltages as low as 2 or 3 V cause alignment.

Alignment can also be achieved by interaction of the liquid crystal with the top and bottom surfaces of the cell. In the absence of an electric field the molecules may be ordered parallel to preferred directions on the surfaces. Such a preferred direction may be introduced by wiping the surface in a single direction or by evaporating a dielectric, such as magnesium fluoride, obliquely on the surface. If a thin cell is formed with two such cell surfaces parallel to each other, all the molecules will be parallel. If one surface is now rotated by 90°, the orientation of the molecules will slowly change as one proceeds through the cell from one surface to the other making a total change of 90°. The gentle spiral of the molecular orientations can be used to change the direction of orientation of transmitted linearly polarized light. If the polarization is parallel to the molecules at the front surface of the cell and if the pitch of the molecular spiral is not too great, the direction of light polarization will follow that of the molecules and will also be twisted by 90° in passing through the cell. This effect is independent of the wavelength of the transmitted light.

The liquid-crystal switch is produced by applying both of these ordering mechanisms to the same cell. With no voltage applied, the direction of polarization of the transmitted light is rotated by 90°. With the application of a strong electric field across the cell, virtually all the molecules orient parallel to the field and polarized light will pass through without having its direction altered. The application of voltage then causes transmitted plane-polarized light to switch its direction of polarization by 90°. This is the unique feature of the cell.

The final step in producing a color display is more familiar. It involves the addition of a birifringent sheet to change linearly polarized into elliptically polarized light. A common demonstration is to place cellophane between crossed polarizers. Colored light is transmitted. If one of the polarizers is rotated by 90°, the complementary color is produced. Exactly the same phenomenon is used in the color switch; the liquid crystal is used to switch the polarization and therefore the color.

Most of the technical problems requiring solution to produce a practical large-area color switch have been solved. The RSRE group is now concentrating on finding applications for their color switch that will guide further development and justify its transition to industry.

RSRE feels that the use of panel displays is in its infancy and that there is a long-range potential for improvement over the CRT that is similar to the improvements introduced into electronics by the advent of solid state devices. RSRE's record of achievement suggests attention to this view. (Clifford C. Klick and A.W. Pryce)

MATERIAL SCIENCES

SHEFFIELD INTERNATIONAL CONFERENCE ON SOLIDIFICATION AND CASTING

Response within the international solidification community to this first general conference on the topics covered since the Brighton Conference of ten years ago might almost be characterized as overwhelming. The

International Conference on Solidification and Casting, held at the University of Sheffield on 18-21 July, was extended beyond the initially planned 20 July conclusion date so that time could be found to accommodate presentation of the 81 papers accepted by the organizing committee. The meeting was truly international in composition, with the 235 participants representing 28 countries.

The Conference surely had the busiest schedule of any attended by this reviewer, as it consisted of 7 sequential sessions with 10 to 12 presentations in each. This format allowed many topics to be covered, but left little time for discussions or relaxation. Lest the attendees felt too overworked, however, the organizers arranged a dinner, plus an exceptional social event. All participants and spouses were guests of the City of Sheffield at a civic reception hosted by the Lord Mayor and at an elegant dinner and ball.

The remaining evening of the Conference was, in a sense, a mixture of business and pleasure, for all were invited to attend the 26th Annual Hatfield Memorial Lecture with a buffet following. This year's lecturer, Dr. Richard Weck (Director General of the Welding Institute, Abingdon, Cambs., UK), spoke on the responsibility of the steel industry to produce steels meeting quality standards necessary for production of weldments with the strength and integrity required in modern engineering applications. A major thesis of his lecture was that requisite standards could be achieved at an acceptable cost if the producers were to devise ways of incorporating, in an integral manner, inlays of superior-quality steel into those portions of their mill products that are to be subsequently welded.

Topics discussed in the seven technical sessions covered such a broad range of research and development activities that a brief report such as this can only sample the ideas presented. In the hope of making this sample representative, I will comment on one talk from each session.

In the session on Basic Studies, M.P. Stephenson (Tube Investments, Ltd., Birmingham) and J. Beech (Univ. of Sheffield) presented a study of "*In Situ* Radiographic Observations of Solute Redistribution During Solidification." They used an x-ray vidicon tube and a TV monitor to make real-time observations of morphology and solute distribution in 300-μm thick aluminum alloy samples sandwiched between two pieces of graphite. With their experimental geometry, resolution was approximately 10^{-2} mm. Good contrasts were obtained when the liquid and solid phases had differences in linear absorption coefficients of greater than $1\ (mm)^{-1}$. They studied the effect of growth direction and interface speed during solidification of Al-Au and Al-Ni alloys, with confidence that their results were unperturbed by quenching effects. As an example of their results, they found that when solidifying Al-2% Au alloys, pronounced solute partitioning occurred ahead of the solid/liquid interface during upward growth, but with a downward interface velocity of 12 μm/sec, no solute accumulation was discernible.

The session on Eutectic and Peritectic Solidification, began with a keynote address under the same title by Professor Mats Hillert (Royal Institute of Technology, Stockholm). He introduced his paper with the hypothesis that theoretical treatments of solidification phenomena are frequently made unnecessarily complicated by including both heat and mass flow in the analysis. Using the assumption (common to his many analyses of solid-state transformations) that the system can be treated as isothermal, he presented solutions for the growth velocity and thickening kinetics for degenerate eutectic growth and for the peritectic reaction and transformation. On another front, he pointed out that there has been surprisingly little work on the effect of ternary additions on eutectic growth. With a "rough" theoretical treatment he demonstrated that the width of the two-phase dendrite-like cellular structures, that occur when ternary additions are made to a binary eutectic, is not at all controlled by the same factors that operate in ordinary dendritic growth. He predicts that, contrary to ordinary dendrites, the thickness of these two-phase dendrites will decrease with increasing alloy content.

Hillert also presented an interesting discussion of problems involved in producing aligned structures by peritectic reactions. He predicted that if the solidification temperature can be depressed well below the peritectic temperature, aligned structures should

be attainable in systems in which the solid phases involved exhibit fixed stoichiometries.

In the session on Nucleation and Grain Refinement, J. Campbell and P.D. Caton (Fulmer Research Institute, Ltd., Slough, UK) presented an interesting study of "The Grain Refinement of Electroslag Remelted Ingots." In experiments with an austenitic stainless steel, Inconel 600, and with Nimonic 90 they achieved grain-size refinements of up to 100 by introducing particles (approximately 3 mm in diameter) of the same composition as the feed stock directly into the melt. The 75-mm-diameter ingots were electromagnetically stirred during the refining process to aid particle dispersal. The stirring was found to improve surface finish and to promote grain multiplication as well as to reduce power requirements by up to 20%. Particle additions of up to 53% were attainable without adverse effect. One of the most interesting metallurgical effects was that reduced solute redistribution in the Nimonic 90 resulted in improved mechanical properties; e.g., homogenized material was softer and aged material was harder than control materials. A limitation to this approach is that the economic application is dependent upon availability of low-cost feed particles (preferably of approximately spherical shape with about 3-mm diameter) at a low cost.

In the session on Solidification and Quality Control—Continuous Casting, five of the eleven papers presented calculations related to heat-flow effects during continuous casting. In one of these, J. Mathew (Combustion Engineering, Inc., Slough, UK) and H.D. Brody (Univ. of Pittsburgh, PA) discussed the "Simulation of Heat Flow and Thermal Stresses in Axisymmetric Continuous Casting." Theirs is a finite-element analysis that takes into account the heat flow and displacements in the axial and radial directions of the casting and accounts for the temperature-dependence of material properties. The model, which can account for all boundary conditions normally encountered in continuous casting, was applied to the casting of 5084 aluminum-magnesium alloy at different rates. They found that increasing the casting rate from 8.9 to 10.2 cm/min should increase the maximum normalized stress from 1.7 to 3.5: it is just in this range of cooling rates that centerline cracking occurs experimentally. Other calculations such as the effect of casting rate on the temperature and freezing-range profiles were also in agreement with experiment, indicating that a model such as this could be valuable to operators of continuous-casting installations. More general use must await, however, the availability of additional data on the temperature-dependent properties of commercial alloys. Some such data is becoming available, as evidenced by the paper in this session by Kinoshitu, Kasai, and Emi (Kawasaki Steel Corporation). I will not summarize this paper, but mention only that they have generated some valuable data on "Crack Formation and Tensile Properties of Strand Cast Steels up to their Melting Points."

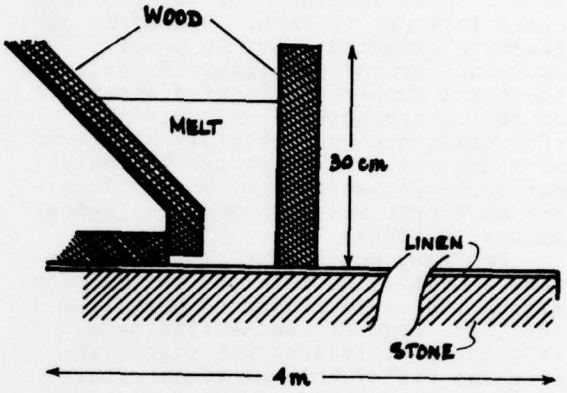
In the session on Solidification and Quality Control, U. Feurer and R. Wunderlin (Swiss Aluminum, Ltd.) presented an "Investigation of Porosity Formation and Acoustic Emission Measurements during Solidification of Aluminum Alloys." Experiments with both $NaHCO_3$ in water and with aluminum alloys convinced the authors that their experimentally observed acoustic emissions correlated with the formation of hydrogen bubbles in the liquid. From the aluminum-alloy solidification experiments they concluded that the total acoustic emission depended on the hydrogen content of the melt, the type of nucleation site (e.g., between dendrite side arms and in the interdendritic fluid), and the alloy composition (possibly because of a vapor/liquid surface-energy dependence on composition). They then made a theoretical prediction of acoustic emission with time that incorporates the dependence of hydrogen content in the liquid upon volume fractions of dendritic and eutectic phases solidified and on the temperature-dependence of hydrogen solubilities. This rather simple theory gave a reasonable fit with experiment.

While the data obtained are less comprehensive than those presented in the same session by Entwistle, Gruzleski, and Thomas (McGill Univ., Montreal, Canada), the ease of data gathering compared to the time-consuming density measurements of the latter authors may well recommend the acoustic-emission technique for quality-control application.

The next-to-the-last session was a diverse one, covering Structure and Property Relationships and Welding. In their presentation, M. McLean and P.N. Quested (National Physical Laboratory, Teddington, Middx., UK) discussed the "Effect of Variations in the Growth Rate and Temperature Gradient on the Microstructure and Creep Properties of Directionally Solidified Eutectic Composites." The five eutectic alloys they studied were produced at low growth rates (G) with steep temperature gradients (R). These growth conditions resulted in a refinement of structure that produced improved creep properties in three of their nickel-based superalloys, so long as the G and R values employed resulted in plane-front solidification. The cellular microstructures that were produced with excessive growth rates had less attractive creep properties than the less fine structures grown under plane-front conditions.

Creep properties of both the 73C (a Co,Cr - Cr_7C_3 alloy) and the Fe, Cr, Al, Y - Cr_7C_3 alloy deteriorated with the small fiber sizes produced at high G and R values. Microstructural observations revealed that the Cr_7C_3 strengthening fibers in the 73C alloy were not stable during the creep test, but transformed, probably to $M_{23}C_6$. This transformation, and a similar one believed to occur in the Fe, Cr, Al, Y - Cr_7C_3, limits the utility of structure refinement for creep inhibition. Similar results would probably occur in all other alloys with unstable structures.

The final session entitled New Processes and Products covered such topics as stircasting, melt extraction, laser glazing, and electrostirring and directional solidification of steels. One process presented was new to most of the audience but has been used in one form for at least two hundred years. A. Handasyde Dick, M.C. Simms, D.D. Double, and A. Hellawell (Oxford) described "A Sheet-Casting Process for Aluminum and Aluminum Alloys" which is based on the process long used to produce lead-tin sheet for the fabrication of organ pipes. The historic method consists of running a wooden box of the design shown in the figure along a stone slab covered with linen cloth. The linen (or sand in the case of roofing sheet) serves to prevent the trapping of air or moisture under the sheet. The sheet produced by the authors using a modification of the historic technique is a few millimeters thick (typically 2 to 5 mm), the width of the gating mechanism 100 mm (in this work), and typically 3 m long. The sheet-cast aluminum alloys have a pronounced dendritic surface structure which could be smoothed by the addition of a small amount of sodium.



The process could probably be scaled up to permit continuous casting of sheets 2- to 5-mm thick by using a contrarotary drum or belt. The authors believe the plant would be simple, relatively cheap, and require a minimum of maintenance.

In his concluding remarks, Professor J. Nutting (Univ. of Leeds, UK) expressed the opinion of many that the Conference was most successful, and that another one of this type should be organized in less than another ten years. (Jack D. Ayers, Naval Research Laboratory, Washington, DC)

A CONUNDRUM: IMPROVEMENT IN THE PROPERTIES OF BERYLLIUM IS NOT MIRRORED BY INCREASED USE

The Fourth International Conference on Beryllium was held in London from 4 to 7 October at the Royal Society, with sponsorship also by the Metals Society. A smooth organization combined with the visceral and aesthetic pleasures of lunches and cocktails in the Georgian atmosphere of the Society's headquarters made for a

pleasant meeting. What a refreshing contrast to the functional (on occasion) meeting rooms of hotels, the normal venue for meetings in the US. The Conference attracted a total of 129 people, although quite a number less than that attended all four days. A successful feature of the Conference organization was the blocking of subjects into interest areas, permitting people to attend those sessions (or days) of specific interest to them. Since the organizers expected about 60 people, and since by one participant's estimate the total number represented about 20% of the active workers in the field, the Conference can certainly be viewed as a success. This success was only marred by the absence of anyone from the US Energy Research and Development Authority (ERDA).

However, while such numbers indicate a continuing interest in the properties and applications of beryllium (Be), the tone of the meeting made it clear that it does not signal increasing use of the material. Quite to the contrary, a general mood of pessimism prevailed punctuated only occasionally by brave statements. Particularly for structural applications, the long time frame needed to develop the requisite strength, toughness (ductility), and fabrication properties that now appear to have been largely achieved, has led to other materials, particularly composites, being used instead of Be. The concern over toxicity and quite rigid health-safety restrictions have further limited expansion into potential new areas, such as consumer goods, although in Japan some Be parts are now being used in audio speakers. Thus, while Be continues to play an important role in nonstructural applications, such as optical mirrors, and inertial and gyroscopic systems, the critical concern is whether the level of market generated by these and some structural applications is sufficient to sustain viable Be production and large-scale fabrication facilities.

There are only two companies in the US that produce Be, Kawecki Berylco (KBI) and Brush-Wellman, and the current depressed market for the metal could lead to a critical reevaluation of the commitment these companies have towards the product. For example, only about 10% of the total sales of KBI are attributable to Be. Both users and producers alike voiced the opinion that this mirrors an insufficiency in the capital base needed to continue the very vigorous research and development programs being carried out by these two companies, as well as by a few smaller companies specializing in fabrication or nonstructural applications. The solution to these problems are not simple nor short range. Certainly the improvement in properties, demonstrated in many of the papers, showed that any pessimism on the future of Be products is not yet accompanied by defeatism or a reduction in research output.

The opening keynote address by Dr. D. Webster (Lockheed-Palo Alto, CA) stressed the main theme of the mechanical properties papers, namely that refinement of grain size and control of inclusion content (primarily BeO), is necessary to obtain elongation values greater than about 5%, the minimum value required to make the material in any way acceptable to structural designers. He suggested that in fine-grained Be, enhanced grain-boundary sliding can promote improved ductility, although it appears to be accompanied by a fracture mode transition from transgranular brittle cleavage to elastic grain-boundary fracture (a brittle fracture with little evidence of associated plastic deformation). Subsequent papers discussed fabrication techniques that could lead to elongations of this amount and more, although these would not always be isotropic values.

The propensity for Be to fracture brittlely in a cleavage mode was treated in a somewhat philosophical paper by S.F. Pugh, [Atomic Energy Research Establishment (AERE), Harwell, UK]. He had predicted about 25 years ago that Be was intrinsically brittle; in this paper he reexamined his prediction *vis-à-vis* the counter argument that purity is the dominant controller. Pugh, using the somewhat general correlation of the ratio of the elastic bulk modulus to the elastic shear modulus to ease of slip, showed that Be has the lowest ratio of all the hexagonal metals. He believes the resultant hard-shear mode has its origin in the partially covalent nature of the bonding in Be. Slip by plastic deformation is then a difficult stress relaxation mechanism, and brittle cleavage occurs. The crack transition to intergranular cracking

in fine-grained Be is suggested to be related to the presence of grain-boundary particles. This is an interesting argument that appears conceptually correct, but needs to be developed further to take into account such factors as microstructure. In a practical sense, if the requisite ductility parameters are reached, the final fracture mode is relatively unimportant since structures are rarely designed to total elongation.

Prof. G.V. Raynor (Univ. of Birmingham, UK) looked at ways of predicting the chemical composition of beryllides, the Be intermetallic phases, using a hard-sphere model. He has developed reasonably successful predictive rules, similar to those for other compounds, relating the stoichiometry of the compound to the atomic radius of the metal and its position in the periodic table.

Dr. T.A. Myers (Univ. of Manchester, UK) examined the reliability of using different proposed pseudopotential-distance relationships in a calculation of vacancy and stacking fault energies. His calculations show that Be has high vacancy formation and stacking-fault energies compared to most other hexagonal metals. The former value is in agreement with the high activation energy of 1.6-1.7 eV for self-diffusion in Be. The high stacking-fault energy was supported by the results of an experimental paper by Dr. F. Aldinger (Max-Planck Institute für Werkstoffwissensechaften, Stuttgart, FRG). He used the maximum resolving power of the electron microscope to predict a lower value of the basal-plane stacking-fault energy of 790 erg/cm^2 for pure Be. This high value restricts the ease of basal cross slip, and was used to explain the occurrence of basal cleavage microcracks resulting from dislocation pile-ups. He showed further that an increase in temperature affects the relative stacking-fault energy of the basal and prism planes, which, he suggests, explains the ductility increase above 470 K, when presumably extensive cross slip becomes possible. Although self-consistent, more direct experimental support of the model is needed.

The subject of microcracks in Be was treated in several papers; their importance in affecting ductility and dimensional stability is obvious. The results presented were often contradictory and thus led to some confusion in interpretation. One reason for this is possible difficulty in discriminating between microcracks and microtwins, both of which can occur. In fact, some of the reported observations of blunted microcracks that spontaneously disappeared upon heating must surely be wrong; the researchers must have been observing detwinning instead.

Dr. J.S. White (AERE, Aldermaston, UK) described a series of studies on thin foils of extruded ingot or hot-pressed Be, fractured in tension at both ambient and high pressures and then examined in the electron microscope. The hydrostatic pressure enhanced fracture ductility, as expected. White attributed this to subgrains acting as crack blunters. Such cracks are actually found prior to total fracture in specimens taken to the necking strain.

The dimensional instabilities of Be parts of the order of 100×10^{-6} observed, for example, during the manufacture of gyroscopic parts were studied by Dr. D.C. Plane (Plymouth Polytechnic, UK) using internal-friction techniques. The behavior was rationalized as being due to the depinning of dislocations from impurities and was analyzed using the well-known Granato-Lucke model. The calculated internodal and interparticle spacings were in reasonable accord with experimental or inferred values, lending credence to this approach. This explanation is also consistent with the observations that annealing prior to and after manufacture reduces the microstrain, and that the extent of the strain varies with material and presumably grain size and purity.

A series of four Russian papers were presented (all by the same person, G.F. Tikhinskij) summarizing work at the Physico-Technical Institute in Kharkov. One quite remarkable result was presented. They claimed that by the use of programmed deformation and thermal treatment on 99.5% purity Be, isotropic, equiaxed 45 μm grain-size material with the following room-temperature mechanical properties could be obtained: 75,000 psi ultimate tensile strength and 22% elongation, a quite significant achievement, making Be quite competitive with structural aluminum, for example.

Another major portion of the Conference was devoted to a discussion of Be-based applications, both current and proposed. By means of introduction,

the following listings presents those properties of Be, either obtained or strived for, that make it useful as well as those problems that must be overcome to afford it greater applicability:

Positive Factors—high modulus-to-weight ratio, dimensional stability, thermal expansion compatability with numerous materials to which it is joined, reasonable high-temperature strength and toughness, good optical properties, low inertial properties, low nuclear cross section for neutrons, and a good neutron moderator. Negative Factors—cost, low toughness, poor creep ductility, bonding problems due to oxide tenacity, toxicity, and inbuilt prejudice towards its use.

In a paper on structural applications, S. Channon (Aerospace Co., CA) discussed the need for an improved data base beyond uniaxial tensile properties (e.g., biaxial, impact, bearing strength). He also suggested that future development work concentrate on a more limited number of alloys, with a hopeful identification of a workhorse alloy. There are also requirements to control crystallographic texture (probably by secondary forming); increase microyield strength to improve dimensional stability; develop selected use of Be components in multimaterial hybrid structures, particularly for stiffness and weight-critical application; and to reduce primary and secondary fabrication costs. His opinion was that many or most of these properties are attainable, provided there is sufficient financial incentive for companies to carry through on development programs.

In the area of nonstructural applications, many uses are well defined, and the consensus was that associated problems are minor compared to those presented above. A number of papers discussed the good optical properties of Be that have led to its use as x-ray tube windows because of excellent transparency to soft x-rays, as well as in proportional x-ray counters, high-speed scan mirrors and telescopes, and infrared systems. Further, Be's resistance to thermal shock and relative inertness to propellents and combustion products make it useful in thermal rocket nozzles. Its low density makes it useful in aircraft brake systems. A quite important area is based on Be's good inertial response and dimensional stability that make it useful for navigation systems where any movement of the mass center appears as a navigational error. Dr. J.S. White in a second paper discussed this application at length. The aim as he sees it is not only to design symmetrical parts to avoid geometric effects, but also to avoid dimensional instabilities resulting from either microyielding due to the imposition of an applied stress (elasto-plasto instability), inherent instability that manifests itself as an external stress-independent, time-dependent dimensional change resulting from either microcreep or from solid-state aging reactions, or from changes in the residual stress pattern; this final factor is really a subset of the inherent instability problem. White found in his study that heavy machining of the surface is the only factor leading to serious dimensional instabilities ($>10 \times 10^{-6}$). He concluded that since machining damage is routinely removed, instability is not an uncontrollable problem to date unless changes of the order of less than 1 part in 10^6 cannot be tolerated. For such applications advanced development is needed. Control requires an understanding of the role of texture, microstructure, microyield stress, and thermal treatment. Extrapolation of data from existing studies to new alloys is complicated by the fact that these properties do apparently vary with the grade of Be and its method of production (e.g., powder, casting, etc.).

An excellent Conference summary was provided by Dr. G.C. Ellis (AWRE, Aldermaston, UK) in a prepared discussion. (He was also the dinner speaker at the Conference banquet). He saw the current overall position for Be as follows: There are only two Be firms in the Western hemisphere, with both operating at a very low level of capacity. Their weak position is all the more distressing since they have had a large and fruitful property-development program. The overriding negative factors for expanded use of Be are toxicity and cost. Any significant long-range improvement in its acceptability and viability will not come from applications such as gyroscope, mirrors, x-ray windows, etc., since these are low tonnage uses. Instead Be must become a viable structural material. The product must be so outstanding that designers will

be forced to accept it. To accomplish this goal he suggested the following development programs, to be carried out jointly by producers and users: 1) exploit the production capacity for Be powder by developing and fully characterizing optimized powder alloys, and 2) stress the use of Be for elevated temperature applications and for structural applications requiring a high bearing strength. There were no vocal objections or counter proposals to his proposals from the audience.

By the end of the Conference it was clear that despite the mood of pessimism many people stood ready to try to solve the puzzle and thereby make Be a more successful and widely used material. (I.M. Bernstein)

A FATIGUING EXPERIENCE: AN AGARD CONFERENCE ON INSPECTION OF AIRCRAFT COMPONENTS

The Fall 1977 Meeting of the Structures and Materials Panel of the NATO Advisory Group on Aerospace Research and Development (AGARD) was held in Voss, Norway, and included a Specialists Meeting on Nondestructive Inspection (NDI) Relationships to Aircraft Design and Materials; the term Nondestructive Evaluation (NDE) is also commonly used to describe such activities.

Voss, a small city of 7,000 population in southern Norway, about an hour by train east of Bergen, proved to be a comfortable and attractive site for the meeting. Attendees were treated to a full spectrum of Norway's weather, from bright sunshine to snow squalls. There was a total attendance of 165, with Sweden and all NATO countries except Iceland and Luxembourg having sent representatives; the dominant countries in terms of number were, respectively, the US, UK, and interestingly, Italy. Prominent among the participants were users of aircraft and thus of NDE techniques for aircraft, such as the commercial airlines (KLM, SAS, Sabena, and so on), several of the European military establishments, and US Air Force and NASA representatives. Secondly, there were groups of people who are doing research on advanced NDE techniques. And finally, there were the manufacturing-inspection people who played a central role in the extensive discussions that were held.

There were three sections spread over the three days of the Specialists Meeting, entitled "General" (techniques, needs, and status of technology), "Metallic Materials and Structures," and "Composite Materials and Structures." The sections included considerable wide-ranging discussion, and in many cases the resulting interplay of viewpoints produced the most valuable insight into both the speaker's topic and the field itself.

The following problem areas received the most attention: 1) The operator problem: This is the largest problem that seems to exist in that cracks in structures are not being found. They are findable; that is, they are large enough to be detected by existing techniques, but they are not actually being found by the procedures that are being followed. Most people agreed that the cause of this is predominantly boredom and mental fatigue. How to motivate an inspector to remain vigilant even though he knows that in only one of perhaps a thousand parts will there be a detectable flaw, is a problem without a ready solution. Suggestions ranged from intensively trained, better-educated inspectors to more complete reliance on automated NDI facilities. By and large the UK favors the former approach and the US the latter. 2) New and improved NDE techniques: A wide variety of new or modified approaches were suggested, ranging from acoustic emission, small-angle neutron scattering, magnetic susceptibility, x-ray diffraction, and internal friction to holography. While each of these has certain advantages, the key necessity of making all suitable for reliable field testing has still not been established. This is especially true of holographic techniques, which are extremely sensitive to vibration, and of other techniques such as neutron scattering, because of the associated bulky instrumentation. One intriguing aspect of papers in this area is the apparent inverse relationship between the complexity of the technique and the technological level of the proposing country. 3) Improved communication with the design community: The designer must understand the inspection needs and design the structure not only so it can be reasonably inspected, but

also so that the actual service problems encountered are anticipated by the design. To put it another way, it is common for fatigue cracking to be expected in one location but to actually occur in another. Or, the design could be oriented toward a toughness problem and something like a stress-corrosion crack would actually occur in service. This means that the design is seriously inadequate, namely, that it does not address the actual failure mode of the structure. 4) New problems: A prime concern was the development of adequate inspection procedures for composite structures. It seemed evident that these materials are of great interest because they are beginning to appear in both commercial and military aircraft, yet many felt that current technology is really not able to deal with them in the way that one is used to dealing with metals. The adhesive-bond-strength problem appears most critical, particularly the identification of weak interfaces in these materials, for which there is no existing inspection technique. There are procedures that identify so-called de-bonds, that is, areas where the material is not bonded together. But to find weak bonds that are nevertheless in physical contact seems to be something for which there is presently no technique.

In addition to the specialist's meetings, a considerable amount of time and effort was taken up with such parallel activities as working activity sessions, subcommittee meetings, panel business session, and technical program and editorial committee meetings. In general, these were open only to panel members or by special invitation, but those with a strong interest were usually admitted, particularly to the working activity sessions.

These sessions are quite important because the subject under study will serve as a future specialist meeting; several of these are usually ongoing at the same time. As an illustration, one of the working groups is setting up a round-robin cooperative testing program on the corrosion-fatigue susceptibility of aluminum-alloy aircraft components. Several laboratories in a number of NATO countries will be involved in order to establish the reliability of the data, as well as hopefully to provide needed information to develop more resistant alloys. An important goal is to prevent funding constraints and other laboratory commitments from diluting the results of the program.

A soon-to-be published conference report will discuss these various aspects of the meeting in more detail. [A.W. Thompson (Carnegie-Mellon Univ., Pittsburgh, PA.) and I.M. Bernstein]

MATERIAL PREPARATION AT RSRE—TOWARDS A MORE PERFECT CRYSTAL

As pointed out in the article "Panel Displays" (p. 485 of this issue), the Royal Signals and Radar Establishment (RSRE) at Malvern, Worcs., UK, is a large electronics laboratory with a total staff exceeding 3000. RSRE's interests extend from research through development. Its operation is characterized by the high level of its successful application and by proven ability to develop cooperative programs with industry.

The Establishment's Electronic Materials Division is headed by Dr. W. Bardsley who has a staff of over 30 covering a wide range of disciplines: chemistry, physics, electrical engineering, and theory. This group is faced with the problem common to all materials staffs—how should the need for research and development of new materials and processes be balanced against the requests for service from other parts of its parent laboratory? At RSRE this is solved in two ways. One is by actively transferring new technology to industry. For instance, there is now no longer any GaAs materials work going on at RSRE even though the Division had been heavily involved. The device and systems groups at RSRE now turn to industry for these materials. The other approach to finding a proper role for materials is by concentration of the materials research effort in areas in which there is a distinct applied need and for which the group feels there are good opportunities for advancement. As a result, there is a strong tradition of research and achievement in the materials field, and also in areas of strong practical interest.

As the largest electronics research laboratory in the UK and with its support coming from various arms of the government, RSRE groups take seriously

a large responsibility for the development of both military and commercial electronics. The role of the Electronic Materials Division is to plan the future, conduct research, develop new materials and techniques, supervise related research and development contracts, and oversee and guide the rapid but orderly transition of new technology into industry. To make such a broad mandate work—and this group at RSRE seems to be particularly successful at it—requires both a high degree of talent and dedication to the role. It also requires that the sponsoring organization show its confidence by accepting the laboratory's technical leadership and by providing stable financial support as seems to be the case here.

InP is the material on which the greatest amount of attention is currently being spent at RSRE. With its high mobility for electronic transport, it would be a logical material to follow Si and GaAs in the push to ever higher frequency in electronics. However, InP is notoriously difficult to prepare. Phosphorous compounds tend to be polymorphic, they are very reactive, and the high vapor pressure of P requires that crystals be grown at high temperatures and high pressures to achieve stoichiometry. By use of apparatus that will be described later in this report, bulk InP is prepared from the melt with a lower limit of 10^{15} defects/cm^3 in undoped materials. Such materials are useful for substrates for electronic devices. On these materials thin layers of InP may be deposited by chemical vapor deposition. The best of the vapor-deposited materials has a defect concentration of only 10^{13}/cm^3 and an electronic mobility of 100,000. There are difficulties, however: making contacts has been a problem; also, the thickness of the vapor-grown films and the impurity concentrations are not yet reproducible enough for high-quality device manufacture.

Supporting research on InP has involved careful studies of the deposition of the material under high vacuum with accompanying analysis of the surface chemical composition and structure in the same vacuum using electron diffraction, Auger, and mass spectroscopy. One of the results of these investigations has been the discovery that there is appreciable evaporation of InP molecules from the surface at temperatures as low as 325°C. Since many of the normal device-processing steps involve heat treatments well above this temperature, changes in device fabrication may be necessary for InP. Another result of these studies and of the electron-microscope work has been the discovery that at sufficiently high temperatures P leaves the surface and In is left as a collection of small droplets. They find that putting Ag down on such a surface produces single-crystal Ag and makes an extraordinarily good ohmic contact.

A long-time interest of RSRE has been in infrared optical systems. In particular they are looking to the use of the atmospheric window in the 8 to 13 micron range. A useful optical material in this wavelength range is Ge which can be used in many cases for windows or simple lenses. However, for high-precision lenses another material is needed for use with Ge in producing achromats. For this purpose J.A. Savage and his associates are concentrating on Ge-As-Se optical glasses. They are concerned with making physical measurements on a wide range of compositions so that the composition may be optimized. Also they are investigating the preparation of glasses by using a hydrogen distillation method as a way to remove oxygen from glasses formed from relatively inexpensive raw materials.

Another area of concern is the development of solid-state lasers that emit in the 2-μm region where the potential of accidental eye damage is reduced from that for lasers operating in the visible or near infrared. Work is currently underway on $YLiF_4$:Er, Tm, Ho. Although the field use of lasers would be facilitated by the development of a good 2-μm laser, such a system would also need a more efficient optical detector than is now available in order to compete in performance with the YAG:Nd laser that works in the near infrared.

A variety of materials is being studied for use in surface acoustic-wave devices. For applications requiring materials with a low acoustic velocity of about 1000 m/sec, Tl_3VS_4 is being produced. In the range around 3000 m/sec in which quartz and lithium-niobate are frequently used, $AlPO_4$ and $GaPO_4$ are being developed because of their high electromechanical-coupling coefficients. AlN and GaN

formed as epitaxial films are possibilities for applications requiring higher velocities of about 6000 m/sec.

An old problem in cathode-ray tubes is the relatively low efficiency of conversion of electronic energy into luminescent light. Over the years a great deal of empirical information on phosphor systems has been collected, but there is little conclusive information on the energy-loss mechanisms. A rather fundamental effort is underway at RSRE to study these problems in a model system. D. Robertson is preparing YWO_4:Eu crystals as part of such a study. ONRL Conference Report C-4-77 discusses the approach and some preliminary results of the RSRE research.

A materials project, only recently inaugurated, is to establish a facility for growing 4-inch silicon crystals now widely being used for large-scale integrated electronics. There is no other UK facility for growing crystals of this size, and it is the feeling at RSRE that such technology should be available. They aim to develop the skills for growing this type crystal and for preparing the blanks and then to interest industry in taking over.

One of the problems that troubles silicon-crystal production is that of striae. D.T.J. Hurle has been studying the possibility that instabilities in the hydrodynamic convective flow in the molten liquid could be the source of the striae. Experiments on molten gallium confirm the theory describing these effects. It has been found experimentally that the oscillations can be damped out by the application of a sufficiently high transverse-magnetic field.

Central to much of the success of the materials group in preparing large single crystals has been the development of elegant crystal-growth equipment. They have now constructed a total of 16 separate growth facilities built around the same general design. This is an enclosed apparatus, with the crucible heated by induction, and capable of operation at temperatures up to 1200°C and at pressures up to 750 lbs/in^2. A TV camera observes the crystal where possible, but an automatic constant-diameter control system allows for crystal growth over a period of a week without attention from the operator. This extraordinary control is largely the work of G.C. Joyce who developed the reliable and sophisticated electronics required. In this system, the crystal is pulled from the melt at a constant speed. The rate of growth of crystal volume is the time derivative of the weight of the crystal or of the crucible and liquid. For a good cylindrical crystal this derivative must be kept constant. The control system achieves this by altering the induction-heater power to maintain constancy. However, thermal lag and several other effects would normally lead to an oscillatory growth pattern as the temperature alternatively overruns and underruns the desired value. The electronics are designed to anticipate these phenomena and adjust for them. There are three separate adjustable feedback loops. One adjusts for lags in the thermal heating of the crucible and its liquid and prevents overshoots in the temperature of the melt. A second corrects for the change in the miniscus angle at the crystal-liquid interface as a function of height of the interface above the liquid. It also corrects for the difference in density between the liquid and solid that can affect the weight of the crucible as the liquid-crystal interface moves. Finally, there is a vertical force exerted on the crucible by the induction heater if the crucible is not exactly centered. This force depends on the induction power and would appear as a change in weight if not corrected for.

It has been found that it takes about six crystal growths of a new material to optimize all the adjustments in the electronics. In some cases this can involve considerable time and expense. To aid in the learning process, an electronic crystal simulator has been developed that reacts to the crystal-growing controls as would a real crystal. Inputs to this device are the melting point, thermal conductivity, heat of fusion, and other physical data. The simulated growth process may be speeded up—typically by a factor of ten—so that rough adjustments may be made quickly. The final adjustments are then made on real crystals. A commercial model of the RSRE crystal-growth apparatus and the associated electronics is being marketed by Metals Research of Cambridge (UK).

To support its activities the Materials Division at RSRE has a well-equipped analysis section with x-ray

equipment and 2 scanning electron microscopes. A new microscope operating at 120 kV has a resolution in transmission of 4 Å and 15 Å when used in a scanning mode. This apparatus was particularly useful in studying the contacts of Ag on InP described earlier.

The RSRE's Materials Division is a large, self-sufficient, and resourceful group that have long been among the leaders in the field of crystal-growth research. At the same time they pay attention to their responsibilities as a service organization in support of the rest of the laboratory and effectively integrate their efforts into the broader RSRE program. That seems to be a narrow path to tread; but the RSRE materials team walks it very well. (Clifford C. Klick)

9TH ANNUAL BRITISH MASS SPECTROMETRY MEETING, UNIVERSITY COLLEGE OF SWANSEA, WALES

The 9th meeting of the British Mass Spectrometry Group during the last twelve years was held 26-29 September at the University College of Swansea. It was attended by more than 250 scientists from throughout Europe and the United States. This was by far the largest attendance in the history of the Group. The reason for nine meetings in twelve years is that the Group does not meet every third year when the International Triennial Meeting takes place at some European site. The President of the British Mass Spectrometry Group is Dr. Alan Carrick of Kratos AEI who is to be complimented for organizing an outstanding program.

Among the highlights of the meeting were the papers presented by Prof. Donald Hunt (Univ. of VA) who described his very exciting work in negative-ion, high-pressure mass spectrometry. Hunt has been able to modify a chemical-ionization, quadrupole mass spectrometer to detect and record positive- and negative-ion spectra simultaneously. The chemical ionization produces positive ions and thermal electrons. Hunt's technique uses these thermal electrons to produce negative ions. By a very ingeneous pulsing technique and using two electron multipliers, he has been able to detect and record both ion spectra. With this technique he has characterized femtograms of organic molecules such as kepone, TNT, etc. The great sensitivity obtained is due to the fact that thermal electrons are not diffusion limited. Therefore, they collide with a much greater number of molecules, producing more negative ions.

Several of Professor John Beynon's students from the University of Swansea presented papers which describe the use of the mass-analyzed ion-kinetic-energy spectrometry (MIKES) technique that they have developed. The technique is used to measure the kinetic-energy release accompanying mass spectrometric-induced fragmentation processes in organic molecules, as well as the kinetic-energy loss or gain upon collision with a second body. It has been applied to the study of energy partitioning, the determination of reaction mechanisms, the correction of ion enthalpies, and ion-structure determination. Dr. John Chapman (Kratos AEI, Manchester, UK) described the modifications of a Kratos AEI MS-30 mass spectrometer for chemical ionization and pressure-enhanced spectra. His paper illustrated the use of perfluorokerosene for chemical mass marking in the pressure-enhanced mode of the MS-30. Professor Keith Jennings (Warwick Univ., UK) described negative-ion reactions using O^- and OH^-. Jennings pointed out that frequently the M-1 ion in many ion-molecule spectra is not due only to the reaction of O^-, but is also produced by a reaction of OH^-. OH^- is produced in an earlier step in the reaction between O^- and the hydrocarbon. Jennings' technique was able to resolve these hydrogen-transfer fragmentation mechanisms. In a series of papers, Professor John Todd and his students (Univ. of Canterbury, UK) described several techniques that used the Quistor ion source. The Quistor is a quadrupole ion-storage trap. In conventional chemical-ionization studies, the ion-source pressure is raised to produce ion-molecule collisions and reactions. This elevated ion-source pressure requires that extensive additional equipment be added to the mass spectrometer. In the Quistor, however, reactions are effected by increasing the residence time of the reacting species in the ion source, thus eliminating the auxiliary equipment needed for

high-pressure mass spectrometry. Therefore, with this device ion-molecule reactions may be studied at low pressures. The advantage is that a Quistor can be used to make a very small, low-cost, portable mass spectrometer for the study of high-pressure reactions. However, from the information presented in these papers, there is a great deal of work remaining before the Quistor is ready for such an application.

Prof. H. Leibl (Max-Planck Institute, Garching, FRG) reviewed the use of Secondary Ion Mass Spectrometry (SIMS) to characterize various surfaces. SIMS has been used to profile surfaces chemically to a depth of 100 Å. He explained both the static and dynamic versions of SIMS that were used to obtain a very complete and detailed analysis for a number of surfaces. Prof. Brian Millard (National Hospital, London, UK) dealt with single-ion monitoring and analytical techniques for the detection and characterization of molecules of biological and drug interests. By using these techniques, femtogram analysis was carried out. The reasons for loss in sensitivity in most gas chromatograph-mass spectrometer systems were very carefully delineated. The loss of sensitivity is generally due to poor gas chromatographic techniques and an incorrect choice of ions for monitoring. Dr. J. Caldwell (St. Mary's Hospital, London) spoke of the mass-spectral analysis of a variety of compounds that are used in the delivery rooms of hospitals and discussed a large program being carried out to determine the manner and magnitude of drug transfer between mother and child. The metabolic breakdown of most drugs appears to be far slower in babies than in their mothers.

The 9th meeting of the British Mass Spectrometry Group was an outstanding conference, and the Group's officers are to be congratulated. The large attendance underscored that the use of mass spectrometry in the basic sciences, as well as its application especially in the biochemical area, is growing. This growth primarily is due to the analytical power of the gas chromatograph-mass spectrometer computer system and the extensive data bank of mass spectra. The system has made it possible for scientists who are not trained in mass spectrometry to obtain and interpret mass-spectral data on complex organic mixtures readily. Having organized many conferences in the US, we know the considerable amount of work that is involved. We wish the British Group every success and hope that their future programs retain the high quality of the Swansea meeting. (F.E. Saalfeld and J.J. DeCorpo, Chemistry Division, Naval Research Laboratory, Washington, DC)

MECHANICS

AERONAUTICS AT THE POLYTECHNICUM OF TORINO

It was with keen anticipation that I visited the Polytechnicum of Torino, one of the foremost institutes of technology in Italy, in order not only to become acquainted with the research activities in Aeronautics but to learn more about the style of Engineering Education in Italy as well (see also Barcilon, "Research Climate in Italy," *ESN* 31-6:239 and Blachman, "Information Theory in Trieste," *ESN* 31-6:229). The tradition of technology in Italy reaches back into Roman times when the Coliseum in Rome and the Arena in Verona (circa 100 BC) along with the many aqueducts, roads, bridges, and other structures were built.

Italy's contributions to aeronautics are manifold and imaginative and include, for example, the pre-WWII speed-record-holding Macchi-Castoldi seaplane powered by tandem FIAT engines driving coaxial counter-rotating propellers and the ducted propeller-with-afterburner Caproni-Campini jet aircraft which also flew before WWII. After WWII, the noted fluid dynamicists, Luigi Crocco and Antonio Ferri, among others, emigrated to the United States to assume professorships in our universities.

Engineering students in Italy enroll in a five-year curriculum leading to a Dr. Eng. degree which is a "professional" doctorate that does not entail original research. The degree is roughly at the level of the American Master's degree. The Aeronautics program in the Polytechnicum is contained in the Institute of Applied Mechanics, Aerodynamics, and Gasdynamics (IAM)

and the Institute for Aircraft Propulsion (IAP). Some 100 students are enrolled for the Dr. Aero. Eng. degree although the IAP and the IAM also instruct an additional 600 mechanical engineering students in service courses. Graduates of the five-year curriculum may continue postgraduate studies leading to the Dr. Aerospace Engr. degree only at Torino or the University of Rome.

The director of the IAM is Prof. G. Jarre, and the faculty of the Institute consists of 10 professors in various fields such as aerodynamics, gas dynamics, aeronautical dynamics, systems, applied mechanics, and solid mechanics. My visit was coordinated through Prof. C. Ferrari, the senior professor of the Institute and a former director, who explained the organization and arranged for me to meet with some of his colleagues at the IAM and the IAP.

Prof. M. Onorato, who worked postdoctorally at Brown University with Prof. J.H. Clarke in radiative gas dynamics, is currently involved in research on gasdynamic lasers. The principle is to pump energy into a nonequilibrium vibrational mode of the gas molecule which then dumps its energy in the form of coherent radiation. Accordingly, a mixture of CO_2, N_2, and H_2O is heated to an equilibrium temperature of 1800 K and then expanded rapidly through a short (plug) nozzle with an expansion-area ratio (throat to exit) of 1:50. The translational temperatures of the gases adjust rapidly to the change and are therefore in equilibrium, but the vibrational temperatures do not and therefore are in a suitable state to lase. The actual nozzle consists of an array of two-dimensional minimal length nozzles which are 5 cm long and have throats 1 mm wide. The lasing chamber is formed by the nozzle exits, and the direction of radiation is perpendicular to the flow direction. Onorato has performed theoretical calculations of the flow fields including nonequilibrium effects and conducted concurrent experimental tests. He is presently extending the theory to account for viscous effects at the boundaries. Onorato has also worked in strong shock-wave structure as influenced by energy loss through bremsstrahlung radiation (electromagnetic radiation caused by ionized-particle interactions).

Other research activities of the IAM have been in such diverse areas as freeze-desalinization of water, locomotion of aquatic animals, drag reduction through polymer additives, boundary layers, and generalized radiative gasdynamics. The laboratory of the IAM contains a low-turbulence wind tunnel for boundary-layer research, a pressurized (3-atm) subsonic wind tunnel with a 3-m-diam. test section for velocities up to 100 m/sec, a water tunnel, a shock tube, and a flow test facility for evaluating the drag-reducing effects of polymer additives in water.

The IAP with five Professors is directed by Prof. M. Andriano. The activities of the Institute lie in the areas of experimental work on internal-combustion engines, numerical compressible fluid mechanics of turbomachinery, and nonlinear programming and optimization. The people active in these fields were introduced to me by Prof. M. Pandolfi who works in numerical fluid mechanics and was a student of Prof. G. Moretti of the Polytechnic Institute of New York (formerly Brooklyn Polytech.). Pandolfi has also cooperated with Onorato in a numerical investigation of radiating blast waves and is presently active in numerically modeling free-surface flows.

An interesting experimental investigation of the flow field in a small diesel-engine combustion chamber is being conducted by Dr. A. Catania under Andriano's direction. Catania is using hot-wire probes to measure the velocity and temperature distribution of the flow field in the combustion chamber of a test engine before combustion. The object of the exercise is to evaluate the effectiveness of various combustion-chamber designs for an automotive manufacturer. In a good design, air enters the cylinder through the inlet valves in such a way that it swirls inside the combustion space. It is important that the air continues to swirl so that the temperature and composition of the combustion products are brought as close to homogeneous as possible by the swirl-induced mixing. To reduce viscous and thermal conductivity losses, the surface-to-volume ratio of the combustion chamber must be as small as possible. Also, the fuel injection spray must be so located

as not to reach the surface of the combustion chamber; the fuel which would wet the surface would combust poorly and lead to engine inefficiency. Catania has used hot-wire probes successfully to measure precombustion temperatures up to 850°C; the probe material was an alloy of platinum and rhodium.

In the area of optimization, Dr. N. Nervegna has studied such problems as a diesel engine-torque converter-gear box system, a space radiator of minimal weight, and a thermodynamic cycle for a high-temperature, helium-cooled, nuclear reactor. Nervegna's approach is to select an objective function to be optimized in terms of the n parameters involved. The usual procedure for this is to evaluate the objective function at the vertices of a minimal, generalized polyhedral element in the n-dimensional parameter space (line segment for one dimension, triangle for two dimensions, tetrahedron for three dimensions, etc.) and to reflect the vertex having the highest value through the centroid of all n vertices to obtain a new vertex at which the objective function is evaluated. The remaining (n-1) vertices of the old polyhedron and the new vertex form a new polyhedron upon which the procedure is repeated, etc. Nervegna's improvement for faster convergence consists in reflecting through the centroid of the remaining (n-1) vertices instead of all n vertices. Another modification is to combine this search procedure with evaluations of the gradient of the objective function to obtain the zeros in gradient.

I was impressed with the program at the Polytechnicum of Torino, particularly in view of the fact that there are very few postgraduate students and that very low faculty salaries necessitate moonlighting by most of the Faculty to keep body and soul together. (Martin Lessen)

ONRL REPORTS

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

THE INSTITUTE OF AERODYNAMICS AT THE UNIVERSITY OF NAPLES

Though it is located in the beautiful and relaxed south of Italy, the Institute of Aerodynamics (IA) of the Faculty of Engineering at the University of Naples is a beehive of activity. The Institute's faculty includes the Director (Prof. Luigi Napolitano), two additional chairholders (Profs. Rodolfo Monti and Giovanni D'Elia), besides eleven other professors, and it graduates some fifty students per year with the degree of Laurea (Professional Doctorate). Though there are no graduate students at the IA, there is a considerable amount of research activity taking place over a range of topics that are usually considered outside the purview of Aerodynamics *per se*.

In the area of Bioengineering, Monti described work in progress in Thermography and Fluid Mechanical Aspects of Oxygenators; both projects are sponsored by the Consiglio Nazionale delle Ricerche (CNR), the Italian equivalent of our NSF.

Thermography is a noninvasive method of tumor detection (used most frequently in breast-cancer diagnosis) which depends on the higher metabolic production of heat at a tumor site causing a higher skin temperature; this increased skin temperature is then detected by an infrared radiometer that prepares a thermal mapping of the region being examined. A difficulty in applying the method arises in achieving a reliable equilibrium skin-temperature distribution after the patient disrobes for the thermography because the thermal diffusion times from the tumor to the skin are generally longer than the few minutes usually allotted for equilibration; the actual thermal equilibration time after disrobing may be of the order of three hours. Monti and his co-workers have made analytical and numerical studies of transient and steady heat transfer in the human body in the presence of tumors. They have correlated the calculated location of the expected lesion with the actual lesion at time of surgery. In addition, they have studied the influence of ambient temperature and skin cooling on the reliability of the diagnosis and have explored an alternative technique of chilling the skin and then observing the transient temperature and its time-wise derivative. This latter method

has shown greater predictive accuracy than the "equilibrium" method when checked by clinical experiments in the presence of known tumors.

There are some severe fluid mechanical problems in connection with membrane oxygenators. The diffusion of oxygen across a membrane is governed by the diffusivity of the membrane and the difference in partial pressure of oxygen on both sides of the membrane. If oxygen is not transported away rapidly enough on the blood side of the membrane, the diffusion across the membrane will slow down. Two methods have been suggested to promote the diffusion process; to generate turbulence in the blood or to section the membrane so that it presents multiple leading edges. Turbulence will transport the oxygen away from the blood-membrane interface while the leading edge flow about the membrane causes a thin boundary layer and enhanced diffusion. Unfortunately, both turbulence and leading-edge boundary layers are associated with high local shearing rates of the blood and so cause excessive hemolysis or destruction of red blood cells.

The problem of hemolysis can be dealt with by using a hydrophilic (wettable) membrane which causes a layer of fluid to be interposed between the blood and the membrane; in addition, the oxygen is provided by an oxygen-saturated saline solution on the other side of the membrane. With this type of oxygenation, nutrients can be added to the oxygenated saline solution and waste products removed. However, oxygen diffusion rates are much lower in this device than those of nonwettable membranes, hence the necessary apparatus is much more cumbersome.

An attractive possible solution being studied at the IA consists of adding oxygen and possibly nutrient-enriched plasma to the blood at one point and filtering the plasma out of the blood at another point to maintain a normal hematocrit (red cell count). One- and two-dimensional analyses of this process are in progress.

In the more classical area of astronautics, Monti is engaged in studying hybrid gas generators consisting of liquid oxygen-solid fuel, and ram-rocket systems for propulsion. The ram-rocket consists of a hybrid gas generator to which ram air can be added upstream of the solid fuel during operation in the atmosphere. Calculations show that such a ram-rocket system is attractive for a variety of missions.

Napolitano, the Director of the IA, is engaged in a number of theoretical investigations including application of splines, applied functional analysis, and free convective flows. Splines, invented approximately thirty years ago by Prof. I. Schoenberg (most recently Univ. of Wisconsin), is a method of optimal curve fitting through specified points using piecewise continuous polynomial curves; the fit is optimized by minimizing the integral along the curve of the qth derivative squared of the curve. If the total number of points is n, q must be less than n. For a Hermite, closed spline, not only are the coordinates of the points specified but also the derivative of the curve at the points. The work on curves is being extended and applied to surfaces and hypersurfaces.

In the area of applied functional analysis, nonlinear elliptic boundary-value problems are being studied. Hybrid functionals and new functionals for variational methods are being constructed and applied to finite element methods of solution.

Napolitano's study of free convective flows is concerned with the role of gravity terms that are usually included in the momentum equations but neglected in the energy equation. He is ordering these terms to see which are of importance. In the area of low-gravity, free-convection flow he is studying surface driven flow caused by an inhomogeneous temperature distribution. Since surface tension is a function of temperature, it is clear that an inhomogeneous surface-temperature distribution will induce a flow.

Napolitano's program for the study of free convective flows therefore includes the mathematical modeling of the flows, the solution for the equilibrium-flow configurations including the free surfaces, the study of the stability of the equilibrium configurations, the design of experiments to simulate low gravity using immiscible liquids of almost the same density, and finally rocket and spacelab experiments.

The programs that I saw at the IA are ambitious and if successful, meaningful. (Martin Lessen)

OCEAN SCIENCES

APPLICATION OF REMOTE SENSING TO OCEAN SURVEILLANCE—AGARD LECTURE SERIES

The NATO Advisory Group for Aerospace Research and Development (AGARD) sponsored a lecture series during the period of 3-11 October on the utilization of remote sensing for ocean surveillance. This series treated eight subjects over a two-day period, and was delivered in each of the following cities: Oslo, Norway; Den Helder, the Netherlands; and Rome, Italy, thus underscoring the importance of giving this subject the widest dissemination among the NATO community. The significance of the topic was further underscored through the presentation of the keynote address at all three locations by the Chief of Naval Research, Rear Adm. R.K. Geiger, USN, and the moderation of the series by the Director of Navy Technology, Dr. R.N. Keeler. The technical papers were of high quality, rather detailed, and tutorial in nature, although the application theme of the various sensing techniques was highlighted in all cases. Specific topics treated included microwave radiometry, infrared radiometry, visible spectrometry, side-looking radar, and ELF communication and detection. Speakers included scientists from the US, Germany, Italy, the UK, and France.

In his keynote address, Admiral Geiger pointed out that remote sensing is a technological and scientific field that has undergone major advances in the last three decades owing to the growth of aerospace technology in both the defense and civil sectors, the concurrent rapid advancement of data-processing capability and communications technology, and the requirements of the military departments for early-warning reconnaissance and surveillence and those of the civilian agencies for accurate weather forecasting. He pointed out that two aspects of ocean surveillance that are of vital interest to the Navy are (1) the detection, location, and classification of targets, and (2) the ability to measure and predict the environmental parameters to support command decisions for improved mission effectiveness. These aspects when applied to remote sensing in general are, of course, vital to the Army and Air Force as well. The information must be timely and accurate, particularly in the case of the highly dynamic environment in which the Navy must operate. Recent basic research has revealed that the ocean's structure is of a much greater complexity than previously believed and is analogous in many ways to the atmosphere. One important analogy is the "oceanic weather." It is with the intent of being able to predict oceanic weather accurately in real time that the Navy is sponsoring and monitoring the various research and technological developments described in this AGARD lecture series.

In the opening technical paper, E. Raschke (Univ. of Cologne, FRG) briefly outlined the basic fundamentals of the atmosphere and the oceans, emphasizing the radiative transfer aspects, the nature of the interaction of electromagnetic radiation with the atmosphere and oceans, and the parameters of interest at the atmosphere/ocean interface. He pointed out that the electromagnetic spectrum of particular interest in remote sensing ranged from the ultraviolet (0.2 μm) to the microwave (10 μm). Subsequent papers treated various devices and techniques currently being utilized and developed to exploit remote sensing.

Papers by J. Hollinger, (Naval Research Laboratory, Washington, DC) and E. Windsor and H. Mooney (British Aircraft Corporation, Space Systems Group, Bristol) addressed remote sensing by means of microwave scanning radiometry, a technique for passively sensing the microwave radiation from various objects and earth formations. Its advantages over active microwave sensing devices (radars) are that it uses very little power and is covert and difficult to jam. It offers several potential advantages over passive sensors operating at the infrared, optical, and ultraviolet wavelengths—specifically all-weather day and night operation. Further, it is capable of detecting metal objects (targets for example) that appear cold, as they emit negligible microwave radiation and reflect principally the low-temperature radiation from space and the atmosphere, against the relatively hot-earth background. This permits the detection and tracking of missiles even after burnout, resulting in more

accurate and current trajectory determination. A microwave imager, however, needs to use large aperture high-gain antennas with narrow beams in order to obtain the high resolution and signal-to-noise ratios required for detection and tracking. With current technology, passive microwave sensors capable of detecting targets the size of aircraft or ships would require prohibitively large antenna structures for satellite installation, but would be feasible on aircraft due to the lower altitude. The use of passive microwave sensors on satellites has been investigated for measurements of the ocean's characteristics and for observation of the polar ice caps and of the atmosphere's meteorological and climatological conditions. The resolutions available for these remote sensing applications have been shown to be feasible, and hardware is currently being developed for space tests. The authors, after detailing the physics of passive microwave sensing, concluded by outlining the results of system studies for both airborne and space-borne systems.

Papers by H. Hodara and W. Wells (Tetra Tech, Inc., Pasadena, CA) and W. Barnes (NASA, Goddard Spaceflight Center, MD) treated the physics and state-of-the-art applications of infrared and visible spectrometry with respect to remote sensing of the oceans. Hodara and Wells derived an equation that describes radiometric temperature fluctuations in the top millimeter of the sea surface and identified sources of errors masking the true sea temperature changes, such as humidity fluctuations in the air column between the sea surface and the radiometer, and reflected sky radiance from the rough sea surface. They pointed out that these masking effects could be minimized by proper design of the radiometer. Similar derivations were made for the visible. A good deal of discussion was stimulated as to the validity of several of the assumptions used. The Barnes paper discussed the current status of visible and infrared sensors designed for remote sensing of the oceans. Emphasis was placed on multichannel scanning radiometers that are either operational or under development.

J. Genuist (Thomson-CSF, France) presented a summary on the use of side-looking radar (SLR) to obtain very high-resolution images of the terrain overflown by an aircraft. Two data-processing methods were described and different experimental results were presented for each process: low pass filtering and optical correlation. The conclusion reached was that various trials that have been made to improve both techniques have enabled the theoretical limits of resolution to be approached.

G. Tacconi (Univ. of Genoa, Italy) presented some of the fundamentals of ELF (electromagnetic radiation in the 1.0- to 10-Hz range) propagation, and discussed the use of such radiation for communications, detection, and evaluation of geophysical structure of the propagating medium. ELF waves suggest applications for communications through dissipative media such as sea water because of their long wavelengths and the relative skin depth of the sea water. Underwater as well as satellite-to-submarine links were discussed together with the potential problems associated with their implementation.

The lecture series was concluded with a round-table discussion involving all of the speakers. Many points on the details of the various papers were brought out as well as the general subject of how to provide adequate data processing for the vast amounts of remote-sensing data that will be pouring into various centers. No specific conclusions were drawn on how to resolve this problem which is complicated by the fact that there are currently many data-processing centers servicing various programs and these centers are worldwide. The subject was left as one for further study as interaction of the programs and centers evolves.

In general the series was most informative, covering everything from the reasons for the high priority placed on remote sensing by the Navy, through the basic methods of operation of remote-sensing detectors, to current and potential application of different systems. The quality of the papers was high, and the method of presentation and subjects covered were well thought out. (Robert W. Rostron)

NATO AIR-SEA INTERACTION SYMPOSIUM

The North Atlantic Treaty Organization (NATO) Symposium on Turbulent Fluxes Through the Sea Surface, Wave Dynamics, and Prediction was held near Marseille, France on the Ile de Bendor from 12-16 September 1977. The joint directors of the Symposium were Prof. A. Favre, Institute de Mécanique Statistique de la Turbulence (IMST), Marseille, France and Prof. Dr. K. Hasselmann, Max-Planck Institute für Meteorologie, Hamburg, FRG. They opened the meeting with additional comments by Dr. M. Di Lullo from the NATO Division of Scientific Affairs and a member of the NATO Air-Sea Interaction Panel. This five-day symposium was very well organized, gathering together leading theoreticians, laboratory experimenters, and operational-prediction people. The success of the meeting was facilitated by the site's being a very small island. This encouraged exchange of ideas between the 75 participants; conversations were always dynamic and sometimes quite turbulent. We agree with Dr. J.A. Anderson (Chr. Michelsen Institute, Bergen, Norway and NATO Air-Sea Interaction Panel Member) who, in his closing speech, predicted advances in man's understanding of air-sea interaction phenomena as a direct product of the meeting.

Reflecting the title of the Symposium, there were three sections: fluxes, wave dynamics, and prediction. The selection of papers by the scientific committee was very well balanced between these topics. In addition to Favre and Hasselmann, the scientific committee included Prof. H. Lacombe (Laboratoire d'Oceanographie Physique du Muséum National d'Histoire Naturelle, Paris, France), Prof. M.S. Longuet-Higgins (Univ. of Cambridge, UK), and Prof. E. Mollo-Christensen (MIT, Cambridge, MA).

The interdisciplinary papers presented in the fluxes sessions added a dimension to the Symposium usually not found at a wave-dynamics or wave-prediction conference. Heat, water vapor, momentum, particulate, and droplet fluxes were discussed. The role of the surface microlayer in wave generation and measurement, particularly by remote techniques, was mentioned. An excellent review paper on particulate matter exchange across the ocean-atmosphere interface was presented by R. Chesselet (Centre de Faibles Radioactivités Laboratoire, Gif-sur-Yvette, France). The mechanism of upward transport of particulates from the sea is not very well understood. It is believed that estimates of 10^{18} bursting bubbles per second over the ocean may explain the sea salt but not the 10^{9} tons per year of particulates transported from the sea to the atmosphere. The papers on fluxes included bulk-measurement techniques in the field, and laboratory studies with the general theme that flux processes, wave generation, and wave propagation are dynamically coupled. Although the relationship of the laboratory studies to the real world was challenged, it was obvious that such investigations are necessary to increase man's understanding of the complicated interrelationships and that the laboratory work can be of significant assistance in the design of field measurements. J.A. Businger's (Univ. of Washington, Seattle, WA) paper on the structure of convective elements in the atmospheric boundary layer clearly demonstrated the problems associated with field measurements caused by intermittency of the fluxes, that is the differences in the specific observations from within a convective element or outside the element.

One of the most challenging problems for air-sea interaction scientists has been the direct measurement of evaporation over the sea. Dr. Liliane Merlivat (Commissariat à l'Energie Atomique, France) showed laboratory data obtained in an air-water tunnel at IMST indicating that the distribution of D and ^{18}O in the air over a water surface can be related to evaporation. Agreement between experimental and theoretical isotopic distributions was convincing, and the ability to obtain drag and bulk evaporation coefficients from the observations is a promising new development. K.H. Fischer and his associates (Institut für Umweltphysik, Universität Heidelberg, FRG) reported on the measurements of transports of vapor, CO_2, and other gases. This paper, delivered by K.O. Münnich (Heidelberg), indicated isotope techniques will be increasingly used in the future both in the field and in the laboratory. E.P. Jones and S.D. Smith [Bedford Institute of Oceanography (BIO), Canada] reported on other field observations of CO_2 fluxes measured at Sable Island during a period of ocean warming, when the

solubility of CO_2 decreases and CO_2 is therefore released from a saturated ocean. This experiment is an example of the ingenious choice of circumstances for a well-conceived experiment, giving credible results. The B.R. Bean and R.F. Reinking [National Oceanic and Atmospheric Administration (NOAA) Environmental Research Laboratory, Boulder, CO] paper, presented by Bean, reported on aircraft observations of fluxes in the Global Atmospheric Research Program Atlantic Tropical Experiment (GATE). In another paper, S.D. Smith (BIO) reported on observations of eddy fluxes of momentum and heat in gale-force winds over the Atlantic. Particulate transports in the form of water droplets and their effect on evaporation was discussed by S.C. Ling (Catholic Univ. of America, Washington, DC) and R.L. Street (Stanford Univ., CA). Their papers led to extensive discussion both inside and outside the meeting room for the remainder of the conference.

Longuet-Higgins chaired a session entitled "Non-Linear Dynamics of Surface Waves" which included papers on white caps, turbulence in the top millimeter of the ocean, the influence of bottom topography, the interaction of local wind-driven waves and swell, and reports on the dynamics of surface waves. He opened the session with an eloquent discussion of the advances in the analysis and calculations of nonlinear wave processes such as those leading to initiation of white caps in deep water and resonant interactions. He reported that the steepest waves are not the most energetic. Longuet-Higgins also made a few remarks about the possible importance of strong interactions in nonlinear wave processes, mentioning the group or envelope soliton, the results of H.C. Yuen and B.M. Lake ["Nonlinear deep water wave; theory and experiment," *Physics of Fluids* 18, 959-960 (1975)] on soliton collision, and the possibility that the kind of strong interactions represented by soliton solutions to the nonlinear surface-wave problem may prove important. There were many detailed papers presented in this session; for example, D.E. Hasselmann (Univ. of Hamburg, FRG) showed that the so-called weak-interaction theory between long waves and short waves is essentially a sophisticated way of expressing a Fourier description of the original wave equation. M.J.H. Fox (Univ. of Cambridge, UK) gave a detailed paper on what he believes is the first accurate calculation of the nonlinear transfer of energy within a continuous spectrum of water waves. D.J. Webb (Institute of Oceanographic Sciences, Wormley, UK) gave a very thought-provoking paper on Klaus Hasselmann's equations for describing the nonlinear interactions between sea waves. Webb attributes the nonlinear peak in the wave spectrum to the higher wave numbers and suggests the primary physical process is the scattering of waves near the peak of the wave spectrum by short waves. His analysis leads to the conclusion that long waves get longer and short waves shorter. The eleven presentations on nonlinear dynamics of surface waves and the discussion indicated that there has been progress in describing these phenomena.

A session chaired by O.M. Phillips (Johns Hopkins Univ., MD) entitled "Wind-Wave Interactions" focused on the generation of the ocean-wave spectrum with considerable emphases on the differences between laboratory and field wave-generation mechanisms, on wave-wave interactions and on the white-cap or breaking-wave mechanism. Although the laboratory and field spectra appear similar, the general consensus is that at high wave numbers, the extension of laboratory findings to the real world requires caution. However, laboratory studies such as those reported by A. Ramamonjiarisoa (IMST) suggest that the generation of gravity wind-waves in the laboratory is related to the mechanism causing the smallest capillary-gravity waves. Near-surface current was suggested to be important, but the question of air-water interactions that supply the energy was not addressed. Several papers were concerned with the air flow close to the surface of wind-generated waves. F.W. Dobson (BIO) presented field data on atmospheric-pressure fluctuations over surface-gravity waves and related these data to energy and momentum transfer to and from the waves. A controlled experiment in the IMST wind/wave tank, reported by J.A.B. Wills (National Maritime Institute, UK) showed a separation of air flow over steep waves, but not over shallow ones. On the basis of field and laboratory observations, CDR C.E. Dorman, USN

(Arlington, VA) *et al* suggested that there possibly may exist an air-sea interaction group soliton as a product of the process of instability that generates waves and the nonlinear processes that control the finite-amplitude development of wind waves. The field and laboratory papers were complemented by a sophisticated presentation of a numerical model of air flow over waves by P.A. Taylor (Univ. of Southampton, UK). The Wind-Wave Interactions session ended with an optimistic presentation by Prof. W.J. Pierson (City Univ. of New York) on the study of the marine boundary layer using satellite data.

The last session of the Symposium, chaired by K. Hasselmann, dealt with numerical wave-prediction models. Wave-forecasting models were presented by authors from Germany, France, Italy, England, and the US. Most were based on Hasselmann's papers of the early 1960s that used the classic transport equations as the basis for wave prediction; almost all of the numerical models compared their results to the early spectral ocean-wave model of Pierson and the work of his students over the past two decades. A practical quasi-linear forecasting model for the Adriatic was presented by L. Cavaleri and P. Malanotte Rizzoli (Laboratorio Dinamica delle Grandi Massi, Venice). T.J. Weare and B.A. Worthington (Hydraulics Research Centre, Wallingford, UK) reported on hindcasting severe wave conditions for the North Sea. Dr. Ross (NOAA, Miami, FL) and V. Cardone (City Univ. of New York) jointly reported on their hurricane wave forecasts while S.M. Lazanoff (Met Optics Corp., US) talked about his work with N.M. Stevenson of the US Navy Fleet Weather Central (Monterey, CA) concerning wave climatology for ship routing and design criteria for offshore structures. The general impression is that while wave forecasting is making rapid progress, there are still a number of points on which the justification for different regions could be put on a more common basis, although the practical results of forecasting using the present state-of-the-art are very important to offshore operations. It is obvious that further development of the numerical models will require introduction of additional physical and mathematical techniques. As the various models are developed it appears that Hasselmann's suggestion of designing some kind of skill score for objective comparison should be adopted.

The entire Symposium was by all criteria successful, unusually exciting, and very well organized. The peaceful surroundings while cloistered on the Isle of Bendor provided ample opportunities for discussion. The host laboratory was well represented at the Symposium, and produced a number of interesting new results, ranging from observations at the habitable moored buoy in the Mediterranean, BORHA II, to precise measurements of profiles, fluxes, and dispersion relations made in its large laboratory facilities.

Nonlinear-wave theory seems to be coming of age, and nonlinear wave-generation theory may be just around the corner—so we guess from the exposition of Longuet-Higgins, the remarks of Phillips, and the hints given by others and by reported observations. Isotope methods are coming into use, and particulate transport is going to receive more emphasis, both in meteorology and in pollutant-transport processes.

For those with interest in the details of the reports and discussions, the proceedings will be available from Plenum Press in the near future. [Erik Mollo-Christensen (MIT, Cambridge) and Paul F. Twitchell (Office of Naval Research, Boston, MA)]

PHYSICAL SCIENCES

A MAX-PLANCK LASER INSTITUTE IN GARCHING—MAYBE?

A new Max-Planck Institute for laser research may be in the making. In January 1976 the Projectgruppe für Laserforschung der Max-Planck-Gesellschaft (PLF) was established at Garching, FRG. Under current plans the group will operate for five years with the decision on whether it will become a permanent Max-Planck Institute slated for 1979. Funding comes directly from the Bundesministerium für Forschung und Technologie (BMFT). The PLF is situated on the Max-Planck Institute

für Plasmaphysik (IPP) site and currently uses their facilities. The University of Munich is on an adjacent site.

A group of scientists formerly under the IPP make up the PLF whose charter was enlarged from nuclear research to include high-power applications to chemistry, isotope separation, and spectroscopy. The laboratory is composed of the following groups: Iodine-laser development and laser-matter interaction under Dr. S. Witkowski, Laser chemistry under Dr. K. Kompa, and Laser spectroscopy and chemical reactions under Professor H. Walther. Kompa is the current project director under a system in which the leadership rotates among the three group leaders. Currently they have a staff of 74, but plan to expand to a final figure of about 100 within the next year. In addition to the regular staff, many scientific positions are filled by visiting scientists through the Postdoctoral Research Associateship and Senior Fellowship Programs. About 50% of the staff work on laser fusion, 25% on laser spectroscopy, and the remainder on laser chemistry. The annual budget is DM 10 million.

Close ties exist with the University of Munich where both Walther and Kompa have appointments and several other PLF staff members teach courses. Beyond this a number of university students work on research projects at the PLF.

Witkowski's group is studying high-power laser development and laser interaction with materials. Systems with potential application to laser fusion include Nd:glass, CO_2, and iodine. The PFL concentrates on the C_3F_7I photodissociative iodine laser for this application. This system was selected instead of CO_2 because of the energy transfer problems associated with the longer wavelength radiation. It was chosen over the Nd:glass system because of self-focusing and cooling problems associated with Nd. Their flashlamp-pumped C_3F_7I system produces pulses having 1-TW peak power with 500-psec full width at half maximum power and 400-psec rise time. The overall system efficiency is 0.15%, and the laser can be fired once each 8 minutes. They have completed preliminary studies on beam diagnostics and target interaction and have determined that the beam output from the final amplifier stage is 5 times diffraction limited and can be focused to a 70-μm spot. Their continuing research aims at achieving shorter pulse duration and better prepulse isolation.

To date most of their laser-materials interaction research has been with a Quantel Nd:glass system that produces 1-J, 30-psec pulses at a rate of one per minute and with a smaller iodine system that produces 30 J in 1 nsec. They have measured absorption versus reflection for various pulse lengths, energies, and target materials, with results similar to those previously obtained at Los Alamos. For additional details see *ESN* 29-6:280 and 31-9:375.

The laser chemistry group is concerned with laser development and the application of lasers to chemical separation. They have built CO_2, CO, and HF systems, but their work on a transverse-excited atmospheric (TEA) CO laser seems most promising. Using a standard CO_2 laser design and cooling the electrodes and incoming CO lasing medium to -20°C, Mr. W.E. Schmid has built a TEA CO laser with 5 J per pulse output. The pulse properties are 100-KW peak power, 30- to 70-μsec pulse width and 2% efficiency for an active volume of 1.25 liters. The laser oscillated on as many as 18 P-branch transitions and with as much as 30% of the energy in a single line when intercavity selection was used. At operating temperatures below -20°C the discharge becomes unstable. The electrodes use a sliding spark arrangement and are fabricated using a copper mesh embedded in plastic. (This work was described in a paper at the Fourth Colloquium on Electronic Transition Lasers at Munich, 20-22 June 1977; see *ESN* 31-9:372.)

Using a CO_2 laser to excite SF_6, they have been able to separate the ^{34}S molecular species from ^{32}S. They have demonstrated separation of a few grams of the ^{34}S molecular species through the selective dissociation of the ^{32}S containing SF_6 molecules. Other studies on ammonia systems have also been undertaken, but the number of chemical systems to which this technique is applicable is currently limited by the lack of continuously tunable high-power lasers.

In an experiment conducted by Dr. D. Proch, the efficiency of dissociation of SF_6 by CO_2 radiation is being studied. Focused laser light is used to irradiate a molecular beam of SF_6 at right angles to the beam, and a mass

spectrometer to study the fragments produced. The experiment is conducted in a cryogenic-pumped reaction vessel.

The emphasis in Walther's group is the application of tunable sources to the understanding of chemical reactions. The group is studying allene (C_3H_4) using tunable Pb_2SSe sources in the 5-μm range, their semiconductor lasers being purchased from AEG Telefunken. They are building an iodine laser-pumped parametric oscillator for the 2.6- to 5-μm region using a $LiNbO_3$ crystal as the nonlinear element. Stimulated Raman scattering in strontium vapor is being studied in order to produce a tunable source in the 16-μm region. In other work in the group a dye laser is being used to study the interaction of two crossed molecular beams of rubidium and hydrogen or rubidium and potassium.

The decision as to whether the Projectgruppe becomes a Max-Planck Institute depends on several factors, some of which are political in nature. If the decision were based on merit alone we feel that the answer would be yes. The caliber of the personnel is very good and the quality of the laboratory equipment and instrumentation is exceptional. [MAJ James Gorrell (EOARD) and Vern Smiley]

LASERS AND MAGNETIC RESONANCE

At the end of August a conference entitled "Optical Techniques in Magnetic Resonance Spectroscopy" was held at Trinity College, Univ. of Dublin. Professor Brian Henderson and his associates at Trinity provided facilities and services that created an intimate and relaxed meeting of less than 200 attendees. However historic the setting and the customs of the University, the Conference itself was concerned with a field that is new and expanding in many directions. Magnetic resonance techniques are well established in solids. These techniques include electron-spin resonance (ESR), nuclear magnetic resonance (NMR), and the combination of the two called electron nuclear double resonance (ENDOR). The opportunity currently being exploited is to determine what new kinds of things can be studied if a strong optical source—usually a laser—is added to this arsenal of experimental tools.

Professor Clyde A. Hutchinson, Jr. (Univ. of Chicago) reviewed the early experiments in which he studied some of the rare-earth ions such as Nd^{3+} and Dy^{3+} in host materials like $LaCl_3$. By irradiating with light, the rare earths could be placed in a long-lived excited state with a slow fluorescence. If a magnetic field and microwaves were applied to these materials at the same time, the fluorescence intensity was modulated as the magnetic field was varied. This was due to magnetic resonance occurring in the excited states of the rare-earth ions. As a result it was shown to be possible to study the excited states of centers with the elegant tools long in use for the ground state. From this beginning a wide range of materials has been studied and an equally wide range of techniques has been employed. In this report some of these directions will be sketched to indicate the vitality and variety of the field.

H. Lengfellner and K.F. Renk (Regensburg, FRG) studied *ruby*—$Al_2O_3:Cr^{3+}$. As is well known, optical pumping raises the Cr^{3+} ion to two closely spaced excited metastable states. By applying a magnetic field, each of these levels is split into two levels, the amount of splitting being dependent on the magnetic field. The energy of transition from the lowest of these four levels to the two highest can be varied by the magnetic field. Lengfellner and Renk irradiate the crystal with far infrared light in the millimeter wave region and look for resonance absorption as the magnetic field is varied. Rather than looking directly for absorption of the infrared light, however, they seek variations in the visible fluorescence of the Cr^{3+} ion as resonance occurs. Data produced on the energy difference and g value of excited states in this way are in good agreement with those of other measurements.

A summary of studies on excitons in silver halides and alkaline earth fluorides was given by W. Hayes (Univ. of Oxford, UK). These materials, like the alkali halides that had been unraveled earlier, have some long-lived triplet exciton states that can be produced by optical excitation. In the alkali halides the exciton becomes self trapped as its hole part becomes

localized between two halogen ions, and the electron circulates around the trapped hole. In AgCl, however, the hole appears to become trapped on the Ag^+ ion to make it Ag^{2+}. Other materials such as CsF and SrF_2 also differ from the alkali halide case in the details of their trapped excitons.

A variation of these techniques was used by K. Hahn, K.E. Mauser, H.J. Reyher, and A. Winnacker (Heidelberg, FRG). They saturate the absorption of the center (F-centers in CsCl and CrBr) by intense irradiation with a dye laser. This places most of the centers in the relaxed excited state. ESR experiments on the relaxed excited state will change the relative population of the "spin up" and "spin down" centers. Transitions to the ground state occur, but the altered spin distribution memory is retained and now appears in the ground state of the center. This variation in the ground-state spins is sensed by magnetic circular-dichroism measurements of the absorption from the ground state simultaneously with the dye-laser excitation. In this case the ground-state spin system reflects resonance absorption in the relaxed excited state and allows measurements that have not previously been possible.

The optically excited states of F-centers in CaO were discussed extensively by Y. Merle D'Aubigné and R. Romestain and their co-workers (Grenoble, France). They followed the effects of internal strains and the phonon effects leading to Jahn-Teller splittings in this system. J.J. Davies (Univ. of Hull, UK) studied optically excited ZnZnS:Cl with the aim of clarifying the role of various centers in this fundamental luminescent material.

S. Geschwind (Bell Laboratories, Whippany, NJ) described a very different optical technique. He applied spin-flip Raman scattering to a study of electron dynamics in CdS. In this process one may have electric dipole coupling of an optical field to the spins in an external magnetic field such that the light may flip the spin and undergo a frequency shift corresponding to the Zeeman energy. If the electrons are localized, the linewidth of the frequency-shifted light or Raman components will correspond to an EPR linewidth. However, if the electrons are delocalized, as happens with heavy impurity doping, the translational motion of the electrons introduces a Doppler width whose details can be used to analyze the electron dynamics.

Another quite different development was described by B.P. Zakharchenya (Ioffe Institute, Leningrad, USSR). He and his associates have observed linear polarization of recombination radiation in the hot photoluminescence spectrum of p-type GaAs cubic crystals excited by linear polarized light. This is because light irradiation of the band of heavy holes in GaAs generates electrons with the momentum predominantly perpendicular to the electric vector of the exciting light. This polarization is also reflected in an effective nuclear polarization produced by hyperfine interactions between the light-oriented electrons and the nuclei. The research has involved a detailed study of this interaction and its relationship to nuclear magnetism.

From the earliest days it was evident that the optical detection of magnetic resonance is ideal for organic materials that have a long lived triplet excited state. As a result there has been very widespread use of such techniques for studies of all kinds of problems in organic materials. Roughly half of the Conference was devoted to these materials. It may be worth noting that there is a large concentration of effort on organic materials in Germany. Six different groups gave papers at this Conference. An important theme was the determination of structure in the optically excited state. This was studied in many materials such as charge- transfer molecules, hormones, various dyes, and chlorophylls, among others.

There was special interest in a paper given by P.A. Chiha, R.H. Clarke, E. Kramer, and N. Lasser (Boston Univ., Boston, MA) who were concerned with studies of the photoexcited triplet states of anthracene, pyrene, or benzopyrene molecules bound to DNA. Since the amount of experimental material is very small, ordinary techniques would be difficult. Instead they measured the optical absorption transition from the lowest excited triplet state to a still higher triplet state and noted modulations of this transition by microwave resonance of the lower triplet. The level splittings and the dynamics found for the complexes were compared with simpler solvent systems to give information

on the nature and local site interactions within DNA.

The impression left by the Conference was that using complex combinations of optical and microwave equipment large varieties of materials and problems are being attacked with great ingenuity. The rate of change of the field seems very rapid indeed; it should be worth watching. (Clifford C. Klick)

PROBING THE STRATOSPHERE WITH LASERS AT VERRIERES-LE-BUISSON

The Service d'Aéronomie du CNRS is, as the name implies, a laboratory of the Centre National de la Recherche Scientifique (CNRS), but it also receives support from the Centre National d'Etudes Spatiales (CNES) which does not itself have laboratories. The Service d'Aéronomie, which specializes in upper-atmosphere and space research, is located in the Paris suburb of Verrières-le-Buisson. Professor J.E. Blamont, the head of the establishment, unfortunately was in the US during my visit. Altogether there are about 100 people at the laboratory of whom about 20 are in the lidar group that I visited.

I was escorted through the experimental laboratories by Dr. G. Megie, who first showed me some of his work in Paris at the Ecole Polytechnique where he is collaborating with Dr. Y.H. Meyer's Molecular Physics Group (see *ESN* 31-10:421). This joint project with Meyer's group centers on obtaining a very narrow high-energy source for gaseous measurements. A narrow spectral width is needed to obtain information on the line widths of the gas being probed. The goal is to obtain more than 1 J of energy with a spectral width less than 5×10^{-3} Å. They intend to injection-lock a pulsed oscillator with a narrow-band cw dye-laser oscillator and then increase the output of the second oscillator with amplifiers until the desired energy is reached. In addition, high-energy, narrow-band lasers are developed at the Ecole Polytechnique for stratospheric lidar experiments. Earlier lasers used by Megie and his colleagues were developed by Meyer's group. Now the Aéronomie group is carrying out some of its own laser development. Previously, a 3- to 5-J (before spectral narrowing) basic laser was developed here for Na measurements.

The basic laser consists of a tunable dye, oscillator-amplifier system. The oscillator and amplifier each have two flashlamps placed at two of the foci of a biellíptical cavity while a dye cell is placed at the common focus. The four flashlamps each with its separate capacitor are wired in parallel and synchronized by the use of a common spark-gap. Jitter in flashlamp firing is less than 0.1 μsec. Spectral narrowing of the oscillator is achieved by using an intracavity Fabry-Perot (FP) etalon with a spacing of 20 μm and mirror reflectivities (R) each equal to 0.5. A spectral width of 2 Å is achieved in this way. A second FP etalon is added (200-μm spacing, R = 0.3) to reach a bandwidth of 0.1 Å at 5896 Å. Output energy (narrowed to 0.1 Å) is 1.2 J with a pulse duration of 3 μsec.

The output beam from the previously described laser is frequency-doubled with a nonlinear crystal to work in the uv for O_3 and NO_2. An output energy of 100 mJ is obtained at 3000 Å.

A dye-laser source for measurement of Li vapor is also under development. Megie would like to obtain 1 J of pulsed energy with a spectral width of 50-70 mÅ. This is broader than the width of the Li line which is about 20 mÅ. An output somewhat broader than the line being probed avoids interpretation of results when the laser output is narrower than the line. The dye being used is RH 640.

Megie described another laser source for stratospheric measurement of K vapor at 7699 Å. It is composed of a ruby laser-pumped dye system with one oscillator and four amplifiers. The dye is 3,3' dimethyl 2,2 oxatricarbocyanine (DOTC) dissolved in dimethylsulfoxide (DMSO). Output is greater than 1 J with a pulse duration of 30 nsec.

From the Ecole Polytechnique we went to the main laboratory of the Service d'Aéronomie at Vierrières-le-Buisson to see the lidar system. Megie's colleague, Dr. Marie-Lise Chanin, who also works with lidar measurements, joined us there and we discussed the lidar program. Most of their past measurements have been made in the stratosphere on Na and K vapor

using laser sources previously described.

The basic elements of the lidar system are a laser transmitter, an 80-cm-diameter f/3 telescope, a photomultiplier and a 50-MHz counter and tape recorder. As with all lidar systems, a laser pulse is sent out and a measurement of the backscattered or fluorescent radiation as a function or range is recorded. When this system is set up for Na or K, a rotating shutter is used to block the photomultiplier from Rayleigh scattering from the first 5 km. A small fraction of the laser output goes to a resonance absorption cell containing Na or K vapor which checks the laser for correct wavelength and also serves as a power monitor for relative calibration. Photoelectron counting is used in the receiver for the upper-atmosphere work. Sometimes signals are averaged for as long as 30 minutes for Na and for 2 or 3 hours for K experiments.

At the time of my visit the lidar was modified for detection of NO_2 by the fluorescence method. Some of the electronics are changed for this experiment as lower altitudes are probed, and signals may be more intense.

The use of lidar for measuring stratospheric Na was reported earlier by M. Sanford and A. Gibson in 1970. Blamont, Megie, and Chanin use the same laser principal. A tunable dye-laser source is adjusted to coincide with a resonance line of the atom being probed, in this case the D_2 line of Na at 5896 Å. The atoms scatter radiation at the same wavelength with an enhanced cross section many orders of magnitude larger than nonresonant Rayleigh scattering. The method therefore, is both sensitive and selective.

The group makes stratospheric measurements with the lidar at Haute Provence Observatory in the south of France. Measurements are made at night in order to avoid daytime sky background radiation. Observations have been made over a period of more than 3 years on the Na which is located mainly at altitudes between 80 and 100 km. Time-dependent stratifications have been observed and attributed to propagation of gravity waves at these heights. They have also found that the total column abundance of Na was enhanced during meteor showers thus providing evidence for a meteoritic origin of part of the sodium.

Megie *et al* have also made simultaneous measurements of atmospheric Na and K using two transmitters described previously. They noted a similarity in the day-to-day variations of the two layers; however, the long-term behavior is different. A seasonal variation was observed in the Na layer but none in the K layer. The abundance ratio of sodium to potassium was found to vary (during one year of data collection) from a low value of ∿10 during summer to a high value of ∿50 during winter. This suggests that there are two different origins of these elements in the upper atmosphere. Megie *et al* believe that one origin for both is meteoric and nonseasonal and that in addition a terrestrial source exists in which a vertical transport of salt particles occurs in winter at high latitudes during breakdowns in the circulation pattern of the polar stratosphere.

Experiments are now being conducted on NO_2 with a two-channel lidar. The atmospheric NO_2 is excited with a dye laser in the blue region of the spectrum and the signals are received by two photomultipliers one observing NO_2 fluorescence at ∿8000 Å, the other for reference in the blue region. This system was undergoing initial tests at the time of my visit, and insufficient data had been collected to determine its ultimate capability.

There are only a few groups carrying out stratospheric probing of gases by lidar. I found this laboratory innovative and productive in this area. Part of their success is due to their relationship with laser people at the Ecole Polytechnique (Meyer's group) as well as their own ability in the development of high-energy tunable lasers at various wavelengths.
(V. Smiley)

ONRL REPORTS

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

PSYCHOLOGICAL SCIENCES

THE SIMULATOR INSTRUCTOR: A NEGLECTED DIMENSION OF FLIGHT TRAINING

In a university teaching laboratory it goes without saying that the apparatus is a mechanism through which the instructor imparts skills and knowledge, but in the world of teaching flying skills the apparatus is the focus, not the instructor. Air forces and commercial airlines use flight simulators very extensively in pilot training, and they often treat them as earth-bound aircraft rather than teaching apparatus in the hands of an instructor.

The Flight Simulation Group of the Royal Aeronautical Society held a symposium in London on 22 September 1977 on behalf of the simulator instructor, and the message was that we have neglected the instructor and so we are not getting full value from these training devices that often cost us millions. Instructors should not be drawn from the ranks of nonpilot technicians with a secondhand knowledge of flying, the lesser pilots of the organization, or retired pilots, as is sometimes done, whose flying skills and knowledge of current aircraft and practices go downhill after retirement. Instead—and there was no disagreement heard on this principle—simulator instructors should be fully qualified pilots in the aircraft being simulated, and the best ones of the organization at that (no one faced the problem of the best always being in short supply).

A panel of six speakers was assembled by J.M. Rolfe, a research psychologist with HQ RAF Support Command (RAF Upwood, Huntingdon, Cambridgeshire) and, if audience reaction is a fit judge, the best presentation of the day was given by Major G.A. Long (Tactical Air Warfare Center, USAF Tactical Air Command). Long has been the F-16 simulator program manager, and he has been intimately involved with the design of both the pilot's and the instructor's stations and how they should be used. The F-16 aircraft and its simulator-to-be are good examples of modern-day system complexity. The F-16 has five onboard computers and a very elaborate man-machine interface; the simulator will have not only all this equipment and its functions represented for the pilot trainee, but also repeater versions represented for the simulator instructor so that he can follow the actions of the trainee on the simulated flight. Furthermore, the instructor's station will have controls for preprogrammable simulator functions for presenting standardized training exercises, and a variety of audio and video aids for debriefing purposes. All of this must be orchestrated into a meaningful learning experience. Little wonder that Long, and the audience, believe that the simulator instructor and his station require our best shot. The technology that has made the F-16 aircraft an engineering achievement is the same technology that will be used to build the F-16 simulator, and Long is obviously pleased with it and proud of it, but he feels that the simulator instructor can be the limiting factor in the simulator's training capability. Stated another way: The elegant simulator hardware has a very human instructor in the middle of it, and the training will be no better than he is.

Long's main design idea was his "philosophy of equivalence" in which the simulator instructor's station should closely parallel the pilot's cockpit so that the instructor's task will be similar to the one that is performed while flying. The instructor's station will feel comfortable to the instructor because he will be a pilot trained in the aircraft being simulated, and he will learn to operate the simulator easily. Maybe so, but the instructor in the university teaching laboratory needs more than familiar equipment. Without pressing the academic analogy too hard, the laboratory instructor needs a good set of lecture notes (the simulator syllabus), a good set of laboratory problems (the various navigations and combat exercises), he should deliver feedback on student errors and questions (the capability to interrupt a training exercise and comment on performance) and he should have good examinations (devices for the measurement of proficiency so that the pilot trainee and the simulator instructor have quantitative information on the skill level that the trainee has attained). Perhaps a few instructors have the intuitive skill to do much of this without special training but, for the rest of them, simulator

instructing will be like playing an organ where the hands and feet are all going at once; the trainee will get little out of a simulator instructor like this. Long and others at the meetings said that a training course for simulator instructors is the answer. The assignment of untrained personnel to simulator instructing is a practice that should be abandoned, to be remembered only as a faltering way of a less sophisticated day in the history of flight simulation. (Jack A. Adams)

HUMAN FACTORS AND MODERN COMMUNICATION TECHNOLOGY

The Imperial College of Science and Technology, University of London, held a Symposium on Human Factors of Communication Technology on 13 September 1977, and it turned out to be a discussion of the problems encountered in improving ordinary communications by devices such as conference by telephone (teleconferencing), the audio-visual picturephone, and the computer. The meeting was organized by Professor Colin Cherry and his associate, Paulina Chan, of the Electrical Engineering Department. It may seem odd that a meeting on human factors, with a strong psychology flavor, should be sponsored by a professor of engineering who is widely known in the field of information theory. Yet, Cherry's behavioral interests were broadly hinted as early as 1957 in his book *On Human Communication* (Chapman and Hall, Ltd., London).

All of us use reference material every day, and we hardly think how much time that we spend at it—the housewife looking for a recipe, checking the theater column in a newspaper for a play, calling up the airlines for a flight. The swift availability of this information would be a boon to us all, or so it seems to the UK Post Office. Dr. Graham Sharpless (Philips Research Laboratory, Redhill, Surrey, UK) described how the Post Office will be running a field test in June 1978 of a computer-based information system, called Viewdata, that can make substantial amounts of routinely needed information from a computer data base available in the home or office via the telephone lines (for accounts of Viewdata that would be more satisfying to the engineer reader, see *ESN* 31-2:72, 31-6:224). One thousand units will be used in the test, half in homes and half in business establishments. The display unit looks like a standard TV set with a simple numeric keyboard attached, although it's not (presumably, in the future, home TV sets could be sold with a built-in adapter to receive and display computer-based information from the telephone lines). The unit of stored information is the "page," that can have up to 24 rows of 40 alphanumeric characters, in color if desired, or it can have graphic information along with printed material. The computer will store 60,000 pages. The term "page" has an appropriateness because the information is presented to the viewer like the page of a book or a slide. The idea of a system such as this is not new with the UK Post Office. The Reuters news service uses cable TV in New York City to present specialized financial information with a 2000-page system.

The pages are ordered in major categories, and within these the information is hierarchically arranged as a "tree." The keyboard is used to turn on index pages, and one starts by choosing a major category like Concerts, Theaters, or Recipes and Food Information. For example, suppose a housewife wants a recipe for cole slaw. She selects Food Information and Recipes, from which she selects Salads. Within the Salads subcategory she chooses Cabbage, and within the Cabbage option she selects Cole Slaw. The recipe for cole slaw then appears. Retrieval is slow, taking 4-10 pages and up to 8 sec per page to obtain the desired information. The successive keyboard operations and delays may be frustrating for the user, which is one human-factor problem. Another is that the system is poor for browsing. The housewife in search of a salad recipe may not enter the system with a firm decision to serve cole slaw. Instead, she may wish to look at a number of recipes and find something new and exciting. This would be a clumsy, time-consuming operation with Viewdata. The rapid accessing of information with various search strategies is a problem which the designers may have to solve for full public acceptance.

Another theme heard was that bothersome human factors also intrude on the

aids that communication engineers have given us for group meetings without leaving the privacy of our offices. Being able to hold a simultaneous conference by telephone or picturephone rather than endure travel to a live conference should appeal to our sense of efficiency and be accepted by us all. Not so. Acceptance of these new communication methods has been slow. People appear unwilling to give up live face-to-face contacts. Perhaps they like the travel to conferences, perhaps they like the social side of meetings, or perhaps live meetings help them maintain contacts and visibility. In the Orient, meeting a person face-to-face shows respect, and there may be elements of this in the West. That the acceptance of these new devices has been slow shows that the need for them is not strong. Put another way, the teleconferencing and picturephone methods are inventions looking for a need rather than the other way around. The Viewdata system may have the same problem. Who wants it? Fortunately, the UK Post Office is not rushing into Viewdata without a field test on a sample of users. The Post Office should be able to back off from Viewdata without embarassment if user rate is low and attitudes toward it are poor. (Jack A. Adams)

SPACE TECHNOLOGY

SATELLITE HEAL THYSELF

Satellite Onboard Computer Technology Development at British Aerospace Corporation

Early in 1977 the British aerospace industry was partially nationalized through the merger of Hawker Siddeley Aviation, Hawker Siddeley Dynamics, British Aircraft Corporation, and Scottish Aviation. The new entity is known as the British Aerospace Corporation. It is interesting to note that one of the largest British aerospace corporations, GEC Marconi, was not included in the nationalization merger. Each of the merged companies still retains a great deal of autonomy and competes with the others for aerospace contracts, both National and foreign. This article will treat one of these companies, Hawker Siddeley Dynamics whose product divisions include space equipment, guided weapons, infrared and mechanical equipment. In particular, the Space Division, under an Executive Director for Space, P.L.V. Hickman, will be reported on with an overall view of current production programs as well as a look at several internal technology development programs, particularly a satellite onboard computer.

Hawker Siddeley Dynamics (HSD) Space Division's organizational structure consists of several program offices including communications satellites, scientific satellites, and launch vehicles; an office of the Chief Engineer; and various supporting divisions including marketing, costing, and production. The Chief Engineer is essentially in charge of research and development and his office provides support to the various program offices as required. The R&D program is maintained to assure technical competence at the systems level as a prime contractor, subcontractor, and supplier of special equipments. Some of the past programs for which HSD has been prime contractor include: ESRO II, the first satellite launched by the European Space Agency (ESA), which carried a scientific payload designed to measure the energy spectrum of primary cosmic-radiation electrons; ESRO IV, another ESA scientific satellite, designed to investigate the nature of drift ions and electron temperatures and densities; X4 MIRANDA, the first all-British three-axis-stabilized satellite designed to study advanced spacecraft technology in the areas of attitude control, lightweight flexible solar arrays, and star, earth, and sun sensors; and the Blue Streak rocket that was the first stage of a British-French-German rocket known as the EUROPA.

HSD is currently prime contractor for the ESA-sponsored satellites OTS (Orbiting Technology Satellite), designed to demonstrate transmission techniques for future European regional-coverage communications satellites, and MAROTS, a communications satellite designed to provide maritime communications services. At the subsystem level, HSD is currently providing the

pallet section for SPACELAB which incorporates advanced lightweight structure technology and which will serve as the platform for mounting SPACELAB experimental payloads; the antenna dish for the INTELSAT V communications satellite; and the autopilot electronics and other component subsystems for the ARIANE launch vehicle (an expendable launch vehicle in the Atlas Centaur class). To assist in accomplishing its mission as a top-notch spacecraft contractor, HSD is well equipped with the latest in clean-room, environmental testing, and computer facilities, and boasts the largest commercially available anechoic chamber in the world for electromagnetic measurements.

Turning to the area of technology development, one of the more interesting and highest-priority programs underway at HSD is their satellite onboard computer (OBC) project. This project was stimulated by the realization that as satellites become more complex, the need for automatic operations in orbit would increase. The program started in 1972 when HSD began to examine the electronics that would be required for satellite applications in the 1980s. The conclusion reached was that a long-life high-reliability onboard computer processor would be required to handle various housekeeping functions and in some cases direct payload functions. It was further decided that to attain such a device it would have to be designed from scratch, as the use of off-the-shelf microprocessors in a piecemeal fashion would not be effective. Various items had to be taken into consideration such as expected failure modes in the satellite and their effects on the satellite function involved. The spacecraft contractor would specifically need to take into account reconfiguration capability and the interaction between software and hardware design to meet that requirement. Based on these items and certain assumptions about various satellite payloads, HSD formulated a program that has been on-going since 1975. The intent is to have an engineering model of the computer available in 1979 at which time the model is expected to be one to two years ahead of the state-of-the-art.

The OBC is being developed to be as powerful as a commercial minicomputer while possessing the special characteristics required for in-space use. These characteristics include self-repairability for unattended use over an operational period of 7-10 years in space, low weight and power consumption, and small size. To achieve this, use is being made throughout the design of custom, large-scale integrated-circuit (LSI) technology. The reliability goal for the OBC will be 0.95 over a seven-year period. The mass of the computer is to be less than 20 kg with approximate dimensions of 280 × 210 × 245 mm high. Power requirements are anticipated at less than 15 W. The system is completely modular, and any combination of units up to 16 is possible. The central processing module (CPU) consists of two identical CPUs each capable of 16-bit parallel operation with 8 software accessible registers and 7 software invisible registers. The instruction time is about 3 μs, and the operating memory is about 20-K words. In order to meet the system requirement of satellite operation, the CPU has three major distinguishing features: it is designed to be programmed in a High Level Language (HLL); it supports a variety of multiprogramming operating systems; and it has built-in systematic and comprehensive error-detection and fault-management facilities. Except for shielding against the natural space environment, the unit is not radiation hardened.

Several other areas of space technology development underway at HSD include a multichannel radiometer for the Nimbus G scientific satellite that is designed to measure the temperature of the stratosphere and mesosphere up to an altitude of 90 km. It is the first radiometer capable of simultaneously measuring the mixing ratio of six constituent gases of the Earth's atmosphere. The device incorporates a complex optical system that allows the incoming energy to be split into six separate optical channels. An electronics package provides power, control logic, signal processing, and data-handling functions. HSD is also developing an advanced Bearing and Power Transfer Assembly that rotates solar-array panels at the rate of one revolution per day in order to keep the array pointing continuously at the sun for maximum energy utilization. The device also provides the means of transferring the electrical power generated by the solar cells to the spacecraft power bus.

HSD is deeply involved in developing foreign markets as evidenced by its current efforts to obtain the contract for the ESA-sponsored European Communications Satellite (ECS) and the regional communications satellite for the League of Arab States (ARABSAT). This places the Company in heavy competition, not only with other UK spacecraft companies but also with its American counterparts. Based on these efforts and past performance in obtaining prime contracts for a variety of different types of satellites, one cannot help but feel that HSD is in the forefront of exploiting the utilization of space and space technology as an aerospace corporation. (Robert W. Rostron)

NEWS & NOTES

AN OPEN URSI SYMPOSIUM AT LA BAULE

The International Scientific Radio Union (URSI) has, in the past, operated a kind of closed shop by limiting participation in its International Symposia to authors and attendees who were either members or invitees of the various National Committees. At the XVIIIth General Assembly held in Lima, Peru in 1975, it was decided to open participation in International URSI Symposia to any interested person. Commission F (Wave Phenomena in Non-Ionized Media) was the first of URSI's eight Commissions to follow this recommendation, holding an Open Symposium at La Baule, France, on 28 April-6 May 1977. The response was reasonably heavy, with 140 papers accepted from 17 countries.

John Saxton of the Appleton Laboratory provided historical perspective by tracing the evolution of the interrelationships among the various international telecommunications organizations (ITU, CCIR, CCITT) that serve as customers for the scientific output of Commission F. He also set the tone of the conference by indicating the technical areas having greatest impact on practical problems in space and terrestrial communications at microwave frequencies. The topics emphasized were cloud and precipitation effects on a worldwide basis, and tropospheric propagation in clear air. The organizers added variety by scheduling additional sessions on remote sensing, transmission-channel characteristics, and preliminary experiments with the ATS-6 satellite. The interested reader will find most of the papers appearing shortly in special issues of *Annales Des Télécommunications* (effects of precipitation, transmission-channel characteristics, ATS-6 propagation experiments) and *Radio Science* (propagation in clear air, remote sensing in the subsurface, surface and atmospheric regimes). These are scheduled for early 1978. Others of the papers were published shortly before or after the Symposium itself.

On the whole, the meeting satisfied rather well the stringent criteria for success enunciated by Nunn in an earlier issue of this periodical (*ESN* 31-2). Most of the participants judged the locale and local arrangements to be congenial, their colleagues to provide amiable and interesting social and intellectual interactions, and the body of presented papers to carry a reasonable technical message. There were few multiple sessions, so fragmentation by discipline was minimized and the symposium was kept cohesive, if not totally coherent. The only sour note, accepted with amused incredulity by the conferees, was sounded by an edgy bureaucracy which cancelled a scheduled trip to the shipyards of St. Nazare because of the presence of Japanese nationals in the party, then prohibited a substitute excursion to the Concorde assembly plant because of the presence of Americans. In seeking a diversion sufficiently innocent of economic/political implications to win the approval of the authorities, the local committee submitted a tour of the Muscadet vineyards of the Nantes region, which was finally approved. For all that, the Symposium was an auspicious beginning to what must become continuing URSI policy for its international scientific meetings. (Lewis B. Wetzel, Naval Research Laboratory, Washington, DC)

PERSONAL

Dr. R. Barker and Dr. G.R. Luckhurst, Readers in Chemistry at Southampton University, have had the title of Professor conferred upon them.

The Court of the University of Edinburgh has appointed Professor Jeffrey H. Collins, at present Personal Professor of Industrial Electronics in the Department of Electrical Engineering, to the Chair of Electrical Engineering following the retirement of Professor W.E.J. Farvis.

Professor Sir Sam Edwards has been appointed Chairman of the Council of the British Association for the Advancement of Science. He was Chairman of the Science Research Council from 1973 until September 1977.

Dr. M.J. Lanigan, formerly General Manager, Plessey Processor Unit, Slough, has been appointed Professor of Digital Electronics at the University of Kent in Canterbury.

Dr. M.J. Morgan, Lecturer in Psychology and a Fellow and tutor of Queen's College, University of Cambridge, has been appointed to a Chair of Psychology at the University of Durham.

On 30 November 1977, the Royal Society awarded the following medals: The Copley Medal to Dr. F. Sanger of the Medical Research Council's Laboratory of Molecular Biology at Cambridge; the Davy Medal to Professor A.R. Battersby, Professor of Organic Chemistry at the University of Cambridge; the Buchanan Medal to Sir David Evans, now at the Sir William Dunn School of Pathology, University of Oxford; the Hughes Medal to Professor A. Hewish, Professor of Radio Astronomy at the University of Cambridge.

Dr. G.M. Stephenson, Reader in Psychology at the University of Nottingham, has been appointed Professor of Social Psychology at the University of Kent.

Professor Arthur Summerfield, Professor of Psychology at Birkbeck College, University of London, has been elected president of the International Social Sciences Council in Paris, which advises UNESCO.

Dr. J.A. Tyrrell, FRS, Deputy Director of the Medical Research Council's chemical research center, Northwick Park, London, has been appointed Managing Trustee of the Nuffield Foundation.

Dr. Stanley Whitley, Chief Physicist at the Capenhurst nuclear plant in Cheshire, is one of eight scientists to be awarded the 1977 Krupp von Bohlen und Halbach Energy Prize, worth DM 500,000 (about $224,000) for his work on Britain's centrifuge uranium-enrichment plant. His share will be about $27,750.

Professor William Leslie Wilcock, Chairman of the School of Physical and Molecular Sciences and Professor of Physics at the University College of North Wales, Bangor, has been awarded the Arnold O. Bechman award by the Instrument Society of America. It is awarded for contributions to the conception and implementation of a new principle of instrument design, development, or application.

Dr. P.N. Wilkinson, previously at the Owens Valley Radio Observatory, California Institute of Technology, has been appointed Weir Research Fellow at the Nuffield Radio Astronomy Laboratories, Jodrell Bank, near Manchester, as of 1 November 1977.

OBITUARIES

Dr. William Bullerwell, FRS, FRSE, Deputy Director of the Institute of Geological Sciences, died in November at the age of 61. After WWII service, he joined the Geological Survey of Great Britain in 1946. Soon after, he established a Geophysical Department and in 1949 he started a regional gravity survey of the UK, the first results of which were published in 1954. As Chief Geophysicist from 1962 he broadened the Department to cover all aspects of science. In 1965 the Institute of Geological Sciences was formed by the amalgamation of the Geological Survey and the Overseas Geological Surveys, and in 1967 Bullerwell was appointed Deputy Director. His numerous overseas activities included membership in the International Gravity Bureau, and on behalf of UNESCO and its associated bodies, he guided much geophysical mineral exploration in the Far East.

Mr. Arthur Fage, CBE, FRS, FRACS, died 7 November at the age of 87. He was one of the last survivors of the group of scientists who, in the years before WWI, began to establish the reputation of the National Physical Laboratory in aerodynamics research. He joined the NPL in 1912, and worked, as did the other scientific staff, on problems as they arose. They often designed and even constructed their own apparatus. This background afforded Fage the experience to write *The Aeroplane*, five editions of which appeared between 1915 and 1918. A

second book, *Airscrews*, was published in 1920. Upon its completion, Fage began to concentrate on fundamental research on fluid motion, especially on boundary layers and turbulence. This work led to the publication of many scientific papers, securing his international reputation. In 1925, Fage was made Deputy Superintendent of NPL and in 1946 he became Superintendent. Shortly after his retirement in 1953, he was awarded the honor, Commander, Order of the British Empire (CBE).

Professor William Klyne, FRIC, died on 13 November at the age of 64. After previous experience as a Lecturer and later as a Reader in Biochemistry, he was appointed the first Professor of Chemistry at Westfield College, University of London, in 1960 and was one of the chief architects of the newly founded Science Faculty there. His research interests spanned a wide area including the stereochemistry of organic molecules, study of biologically important compounds such as steroids, and application of chiroptical techniques to chemical problems. He was the author of the book, *The Chemistry of Steroids*, and a multivolume *Atlas of Stereochemical Correlations*, published in 1957 and 1974, respectively. As a result of his gift for forging international collaboration links, Westfield College became the home of the MRC Steroid Reference Collection (also supported by the US National Institutes of Health) from which samples are sent to research groups in all parts of the world. Under his guidance, Westfield also became a nationally supported center for chiroptical studies.

Dr. Stanley Raimes, Reader in Mathematics, Imperial College of Science and Technology, University of London, died on 1 November at the age of 56. His career was entirely spent with Imperial College where he was educated and later became a Lecturer. He became a Reader in Mathematics in 1960. For some twenty-five years, he was the principal teacher of mathematics to undergraduate physicists and was the author of two well-known textbooks, *Wave Mechanics of Electrons in Metals*, and *Many Electron Theory*. His research work was concerned with the calculation of the cohesive energies of metals and alloys. He was one of the first to recognize the importance of the new ideas of the 195 Oera regarding plasma oscillations in metals, and he wrote several papers on this subject.

ONRL REPORTS

R-11-77 INFORMATION THEORY IN HUNGARY by N.M. Blachman

This report discusses the work of the Mathematical Institute of the Hungarian Academy of Sciences with emphasis on its Information Theory and Statistics Groups. The work of the Institute for Communication Electronics of the Technical University of Budapest is also mentioned together with a general picture of the Faculty of Electrical Engineering. Some remarks are included concerning information-theoretical research elsewhere in Hungary.

C-10-77 SIXTH ANNUAL CONFERENCE OF THE INTERNATIONAL SOCIETY FOR EXPERIMENTAL HEMATOLOGY, BASEL, SWITZERLAND, 28-31 AUGUST 1977 by R.I. Walker

This report summarizes a meeting held in Basel, Switzerland (August 1977) in which over 300 scientists from Europe, United States, and several other countries interchanged current information regarding clinical and laboratory experience in hematology. The presentations concerned regulatory mechanisms behind cell proliferation and functional aspects of matured cells. Applications of these basic science principles to treatment of hematologic disorders in human and animal models were described.

C-12-77 OPTICAL FIBERS, INTEGRATED OPTICS, AND THEIR MILITARY APPLICATIONS, LONDON, ENGLAND, 16-20 MAY 1977 by V.N. Smiley

A review is given of some of the papers presented at a Conference which was held in London, 16-20 May 1977. Emphasis is placed on past, present, and future devices for military applications. The review is organized in the same manner as the Conference format under the subtitles: systems, integrated optics, propagation, sources and detectors, and couplers.

C-13-77 SEVENTH INTERNATIONAL CONFERENCE ON AMORPHOUS AND LIQUID SEMICONDUCTORS AT EDINBURGH by S.G. Bishop, T.L. Reinecke, U. Strom, P.C. Taylor, and C.C. Klick

A review is given of the Seventh International Conference on Amorphous and Liquid Semiconductors held in Edinburgh at the end of June 1977. Topics covered in the report include the nature of localized states in chalcogenide glasses, dispersive electronic transport, electronic conductivity at the Si-SiO_2 interface, amorphous Si and Ge, thermal and vibrational properties of amorphous solids, luminescence in oxide glasses, and disordered organic solids.

C-14-77 MICROWAVE MAGIC by J.B. Bateman

This is a report, with critical comment, of a meeting convened by a microwave research department within the French

C-14-77 (cont'd)

national research center for space and aeronautics in order to present the results of current French research on the biological effects of microwaves. The report proper is preceded by notes on the sponsoring organizations and by critical remarks on a series of papers describing the remarkable biological properties of the physically uncharacterized radiation emitted by an apparatus assembled by the inventor, A. Priore. The topics discussed ranged from specific effects of microwaves on microorganisms and on the vertebrate central nervous system, to discussions of microwave thermography and microwave heating in the diagnosis and treatment of cancer. The empirical approaches generally used deflected attention from any thorough-going attention to the vexed question of thermal versus non-thermal effects, although a useful distinction was drawn between the conditions under which non-thermal effects might be detectable and those under which such effects would be obscured by temperature changes.

C-15-77

ACOUSTIC DETECTION OF NEUTRINO INTERACTIONS IN THE OCEAN: THE 1977 DUMAND SUMMER WORKSHOP, MOSCOW, 26-28 JUNE 1977 by A. Roberts

This was the third in a series of Workshops to foster the collaboration of high-energy, cosmic-ray, and theoretical physicists, astrophysicists, astronomers, acousticians, computer scientists, geophysicists, oceanographers, ocean engineers, and other assorted enthusiasts, all captivated by the objective to use the ocean as a gigantic neutrino detector.

C-17-77

THE THIRTEENTH IUPAP CONFERENCE ON STATISTICAL PHYSICS by H. Ruskin and R. Cherry

This report summarizes selected papers and reviews given at the Statphys-13 Conference held this summer in Haifa, Israel. Topics mentioned include fluctuation scaling, percolation processes, series expansions and renormalization techniques applied to various problems, fluids and turbulence, random systems, and many other areas of investigation in which the methods of Statistical Physics have been successfully employed.

SUBJECT INDEX FOR VOLUME 31, ESN ISSUES 1 THROUGH 12, 1977

The articles are listed chronologically under subject heading with title, author, and issue page numbers. Thus, 2:58 indicates issue 2, page 58 of Volume 31.

AEROSPACE

Man-Powered Flight	4:133	Patterson
The X-114 Airfoilcraft Wing-In Ground Effect	6:215	Hart
Ich bin ein atmosphärischer Elektriker	8:293	Hale
Using Space—Today and Tomorrow	11:471	Rostron
Satellite Heal Thyself	12:514	Rostron

BEHAVIORAL SCIENCES

Behavioral Science in Greece	1:1	Miller
The Human Factors Group at the Royal Aircraft Establishment	9:383	Adams
Aircrew Training Research at Science 3 (RAF)	9:384	Adams
A Mental Test for All Seasons	9:386	Adams
Measuring Flying Proficiency in the Swedish Air Force	10:426	Adams
Booze and Behaviorism	10:427	Adams
The Eyes, the Hands, and the Cockpit	11:466	Adams
The Spirit of Negotiation Runs High in Denmark	11:467	Adams
Our Babel of Tongues	11:468	Adams
The Simulator Instructor: A Neglected Dimension of Flight Training	12:512	Adams
Human Factors and Modern Communication Technology	12:513	Adams

BIOLOGICAL SCIENCES

A Discussion of Gravity and Biological Systems	1:4	Bateman
A Symposium on Carbon Dioxide and Breathing	3:113	Bateman
Immune Responses in Scotland	3:117	Woody
An Up-Date on Burn Toxin	4:162	Woody
Through Thick and Thin to Membrane Electrochemistry at Orsay	5:172	Bateman
Leucocyte Cultures in Germany	5:174	Woody
A Quail of a Tale	7:262	Bateman
Chaim Shebe Medical Center	10:391	Miller
ELISA in Stockholm	10:393	Joseph
Water Pollution, Purification, and Methodology	10:394	Joseph
Microwaves for Biologists	11:433	Bateman
Microwaves Updated	11:435	Bateman
Functions of Microbial Membranes	11:439	Sippel

CHEMISTRY

Visit to the Deutsche Gesellschaft für Chemisches Apparatewessen	2:38	Yeager
Molecular Relaxation Processes	3:81	Peebles
Inorganic and Electrochemistry at the NTH	4:135	Seegmiller
1976 EUCHEM Conference on Molten Salts	4:136	Seegmiller
Metallurgy at the University of Saarlandes—The New Look	4:140	Sosin
Centenary of the Royal Institute of Chemistry	5:176	Schulman
6th European Symposium on Fluorine Chemistry, Dortmund, Germany	7:264	Seegmiller

COMPUTERS

The Second International Meeting on Very Large Data Bases	1:6	Gordon
EURONET—European On-Line Information Network	2:39	Gordon
Report Cards for Computers	3:84	Gordon
EUROCOMP '76	3:86	Rummler
Standardization of Real-Time Operating Systems	3:87	Rummler
Visualization Techniques and Aesthetics at the Computer-Aided Design Centre, Cambridge	4:141	Gordon
Computerized Command and Control of UK Police Resources	4:143	Blachman
A Plan to End US-Japanese Dominance in Computers and Electronic Component Technology?	5:177	Rummler
A New Approach to Sponsoring Computer Science Research and Development	6:217	Rummler
Help for the Handicapped	8:294	Blachman
Institut de Recherche d'Informatique et d'Automatique	8:296	Birkhoff

EARTH SCIENCE

Progress on the Winter (HF) Absorption Anomaly	1:11	Hale
Radar Meteorology in the UK	1:13	Barcilon
The Institute for Atmospheric Environmental Research, Garmisch, FRG	1:14	Barcilon
The Institute for Meteorology and Geophysics, Innsbruck	3:100	Barcilon
The Institute of Theoretical Meteorology in Munich	3:102	Barcilon
The UK Meteorological Office College	3:104	Barcilon
Acid Rain Precipitation in Norway—The SNSF Project	4:148	Barcilon
Meteorology in Bologna and Rome	6:217	Barcilon
Meteorology at Uppsala, Sweden	7:266	Barcilon
The International Meteorological Institute and the Meteorology Department, Stockholm	8:297	Barcilon
The Institut de Mécanique of Grenoble	8:300	Barcilon
Geophysical Fluid Dynamics in Munich	11:441	Barcilon
GLORIA II IOS	11:443	Pryce & McKendrick

EDUCATION

On the Care and Feeding of Technology in Academe: Cranfield Institute of Technology	4:144	Sosin

ELECTRONICS

Goals-Oriented Research: A Visit to STL	3:88	Gorrell, Nedoluha, & Sosin
Chelsea Amorphous Semiconductors Meeting	3:92	Taylor
Electronics and Hornets' Nests Meet at Tel-Aviv University	5:178	Blachman
Deep-Level Impurities in Semiconductors	9:339	Cooper
Some Electronics at Chalmers University of Technology	9:341	Schulman
The GEC Hirst Research Centre	9:344	Blachman
GEC-Marconi Research Laboratories, Great Baddow	9:346	Blachman

Communication and Stochastic Calculus	10:400	Blachman
NATO SHAPEly Communications	10:402	Blachman

ENERGY

High-Temperature Batteries	6:219	Sosin
Wind Power—The West Wind Doth Blow	8:302	Sosin
Night-Storage Heaters—Energy Conservation, Research, and Economics	8:305	Sosin
A Place in the Sun: Some Solar Engineering in Israel	8:307	Sosin
A Conference on the Economics of Solar Energy—Can the UK Afford It?	10:396	Sosin
Sweden's Biomass Production Potential	10:398	Sohns

ENGINEERING

The 14th International Union of Theoretical and Applied Mechanics Congress: "From Delft to Delft"	1:16	Lessen
Hochschule der Bundeswehr, Southern Style	1:18	Nunn
Failure Prevention by Wear Monitoring: A Field for Engineering Supersleuths	1:20	Sosin
Thermo and Fluid Dynamics Research at TU München	1:23	Nunn
IEE International Conference on Millimetric Waveguide Systems	1:25	Blachman
Belfast—Progress in the Thick of It	1:28	Nunn
Further Observations on Engineering Research and Education at the Technion	2:40	Nunn
Radio Research at Helsinki University of Technology	2:43	Cheng
Sehr Grosse Vortex Valven	3:95	Nunn
The Fluid Mechanics Research Institute at Essex	3:97	Lessen
Applied Flow Research at the Institute für Strömungslehre in Darmstadt	3:99	Lessen
Communication Engineering in Finland	4:145	Blachman
IEEE-EUREL-URSI Eurocon '77—Communications	6:224	Blachman
Electrical Engineering and Allied Topics at Beer-Sheva	6:226	Blachman & Schulman
Information Theory in Trieste	6:229	Blachman
Direct Satellite Broadcasting	7:269	Blachman
Electrical Engineering at King's College, London	7:271	Blachman
Electric Vehicle Development Conference	8:308	Soper
Radio Interference in Montreux	8:312	Hagn
A One-Day Meeting on Adaptive Processing in Underwater Acoustics	8:313	Pryce
Why Is Color TV So Much Better Over Here?	11:445	Blachman
Postal Automation in London	11:447	Blachman
Suspension in the Transport Industry	11:448	Patterson
Seventh International Congress on Instrumentation in Aerospace Simulation Facilities	11:450	Hill
Video Discs: Yet Another Use for Your TV Set	12:481	Blachman
Information Theory in Hungary	12:482	Blachman
Panel Displays	12:485	Klick & Pryce

Volume 31

GENERAL

ANVAR—Research Development the French Way	1:31	Barcilon
Zip Codes in the UK	2:45	Blachman
Symposia Ad Nausea	2:48	Nunn
UK Reactor Decisions?	3:106	Pryce & Sosin
4th World Congress of Engineers and Architects in Israel	3:110	Nunn
Appeal to a Higher Authority: British Council of Churches Public Hearing on Fast-Breeder Reactors	4:150	Sosin
Telephones in Israel	4:152	Blachman
British Salaries Take a Pounding	4:153	Sosin
Problems Affecting Academic Research in Israel	5:180	Schulman & Blachman
Elscint—An Israeli Science-Based Industry	5:181	Schulman
Egypt: Land of the Past—And of the Future?	5:183	Tall
Common Sense About Common Science in the Common Market	5:186	Schulman
"Trans-Tec '77" Conference: Technology Transfer and the Gospel According to Marks and Spencer	6:231	Schulman
France's VIIth Plan	6:235	Barcilon
Council for Science and Society: Safety and Superstar Technologies	6:237	Sosin
Research Climate in Italy	6:239	Barcilon
Goodbye, Gutenberg!	8:315	Schulman
The French Academy of Science	8:318	Barcilon
Chalmers University and the New Swedish Educational Reforms	9:349	Schulman
Swedish Science Attachés and the Royal Swedish Academy of Engineering	9:350	Schulman
Cuts in French Research Support	10:404	Barcilon
15th International Congress of the History of Science	11:453	Burstyn

MATERIALS SCIENCE

Strength and Deformation of Metals and Alloys	2:49	Bernstein
The Electron Microscope Looks at Surfaces	2:51	Sosin
Metallurgy at the University of Karlsruhe—Emphasis on Convention	3:111	Sosin
The Need for New Welding Processes—Are We at the End of the Old Road?	3:112	Sosin
Materials on the Beam: Success at Sussex	4:153	Sosin
How Long Do Polymers Last in Service?	4:156	Sosin
Defects in Paris—The University of Paris	4:157	Sosin
Spray-Rolling: A New Metals Technology?	5:190	Sosin
Vapor-Deposition and Electron-Beam Processing—Taking the Low Vacuum Road	5:191	Sosin
Conference on Fiber-Reinforced Materials	5:193	Soper
Acronyms, Anyone? (AA)	6:240	Sosin
ISSC3—The Status of Surface Science	6:241	Sosin
All Acronyms Answered (AAA)	6:243	Sosin
Diffuse X-Ray Scattering at Jülich: A Major Campaign Against Interstitials	6:243	Sosin
Hydrogen-in-Metals Conference, Paris, June 1977	7:272	Cathey
Conduction in Nonconductors	8:320	Klick
XIXth Congress Ampère on Magnetic Resonance	8:322	Ailion
Electron Transport and Molecular Solids	9:351	Klick
New Materials for High-Speed Volume Holograms	9:354	Smiley
Photoemission Electron Microscopy—A Renaissance?	9:356	Sosin

Electron Microscopes and Microprobe Analyzers in the Wonderful World of Color	9:360	Sosin
Lasers in Chemistry—A Conference	9:360	Smiley
Bohrish Metallurgy	10:405	Sosin
Safety in a Vacuum?: The Effect of the Environment on Structural Integrity of Materials	10:408	Bernstein
Rare Earths and Actinides: Research and Applcations	11:454	Koon, Williams & Klick
New Directions for Trinity	11:456	Klick
Thermomechanics of Magnetic Fluids	11:457	Lessen
Sheffield International Conference on Solidification and Casting	12:486	Ayers
A Conundrum: Improvement in the Properties of Beryllium Are Not Mirrored by Increased Use	12:489	Bernstein
A Fatiguing Experience: An AGARD Conference on Inspection of Aircraft Components	12:493	Thompson & Bernstein
Material Preparation at RSRE—Towards a More Perfect Crystal	12:494	Klick
9th Annual British Mass Spectrometry Meeting, University College of Swansea, Wales	12:497	Saalfeld & De Corpo

MATHEMATICS AND INFORMATION SCIENCES

The NAG Library of Algorithms for Engineering and Scientific Computing	2:54	Gordon
The Dundee Conference on Numerical Analysis	7:273	Gordon
The Contribution of J.H. Wilkinson to Numerical Analysis—A Giant Step Backward	9:363	Gordon
Getting Things into Focus in Norway—Acoustic-Wave and Water-Wave Research	9:365	Gordon
Computer-Aided Ship-Hull Definition at the Hamburg Ship Model Basin	11:459	Gordon

MECHANICS

AGARD Conference on Fracture-Mechanics Design Methodology	2:56	Mulville
Fluids Research at the Institut für Strömungslehre and Strömungsmachine in Karlsruhe	2:59	Lessen
The Aerodynamisches Institut in Aachen	2:61	Lessen
Turbomachinery Flow Research at the Whittle Laboratory, Cambridge	2:62	Lessen
The Fluids Group of the Institute of Mechanics, Darmstadt	4:159	Lessen
The Institut für Hydromechanik, Karlsruhe	4:160	Lessen
Fluid Mechanics Research at the Aerodynamische Versuchsanstalt, Göttingen	5:196	Lessen
About Dolphins	5:198	Lessen
Fluid Mechanics à la Dansk	7:275	Lessen
The AGARD Symposium on Laminar-to-Turbulent Transitions	8:324	Lessen
Physical Chemistry and Hydrodynamics—The Levich 60th Birthday	9:366	Lessen
The Berlin Symposium on Turbulence	9:368	Lessen
The Second International Conference on Drag Reduction	10:411	Lessen
The XIII Biennial Fluid Dynamics Symposium	10:413	Lessen
Aeronautics at the Polytechnium of Torino	12:498	Lessen

The Institute of Aerodynamics at the University of Naples	12:500	Lessen

OCEAN SCIENCES AND TECHNOLOGY

Marine Science in Greece	1:33	Miller
Norwegian Offshore Technology—Small Is Beautiful	3:119	Nunn & McKendrick
Underwater Transducer Design Problems	3:123	Pryce
The New National Maritime Institute and Its Focus on Offshore Research	3:125	Pryce & McKendrick
Concrete Ships—Is There a Future?	5:200	Patterson
Environmental Loading of Offshore Structures	5:201	Pryce & Lessen
Electronics in the Fish Industry	6:245	Pryce
The Institute for Shipbuilding of the University of Hamburg and the Hamburg Ship Model Basin	6:248	Lessen
Wave Energy and Underwater Technology at Göteborg	7:277	Barcilon
Oceanografiska Institutionen, Göteborg, Sweden	7:278	Barcilon
Wave Research in the French Petroleum Industry	7:281	Barcilon
Water-Wave Dynamics at Cambridge University	8:327	Barcilon
Institut für Schiffbau, University of Hamburg	8:328	Lessen
Oceanography in Bergen	8:331	Barcilon
European Undersea Biomedical Society Meeting	10:415	Greene
Diving Research in Toulon and Marseille	10:417	Greene
Physical Oceanography in Cambridge	10:418	Barcilon
Application of Remote Sensing to Ocean Surveillance—AGARD Lecture Series	12:502	Rostron
NATO Air-Sea Interaction Symposium	12:504	Mollo-Christensen & Twitchell

PHYSICAL SCIENCES

International Conference on Superconducting Devices	2:64	Nisenoff & Brandt
1976 International Conference on Magnetism	2:67	Rado
International Conference on Magneto-Optics	2:70	Prinz
Eighth International Colloquium on Magnetic "Thin" Films	2:71	Williams & Vittoria
Searching for Energy with the "Solar Eyeball"	4:163	Soper
Acoustic Emission and Microstructural Damage	4:165	Pryce
New Gas Lasers—The Search Continues	5:204	Smiley
UK Solid State Conference '77	5:207	Nedoluha
Brighter Holographic Images at Loughborough	6:250	Smiley
Laser Spectroscopy at the University of Sussex	6:252	Smiley
Acoustics at the University of Bath	6:254	Pryce
Atomic and Molecular Physics—A Conference in the UK	7:282	Smiley & Gorrell
Conference on Semiconductor Injection Lasers and Their Applications, Cardiff, Wales, 31 March-1 April 1977	7:285	Gorrell
Guided Optical Military Communications—An AGARD Conference	7:287	Smiley
The 1977 DUMAND Summer Workshop, Moscow	9:370	Roberts
High-Power Lasers and Applications—A Conference at Munich	9:372	Smiley & Gorrell
One-Terawatt Iodine Laser—Asterisk III	9:375	Smiley
Seeking Through Fog and Better Images at Erlangen	9:376	Smiley
Some Physics Research at Chalmers Institute of Technology	9:378	Schulman

Acoustics at Trondheim	9:380	Pryce
Dye-Laser Investigations at the Ecole Polytechnique	10:421	Smiley
Ultra-High-Energy Laser Coatings Available from Ellen Vannin	10:422	Smiley
dBs and the Fans	10:423	Pryce
Lattice Dynamics—1977	11:461	Boyer & Rosenstock
Better Clocks in France	11:464	Klick
A Max-Planck Laser Institute in Garching—Maybe?	12:506	Gorrell & Smiley
Lasers and Magnetic Resonance	12:508	Klick
Probing the Stratosphere with Lasers at Verrières-le-Bruisson	12:510	Smiley

TECHNOLOGY

Viewdata and Teletext	2:72	Blachman
Technological Innovation in the UK—A Case Study	2:75	Gordon
Interactive Design Systems for British Industry(?)	8:333	Gordon