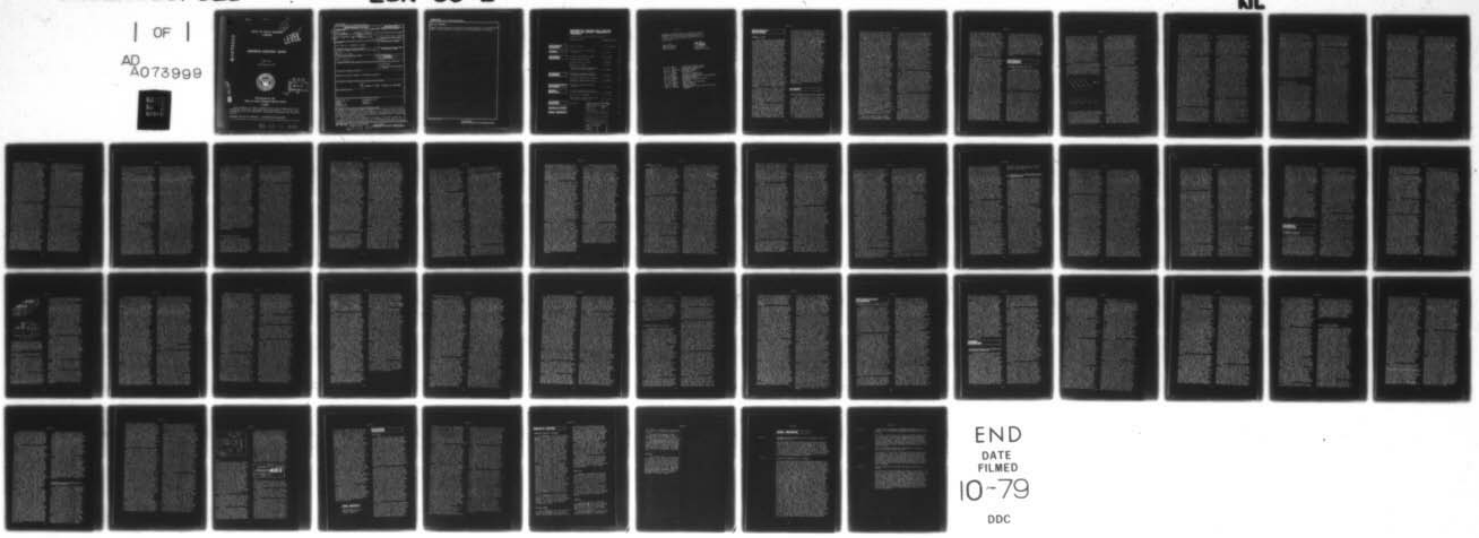
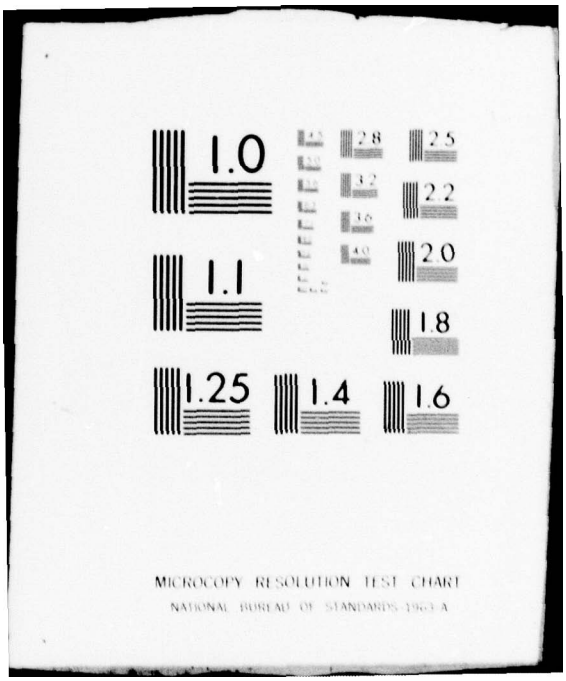
AD-A073 999 OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) F/G 5/1
EUROPEAN SCIENTIFIC NOTES, VOLUME 33, NUMBER 2,(U)
FEB 79 A W PRYCE, V S HEWITSON
UNCLASSIFIED ESN-33-2 NL

| OF |
AD A073999



END
DATE FILMED
10-79
DDC


1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 33-2

28 February 1979

Distributed by the
Office of Naval Research Branch Office,
London

This document is issued primarily for the information of U.S. Government scientific personnel and contractors. It is not considered part of the scientific literature and should not be cited as such.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
(14) 1. REPORT NUMBER ESN-33-2	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
(6) 4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES Volume 33, Number 2,	5. TYPE OF REPORT & PERIOD COVERED Monthly Publication, Februar
	6. PERFORMING ORG. REPORT NUMBER ESN 33-2
7. AUTHOR(s) A.W. PRYCE & V.S. HEWITSON, EDITORS	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research Branch Office London Box 39 FPO New York 09510	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS (12) 49 p.	(11) 12. REPORT DATE 28 Feb [redacted] 79 / 13. NUMBER OF PAGES 41
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED / 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(10) Aubrey W. /Pryce Victoria S. /Hewitson

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

BIOLOGICAL SCI	PSYCHOLOGICAL SCI
ENERGY	SPACE SCI
MATERIAL SCI	SYSTEMS SCI
PHYSICAL SCI	

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

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

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's European Office of Aerospace

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

265 000 79 09 14 032

ITEM #20 CONTINUED

Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Aubrey W. Pryce and Victoria S. Hewitson

28 February 1979 Volume 33, No. 2

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

HERBERT SOLOMON
Chief Scientist

P.F. GIBBER
Captain, USN
Commanding Officer

BIOLOGICAL SCIENCES

ELISA IN LONDON

Dr. Alister Voller of the Nuffield Institute of Comparative Medicine, Regents Park, London, who is also Senior Lecturer in the Department of Clinical Tropical Medicine at the London School of Hygiene and Tropical Medicine, is developing and applying a micro-modification of the Enzyme-Linked Immunosorbant Assay (ELISA). The ELISA is an accurate and relatively simple technique for both qualitative and quantitative detection of substances in biological fluids. It can be used to detect anything that is immunogenic by detecting either the antigen itself or an antibody to the antigen. It has been used extensively in the serodiagnosis of infectious diseases (See "ELISA in Stockholm" by S. Joseph, *ESN* 31-10:393). Voller has led the field in developing micro-modifications of tests to diagnose parasitic diseases, such as malaria, schistosomiasis, trypanosomiasis, as well as viral and bacterial infections. ELISA can also be used for detecting other substances circulating in human blood such as blood clotting factors and carrier-proteins. It has a potentially extensive commercial application in diagnostic medicine. Of major importance is the use of this technique to detect antibodies to rubella (German measles), hepatitis, and other common infectious diseases.

Voller and his colleagues are visited by many scientists, usually under the sponsorship of the World Health Organization (WHO), who work with him for periods of time. He and his colleagues also conduct workshops on ELISA and speak at international conferences. During August and September, he was in the Peoples' Republic of China helping to introduce the technique to scientists there.

A postdoctoral research associate working with Voller is Dr. Donald de Savigny, a Canadian, who is sponsored by the Canadian Medical Research Council. He is utilizing the ELISA technique to diagnose tissue nematode infections. One, filariasis, is caused by several species of tissue invading nematodes of the filaraie family. It is difficult to diagnose and can cause eosinophilia, fever, and lymphangitis. Dog and cat roundworms, *Toxocara*, can also infect humans causing a generalized infection with enlargement of the liver and spleen, as well as, fever, eosinophilia, and occasionally epileptic seizures and eye lesions. This also can be very difficult to diagnose, requiring a tissue biopsy. Serological techniques have been used in the past to assist in the diagnosis of these infections. However, there is considerable cross reactivity between other worm infections, including intestinal helminths. De Savigny has developed a technique in which he cultures the larval stages of the parasites. The parasite secretions, called exoantigens, are taken from the culture medium, purified, and concentrated, and then used as the antigen in the ELISA test to detect antibodies in the blood from patients. Preliminary data show that the technique is exceedingly sensitive for detecting the antibodies to *Toxocara* and that there is no cross reactivity with other parasitic infections. Therefore, for the first time, it appears that there will be a specific and sensitive test for the diagnosis of this infectious disease. De Savigny believes that he can also use exoantigens in serological tests for other parasites that can be cultured *in vitro*. (CAPT G.T. Strickland, MC, USN, Liaison Technologist from the Department of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD)

ENERGY

FUSION RESEARCH AT THE CULHAM LABORATORY

The Culham Laboratory, located in Abingdon, Oxfordshire, is the controlled fusion research center of the United Kingdom Atomic Energy Authority. The British have engaged in theoretical and experimental work in controlled fusion since the very early days of atomic energy. It seemed at one point in the early 1950s that a major breakthrough had been accomplished under the direction of Sir John Cockcroft, but as we now know, the problem proved to be much more formidable than had been expected.

At Culham, activities are limited to investigating the magnetic confine-

ment of plasmas in closed toroidal configurations. Magnetic fields in the toroidal configuration generally have components in two directions: One is the azimuthal direction about the axis of symmetry of the torus and the other is in the direction of the minor circles of the torus. The fields in the azimuthal direction about the symmetry axis are called toroidal fields and those in the direction of the minor circles, poloidal fields. Since the demonstration of relative success in the USSR of the TOKAMAK device, great interest has been focused in many of the controlled fusion laboratories of the world on TOKAMAK type experiments. A pure TOKOMAK device has only applied toroidal fields. At Culham, TOKAMAK research is concerned with two experimental setups: one, a Diverter and Injection TOKAMAK Experiment, denoted DITE, and the other a smaller one called a TOKAMAK Shaping and Compression Assembly and known as TOSCA. In the DITE, magnetic coils pull flux lines out of the principal toroidal magnetic field so that plasma can be diverted away from the experiment and analyzed after it collides with a suitable target and is neutralized in the diverter chamber. In this manner, impurities that inhibit the reaction can also be removed. As the temperature of the plasma rises during confinement its ohmic resistance decreases, and hence ohmic heating becomes less efficient. In order to heat the plasma further, powerful injectors of neutral particles are used to add energy to the plasma. In the TOSCA experiment, various modes of shaping the confining torus are used in order to study the effect of the torus cross section on the stability of the confinement configuration, hence confinement cross sections that are elliptical, triangular, and D-shaped have been and are under study. The DITE apparatus has a major radius of torus of 1.17 m, a minor radius of torus of 0.27 m, a maximum magnetic field of 28 kG, a maximum plasma current of 240 kA and a pulse length of 0.6 sec. Electron temperatures of 15×10^6 K have been achieved on DITE, while ion temperatures of 7×10^6 K, plasma densities of 10^{14} particles/cm^3, and confinement times of 30 msec have also been achieved though not concurrently.

Closely related to the TOKAMAK are the class of confinement configurations known as reversed field pinches. In this configuration, the toroidal confinement field reverses direction from inside to outside the torus. The reverse field pinch promises more effective utilization of the confining magnetic field and operation at a higher efficiency factor β, the ratio of the plasma pressure to the magnetic confinement pressure. The reversed field pinch concept has been applied to an experimental program called the High Beta Toroidal Experiment, or HBTX. A new version of the HBTX experiment, denoted HBTX 1A, is now under construction. The relevant parameters of this experiment are a major radius of the confining torus of 0.8 m, a minor radius of the confining shell of 0.285 m, while the minor radius of the shell liner is 0.26 m. The maximum toroidal current is 400 kA. A reversed field experiment, RFX, has been designed, and it is hoped that this experiment will be built. In this, the major radius of the confining torus is 1.8 m, the minor radius is 0.6 m, and the maximum plasma current is 1.5 MA.

The stellerator, denoted CLEO, is still under study at the Culham Laboratory. It has a major toroidal confinement radius of 90 cm and a minor radius of 14 cm. CLEO differs from the TOKAMAK in having a helical field in addition to the toroidal one, achieved by placing helical conductors around the toroidal confining chamber. Experiments with CLEO indicate that the stellerator confinement system seems at least as efficient as an equivalent TOKOMAK, though there are fluctuations and oscillations that are not yet well understood and that could have an adverse effect on confinement.

An interesting plasma confinement device that has also been studied at Culham is the superconducting Levitron. In this device, a superconducting ring is levitated in the middle of the toroidal confinement cavity. The ring current is of the order of 400 kA. Although the Levitron has permitted investigation of interesting plasma phenomena, it is a highly improbable device for a controlled fusion reactor.

Although not under the direction of the Culham Laboratory, a very important experiment called the Joint European Torus (JET) (see ONRL R-20-75 and *ESN* 29-8:388 by R.T. Schneider) that will be sited in the Laboratory grounds completes the experimental picture there. JET is a joint undertaking of

Euratom and member organizations from the 9 EEC countries and Sweden, and is intended as a study of plasmas in conditions and with dimensions that approach those needed in a full-scale fusion reactor, that is, plasma densities approaching 10^{14} particles/cm^3, temperatures exceeding 15,000,000 K, and a plasma minor radius larger than 1 m. The relevant parameters for JET are: A major radius of 2.96 m, a minor radius for the cross section of 1.25 m in the horizontal direction, a minor radius for the D cross section in the vertical direction of 2.10 m, a pulse length of 20 sec, a toroidal magnetic field of 2.77 T, and a maximum plasma current of 3.8 MA.

The theoretical activity at the Culham Laboratory is under the direction of Professor J.B. Taylor. Some years ago, the stability of cylindrical confinement configurations had been fully explored using an MHD model for the plasma. Because of the cylindrical geometry, the linear stability problem was separable so that finally all modes could be explored through an ordinary differential equation and its characteristic values. However, for a toroidal confinement configuration, the situation is much more difficult. Recent work by Taylor has succeeded in solving the toroidal problem to the same comprehensive degree that the cylinder was first studied. In addition to Taylor's work, Drs. F.A. Haas and P. Fielding are repeating the analysis of the torus using a pressure tensor which is not the same in all directions, and hence anisotropic. They are also exploring the utilization of neutral injection for stabilizing a toroidal configuration.

Another area of theoretical investigation at the Culham Laboratory lies in studying the stability of drift waves. A drift wave is one that occurs at the edge of a plasma confinement configuration, where the properties of the plasma have a gradient. The unstable disturbance of such a configuration has a wave number vector which lies perpendicular to both the gradient of plasma properties and the direction of the confining magnetic field. Drift waves have been extensively studied for the case where the confining surface configuration is planar. More recently, Dr. R.J. Hastie has been studying drift waves where the confinement configuration is toroidal and finds that even in this situation the wave number vector for the drift waves is essentially in a direction perpendicular to the confining magnetic field and the gradient of plasma properties. The interest in drift waves arises because such waves can cause enhanced transport from the plasma. It is possible that the effect of such waves can be estimated by considering that they grow asymptotically until they achieve a saturation amplitude and become marginally unstable. The anomolous transport associated with the marginally unstable linear problem could be related to the actual transport in the nonlinear marginally unstable situation. (Martin Lessen)

MATERIAL SCIENCES

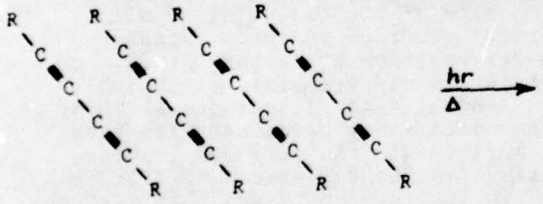
POLYMERS AND SURFACES AT QMC

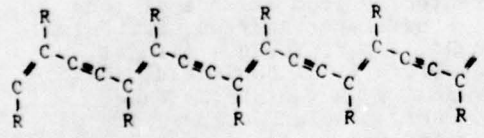
Queen Mary College of the London University, is situated about midway between the Mile End and Stepney Green Underground "Tube" stations. Mile End was the site of the hamlet of La Mile Ende first recorded in 1288. Stepney Green derives from Stybbanhype (c.a. 1000 AD) which loosely translates into Sebbings' landing. As picturesque as these ancient hamlets may have been, the tube stop empties onto the very busy, noisy, and grimy East London street of Mile End Road. The College buildings that stretch out along this road show the greying effects of the surrounding industry and traffic.

So it was a relief to arrive at QMC, be ushered into morning coffee, and warmly greeted by good friends of long standing: Prof. Edgar Andrews, Dr. Peter Reed, and Dr. Robert Young. Also at coffee was Dr. William Bonifield, editor of the *Journal of Materials Science*, which is a very popular journal with materials scientists worldwide. Andrews is head of the Department of Materials and has in recent years been active in determining the intrinsic cohesive and adhesive failure energy of polymers in the rubbery state above their glass transition temperature (T_g). Coincident with this research he has been developing a generalized theory of fracture which he feels can incorporate all the micro-deformation processes involved in polymer fracture, including their time-temperature dependence. Recently, he

has been struggling (his words) with the fracture of epoxy polymers in their glassy region below T_g. The results are not as easily analysed as is the data taken in the rubbery state. Nonetheless, Andrews has found a means of correlating the data to obtain the intrinsic thermodynamic work of fracture. Currently, he has been investigating the adhesive failure of epoxy polymers bonded to titanium. He has been looking at the effect of moisture and heat on crack propagation at the epoxy-titanium interface and believes he can use these data to extrapolate back to an intrinsic interfacial energy. He has also been able to obtain rate constants for moisture debonding of the interface.

Dr. David Bloor and his associates in the Department of Physics have been doing some fascinating work on the properties of diacetylene polymers. They have been preparing single polymer crystals by exposing crystals of the monomer to either heat or light. This solid state polymerization can be represented by:





Because of the highly ordered structure of the monomer crystal and the relatively little atomic rearrangement in the formation of the polymer, the result is a highly ordered polymer single crystal. The R-group can be widely varied, but the compound most extensively studied by Bloor's team is the toluenesulfonate diacetylene; R = $-CH_2-O-SO_2-C_6H_4-CH_3$.

The simplest homolog, when R=H, is polyacetylene which has been studied by a number of laboratories around the world. Polyacetylene is prepared by gas phase polymerization of acetylene and has some interesting electrical properties, notably its conductivity when doped with iodine. It was hoped that the organo-substituted polydiacetylenes would also be electroactive. However, Bloor has found them to be non-conducting even though the crystals are vividly colored and have a metallic sheen. The toluenesulfonate polydiacetylene absorbs strongly below $1.57 \times 10^4 cm^{-1}$. This absorption is due to a delocalization of electrons 2 eV above the ground state. However, this delocalization is not into a conduction band. The electron and hole are apparently delocalized over only a few repeat units.

Doping the polydiacetylene crystals with iodine and other halogens has not induced electrical conductivity as it does in polyacetylene. Bloor believes that in polyacetylene the dopant enters regions of crystal disorder, but because the diacetylene crystals are so structurally perfect the halogen doping is ineffective. They are currently working on ways of introducing regions of disorder in their diacetylene crystals.

The lack of electroactivity of the polydiacetylenes is offset somewhat by their interesting crystallographic properties. Most often the crystals are in the form of thin platlets although they can be made to form fibers. They are unusual as polymer crystals go in that the polymer molecules lie parallel to each other in the plane of the platelet or in the axial direction of the fiber. Most polymer single crystals, such as polyethylene, form platelets in which the molecules are folded with the folds perpendicular to the plane of the platelet (*ESN* 32-8: 271). Bloor and his associates have measured the shift in the 2-eV excitation as the polydiacetylene crystal is mechanically strained in the chain direction. They have been able to show that the measured spectral shift is essentially equal to the shift calculated from a molecular orbital description of the polymer.

The yielding behavior of the polydiacetylenes is also interesting. They exhibit the phenomenen of twinning commonly observed with metal and inorganic salt crystals. The QMC group believe that in this phase change the side group

structure is modified but the backbone structure remains unchanged. Young, in the Department of Materials, is doing an electron microscopy study of the deformation of very thin (~5000 Å) crystals of polydiacetylene. As might be expected, they fail by cleavage between chains, and fibrils of chains can be seen extending across the cleavage. Young pointed out the possible use of the single crystal fibers as reinforcement in composites since they have tensile strengths of 2 GPa, which approaches that of graphite fibers, moduli of 50 GPa, and a relatively high strain-to-failure of 4%.

Dr. Peter Reed in the Department of Materials is continuing his elegant studies of polymer yielding using electron spin resonance (ESR). ESR spectroscopy detects the formation of free radicals as the polymer chains break. Reed had been examining the yielding of nylon fibers in pure N_2, CO_2 and He and finding that the magnitude of the ESR signal (radical formation) increases with the surface area of the fiber. It would appear that the gaseous environments are inducing surface crazes. Reed has launched a study, quite different from his ESR work, on the failure of polytetrafluoroethylene (PTFE) tubes at high loading rates. The tubes are mounted on the end of a shock wave tube, and loading rates of quasistatic to essentially infinity can be achieved. The apparatus has been designed to give minimum interference with the loading frame and uniform stress distribution. The stress can be applied as a step or ramp loading. The strain rate is not especially high because of the finite response time of the PTFE tube. Among the results obtained thus far, there appears to be a maximum in the failure stress with increasing loading rate, and this maximum might be associated with a viscoelastic damping peak. Other features of the results also indicate that even at these high loading rates, viscoelastic processes are involved.

In addition to its intrinsic scientific value, the shock wave loading of polymer tubes is aimed at developing failure criteria for plastic drums used to transport liquids. In a companion study, Reed and his coworkers are dropping 45-gallon drums filled with water and covered with strain gauges onto a platform fitted with pressure transducers. Coupling failure criteria from the shock tube study with the failure analysis of the drums are expected to lead to improved drum design.

Such close coordination between fundamental and applied polymer research in the UK is unusual. In fact, the Science Research Council has formed the Polymer Engineering Directorate (PED) to promote closer links between the universities and the British plastics industry by funding research aimed at specific problems. Reed's study of plastic drum failure is supported by the PED. We hope to report further on the PED in a later *ESN* issue.

In the Department of Chemistry, Dr. John Pritchard is studying the adsorption of small molecules on metal single crystals. He is using low energy electron diffraction (LEED), surface potential measurements, and infrared spectroscopy to determine the bonding and configuration of adsorbed films of small molecules, CO, N_2, ethane, on various metals. The infrared studies are especially interesting since the adsorption level is only 0.1% or less and so the signal-to-noise ratio (S/N) is low. Pritchard and his coworkers overcome this problem by using a liquid He cooled bolometer as the detector. Also, the angle of incidence is set at 88° for maximum adsorption of the wave component vibrating perpendicular to the sample surface. (The parallel component is poorly absorbed and exhibits no maximum.) The principal S/N enhancement is achieved by slightly modulating the beam wavelength and recording the detector signal at the modulation frequency. This gives the derivative of the spectrum. Integration of the signal averages much of the noise. The net result is a reduction of the S/N to 0.01%.

The infrared absorption study, in combination with surface potential and LEED measurements, can reveal detailed information about the configuration of the adsorbed layer, especially as the coverage approaches a monolayer. For example, Pritchard has found that on palladium the adsorbed CO shows continuous changes in the absorption frequency with increasing coverage owing to changes in the type of bonding to the metal and the development of repulsive interaction between CO molecules as the coverage approaches a monolayer.

These studies, especially at high coverages, are very relevant to gas phase catalysis. Currently, Pritchard is in-

vestigating the adsorption of N_2 on nickel and expects to be studying adsorption on iron. In this work the emphasis is to understand the catalytic behavior of these metals.

The scientific excellence of the research at QMC is known internationally, and their current work reinforces this reputation. Much of their success comes from a willingness to adventure on to uncharted ground. Andrews' theoretical work on polymer fracture is unique in its attempt to unify the viscoelastic and molecular rupture contributions to toughness. His novel experimental technique for studying adhesive fracture represents a new approach to this difficult problem. The work by Bloor and Young on the polydiacetylenes is showing that these are a novel class of polymer crystals which may find important practical applications. Reed's high loading rate testing of polymers is innovative both in the design of the equipment and the use of the results in the failure analysis of plastic drums. Pritchard's ability to use infrared absorption to investigate metal/gas interfaces gives him a very powerful tool in the study of gas-phase catalysis. (Willard D. Bascom)

THE FILMS WERE NOT FAT

The 4th International Thin Films Congress was held 11-15 September 1978 at Loughborough University of Technology, about 120 miles north of London. This, the latest in the triennial series of major thin films conferences, included many reports on important developments over the last few years. The Congress program was devoted mainly to the relationships between structure and properties of thin films. This theme was developed for all classes of properties including electrical, magnetic, optical, and mechanical, and attention was given to their relations with many aspects of structure, including crystalline form, morphology, defects, composition, etc. Because of the conference committee's decision to narrow the very large thin film field to this more specialized theme, the Congress attracted less than 300 attendees, somewhat fewer than the 800 or so that might have been expected if the subject had been thin films in general. It is possible that the location had something to do with this, since the previous meetings in this series have been held in much more exciting international cities including Budapest (1975) and Venice (1972). The program consisted of about 200 papers, including 12 invited talks in single sessions, 126 contributed oral papers in triple parallel sessions, and 63 posters.

If you're not in this field, you are probably wondering, as I was, just how thin is a thin film? For purposes of discussion, the thin film community seems to agree that a film is "fat" if it is more than about a micron (10^{-6} m) in thickness. On this scale, structural features of the films can have profound effects on various important properties. The conference program was based on a framework of invited talks accompanied by sessions of contributed papers in the various property categories of structure-property relations.

Perhaps the most logical place to begin a review of the Congress program is with the methods of producing thin films. A variety of new and old methods were evident, some of the newer ones including molecular beam epitaxy (MBE), ionized-cluster beam deposition and epitaxy (ICBDE), and quench condensation (vapor quenching). Reports on methods developed interest from both the practical side (device fabrication) and from the fundamental view (studies of film formation). Some of the newer methods reported involve much better conditions than older techniques, and these allow careful basic studies to be carried out at the same time as offering new possibilities for film structure formation. A.C. Gossard (Bell Labs, Murray Hill, NJ) opened the Congress with a review of MBE, in which an electron beam is impinged at a shallow angle to the surface to impart activating energy to the various vaporized elemental species as they arrive at the surface. The aim of this scheme is the same as in some of the newer ion deposition techniques, that were reviewed by C. Weissmantel (Technische Hochschule, GDR). In these methods, the acceleration of the film forming species offers a versatile way to supply activating energy to the growing film. This solves many problems of conventional thermal or chemical deposition, and leads to the preparation of previously unknown thin film phases. For example, plasma-induced chemical vapor deposition (CVD) enables the rapid preparation of films at reduced substrate

temperatures; Weissmantel discussed results for Si and SiN deposition. It was pointed out that often a compromise must be made between stoichiometrical quality and deposition rates, or between activation effects and radiation damage. Interesting results were reported on the condensation of ionized organic molecules; very hard carbon films have been formed in this way. ICBDE was reviewed by T. Tagaki (Kyoto Univ., Japan); this is a method developed in the last few years which is unique in that clusters of 100s to 1000s of atoms are generated by adiabatic expansion through a nozzle. The clusters are partially ionized by electron bombardment and accelerated onto the substrate. In addition to the general effects of accelerated ions, even more enhanced migration of ions is obtained with this method, and an assortment of special film structures and properties can be obtained. Tagaki described examples of films with high packing density and strong adhesion formed on various substrates, including results for oxide and nitride films (e.g., ZnO, AlN) and the application of the technique to electronic device fabrication reported.

Of course one of the classical areas of interest regards mechanisms of thin film formation, i.e., the details of the nucleation and growth processes. This area was reviewed by M. Krohn and H. Bethge (Akademie der Wissenschaften der DDR) and J.J. Metois and R. Kern (Faculté des Sciences de St-Jérôme, Marseille, France), and quite a few contributed papers presented theoretical models for the behavior of the adatoms. One of the central interests was in the self-diffusion of atoms on substrate surfaces, which has a profound effect on the ultimate shape and structure of an adsorbed layer. The various stages of film development (adsorption, nucleation, cluster formation, etc.) were all treated. Experimental studies reflected the use of a variety of film characterization techniques, including transmission electron microscopy (TEM), Auger electron spectrocopy (AES), low energy electron diffraction (LEED), etc.

Because of various important applications, optical properties comprised one of the most emphasized property categories at the Congress. In fact, the program was actually opened on this theme with two invited talks, by Gossard and O. Hunderi (Norwegian Institute of Technology, Trondheim). Hunderi reviewed the general relationships between structure and optical properties, then centered on metallic thin films produced by quench condensation, which usually produces microcrystalline and sometimes amorphous structures. Additional optical absorption is often found in microcrystalline films, an effect similar to those seen in metal films with other odd structural features, including rough surfaces, discontinuous films, and in two-phase metal-insulator films. For the microcrystalline case, increased absorption is interpreted as being a result of excitation of surface plasmons propagating along grain boundaries, and Hunderi presented theoretical calculations to support this explanation. Gossard's review presentation also dealt with the optical properties of films with rather unusual structure, using MBE to produce alternate ultrathin epitaxial layers of the III-V compounds GaAs/AlAs, each as thin as a monolayer. Optical properties and their dependence on structure were studied for composites of up to 10^4 layers. As would be expected, the layered structures produce optical anisotropy, causing birefringence and polarized luminescence. In addition to these reviews, a number of papers considered the optical properties of a range of this film material, with particular interest in structural effects on band gap, refractive indices, and absorption coefficients, including the effect of film annealing, surface roughness, temperature, etc.

Further considerations of optical properties dealt with the modeling of so-called optical multilayers. The traditional model of a thin film used in optical calculations is a homogeneous isotropic slab of material. However, it has long been known that real films depart from this ideal, particularly in terms of inhomogeneity of refractive index, which the models usually treat by representing an assembly of homogeneous layers of different indices. Taking the analysis a large step closer to the real structure, which may consist of columnar grains rather than layers, a multinational group headed by M. Hams (Newcastle upon Tyne Polytechnic, UK) and E. Pelletier and B. Vidal (Université d'Aix-Marseille, France) presented some perhaps more realistic structural models.

Another important category is transport properties (electrical conductivity). One of the obviously unique "structural" features of a thin film is its lack of thickness, and there is also often a lack of continuity; both these features cause different electrical behavior than for bulk materials. Surface effects predominate in thin films; resistance tends to be high; and as thickness and continuity increase it drops. Thus electrical conductivity in discontinuous metal films was considered by several authors, including a lead paper by K. Uozumi (Univ. of Tokyo, Japan) who reviewed the various models for this situation. A systematic study by T. Anderson and S. Norrman (Chalmers Univ. of Technology, Goteborg, Sweden) exemplified the type of experimental work being done on this subject by describing attempts to determine the dependence of conductivity in discontinuous Au films on structural parameters such as particle size, shape, and distribution, which in turn depend on substrate geometry and chemistry, deposition temperature, annealing, history, etc.

The (lack of) thickness aspect received theoretical attention relative to the so-called "quantum size effect" (QSE), which arises because mobile electrons in a sufficiently thin film of metal or semiconductor are subject to particle-in-a-box quantization. The relevant theory and importance of this for all electronic properties of such films was reviewed by A.A. Cottey (Univ. of East Anglia, Norwich, UK), and experimental data for QSE in Pt films was presented by G. Fischer and H. Hoffman (Universität Regensburg, FRG), who used $Al/Al_2O_3/Pt$ sandwiches to evaluate the electron tunneling characteristics. The relations between magnetic properties and structure were also discussed by Hoffman in a review paper.

Most of the experimental papers involved studies of quite sophisticated properties augmented by very thorough characterization of film structure. An arsenal of analytical techniques was used, often in a single study. For example, in a session of contributed papers on "compounds" in which the particular interest was in the effect of defects and impurities on carrier mobility in semiconductors, a study by J. Kohout and coworkers (Czechoslovak Academy of Sciences, Prague) utilized reflection high energy electron diffraction (RHEED), TEM, AES, and x-ray spectroscopy (XRS) to characterize the structure of GaP films in order to make correlations with electrical and photoelectrical properties.

The composition of thin films is of great importance, of course, and recent advances in surface microanalysis have allowed the determination of this structural aspect with greater accuracy than previously possible. Several reviews and contributed papers evaluated the capability of these methods to analyze thin film composition by depth profiling (composition vs depth plotting) with emphasis on AES. There are certain problems in the interpretations of AES depth profile data that are related to the ion sputtering process used to erode away the surface continuously or sequentially as the profile is obtained. For example, artifacts can arise owing to nonuniform erosion, and this leads to uncertainty in depth resolution. AES depth profiling was applied in several studies, including the subject of diffusion along grain boundaries in thin films, a phenomenon often associated with device failures at elevated temperatures and high current densities.

The Congress program gave limited attention to mechanical properties although some thin films, such as the gold ones used in the electronics industry for electrical contacts, do have requirements in this area, such as hardness and ductility. A paper from J.A. Augie and C.C. Lo (Bell Labs, Columbus, OH) reported on strengthening mechanisms in sputtered pure gold films as compared to electroplated gold solid solutions. Another mechanical property aspect is internal stress, and several papers concerned themselves with its measurement in thin films and its affect on properties in other categories.

Thin film researchers refer to semiconductor chips and such as "devices." These designed arrays of thin film layers were not discussed directly because of the structure-properties theme, but many papers wandered into this area in terms of the application of their thin film work to devices of various kinds. For example, epitaxial multilayers of GaAs are widely used for fabrication of active elements of high frequency microelectronics. A paper by R.V. Konakova and Y. Schwarz (Institute of Semiconductors, Kiev, USSR) treated the problem of low device efficiency

with a structure/electrical properties study. In addition to electronic devices, there were hoards of papers in various other application areas including solar cells, resistors, dielectrics, solar coatings, etc.

Devices for solar cells received quite a bit of attention. In recent years, study in the area of binary semiconductor compounds has been intensified in order to find new materials for γ-ray detectors and solar photocells. III-V and II-VI compounds have been found quite efficient, especially CdTe, to which some international meetings have already been devoted. In general, the key structural features in such films are the minor compositional constituents, such as dopants and impurities which affect the band gap characteristics and may serve as recombination centers. The importance of the nature, location, and concentration of such centers was discussed in a paper by C. Lhermite and C. Vautier (Laboratoire de Physique des Couches Minces, Mont-Saint-Aignan, France), who described methods to determine the band structure, accompanied by a sophisticated experimental structure-properties study. A related aspect of this class of thin films is that the demands for carefully controlled doping present difficulties with some film deposition techniques such as MBE when dopants of high vapor pressure are used. T. Suzuki (Tokyo Institute of Technology, Japan) and coworkers proposed a new method to dope GaAs with Zn by ionizing the Zn with an electron beam and detailed the structure-properties relations.

The typical approach seen in so many of the Congress papers, i.e., chemical/structural information with measurements of physical properties was also reflected in various papers on resistor films, these included such materials as NiCr, Ta, and Ta_2N, where the effect of deposition method on structure and electrical properties was the typical theme, and a series of contributions on dielectric films, particularly SiO_2 and SiN. For example, R. Hezel and N. Lieske (Universität Erlangen, FRG) employed a combination of AES and electron loss spectroscopy (ELS) to study these latter films, with the aim of elucidating the nature of chemical bonding, which is one of the primary interests relative to understanding properties in this application area. Solar coatings, the surfaces that intercept the incident radiation in photothermal energy converters, must have several essential features, including a spectral profile properly matched to the solar emission and thermal reradiation properties, and stability at elevated temperatures. In the application of films of this type, optimum performance always involves a tradeoff between solar absorptance and thermal emittance. Recent developments in the chemical vapor deposition (CVD) of amorphous silicon absorbers with improved temperature stability, and of reflector films of Mo, were discussed by B.O. Seraphin (Univ. of Arizona, Tuscon), and a detailed study of the structural, thermal, and optical properties of selective black nickel coatings was outlined by P.K. Gogna (Indian Institute of Technology, New Delhi, India) and coworkers.

The subject of metastable thin films received considerable attention. Such films may be deposited, by the quench condensation method discussed by Hunderi, or created in-place by ion implantation. Quite different from the ion-deposition processes, ion implantation is a grossly nonequilibrium process that is gaining considerable attention for producing alloy surface layers inaccessible by conventional techniques. J.M. Poate (Bell Labs, Murray Hill, NJ) reviewed the general area of metastable alloy formation. He pointed out that there are obvious similarities between the rapid quenching and ion implantation techniques and that indeed implantation may be viewed as effectively producing quench rates on the order of 10^{14} K/sec. There are two interesting possibilities offered by these techniques, one of which is to produce extended solid solubility, the other to produce amorphous structures. The latter is more difficult to achieve in terms of the quench rate required and in fact is virtually impossible in pure metals; self-implantation leading to amorphous surface layers can be obtained in elements such as Si, however. By requisite choice of alloying elements, on the other hand, amorphous alloy surface layers can be produced on metals; Poate reported on such layers produced by implanting Cu or Fe with Ta or W. It is generally possible to produce amorphous layers on transition metal elements (Fe, Co, Ni) by implanting metalloids (B, P). The subject of amorphous alloy formation was recently the subject of its own third international conference, reported earlier (*ESN* 32:10-326).

Transparent conductive oxides, used in such applications as heterojunction solar cells, are currently centered on the compounds SnO_2 and In_2O_3 (Sn-doped), which are usually produced by reactive sputtering of the metal, or by CVD or vacuum evaporation methods. A group of papers were devoted to the appropriate structure-property relations for this application. W.E. Spear (Univ. of Dundee, Scotland) reviewed recent advances in the new field of substitutionally doped amorphous semiconductors, particularly amorphous silicon. Based on measurements of such electronic properties as conductivity, Hall effect, drift mobility, thermoelectric power, and photoconductivity, he showed that electronic properties can be controlled systematically over a remarkably wide range. Recent work on the charge distribution, profile, and differential capacitance of amorphous barriers and p-n junctions were also reported and their application in "large scale" devices (big chips) was considered.

In summary, it can be said that the Congress adhered very well to its intended structure-properties theme. A very high proportion of the extensive program consisted of top-quality sophisticated analyses in this vein. The techniques used to characterize film structure and properties were varied and impressive. Also, this field, which is essentially a branch of applied solid state physics, seems to approach its problems with rigorous attention to delineation of fundamentals, and even the occasional empirical study doesn't seem to be tolerated, whatever its practical value. Virtually every contributor had a reasonably sound model developed to accompany his experimental data. (Jeff Perkins)

BRITAIN FIGHTS CORROSION

Probably you are thinking that the British should quickly sell the country and ship it off in blocks to Arizona. Actually, the catchy title of this note refers to the rampant activity in corrosion science research in the UK these days. This is demonstrated annually at the Corrosion Science Symposium of the Institution of Corrosion Science and Technology, (ICST); the 19th edition was held this year at the University of Nottingham, 26-29 September 1978. This meeting presents an excellent cross section of the British corrosion science scene, with about 125 delegates from more than 50 sites attending this year. Half these delegates represented universities (about 25 different schools), with the rest about equally divided between government research establishments and industry. Only a handful of delegates were from outside the UK.

This is a meeting that emphasizes corrosion science yet has a very strong applications-oriented flavor, reflecting the balance between the academic and technological communities in the ICST. In particular, the Symposium included an extremely large and active contingent from the Central Electricity Generating Board (CEGB), with no fewer than 10 CEGB sites represented, amounting to a full 20% of the delegates.

The program included about 40 papers on "research-in-progress," with the following topics receiving particular attention: film growth in aqueous solutions, inhibitors and other environmental chemistry considerations in aqueous corrosion, and high temperature gaseous corrosion and oxidation.

The program opened with a session on film growth. Mechanisms of film growth were reviewed in general terms by T.E. Evans (British National Oil Corporation, Glasgow), and several papers considered the stability of films for specific cases, particularly elevated temperature solutions. B. McEnaney and D.C. Smith (Univ. of Bath) discussed scales formed on cast-iron in oxygenated near-neutral waters at about 50°C, and J.G.N. Thomas and coworkers (National Physical Laboratory, Teddington, Middlesex) considered the influence of dissolved oxygen and other factors on the stability of oxide films on mild steel in sodium hydrogen carbonate and sodium chloride solutions at 25-90°C; the latter work has been mentioned in an earlier *ESN* (*ESN* 32-11:384) and has relevance to the corrosion of steel in hot water central heating systems.

Several papers considered the phenomenon of electrolyte ion incorporation in growing anodic films, which can have important influences on film growth kinetics, structure, and morphology. D.H. Davies and G.T. Burstein (Univ. of Cambridge) described their work on

the passivation of cobalt in borate and bicarbonate solutions. They used Auger electron spectroscopy to analyze films formed by constant potential anodization and proved the incorporation of anions from the electrolyte. The presence of these anions profoundly affects the nature and stability of the films, based on correlations between polarization behavior as measured by cyclic voltammetry and the film composition. By this approach it was possible to explain the aggressive nature of bicarbonate and the inhibiting properties of borate in the corrosion of cobalt. B. Pearson and J.S.L. Leach (Univ. of Nottingham) presented a theoretical model based on Fick's law of diffusion to account for the conditions that lead to electrolyte ion pickup and supported the model with some actual examples. J.C. Scully and A. Cakir (Univ. of Leeds) described their research on the classical topic of the breakdown of pre-existing passive films on stainless steel by halide ions. This has long been a subject of controversy, the crux of which is an eternal debate over whether there is some sort of chemical effect of ions from the electrolyte, such as by incorporation and local breakdown of the films. The work reported by Scully approached the problem experimentally by examining the effect of various halide ions on reactivation time and changes in potential under galvanostatic cathodic charging conditions. Both alkaline (K_2SO_4) and acid (H_2SO_4) sulfate solutions were studied. For all solutions the value of the Flade potential was unaffected by the halide additions, but the critical concentrations were seen to exist for effects on reactivation time. The results were interpreted in terms of a faulted or porous film model which argues that halide ions may penetrate pores but that there is no evidence of halide ion migration within the oxide crystal structure.

One of corrosion science's newer tools is the use of ion implantation to modify surface layers and environmental response. The process of ion implantation was concisely reviewed by V. Ashworth [Univ. of Manchester Institute of Science and Technology (UMIST)], whose group is conducting research on the effect of implantation on the corrosion of metals such as copper in aqueous environments. They use an interesting 3-sweep (anodic-cathodic-anodic) potentiokinetic polarization method to characterize changes in corrosion behavior due to implantation. The work has shown (of course) that the novel copper-based surface alloys of improved corrosion resistance can be produced by ion implantation. However, it was reported that the beneficial effects are most marked in environments in which pure copper already tends to passivate and much less significant in environments in which pure copper tends to dissolve (Hmmm). The audience, a conservative and pragmatic lot, expressed serious reservations about the longevity of such surface layers, and the possible disastrous consequences that might arise if the environment eventually reaches the much more susceptible base metal. Other problems pointed out were the difficulties in obtaining these layers at all on complex shapes, the present expense of the process, and difficulties in calibrating the compositions obtained and measuring them accurately.

Considerations of aqueous corrosion also included a session that centered on the effects of environmental chemistry with relation to inhibition. P.G. Fox (Univ. of Nottingham) and coworkers discussed chemical aspects of the corrosion inhibition of copper by benztriazole (BTA). The key result was that BTA doesn't act directly as a chemical inhibitor, but rather as part of a compound that precipitates and covers the surface when a critical "inhibitor" concentration is reached. D. Gabe (Loughborough Univ. of Technology) discussed the use of various Group IV anions for inhibitors. This study has practical relevance in terms of the possible banning, for toxicity reasons, of chromates ($CrO_4^{=}$), the common inhibitor of this class.

Turning to seemingly more practical studies, a "CEGB" session on condenser/boiler corrosion problems included a number of interesting papers. These contributions were uniformly of sound scientific character, emphasizing corrosion mechanisms while dealing in the context of practical situations. W. Moore (CEGB, Midlands) presented work on the chemical cleaning of alloy steels in boilers, particularly the use of citric acid/glyoxal and citric/formic acids, and the mechanisms of oxide scale removal were studied in detail. It was shown why the common cleaning agent for mild steel, ammoniated citric acid, is not

sufficient for alloy steels and why reducing agents must be added to dissolve the oxides produced by the latter materials. V.E. Furlong (CEGB, Midlands) described related work on the effect of various inhibitor systems for use in acid-cleaning of condensers. The idea here is to reduce general dissolution of the base metal while removing the scales. Inhibitor "mixes" in these cases must be effective for both brass and steel components. As compared to boiler cleaning, where the primary aim is to prevent localized corrosion attack under scale deposits, in condensers the main advantage of cleaning is to improve performance.

P.J. Nolan (CEGB Macclesfield) and coworkers contributed an excellent paper analyzing the errosion-corrosion of mild steel in high velocity water and steam/water mixtures. This is the classical problem of perforation of tubes at the outside of bends, yet Nolan provided considerable insight to the mechanisms of corrosion attack. Using a number of careful experimental approaches, particularly detailed metallography, he analyzed the nature of attack and offered interpretations in terms of flow effects on the electrochemistry of the system. The "erosion-corrosion" mechanism proposed differs from others that have been put forward, but seems quite valid and reasonable. He showed very neatly how mass transport analyses correlate with the carefully-determined experimental data on surface structure.

Another very interesting paper related to power plant problems, on acid-dew-point corrosion, was presented by Dr. C.W. Morris (CEGB, Harrogate). This is a problem unique to the "back end" of the power plant where emitted SO_2 may be converted to SO_3 by excess oxygen and then deposited in moisture on plant components as sulfuric acid solution. Typically the acid concentration may be 70 wt. % sulfuric acid. Work in this concentration range falls into a data void; whereas much is known about sulfuric acid corrosion in more dilute and more concentrated ranges, the present range actually yields much higher corrosion rates. Basic research on this situation is badly needed, since the present remedies are strictly meat-axe in approach, i.e., the reduction of excess combustion air in order to limit SO_3 and/or to increase metal surface temperatures above the dewpoint. These require changes in power plant operation that may not be desired or cannot be carried out, and ultimately more corrosion-resistant materials are being sought.

Most of the papers on high temperature gaseous corrosion were also related to power plant applications. The best-lecture award was given in this category to Peter Hunt (Univ. of Newcastle upon Tyne) a student working with Dr. K.N. Strafford, for his presentation on the mechanism of inhibition of high temperature corrosion (in 4:1 O_2:SO_2 bioxidant gas) of Ni-15 Cr alloy by additions of Zr (around 1 wt. %). It was suggested that a pre-existing intermetallic network in the as-cast microstructure is the key factor in explaining the slower scaling rate of this alloy (than binary Ni-15 Cr). The oxidation session was otherwise dominated by contributions from a group at the CEGB main research center, CERL (Central Electricity Research Laboratory, Leatherhead, Surrey), particularly in cooperative efforts with UMIST. These studies emphasized the structure and growth kinetics of oxide films of iron and iron-chromium alloys, a subject of considerable attention over the years. Most of the contributions involved the growth of oxides in carbonaceous gas atmospheres (CO_2/CO). E. Metcalfe and A. Charalambous (CERL) presented studies of CO_2/CO oxidation of pure iron single crystals on an environmental hot stage within a scanning electron microscope (SEM), where oxide crystal growth kinetics and morphology were studied on various crystallographic faces. J.M. Calvert and coworkers (UMIST and CERL) discussed oxide layer formation on Fe-9Cr alloys in CO_2/CO using a radioactive tracer (^{18}O) method, and a similar study was contributed by A. Pritchard (Atomic Energy Research Establishment, Harwell) and coworkers using ^{18}O-deuterium profiling in a 3-MeV nuclear microprobe. P.C. Rowlands (UMIST) and coworkers presented work on transport paths in double-layered oxide scales on ferritic steels, also for CO_2/CO, using SEM and TEM (transmission electron microscopy) data from fracture and polished sections of the oxides to study the pore structure and morphology.

Another consideration for ferrous alloys exposed in carbonaceous gas atmospheres is the uptake of carbon by the alloys. Approaching this problem from the theoretical aspect, F.G. Hicks (CERL) presented a model for the simulation of carbon uptake diffusion in Fe-9Cr alloys

undergoing oxidation in CO_2/CO. The phenomenon of "breakaway oxidation" is believed to be associated with conditions that lead to the deposition of carbon in the oxide, and Hicks' model analyzed this situation. On the same subject, P. Banks and coworkers (UMIST and CEGB, Macclesfield) presented experimental studies centering on the morphology and structure of carbides formed in association with the breakaway phenomenon.

One of the few papers from outside the UK was presented by a Briton, J.M. Harrison (Petten Research Centre, the Netherlands). It concerned carbonaceous gaseous atmospheres, but in this case for the behavior of austenitic superalloys in conditions relevant to the petrochemical industry (CH_4/H_2), not power generation. Here the situation is quite different in that the environment is reducing, not oxidizing. The study involved extensive use of surface microanalytical techniques [SEM, Auger electron microscopy (AES), electron spectroscopy for chemical analysis (ESCA)] to elucidate corrosion mechanisms. The importance of alloy surface condition on the carburization (uptake) behavior was demonstrated, and the use of a unique magnetic susceptibility technique for nondestructive testing (NDT) evalution of subsurface carburization was shown. Another foreign contribution was from M.J. Graham (National Research Council of Canada), who discussed the determination of oxide thickness and structure on iron by the use of Mössbauer spectroscopy.

In recent years it has been the practice to include in the program a somewhat "offbeat" topic with some peripheral relevance to corrosion science but outside the mainstream of the activities of the Institution's members. This year, Symposium organizer Dr. Peter J. Boden (Univ. of Nottingham) selected the topic of surgical implants of materials, where there are clearly identifiable material/environment incompatibilities that can be readily understood in terms of basic materials science and corrosion science principles. The topic was reviewed by Dr. D. Williams (Univ. of Liverpool), a dental surgeon from the internationally prominent biomaterials group at Liverpool, who demonstrated exceptional familiarity with physical metallurgy, and corrosion science, as well as general medicine and surgery.

Undoubtedly the most interesting lecture of the Symposium was presented by Dr. L.L. Shreir (Head, Dept. of Metallurgy, City of London Polytechnic) in accepting the prestigious U.R. Evans Award (previous recipients T.P. Hoar and P. Lacombe). Although not a research paper, his talk made many valuable points regarding corrosion science in technological situations. Shreir accomplished this through the unique and daring approach of reviewing his own professional career. This turned out to be a very effective way of making a number of valid points regarding the education and training of corrosion scientists and engineers. It is impossible to capture the entertaining manner or to relate the numerous anecdotes that Shreir used, but several of his points are worth citing. He emphasized that it is inappropriate to try to separate corrosion science from corrosion technology or academic from industrial research, points that were partly demonstrated by this Symposium itself, and he decried the low status of corrosion science in metallurgical and engineering curricula. He also took time to knock down a few classic axioms of corrosion "science," including "Corrosion protection begins at the design stage" (an "out" for everybody except the designer) and "Avoid crevices, and if they occur fill them in" (often impossible). He also strongly suggested that corrosion science educators should devise means to include exercises in the practical relationship between academic principles and real-world problems, such as through the inclusion of practicums (experience tours).

In summary, this Symposium demonstrated without question that Britain is corroding at a substantial rate, that there are a great number of local sites at which this corrosion (research) is occurring, and that the corrosive environment and corrosion modes at each site tend to be different. Fortunately, each corrosion site has also a group of experts and long practitioners in corrosion science who are carrying out significant studies to understand and ultimately defend against the various forms of deterioration. (Jeff Perkins)

MATERIALS IN SPORTS

Hello again, sports fans. The following report is on the 1978 Annual Conference of the Materials Science Club (UK), which this year chose as its subject "Materials in Sport—Scientific and Techological Aspects." This may at first seem to be a somewhat superficial topic from a scientific standpoint, and in fact, I initially approached the Conference with this attitude. However, since the meeting was organized as a two-day residential conference at the Bisham Abbey National Sport Centre (near Marlow, about 30 miles west of London) and there would be some opportunity to engage in some special sports "laboratories" (squash, tennis, basketball, etc), it seemed that there would be nothing to lose by attending.

As it turned out, the Conference was extremely interesting especially from the standpoint of technological application of new materials. One of the unique aspects of the subject was that it concerns the development of materials for direct application in the consumer market, rather than for industrial or military uses. This puts a special emphasis on expediency and cost-effectivness in R&D, and it was quite startling to see what can be accomplished. It must be admitted that the meeting presented little in the way of basic scientific discovery, and this summary will therefore be limited to some interesting developments in materials which were presented.

The meeting was organized so that the first day was concerned mostly with marine, water, mountain, and air sports, while the second dealt with ball games and sports surfaces. The specific sports applications included water and land yachting, sculling, hang gliding, mountaineering, tennis, squash, badminton, skate-boarding, skiing, fishing, golf, and several others.

Nearly every sport discussed is currently pushing hard at the frontiers of available materials. Ever since the fiberglass vaulting-pole revolution of the mid-1960s, sports manufacturers have come to realize the dramatic gains in that performance can be achieved by using advanced materials. It is important to note that when a new material is introduced it is with the hope that it will not substantially change the nature of the game (as indeed has been the case in pole vaulting), and in most cases this is true. In fact, almost all sports have regulating groups that include controls over the performance of equipment. In addition to the desire to preserve the game, it is important that no player gain an advantage over others simply on the basis of equipment i.e., new equipment must be readily available to all competitors. In recent years golfers have been presented with clubs that hit balls straighter through the development of composite shafts; tennis players have acquired lighter racquets of aluminum, steel tubing, or composites; and other materials developments have had significant impacts on various games.

A dramatic example of this was the recent boom in skateboarding (which unfortunately now has reached a state of market saturation, bemoaned one of the principals at the meeting). Dr. N.A. Waterman [Fulmer Research Institute, UK, and editor of the Fulmer Materials Optimizer, a materials selection scheme reported on by Bernstein (*ESN* 32-7:241)] noted that the 1977 boom was based essentially on one key materials development, namely the resin of which the wheel rolling surface is composed. This has made contemporary skateboards much quieter, faster, and maneuverable than those available in the West Coast skateboarding fad of the early 60s, when the vehicles were essentially small surfboards on metal roller skates. Roller-skate wheels at that time were made of steel or compositions of clay and rubber, and gave an unstable, noisy ride. Elastomeric polyurethane, the essential material for modern skateboarding wheels, was originally intended as a competitor to nylon, but found application as a roller material in the paper-making industry and as a solid tire on industrial equipment such as fork-lift tracks. The unparalleled properties combination of high friction, abrasive wear resistance, and resilience makes possible the spectacular and graceful movements that characterize skateboarding today. The materials used in the wheels, trucks, and decks, and their methods of fabrication are prominently featured in sales promotions, a relatively rare occurrence in consumer marketing. Thus potential buyers are exhorted to buy hand-poured and hot-poured urethane wheels, aircraft aluminum alloy trucks, and pultruded glass-fibre-reinforced plastic decks. Skateboard enthusiasts are quite knowledgeable about choosing between alternate

materials. Even though the preferred material for wheels is always a polyether-based elastomer manufactured by hot casting techniques, this still allows a wide range for tailoring to individual needs; thus softer grades are preferred for freestyle (tricks), harder grades for speed, and intermediate hardness for slalom events. It is interesting to note that the wheel material development has now led to a resurgence in outdoor roller skating per se, according to reports from California.

Another recent sports equipment development concerns aluminum squash racquets, which currently are opposed by a sanctioning group regulation that allows only the classical wooden racquet. One might think that this would not eliminate the use of the very light aluminum racquets from friendly and unofficial competitions, but there turns out to be general opposition to them by court operators who believe that the metal racquets will cause more damage to court walls (which are struck often in squash), not to mention the human body, than conventional wood ones. The analogous problem in tennis, scraping of composition court surfaces by extruded aluminum raquet frames, was solved simply by the now-familiar plastic clip-on guards. In the squash case, experiments have recently been conducted in attempt to eliminate prejudice by showing that aluminum racquets actually cause less damage to wall and body than wooden ones. In this connection, one of the design areas in which there is considerable room for innovation, if not theoretical analysis, is that of selection of the cross section for extruded aluminum alloy racquet frames. George Anderson (Elite Sports International Ltd) and Prof. C.N. Reid (Open University, UK) described the development of the first aluminum-framed squash racquet. The designer here is a bit more limited in his selection of extrusion design than in the tennis case, where there is less chance of inflicting a wound on your opponent with a sharp edge.

Carbon fibre reinforced plastic (CFRP) is a high technological material whose commerical application is increasing rapidly. Originally developed to meet the exigencies of the aerospace industry for high performance lightweight structural materials, it is somewhat paradoxical that one of the largest outlets for carbon fibers should now be in sports equipment, which presently consumes almost half the world production. However, aerospace and sports applications have similar requirements for material properties so that it is not illogical that the unique combination of properties offered by CFRP should be exploited in this way. The commercial and sports breakthrough for CFRP came in 1973 when over 500,000 golf club shafts were manufactured in the US, using an estimated 40 tons of prepreg material. The golf club market has subsequently slowed down, but the manufacturing technology has since been applied to many other items of sports equipment such as fishing rods, ski poles, tennis and badminton racquets, etc. The sports market has actually served to advance the state of technology by demonstrating the effective use of relatively simple but expensive fabrication techniques, such as mandrel wrapping, adhesive bonding, injection moulding, etc. It has enabled the development of process technologies for large scale production, opening up possibilities for use in general engineering and industrial applications.

One of the original developers of carbon fibers at the Royal Aircraft Establishment (a true milestone in materials research), Lesley Phillips, talked about one of his current interests, the application of CFRP in racing sculls. This is an area in which tradition and prejudice are prime opponents to introduction of better and cheaper materials. However, unlike the squash racquet case, there are no official regulations against materials for racing sculls; one can make them of anything he wants, the traditional materials being very expensive wood construction, whose cost can be easily halved by CFRP. Recent developments at RAE have finally allowed the construction of CFRP hulls that are lighter than conventional hulls, this being the primary performance factor.

John Skelton (FRL Corp, Dedham, Mass.) presented fascinating results of a detailed study of ball-string interactions in tennis racquets. This is a materials-related topic in that the study was conducted as a preliminary step to developing a new synthetic string material (i.e., a new polymer) that will produce the reputed superior features of natural (gut) strings. Part of the folklore of tennis that Skelton tried to rationalize with the study was the reported

superior "control" (roughly defined as time-of-ball-on-racquet) one gains with gut strings as compared to the much cheaper nylon strings. He also addressed the controversial subject of stringing tension; one world-class player uses high, another low stringing tension. He reviewed the scores of man-made string designs that have been used in an attempt to reproduce the response of gut strings qualitatively, including some attempts to reproduce manually the cross-sectional microstructure of the gut (essentially a compressed bundle of polymeric ribbons). Skelton's study attempted to characterize the behavior of various strings quantitatively, considering the effect of basic materials properties, particularly stress-strain response as a function of strain rate (ball velocity). In summary, he made the following conclusions in terms of tennis folklore: (1) gut does have better control than nylon in general; (2) only very good (high velocity) players can distinguish between gut and nylon; (3) thinner strings give more control by lowering the effective dynamic modulus (at the sacrifice of string life, of course); (4) touch players should use lower stringing tension, since this increases time-of-ball-on-racquet.

In addition to this discussion of strings, the subject of rope received more attention than I would have believed possible. However, this only reflects my ignorance of the complexity of the subject. The properties of a rope as a whole depend on numerous variables, the most interesting from a materials standpoint being the choice of the type of synthetic fiber (polymer), assuming that natural hemp ropes have been abandoned. This subject was reviewed by B.J. Dunn (Bridon Fibres and Plastics Ltd, UK), who somehow made the subject of rope interesting. In the case of rope, several types of extruded polymers are commonly used: nylon, polypropylene, polyethylene, and polyesters. D. Hutchinson (Univ. of Manchester) also considered ropes, specifically for mountain climbing, where the primary requirements are high-rate energy absorption (for slips and falls) and minimum stretch (high modulus).

It was a startling revelation to me to discover that the primary materials problem in hang gliding is fatigue failure of structural components, with its obviously catastrophic consequences. This arises because of the desire for light weight of the glider, not for the usual lift-drag reasons but because the glider enthusiast typically has to drag the 40-50 lb. rig up a hill and then run with it until he takes off. A wide range of materials are involved in gliders, including aluminum alloys (usually 2024), galvanized steel, stainless steel, and various synthetic fabrics and adhesives. What seemed to be a potentially dangerous design from the standpoint of galvanic corrosion was nonchalantly revealed: the use of stainless-steel guide-wire fasteners in holes in the aluminum alloy frame; it is probably fortunate that at least the more active aluminum comprises the bulkier components, so that the corrosion current is lower.

Land yachting is another sport where light weight and aerodynamics are the key design features that are sought. I was amazed to learn that the sport has progressed to the level of sophistication where the cross-sectional profile of the mast is significant in terms of the overall aerodynamic performance of the yacht. The development of special hollow and tapered glass-reinforced plastic (GRP) masts with an airfoil profile was described by researchers from the Materials Department at the Open University (Milton Keynes, UK) who have been working with yacht manufacturers. Also, P. Ball (Alcan-Booth Extrusions Ltd) described the technology of tapered extruded masts for water yachts.

Several contributions dealt with small boat design. M.G. Bader (Univ. of Surrey), whose primary research area is composite materials, gave a comprehensive review of materials selection tradeoffs, using as an example the application of materials in small sailing craft. He compared conventional structural materials such as steels and aluminum alloys with composites, both natural (wood) and manmade. He also discussed deterioration problems of glass-reinforced plastic (GRP) in seawater. L.P. Ginger (Rolinx, Ltd, England) described the engineering development of thermoplastic hulls for small sailboats, a recent project which involved the largest injection-moulded components in history (by a factor of about 3). Polypropylene was chosen as the polymer for this application on the basis of its engineering properties, cost, and moulding flow rate.

Another category of materials application in sports is sporting surfaces, both in and outdoors. Synthetic poly-

meric materials for sports and games surfaces first appeared in Britain in the mid-sixties when an all-weather athletics track was installed at the Crystal Palace National Sports Stadium in London. This facility, a counterpart to the Bisham Abbey center, is operated and maintained by the Greater London Council, which operates a Scientific Branch that includes a materials laboratory. Graham Tipp, head of the Polymeric Materials Section, described the tradeoffs involved in the selection of synthetic sports surfaces. One of the big advantages of such surfaces is their much greater proportion of utilization on a time basis as compared to conventional ones which become useless due to rain, mud, etc. They also tend to have lower maintenance costs. These factors combine to make synthetic surfaces much more cost effective than might be imagined on the basis of their initial cost.

This brings us back to the subject of the Conference venue itself, which includes one of the most versatile sports surfaces in the world. Among its many uses, various British national teams train here: such sports as cricket, rugby, soccer and tennis can be accommodated indoors under conditions that simulate normal play in terms of temperature, lighting, surface, and space. This has been accomplished with what must be one of the most carefully and intelligently designed indoor sports facilities in the world. From a materials standpoint, the surface is the primary feature of interest.

In summary, the materials R&D presented at this meeting was interesting because it demonstrated what can be done under the pressures of marketplace conditions. Of course, many of the materials developments discussed have drawn heavily on knowledge that derived from high-technology materials R&D. In fact, in the UK, government laboratories are in some cases directly involved with industry in this sort of consumer R&D. Along with numerous small commercial organizations it was interesting to note the participation in this field by universities (Manchester, Surrey, Open, etc.) and high-technology research establishments (RAE, Fulmer Research Institute, etc), whom one might think would be working on more pressing needs. It was obvious from this Conference that the results of public-funded materials R&D are reaching the commercial marketplace more rapidly and in greater proportion than might initially be suspected. (Jeff Perkins)

29TH MEETING OF THE INTERNATIONAL SOCIETY OF ELECTROCHEMISTRY

Many US chemists are probably not acquainted with the ISE; a few words describing it are in order. The Society, founded in 1971 as a successor to the International Commission of Electrochemical Thermodynamics, has about 650 members and has recently been organized into 7 scientific divisions: Electrolytes and Electrochemical Thermodynamics, Electrochemical Physics, Electrochemical Kinetics and Electro-analysis, Organic and Bioelectrochemistry, Electrochemical Energy Conversion, Corrosion and Electrochemical Surface Treatment, and Electrochemical Engineering. It sponsors the internationally recognized journal *Electrochimica Acta*, small meetings dealing with a few selected topics and broad-based annual ones.

The Society's president is Prof. C.W. Tobias (Univ. of California, Berkeley), who was born in Hungary and received his training at the Technical University of Budapest where the meeting was held 28 August-2 September. Tobias in his opening remarks noted that this was the largest meeting in the history of the ISE with about 700 participants from 34 different countries and 469 papers. All papers were presented orally with 2 plenary lectures daily followed by as many as 8 parallel sessions. Within these sessions there were so-called keynote papers scheduled for 30 minute duration, followed by contributed papers of 15 minutes in length. Around 90% of the presentations were in English, with a few papers presented in Russian, French, or German. There were symposia on 4 main themes: electrochemistry of membranes, direct energy conversion, solid electrolytes, and new electroanalytical instrumentation, while each of the Society's divisions had one or more sessions dealing with areas of particular interest to it. In total, the technical program required a booklet of 56 pages while the abstracts distributed to all participants filled two volumes totaling 1200 pages!

Welcoming the participants, Dr. I. Láng, Deputy General Secretary of the Hungarian Academy of Sciences,

briefly reviewed the current state of Hungarian R&D in which 35000 scientists and engineers are involved, roughly double the number so engaged in 1965. Three percent of the national budget is spent on R&D. Of those involved in such activity, 60% are working in "technical development." Fourteen percent of R&D is devoted to basic research, and the government has made a commitment to maintain this distribution of effort for the long term future. He further mentioned the importance attached to international activities stating that about one third of Hungarian scientists and engineers have been abroad for extended visits or for international meetings.

Obviously from such a conference only a sampling of the papers can be reported. In the field of electrode materials there was an interesting keynote lecture by Prof. W. Vielstich (Rheinische Friedrich-Wilhelms-Universität, Bonn, FRG) discussing the relative advantages of aluminum and aluminum alloys over lithium as an anode material for high energy density batteries. In his opinion, aluminum alloys are even better than aluminum itself, specifically aluminum amalgam or aluminum-indium alloys. Vielstich also pointed out that in his laboratory they found ordinary sea water as a very useful electrolyte. In a plenary lecture, Prof. Y.M. Kolotyrkin (USSR) discussed the electrochemistry of alloys pointing out that the solution of alloys is a very complex process, and although it is necessary to know the partial rates of solution of each of the component metals, in an alloy these are interdependent and cannot be resolved by electrochemical methods. To determine the rates of the various processes, it is necessary to use independent analytical techniques such as various methods of electron spectroscopy (ESCA, Auger or XES) or, better still, radioisotope tracer methods. Using this approach, Kolotyrkin's group have found that in a salt solution containing 1% hydrochloric acid, zinc is initially dissolved faster than copper from a sample of alpha-brass, but after 5 minutes a steady state is reached between the two rates of solution with copper going into solution slightly faster than zinc. Another paper dealing with the properties of lightweight anode materials was a keynote one by Prof. A.R. Despic (Belgrade). He compared lithium, magnesium, and aluminum and found lithium, although the lightest, least promising, owing to its susceptibility to corrosion. It appears from his own studies and work in other laboratories that both magnesium and aluminum show great promise when alloyed with minute amounts of other metals. Thus an alloy of aluminum containing 0.02% of gallium, 0.07% indium, and 0.01% thallium is far more efficient as an anode than pure aluminum (*J. Appl. Electrochem.*, 1976). He also pointed out that one of the important problems in using these metals for energy conversion purposes is the high cost (in energy) of producing them in the first place.

In view of the current strong interest in the conversion of sunlight to electrical energy it is not surprising that there were a number of papers dealing with semiconductor electrodes that show potential usefulness for this purpose. Two papers from the faculty of engineering of the Univ. of Tokyo (Prof. K. Honda) dealt with this topic. The first, primarily concerned with the chemical stability of the semiconductor photoanode, presented an extensive review of the literature dealing with stabilizing agents for a variety of semiconductor materials. The second provided an overview of current research in Japan in the field of photoelectrochemistry, including discussion of photoelectrolysis, spectral-sensitization of photoelectrochemical processes by means of dyes, photogalvanic and "hybrid processes" (a combination of a photoelectrochemical process with an ordinary electrochemical process). They conclude that there is promise from the interdisciplinary cooperation among electrochemists, photochemists, and physicists with respect to the ultimate objective of utilizing solar energy in today's world. In his plenary lecture Dr. Adam Heller (Bell Lab., Murray Hill, NJ) reviewed some of their recent research activities dealing with electrochemical solar cells. The most promising candidate so far has been a cell using gallium arsenide anode with potassium selenide and diarsenide in alkaline solution as the electrolyte. They have also studied a variety of photoanodes consisting of n-type semiconductors and a carbon-counter electrode and find that such systems have several advantages over classical p-n junction cells. It is felt

that for efficient solar energy conversion it is important to control the chemistry of the surface states of the semiconductor and to avoid changes in the composition of the semiconductor at or near the surface. One other paper dealing with the materials aspects of electrochemistry that should be mentioned was by Dr. J. Agh (Research Institute of the Electrical Industry, Hungary). He described a "separator" (apparently a membrane) made of polyvinyl alcohol (non-crosslinked) that is useful in preventing the diffusion of the spent electrolyte in zinc batteries.

In the area of fuel cell research there was an unexpected contribution from one of the six scientists from mainland China who were touring several meetings in Europe this summer which dealt with an ammonia-air fuel cell system. Dr. H. Böhm (AEG-Telefunken, Frankfurt, FRG) described a fuel cell using tungsten carbide as the anode and a platinum cathode with phosphoric acid as the electrolyte. This cell will operate effectively with either hydrogen or oxygen or else crude gas plus air mixtures. An interesting paper on a topic of considerable importance (non-noble metal catalysts for fuel cells) was presented by Prof. K. Wiesener (Chemistry Dept., Technical Univ. of Dresden, GDR) covering extensive research to find an electrode material that is catalytically active and yet has the required stability for fuel cell applications. Promising results have been obtained with carbon that has had various pre-treatment with organic materials containing oxygen coupled to the electrodes, with some oxide or mixed oxides adsorbed on metal surfaces, with some carbides (particularly tungsten carbide), and with a variety of organic chelates. In addition they have had very good results with some metal phthalocyanines (both monomeric and polymeric) and tetraphenylporphyrins that had been heated to 500-800°C in a nitrogen atmosphere. Among the latter materials cobalt derivatives are the most stable, and the iron ones most active.

In the field of research dealing with electrolytes there was an interesting paper by Prof. M.J. Weaver (Michigan State Univ.) that describes recent work on the electrochemical properties of rare earth cryptates. They find that in cyclic voltammetry large positive shifts of the formal potentials result in the EuII/III and NbII/III system which are accompanied by a change from irreversibility to complete reversibility. All of the cryptates studied have been found to be inert and stabilized preferentially in the divalent state. In his plenary lecture Prof. R.A. Huggins (Stanford Univ., CA) reviewed the present state-of-the-art with respect to solid electrolytes. He pointed out that both the chemical nature of the mobile ion species and the crystal structure of the host lattice are of importance in determining the transport properties of such ionic conductors. Structural studies (x-ray and neutron diffraction) coupled with theoretical investigations have now largely clarified the mechanism involved in materials of this type. It is now possible to have a fair idea of the minimum energy path followed by the mobile species, and one can predict that for some crystal structures there will be an optimum ionic size that will lead to a minimum value of activation energy for motion. On the more practical side Prof. T. Takahashi (Nagoya Univ.) discussed the behavior of the three types of solid electrolytes that have been identified and classified. In the first group are the silver and copper ion conductors that have been known since the middle sixties. The second group contains the alkaline-metal ion conductors, the best known being sodium-beta-aluminate, but work is underway in various laboratories to find new alkaline metal conductors. The third group involves anionic conductors (fluoride, chloride, and oxide). The best ionic conductor to date is the complex salt $Rb_4Cu_{16}I_7Cl_{13}$; among the alkaline-metal conductors sodium-beta-aluminate has the lowest temperature coefficient, and in general the conductivity increases with increasing temperature. Among the anionic conductors, the highest conductivity that has been found to-date is in $Ce_{0.9}Ca_{0.1}F_{2.9}$, although some of the simpler fluoride (BaF_2 and SrF_2) outperform it at higher temperatures. In general Takahashi feels that there is much promise not only for a better understanding of the mechanism of these conductors, but also for potential practical applications.

Among other contributions was one by Dr. R. Moshtev (Central Laboratory of Electrochemical Power Sources, Sofia, Bulgaria) on recent work on the passivation of lithium in lithium-thionyl chloride electrolyte solutions. He concludes that the passive film protecting

the metal from the strong oxidizer, $SOCl_2$, is practically nonporous and impervious to the electrolyte solution. Studies by a group at the Nuclear Studies Center in Grenoble, France, under the direction of Dr. G. Cauquis of well-known reaction involving the electrochemical fluorination of organic compounds were discussed in another paper. Using the techniques of voltamperometry and tensammetry, they have investigated the fluorination of some alkylsulfonylfluorides by means of sodium fluoride and hydrogen fluoride, they have concluded that in most instances the reaction proceeds by an oxidation mechanism and that the reaction occurs on the surface of the nickel or nickel fluoride at the electrode.

Despite the fact that this was the largest meeting in the history of ISE, it was a most informative one. Interestingly 75% of the participants were from Eastern Europe, although it was difficult to tell whether this was due to the locale of the meeting or to trends in its membership. Papers presented, with significant contributions from the East, covered the wide range of topics within the Society's purview fundamental to advances in a number of potential application areas but particularly in the topical ones of energy conversion, solid electrolytes and corrosion. [George M. Wyman, US Army Research and Standardization Group (Europe)]

PHYSICAL SCIENCES

MICROWAVES IN EUROPE—THE 8TH EUROPEAN MICROWAVE CONFERENCE

In 1963, when this observer was on the team responsible for the Microwave Symposium in Santa Monica, there was a feeling that microwave research activities were on the decline. Far from it now: The participation of about 700 engineers, scientists and physicians (!) in the 1978 European Microwave Conference held in Paris 4-8 September demonstrates that this field is probably more active than ever. And although this Conference might have been expected to deal strictly with applications to systems, still a number of papers with titles such as "Guiding Characteristics and Radiation Characteristics of Planar Waveguides" (H. Ermet, Univ. of Erlangen, FRG) were presented.

The planning and execution of a conference that had the international participation of this one, with an acceptance rate of contributed papers of only 40%, must have generated problems not generally found in conferences in the US. It appears, that these problems were solved satisfactorily by international participation at nearly every step. A Management Committee, chaired by Prof. D. Gudmunsen of Denmark, had representatives from 13 countries. Reviewing of technical papers was apparently a two-step process, with initial reviews by individuals from 16 countries and final decisions by a technical Program Committee with an equally international representation, including the USSR and several other Eastern European countries. The final program was composed of 141 contributed papers and 9 invited ones.

The chairman of the Technical Program Committee, as well as Conference chairman, was Prof. E. Constant (Université de Lille, Villeneuve d'Ascq, France). Both he and the professional organizer, Roger Marriott, can be commended highly for the success of this Conference.

Since only 5% of the attendees were Americans, and since only 2 invited and 20 contributed papers were of American origin, the Conference was indeed principally "European."

As a new arrival in Europe, after an absence of several years, I was surprised to find that all papers were presented in English, in spite of the fact that the Conference was held in Paris. I have since found out that the use of only English at conferences in Europe has become virtually standard practice. (Other surprises were that the cost of registration was $140, even for members of a sponsoring professional society—much higher than in the US.)

The only portion of the program that was in French (with "instant replay" translation by earphone) was the opening address by Dr. Pierre Aigrain, the Minister of State for Research in France.

While there were many topics under discussion those considered to be at the forefront were Millimeter Waves, Gallium Arsenide Field Effect Transistors (GaAsFETs) and Applications, and Microwaves in Medicine. To stimulate up-to-date exchanges of information on these topics, separate one-day workshops on

each were held on the day following the formal Conference program. Since some readers may wish to find out more about these, the following paragraph gives names and affiliations of the organizers.

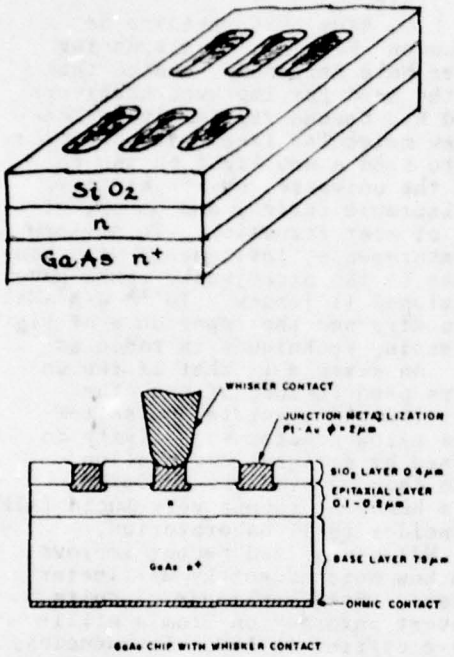
The Millimeter Wave Workshop organizers were Gerard Cachier (Thomson-CSF, Domaine de Corbeville, 91401 Orsay) and J.R. Mahieu (L.T.T., BP No. 5, 78702 Conflans Ste. Honorine). Responsibility for the GaAsFET session was shared by John Magarshack (L.E.P., 3 Avenue Descartes, 94450 Limeil Brevannes) and Henri Deroy (Thomson-CSF/DMH, Domain de Corbeville, BP 10, 91401, Orsay). Coordinators of the workshop dealing with microwaves for medical diagnosis and therapy were M. Gautherie (Université de Strasbourg, Faculté de Medecine, 11 Rue Humann, 67085 Strasbourg) and A. Priou (ONERA - CERT, DERO, BP 4025, 31055 Toulouse).

The subject of millimeter waves has been touted for years as the "important new area in microwaves." Perhaps, because of the desire for secure point-to-point communication in a hostile environment, for passive sensing with good spatial resolution of, say, enemy tanks, and because of the development of solid-state sources, millimeter wave systems are beginning to become a reality.

Illustrations of such passive sensing were given in the invited paper of K. Grüner (Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt, Oberpfaffenhofen, FRG), who presented data and showed a series of impressive slides (with microwave temperature gradations depicted as color changes) of line-scanned radiometric ground scenes taken in both the 32-GHz and 90-GHz ranges. He stated that the improvement in receiver noise figure during the past several years has allowed considerable improvements in radiometer mapping. As an example, a 90-GHz receiver in 1972 had a noise figure of 21 dB (30,000 K noise temperature). Grüner's receiver (1977) had a noise figure of 10.5 dB (2700 K noise temperature). He stated that with the latter, for 10 msec integration time, the temperature differences that could be sensed were 1 K at 32 GHz and 2.1 K at 90 GHz. Since, as is well known, the minimum detectable temperature difference varies inversely with the square root of the integration time, smaller differences can be obtained by longer integration times, but the requirement of rapid line scanning sets an upper limit.

Dr. E.J. Blum (Observatoire de Paris, Meudon, France), in discussing Millimeter Wave Astronomy, stated that despite the need for improved receivers his field has become very active. Dozens of new molecular lines have been discovered to shed a new light on the chemistry of the universe, on its history, through isotopic ratios, and on basic problems of star formation. To perform these measurements, instruments with sensitivities in the microjansky range have been developed (1 jansky = 10^{-26} W/m^2-Hz). Blum also stressed the importance of signal processing techniques in radio astronomy. An example is that if two antennas are used instead of one, the different individual system noise temperatures allow greater sensitivity to be obtained by a signal correlation technique than by straight addition.

In a humorous though very lucid talk M.V. Schneider (Bell Laboratories, Holmdel, NJ) summarized recent improvements in Low Noise Schottky Millimeter Wave Mixers, those nonlinear circuits that convert information from a millimeter wave carrier to lower frequencies. He discussed the desired characteristics of the diodes that result in low noise temperatures (e.g., ideality factor n≈1, low doping concentration at the interface, low series resistance), diode construction (e.g., whisker-contacted, junction-metallized 2-μm-diam. "bathtub diodes" made of 0.15-μm epitaxial n-types GaAs on n+ GaAs), mixer circuits, and mixer performance. A sketch of a "bathtub" diode is seen in the figure on the following page. Some recent circuits have used the crossed-waveguide structure long known to millimeter-wave workers; some are reduced-height waveguides with filters, others use subharmonically pumped striplines, and yet a fourth group has a quasi-optical structure. Among performance figures given, Schneider quoted the following from recent work in which he was involved: At 81 GHz a cryogenically cooled waveguide mixer that used a diode prepared by molecular beam epitaxy and was followed by a cooled paramagnetic amplifier (18 K) had a receiver system noise temperature of 312 K—a very satisfactory figure. Such numbers are now typical; in general mixers now have a noise temperature of a few hundred degrees Kelvin at 100 GHz and about 1000 K near 200 GHz. Improvements at the higher frequencies can be



GaAs CHIP WITH WHISKER CONTACT

Schottky barrier mixer diodes described by M.V. Schneider. Note the "bathtubs" etched in the SiO_2 layer and n-layer (top). These "bathtubs" are then nearly filled with metal, so that a metallic whisker will easily slide into one of them and make contact with the metal (bottom).

expected by using thinner epitaxial layers and new junction geometries for the mixer diodes.

It may be of interest that despite these papers describing improved performances in the millimeter wave range there were virtually no contributions describing the behavior of millimeter wave systems. While this may have been caused by the fact that some of the work is classified, it could also be that, despite the publicity, the millimeter range remains as yet the spectral region of the future.

This pattern was not found for the second of the lead topics: GaAsFETs. For, here, in addition to an invited paper by C.A. Liechti (Hewlett-Packard Palo Alto, CA), the subject was treated in sessions entitled Subnanosecond Logic, Microwave Equipments for Phased Array Communication Satellites, FET Oscillators, FET's Technology and Modelling, and FET Amplifiers. Clearly, the GaAsFET is the hot item in the microwave designer's bag of tricks.

GaAsFETs are of great interest to the microwave engineer because they can replace traveling wave tubes in broadband amplifiers for both low-noise and medium-power amplification. They are also or will soon be of interest to the digital circuit engineer because they are much faster than silicon devices. All this is because of the greater drift velocities for electrons in GaAs than in Si. Greater speed leads to ultrafast, so-called "gigabit logic" circuits. It can be expected that gigabit logic will become much larger dollar-wise than the microwave use of GaAs.

All devices mentioned by Liechti are MESFETs, i.e., they have metal, or Schottky barrier gate electrodes. (Although not discussed in the talk, no dependable passivating technology for gallium arsenide comparable to the oxide technology for silicon has yet been disclosed.)

An example cited of recent low-noise GaAsFET amplifier performance, attained with a MESFET of 0.5-μm gate length, was a device that had a room temperature gain G and noise figure F at 18 GHz of 7 dB and 2.3 dB respectively, with G and F at 77 K of 10 dB and 1.2 dB. Such remarkably low-noise figures are due to high mobility at active layer/substrate interface, short channel length, minimum parasitic capacitance, low contact resistance, and low gate-metal resistance. Predicted were further improvements, such as 0.2-μm gate lengths, that will lead to MESFETs operating at 40 GHz with G greater than 6 dB and F less than 5 dB.

The broad-band feature of GaAsFETs was illustrated recently by an amplifier operating from 4-12 GHz, with maximum F only 2.5 dB above the basic F of the GaAsFET. Liechti predicted low noise amplification over 6:1 bandwidth in the near future.

In the field of power FET's state-of-the art performance is 4 W of output with 6-dB gain at 10 GHz from a single chip. Liechti predicts the power output per chip (at 4-dB gain) to rise to 25 W at 4 GHz; 15 W at 10 GHz, and 1 W at 26 GHz, with 100-W cw output power from 8-12 GHz to be obtained by radial-line combiners.

A number of FET failure modes, such as slow degradation of ohmic-contact resistance, have been identified and corrected, so that the reliability of low-noise GaAs MESFETs has been established. Insufficient life-test data exists at this time to reach equivalent meaningful conclusions for power MESFETs.

As stated earlier, the most important use of GaAsFETs may well be in the construction of digital circuitry with gigabit data rates. Here circuits with medium-scale-integrated complexity (e.g., 100 logic gates, comprised of 500 MESFETs) can already be built with satisfactory yield, thanks, in part, to ion implantation techniques. These logic gates operate with only 2 mW of power consumption, at high speed (100-psec propagation delay), and with adequate noise margins. Though not in the actual hardware as yet, we can soon expect to see such circuits as direct microwave frequency counters, frequency synthesizers, and multiplexers. In looking further ahead, advancement toward large-scale integration (LSI) of more than 1000 gates looks feasible, though major advances in the growth of semi-insulating substrates and in high-yield processing of planar circuits with submicron lines and spacings are necessary. Such ultra-high-speed circuits, of both digital and analog variety, will be used for applications in real-time radar-signal processing, cache memories, A/D converters, and even completely monolithic microwave subsystems.

Although Liechti spoke principally about work in the US, it is well known that Japan is very active in this field. Much gallium arsenide activity exists also in Europe, with at least one company in the UK (Plessey) manufacturing GaAsFETs and claiming to sell the best low-noise units produced anywhere.

It should be no surprise that microwaves can be used to destroy tumors, since microwave cooking is possible because of deep penetration into biological tissue. The use of microwaves for diagnosis was more of a surprise to me. Both subjects were treated in the Microwaves in Medicine workshop. While in the Conference proper there was an invited paper entitled "Microwave Field Influence on Some Chemical and Biological Objects," by A.I. Tereshenko (Kharkov Institute of Radio Engineers, Kharkov, USSR), it dealt principally with problems of nonuniformity of heating during thawing of biological specimens because of nonuniform microwave field distribution and local changes in dielectric constant during the thawing process. Several papers dealing more directly with microwaves in medicine were found in the poster session of the Conference. One of these by Mamouni, Leroy, Houdas, and Maschetto (Université des Sciences et Techniques de Lille, and associated organizations), demonstrated that 9-GHz radiometric techniques could be used to measure subcutaneous temperatures. Another (W. Buck, Universität Stuttgart, FRG) discussed a cooled slotted cylinder antenna for selective microwave heating of a tumor. Two papers discussed new antenna structures for selective microwave heating. Another reported on changes of a few hundred microvolts in the v-i curve for electrodes in contact with an enzyme-substrate system. Quite possibly the most significant paper here, however, was a report by P.C. Myers, N.L. Sadowsky and A.H. Barrett (MIT, Cambridge, MA, and Faulkner Hospital, Boston, MA), who have been applying microwave radio astronomy techniques to the detection of breast cancer. Their work indicates that when used together with infrared thermography, true positive rates for tumor detection of 90% result. This suggests that microwave thermography may be useful as part of a first-pass, no-risk screening procedure.

The work of Myers et al was reported in greater detail in the workshop and is discussed in a separate article (*ESN* 33-1:27).

The use of microwaves in medicine is only one of the nonconventional uses. Others were discussed by Wolfram Schilz (Philips GmbH Forschungslaboratorium Hamburg, FRG) in an invited talk "Novel Microwave Technique for Industrial Measurement." Advantages over conventional measurement techniques cited were contact-free and remote-sensing; signal transmission through otherwise opaque media; insensitivity to a dirty environment and electromagnetic interference; specific interaction, reflection, and absorption; and proportionality of thermally emitted energy to the temperature and emissivity of the object.

An industrial measurement often desired is that of distance with a resolution of a few millimeters. This would be extremely difficult with pulsed radar techniques; the alternative is the frequency modulated continuous wave system (FMCW). Here the instantaneous frequency of an FM signal sent toward the target

is compared with that received by reflection. For linear FM, this results in distance to the target of fc/2k, where f is the frequency difference, c the velocity of light, and k the rate of frequency change of signal sent out. Philips has built instruments using this technique, some with the added features of measurement of velocity or vibrational amplitude. Examples of applications are the detection of buried objects, and the monitoring of human heart beats and respiration. Illustrations of other uses of microwaves are the measurement of the diameter of 3-mm wire to an accuracy of 10^{-3}, the monitoring of gas concentration and oxygen pressure in blood, moisture determination in grain, and thermometric measurement through curtains of hot flames.

A most interesting invited paper on the subject of Microwave Superconducting Electronics was delivered by R. Adde (Institut d'Electronique Fondamentale, Université Paris XI France). Superconducting devices have, of course, been mentioned for years but have always had the drawback of requiring temperatures less than 10 K. While this is still the case, it may soon cease to be such a disadvantage, for there are now strong hopes for the development of small superconducting computers capable of subnanosecond operation and of computational capacity several orders of magnitude greater than room temperature systems of comparable size. Since data acquisition and treatment are now a large part of any electronic system, then why not include microwave superconducting electronics and utilize its advantages!

Some of the devices and systems and performance figures quoted include super-Schottky mixers (Ideality factor of 1; mixer noise temperature T_M = 6 K with (2)(10^{-8}) W of local oscillator power at 10 GHz, or a dynamic range of 10^4 to 10^5 for a 1 GHz bandwidth); Josephson junction mixers (at 300 GHz, a mixer conversion efficiency of 0.4, with T_M = 220 K.); video detectors (using super-Schottky diodes, an NEP, i.e., a minimum detectable power for 1-Hz post detection bandwidth, of (5.4) (10^{-6}) W/$\sqrt{Hz}$ at 9 GHz); superconducting bolometers (comparable to the best semiconductor bolometers); parametric amplifiers (not for front ends, but as excellent i.f. amplifiers); superconducting cavities (Qs as high as 10^{11}); microstrip components (of high quality up to 700 GHz); Josephson junction oscillators (voltage controlled oscillators which, though of very low power, have frequency tuning sensitivities 10^9 times those of conventional VCOs, with much lower phase noise, greater tuning speed and bandwidth); cavity stabilized oscillators of excellent spectral purity (with possible applications in radar, long base interferometry, and frequency synthesis up to the visible); and such instruments as analog sampling devices with a resolution of a few picoseconds, fast counters, and a/d converters.

Adde referred interested listeners to material presented at the Conference on Future Trends of Superconductive Electronics, held on 23-25 March 1978 at the Univ. of Virginia, Charlottesville, VA. He was a contributor to this Conference.

In an invited paper entitled "Utilization of Microwave Bands for Digital Radio Systems," R.W. Swain, (Post Office Research Station, Martlesham Heath, Ipswich, UK) discussed the influence that geographical, national, and systems constraints can have on the utilization of microwave frequency bands for digital transmission of public communications by radio.

An area receiving considerable attention during the last dozen years is that of surface acoustic wave (SAW) devices. A review of this field was given by D.P. Morgan (the Allen Clark Research Centre of Plessey Research Ltd., Towcester, Northants., UK). SAW devices operate generally in the range from 10 to 1000 MHz and owe their popularity to the fact that devices with virtually any desired impulse responses can easily be constructed by proper photolithographic deposition of conducting lines on a piezoelectric substrate (e.g., single crystal quartz or lithium niobate), since the impulse response is virtually the pattern of the conducting lines. This has led to delay lines (with delays of about 3 μsec per cm of substrate length); pulse compressors and expanders; band-pass filters; analog Fourier transformers; and other linear devices; and, because of the utilization of nonlinear response, convolvers and correlators, with wide use for many signal processing applications.

The microwave field has many facets. Some of these were covered by invited talks and followed by a session of contributed papers, such as the subjects

of radiometry, mixers, and microwave acoustics. The most popular subject, GaAsFETs, rated four contributed sessions that covered device technology, modeling, and circuits and systems. An example here was the paper "Improved Design Method for X-Band Microstrip FET Amplifiers without Experimental Adjustment Techniques" (A. Delgado, C. Camacho, V. Ortega, Escuela Técnica Superior de Ingenieros de Telecomunicación, Cuidad Universitaria, Madrid Spain).

Among the session of contributed papers were two dealing with antennas (Example: "A New Travelling Wave Antenna in Microstrip," by W. Menzel, Department Allgemeine und Theoretische Elektrotechnik, Univ. of Duisburg, FRG); several dealing with transmission lines, resonators, circuits and filters (Examples: "Coupled-Line Directional Couplers for MIC," by M. Houdard, Thomson-CSF, Malakoff, France, and "The Design of Multipole Filters for Use in Millimetre Wave Image Line Integrated Circuits," by M.J. Aylward and N. Williams, RC Technology Centre, ERA Ltd., Leatherhead, UK); and sessions covering ferrites, and such miscellaneous devices as phase shifter and oscillator diodes, and communication systems and devices (Example: "Voice Under Data: A Method for Transmitting Hybrid Information Over Microwave Communication Links," by I. Frigyes, Research Institute for Telecommunication, Budapest, Hungary).

The session "Dielectric and Optical Waveguides" had a paper with an interesting tie-in of microwaves to solar energy utilization. In "Theoretical and Experimental Studies of Inductive Grids," R.C. McPhedran and L.C. Botten (Univ. of Sydney, Australia), P. Bliek and R. Delevil (Université de Provence, Marseille, France), and D. Maystre (Université d'Aix-Marseille) discussed theory and good agreement with 26.5-40 GHz experiments of the use of circular apertures in thick conducting screens as high-pass filters and concluded that if such structures are scaled down they should do well in passing visible (desired) radiation and blocking longer wavelength (heat) radiation.

Finally, what can be considered a very successful set of presentations, since it allowed direct interaction between authors and attendees, was the poster session. Consisting of 26 papers, and entitled "Measurements and Novel Applications," this session covered subjects from the theoretical "Applications of the Impedance Transformation Properties for Analysis and Measurements of Microwave Networks with Variable Elements," by J. Modelski and T. Morawski (Warsaw Technical University) to the very applied "Microwave Thawing of Large Pieces of Beef," by A. Priou, C. Fournet-Fayas, A. Deficis, and E. Gimonet (ONERA - CERT, Toulouse, France).

To encourage high quality papers, a Microwave Prize is awarded annually to what is judged to be the best contributed paper. This year's winner, an alumnus of Cal Tech, was Prof. G.T. Wrixon (University College, Cork, Eire). In his paper entitled "A Superheterodyne Receiver from 350-400 GHz" Wrixon discussed a receiver in which he combined quasi-optical techniques with a specially-constructed GaAs Schottky barrier diode of 1.5 μm diam. that was contacted by a low-inductance spring of only 100 μm length. Initial measurements at 380 GHz (λ = 0.8 mm) gave a SSB conversion loss of 16 dB and a SSB mixer noise temperature of 12,900 K. These rather high figures easily reveal the difficulty in making high quality receivers when compared to, say, X-band. Nevertheless, Wrixon suggested methods of improving his mixer to the lower figures of 8.5 dB and 1800 K, respectively.

As can be seen from this survey, many interesting facets of microwaves were brought into focus. As usual, also, there were a few humorous aspects. For example, one German author was described in the book of abstracts as working for the "Institut für Slugsunk, in Oberpfassenhosen," when his employer really was the "Institut für Rundfunk, in Oberpfaffenhofen," and a paper dealing with broadcasting became "broadwasting." But these small errors did not detract from the value of this generally well-run conference.

According to the book of abstracts, copies of the Conference Proceedings, a volume of 835 pages, can be obtained at £23.00 a copy from Microwave Exhibitions and Publishers Ltd., Temple House, 36 High Street, Sevenoaks, Kent TN13 1J6, UK. (Irving Kaufman)

SOME SOLID STATE PHYSICS IN ITALY

Recently I visited three universities in Italy—Rome, Genoa, and Milan—and learned about some of the work there in solid state physics. First, however, I should like to comment on the present health of the university system in Italy. In an earlier note (*ESN* 31-6:239) Barcilon described vividly the problems resulting from the revolution in Italian universities when the doors were thrown open in an almost unlimited admissions policy.

Some of the resulting chaos has been sorted out, and the universities are beginning to regain control. For instance, in the University of Rome about 50% of those declaring a major in physics fail in examinations; standards of performance are being maintained. As Barcilon pointed out, the students are now intensely concerned that the employment opportunities for university graduates are so very meagre. Just as one set of problems seems to be eased, others arise. There are two additional problems that I should like to mention. One is that a new law on universities is expected soon. It will cover items such as university appointments, salaries, duties, qualifications for the PhD, and the relative role of departments vs institutes in the university structure. Obviously it will affect the character of the universities for a long time to come. During my visit the universities were not operating normally because the younger faculty were on strike to influence the government to provide better salaries for them and to resolve their insecure employment status.

The other problem is money. People in solid state physics had lived on constant budgets for several years in spite of national inflation rates of 20% per year. Their money and that of all of non-nuclear physics comes through one organization; nuclear and elementary particle physics are completely separate. What hurts is that the government appropriates less than 10% as much for non-nuclear physics as for the prestigious (in Italy) nuclear fields.

Faced with all of these problems for so many years, the people I saw seemed to react more in sorrow than anger. Given the constraints, they seem to be able to adjust to doing the best research they can with the students and the funding that is available. In many cases the best is very good indeed.

At the Univ. of Rome Prof. G. Chiarotti is head of the experimental work on solid state physics. His own efforts have recently been concerned with looking for the small optical absorption arising from surface states in semiconductors. Using samples with a surface cleaved in high vacuum and measured in the same apparatus, he has seen absorption in both Ge and Si; so far none has been observed in GaAs. In freshly cleaved Ge the symmetry of the surface as seen in low energy electron diffraction (LEED) experiments can be satisfied by having surface atoms raised above or lowered below the geometrical plane in a regular pattern. Theory shows that the raised atoms become negatively charged while those that are lowered acquire a positive charge. Chiarotti reasoned that if this model of the surface were correct, an ac electric field applied perpendicular to the surface would modulate the average positions of those atoms and therefore also modulate the surface absorption band. This has been clearly seen in Ge. A complication is introduced in the interpretation because the electric field also changes the position of the Fermi level at the surface. In Ge this can all be accounted for nicely, and the analysis even gives a value for the force constant for the displacements of the surface atoms.

Chiarotti, and others at Rome, are now engaged in a major effort to establish optical measurement facilities at Frascati where the national synchrotron facilities are being built. By the end of 1978 they hope to have experiments going in SEXAFS (Surface Extended X-ray Absorption Fine Structure), photoemission, optical spectroscopy, and the development of detectors for x-rays all using the intense broadband optical emission from the synchrotron. (See *ESN* 32-1:25 for a description of the French synchrotron facility.)

One of the staff members in Chiarotti's group is U.M. Grassano who has been very active in studying the optical properties of simple defects in insulators. Recently this has been concerned with a detailed analysis of the absorption and emission spectra of NaBr:Tl and an interpretation of them in terms of the crystal field interactions in the solid. A similar goal marks his work in studying magnetic circular dichroic effects in the luminescence of F centers (an electron at a negative ion vacancy) in various alkali halides.

Two of Grassano's recent studies are especially interesting to me because they seem to have uncovered new effects. In one of these M. Casalboni, Grassano, and A. Tanga examined the optical scattering background near the Nd-Yag laser line at 1.06 μm in KCl and NaF with various color centers present. Measurements were made at temperatures between 4 K and 195 K. When only U centers (a substitutional H ion) are present, the scattering is absent. On conversion of the U centers to F centers, the scattering appears. Their conclusion is that this large background scattering, which also appears in many other materials, is luminescence resulting from the return of excited electrons to shallow traps.

The other experiment by the same authors shows that two-photon absorption experiments can be conducted on color centers in NaF. Because the concentration of defect centers is down five orders of magnitude from that of normal lattice ions and because the cross section for two-photon processes is very low anyway, direct absorption measurements would be enormously difficult. Instead, they chose to look at the luminescence from various centers when excited by a Q-switched Nd-Yag laser. The intensity of these spectra varied with the square of the incident laser intensity, which supports the view that it is a two-photon excitation. Such an excitation allows the experimenter to study the even parity excited states of centers that are centrosymmetric.

Both of these studies would be greatly facilitated if the group had access to a tunable dye laser. However, the financial resources for new equipment are limited; the dye laser would take all the available equipment funds for the whole solid state group in Rome for a year.

Prof. G. Boato at the Univ. of Genoa is studying the surfaces of solids using the diffraction of atoms from the surface as a tool. The advantage of this technique is that only the outer layer of atoms on the surface is sampled; this contrasts with many other surface measurements in which penetration below the surface occurs.

In the experiments, a beam of He or Ne atoms is allowed to pass from a high-pressure room-temperature source through a nozzle, chopper, and various baffles and collimators into the high vacuum chamber that surrounds the sample. For He atoms the de Broglie wavelength is about 0.6 Å. The sample is usually cooled to either 10 K or 80 K. Provision is made for rotating the surface around two axes to allow for all diffraction angles. A doped silicon bolometer cooled to 1.6 K detects the diffracted atoms. The system design is such that a collimated incoming beam may be used that has an intensity 2×10^5 times the minimum signal detectable by the bolometer.

Careful and quantitative measurements coupled closely with theory have led to a broad variety of results. Measurement of the intensity of the surface diffraction peaks as a function of temperature has allowed a determination of the surface Debye temperature. Inelastic scattering has been detected, and a beginning has been made in the identification of the relevant phonon processes. There are dips in the scattering intensity at particular angles that can be related to bound state resonances between the incident atom and the attractive part of the surface potential. The relative intensities of the diffraction peaks lead to information about the surface corrugation produced by the repulsive part of the atom surface potential. Boato and his students have studied LiF using He and Ne atoms as a simple test situation. They have also used molecular hydrogen and have studied both the elastic and the rotationally inelastic diffraction of these molecules from LiF. More recently they have studied graphite and silver. In the case of silver they were the first to see diffraction of thermal atoms from such a densely packed metal surface. It seems clear that this technique is both versatile and fruitful in the difficult arena of unravelling the surface properties of solids.

At the Univ. of Milan, G. Benedek is pursuing a program of theoretical studies on surface physics which is closely allied with Boato's experiments. Benedek uses a Green's function approach to determine the surface lattice dynamics of ionic crystals including the long range interionic potentials. He predicts that Van Hove singularities in the surface phonon dispersion curves will give rise to major peaks in the observed scattering. Comparison of the calculated curves with experiments from the Genoa group show excellent agreement. There is, however, much additional data in the experimental curves and a large variety of physical phenomena that

can influence the scattering of atoms. As a result there is a great deal of information about surfaces still to be obtained upon the proper correlation of experiment and theory.

One can conclude that science is alive and well in Italy. Solid state physics is certainly lean and hungry; money is difficult; the university system is bouncing from crisis to crisis; and students are discouraged. Povera Italia! And yet and yet—the inventive genius, the joy of discovery and the sparkle of outstanding research are still to be found in Italy as much, perhaps, as ever. Deo Gratias! (Clifford C. Klick)

ATMOSPHERIC SENSING WITH LASERS

A conference on the use of lasers for investigating the atmosphere was held in London, 9-10 October 1978. Representatives from the UK, Belgium, France, Germany, US, Canada, Italy, and Sweden, presented papers. The topics included the use of lasers for pollution measurements and meteorological applications. The emphasis was on remote sensing laser techniques using either backscattered radiation (lidar) or long path attenuation (transmissometer).

In the first two sessions (Trends in Atmospheric Monitoring and *in-situ* Measurements) speakers from the UK Department of the Environment and the Environmental Sciences Group, Greater London Council (GLC) discussed monitoring in general terms and their individual points of view concerning the needs for pollution monitoring. If the Conference organizers and audience had allowed the tone to be set by these early speakers, there would have been no reason to continue. Both speakers were rather negative regarding what they described as developmental gadgets and new instruments that add to problems instead of easing them. It would not be very encouraging to UK scientists working in this field to learn that some users have little interest in their new developments. Aside from this aspect the Conference was informative and worthwhile.

In the last several years the laser has been put to use for several meteorological applications, and these were reviewed by R. Pettifer (Meteorological Office, Bracknell, UK). The only operational laser system used for meteorological measurements is a device that determines cloud base height. There are many other laser instruments, but they are in developmental status. Other meteorological parameters that can be measured with lasers include visibility, wind, precipitation, temperature, and humidity.

Pettifer holds a somewhat pessimistic view for the future of laser devices for meteorological applications. He feels that after ten years of investigation laser instruments have not generally become useful for routine measurements because of cost and because they are limited by bad weather conditions.

One scheme for remotely measuring wind velocity with a CO_2 laser operating at $\sim$10 μm was explained by J. Vaughan [Royal Signals and Radar Establishment (RSRE), Great Malvern, Worcestershire, UK] (See *ESN* 32-10:344). The eye-safe, 5-W, cw-laser beam is focused at the position in space under investigation. Radiation backscattered by aerosols is collected by the receiver telescope which doubles as the transmitting telescope. The velocity information, obtained from the Doppler shift in the backscattered radiation, is extracted from an ir detector in the receiver using heterodyne techniques. Ranges beyond 1 km are possible. Vaughan predicts that when stable compact pulsed lasers become available, ranges of tens of kilometers will be possible and the detection of clear air turbulence may then become practical.

J.W. Britton [Flight Systems Department, Royal Aircraft Establishment (RAE), Bedford, UK] described a laser anemometer based on the same scheme, but modified to contain four telescopes. Each telescope is independently adjustable in range and elevation. The laser beam can be sequentially presented to each telescope. This device then can scan a predetermined sequence of points in space. The instrument is being used to measure wind velocity, wind shear, and turbulence. As one would expect from the dependence of the size of the focal "spot" with range, turbulence measurements at long range differ from those at short range.

For some years it has been hoped that extinction measurements in mists and fogs with ir lasers could yield information on pertinent meteorological variables including visibility. However, J.C. Petheram (Plessey Radar Ltd, Atmospheric Sciences Group, Cowes, Isle

of Wight, UK), in a report summarizing field work with three-wavelength (0.63, 1.06 and 10.6 μm) transmissometers at two different locations found rather poor correlations between extinction values and meteorological variables. Furthermore, the results were site dependent.

The use of multi-wavelength lidar for quantitative remote aerosol sensing was described by W. Carnuth (Institute for Atmospheric Environmental Research of the Fraunhofer Society, Garmisch-Partenkirchen, FRG). His group has a two-wavelength stationary system using a 0.6943-μm ruby laser and a frequency-doubled output at 0.3472 μm as well as a four-wavelength mobile system (10.6, 0.53, 0.6943, and 0.3472 μm). Both of these systems are used for determining aerosol concentration profiles vs height up to 35 km. F. Koepp described work on aerosol measurements by another group from Germany, Deutsche Forschungs-und Versuchsanstalt für Luft- und Raumfahrt (DFVLR) in Oberpffaffenhofen, FRG. They made lidar measurements looking down from an aircraft over the US and Germany as part of an assessment of a spacelab-borne lidar which will be a future NASA experiment (see *ESN* 33-1:31).

The use of a two-channel polarization-sensitive lidar system to discriminate between ice crystals and water drops was described by V. Smiley [Office of Naval Research (London) and Desert Research Institute, Reno, Nevada]. He has been making measurements at the South Pole and also at a coastal region in Antarctica with a polarized laser transmitter and a two-channel receiver. One channel measures the backscatter received polarized parallel to the outgoing beam and the other measures the backscatter polarized perpendicular to it. The ratio of these two quantities is called the depolarization. Spherical water drops have zero depolarization in the backscatter while ice crystals strongly depolarize the light. Smiley has found that not only are there pure ice-crystal layers present in the troposphere but that pure water-drop layers as well as mixed-phase layers also exist at various times in the polar troposphere during the austral summer in spite of temperatures being well below freezing. Often these layers precipitate ice crystals and sometimes are not visible, hence the term clear-sky precipitation is used.

The Meteorological Office (Bracknell, Berks., UK) has been conducting lidar measurements of stratospheric aerosols and cirrus clouds. This work was described by J. I. Gibbs. They are particularly interested in the "Junge Layer" at an altitude of about 20 km where aerosols, mostly of volcanic origin, accumulate. These aerosols influence the radiation properties of the atmosphere, hence knowledge of their effects on radiation and temporal changes are important. In private discussions with this group it was brought out that the UK is a very poor location to conduct this kind of work because of the low probability of clear weather.

A few papers were presented on the subject of pollution monitoring using long path transmissometers operated in the differential absorption mode. This requires measurement of transmission at two wavelengths one of which coincides with an absorption line of the gas under study and the other at a wavelength free of absorption. B. Marthinson described a computer-automated system in operation by the Department of Electrical Measurements, Chalmers Univ. of Technology, Gothenburg, Sweden. It uses a CO_2 and diode lasers and is capable of scanning 2 simultaneously operating lasers to 54 different wavelengths. The group has used the instrument on ethylene, vinyl chloride, and SO_2.

The subject of differential absorption measurements of backscattered radiation, i.e., by lidar, was reviewed by H. Walther (Sektion Physik der Univ. München and Projectgruppe für Laserforschung der Max-Planck-Gesellschaft zur Föderung der Wissenschaften e.v., Garching, FRG). The most recent work carried out by his own group consisted of H_2O vapor determinations near a power plant cooling tower and also ethylene profiles near a petrochemical factory. Both measurements were made with a CO_2 laser transmitter tuned to the pertinent absorption lines by a grating.

In spite of the "cold water" treatment by UK environmental officials, the meeting was of value to people working in the field as well as to those who would like to apply these new techniques to pollution monitoring and meteorological measurements. As evidenced by the large number of papers on the subject, differential-absorption lidar has become a topic of keen interest in the last few years. Also a fairly large number of mobile lidar instruments have been built and placed in operation recently. It remains to be seen, however, how long it will take before lidar measurements will be widely accepted by environmental agencies as valid for enforcing environmental pollution regulations. (Vern N. Smiley)

PSYCHOLOGICAL SCIENCES

EUROPEAN RESEARCH ON HUMAN BIORHYTHMS

Biorhythm refers to cyclical effects in behavioral, physiological, and biological measures, and there is a crank side and a serious side to it. The crank side will appear in popular magazines and will try to sell you a computer printout of your emotional and intellectual cycles from birth to death. The serious side has responsible scientists who are conducting laboratory and field studies in search of periodicities in human functions and the effects of disrupting them. Systematic evidence is beginning to appear on a 90-minute cycle (see *ESN* 32-4:153), but the circadian, or 24-hour, rhythm, is the most widely studied, and Europe is the locus of the study of it in humans.

There are four centers of research on circadian rhythms in Europe. One is the Perceptual and Cognitive Performance Unit, Medical Research Council, attached to the Laboratory of Experimental Psychology, University of Sussex, Brighton. W.P. Colquhoun is the professor in charge. A second is the Institut für Arbeitsphysiologie in Dortmund, West Germany. Their research on circadian rhythms is headed by Professor J. Rutenfranz. The third is the Institut für Umwelthygiene of the University of Vienna, where the biorhythm research is directed by Professor M. Haider. On 21-23 September 1978 Haider conducted the "European Seminar on Performance-Time Functions," which had many of Europe's leading investigators of circadian rhythms present. The fourth is the DFVLR-Institut für Flugmedizin, Bonn-Bad Godesberg, West Germany, with Dr. K. Klein as the director (see also *ESN* 24-6:166). As might be surmised, the interest of Klein's group is the effect of the circadian rhythm on the efficiency of aircrews. These research centers are manned by both MDs and experimental psychologists.

The basic datum of the circadian rhythm is that human body temperature follows a 24-hour cycle. Temperature will rise in the waking hours, peaking in the late afternoon and early evening, and then decrease and reach a minimum in the early morning hours during sleep. Various behavioral and psychological measures will track the temperature function. For example, in one study by Aschoff et al., (reported in *Aspects of Human Efficiency*, edited by Colquhoun, published by English Universities Press, 1972) measures of reaction time, tapping, time estimation, speed of canceling random digits on a page, and grip strength, were all in synchrony with the body temperature function. Measures derived from urine samples showed the same synchrony. These are the kinds of data on which the phenomenon of circadian rhythm is based. No one knows the explanation of it. While body temperature is the basic function against which other measures are referenced, investigators shy from saying that changes in body temperature cause changes in the other measures. Correlation is not causality.

Of special interest to workers in this field is disruption in the circadian rhythm and its effect on performance. The most familiar effect of disruption is jet lag, where one's pattern of living gets out of synchronization with the circadian rhythm. The body temperature function is unable to track the environmental time cues quickly so, perhaps, we are required to do our daytime activities when the temperature curve is in its nighttime phase, or vice versa. Getting back into phase takes time, as all international travelers know. Sleep disturbance is a particularly prominent symptom of jet lag. Klein has been a keen analyst of circadian rhythms and the performance of aircrews, particularly international ones that cross several time zones and have their circadian rhythms disrupted (for a review, see the chapter by Klein et al., in R. Mackie (Ed.), *Vigilance Theory, Operational Performance, and Physiological Correlates*, New York, Plenum, 1977). The official regulation governing work and rest for German aircrews is based on the circadian rhythm and its disruption, which Klein estimates to be an efficiency loss in the neighborhood of 8-10%. Even a minor disruption of one hour when daylight savings time is adopted has its consequences. T. Simon and S. Folkard of Colquhoun's unit found that the effect on body temperature persisted for six days. Effects on waking up time after the change to daylight savings time lasted five days. They have evidence

that road accidents increase in the week after the change. [See their paper in *Nature* 241, 688-689 (1976)].

A preoccupation of the participants in Haider's seminar on performance-time functions was shift work, or a change in work pattern, usually the change from day to night work. The change should disrupt the circadian rhythm, which should take its toll, according to modern thinking. Knauth and Rutenfranz [*International Archives of Occupational and Environmental Health* 37, 125-137 (1976)] found that the body temperature function had not yet fully adapted after 21 days. Correlating disruption of the circadian rhythm and of work performance is not easy because social factors introduce confounding elements. A person who works at night must sleep in the day, which is noisier, so he is less well rested. He sees his family less, which can be a source of tension. Social patterns with friends can be disrupted. One possible solution is permanent night workers who fully adapt their work, family life, social life, and circadian rhythm, and presumably find contentment thereafter. (Jack A. Adams)

SPACE SCIENCES

THE XXIX CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION

The XXIX Congress of the International Astronautical Federation (IAF) met in Dubrovnik, Yugoslavia, 1-7 October 1978. The theme of the Meeting was "Astronautics for Peace and Human Progress" and consisted of programs developed by the IAF, the International Academy of Astronautics (IAA), and the International Institute of Space Law (IISL). The Co-Chairmen for the entire program were Profs. C.C. Chernyi (USSR) and R. Monti (Italy). The program was augmented by a series of current-event reports and extremely informative scheduled press conferences. This review will attempt to reflect some sense of all these aspects of the meeting along with personal observations and conclusions of what occurred both inside and outside of the formal congregating areas. Obviously it is not possible to cover all aspects of the meeting since there were five simultaneous technical sessions as well as the current events meeting and press conferences. In order to reflect a consistent picture this report draws upon personal notes, the preprinted abstracts and formally issued daily reports of the meeting. All formal papers are available from the IAF.

About 600 professionals from 36 countries and 5 continents registered. The geographical distribution was most interesting as is indicated by the following list of nations with 10 representatives or more: Czechoslovakia (16), France (61), German Democratic Republic (GDR) (10), Federal Republic of Germnay (FRG) (65), Italy (15), Japan (14), Poland (10), UK (13), USSR (73), US (120), Yugoslavia (123).

The heavy registration from the Eastern European countries must be noted (roughly 40% of all attendees). The reason for this was apparently twofold. First, the East Europeans apparently find permission for travel within the confines of their political sphere much more readily attainable. Indeed, the IAF meets more frequently in East Europe than most other international organizations. And, second, the East Europeans obviously believe a great deal of prestige is due them from their recent space achievements and their general space effort. This fact was made most evident by the presence of a contingent of six East European cosmonauts: Alexei Leonov (USSR), Vitali Sevastianov (USSR), Valeri Kubasov (USSR), Peter Klimek (USSR), Vladimir Remek (Czechoslovakia), and Miroslov Hermaszewski (Poland). The presence of Leonov, Russia's claim to the first man to walk in space, and the first multinational space team of Klimek, Remek, and Hermaszewski drew a great deal of attention.

The technical meetings consisted of the following symposia: On-going Space Activities; Systems for Space Exploration (Scientific Spacecraft, Unmanned Solar Exploration, Space Power Systems, Materials and Structures, Propulsion and Bioastronautics); Communication Satellites (Operational Systems, Experiments, and Future Systems and Technology); Astrodynamics (Natural Systems, Optimization, Motions Around Centers of Mass); 11th International Space Rescue and Safety Symposium; Supervised Experimental Model Rocketry; Earth Exploration from Space (Observing the

Earth, Weather and Climate, Earth and Ocean Sensors, Mission Applications and Spacecraft, and Pollution of the Atmosphere); 7th International Review Meetings on Communications with Extra-Terrestrial Intelligence; 8th IAF Student Conference; 21st International Space Law Conference; 5th International Symposium on Space Relativity; Fluid Mechanics in Planetary Atmospheres; Space-Based Power Systems for Earth; Space Processing; 8th International Symposium on Space Economics and Benefits; and the 12th International History of Astronautics Symposium.

Chernyi and Monti did a memorable job in organizing the meeting, and there were numerous outstanding and very informative papers. Many were reviews of efforts familiar to those working intimately in a specific field, but so developed as to give excellent prospectives and insights into the true state-of-the-art. The most disappointing aspect of the meeting was the limited discussion and very low attendance at the technical sessions, which averaged, except for the opening sessions, at most 30 persons.

Without doubt the most active interest in papers was that associated with communication and weather satellites. Since space telecommunication systems have become very economically viable, the expansion of space research in this area appears to far outpace all others. Although the meeting showed the tremendous progress made in Earth sensing, dramatic results in this area appeared to be more difficult to pinpoint, although there is no doubt that progress is substantial. Nevertheless, the sessions devoted to these topics alone, and those which included their legal aspects, particularly with respect to remote sensing, fully justified the Congress theme title "Astronautics for Peace and Human Progress."

The invited plenary lecture was delivered by Academician Leonid I. Sedov, leader of the Soviet delegation. His basic thesis was that the rapidly developing scientific and technological achievements should be used to play an important role in "the development of modern material and spiritual culture" and not to wage war. He stated, "The duty of all scientists, scholars and engineers is to persuade all the world's nations and their governments of the necessity of war avoidance..." He focused on starvation, higher living standards, longevity, and reduction of pollution as the areas for scientific research rather than "expensive terrifying weaponry."

The initial opening forum relating to "On-going Space Activities" was the only other event of the opening proceedings and had no other conflicting session. As planned, Dr. Robert A. Frosch, NASA Administrator, Mr. Roy Gibson, Director General of the Europe Space Agency (ESA), and Dr. Boris N. Petrov, Chairman of the Intercosmos Council, Moscow, were to present overviews of their on-going and prospective space programs. Unfortunately, Frosch was delayed owing to President Carter's visit to the Kennedy Space Flight Center on the occasion of NASA's 20th Anniversary.

Gibson reported that the Convention of the European Space Agency, signed in 1975, gives his agency the task of strengthening European cooperation in research and technology for purely peaceful purposes and the strengthening of European space policy. He then briefly reviewed the major activities in the European space program and gave emphasis to the realization of the Ariane Landing Program.

Petrov tried to emphasize that the Soviet Union recognizes the importance of cooperation with other countries in space exploration and that multinational cooperation with socialist countries is developing within the Intercosmos Programs as well as bilateral cooperation with India, France, Sweden, and the US. He further stated that the internationally manned missions with the other countries who participate in Intercosmos will continue and that candidate cosmonauts from Bulgaria, Cuba, Mongolia, and Romania are now undergoing training near Moscow.

In his paper prepared for the Congress and reviewed a few days later, Frosch said the US space efforts fall into three categories: The use of near-Earth space for remote sensing, communications, and other programs directly beneficial to human welfare; the scientific exploration of the solar system to improve our understanding of our planet and its phenomena, coupled with exploration by observation of the universe in a continuing effort to understand the place of Earth and man in the cosmos; and investigation of the Sun-Earth relationships basic to the whole biosystem in which we evolved and live. He further emphasized the international interest in Landsat, the general acceptance of satellite communication and weather information data, and the fact that the US would continue to improve

and make optimum use of existing systems such as the Landsat Earth Resource Satellite, the NIMBUS environmental quality monitoring satellite, and the TIROS weather satellite. Naturally he reviewed the merits of the Space Shuttle and the fact that this system would eliminate many space and weight restrictions currently affecting space and satellite systems.

The first day's afternoon session, which drew the biggest attendance, was related to operational communication satellites. In his paper, H.W. Wood (Intelsat, Washington) stressed Intelsat development and reported that the Intelsat V spacecraft will be in operation in 1980. He said that in the 1990s large-scale space stations equipped with complex orbital antenna forms and multiple communication packages for a variety of uses would be technically feasible and would have the potential for substantial cost savings to consumers. H. Svetarja, A.P. Djiwatampu, and A. Gunawan (PERUM Telekomunikasi, Indonesia) reported the improving implementation of telecommunication systems in Indonesia with its 3000 inhabited islands. This is probably the prime example of space benefit to a developing nation.

Papers by Intelsat Interim (Paris), Western Union, and the Japanese Radio Research Laboratory (Koganei City, Japan) reported on their developing communication systems as well. It appears to this observer that this field is on the verge of enormous and rapid development in the same respect as the explosive technological development that took place in the solid state device field.

The next day's meetings on Communications with Extra-Terrestrial Intelligence (CETI) are difficult to evaluate. It was interesting to note, as stated by others, that none of the papers discussed whether there is life in outer space, but all argued the ways and means of detection with, perhaps, the underlying premise that life does exist.

During the next three days' there were a number of sessions concerned with Earth exploration from space. C.M. Hayden [National Oceanic and Atmospheric Administration (NOAA), Madison, WI] reported on satellite data and the importance of their utilization in short-term weather forecasting. Indirect sounding of temperature and moisture has in the 10 years of operational data given excellent results. As sounding instruments evolve and meteorological modelling improves, very reliable 2-3 day numerical forecasts are in the future. The group from Dornier System GmbH (Frierichshafen, FRG) discussed the ESA sponsored Sun Observatory and Climatology Satellite Program which hopes to monitor the Earth's radiation budget by obtaining simultaneous measurements of the total and spectral distributions of incoming solar radiation, reflected radiation fluxes, radiation leaving the Earth's atmosphere, and diurnal features of the atmosphere and its variation with solar age. They also seek to determine the physical nature of the spatial and temporal change of the radiation budget and its parameters and to deduce information about the stratospheric ozone and temperature profile, cloudiness and cloud coverage, aerosols and concentration of trace constituents, water vapor content, temperature of the Earth's surface, and global coverage of vegetation areas, oceans, snow and ice fields. A Japanese Radio Research Group reported on their use of microwave techniques for sensing precipitation. An unscheduled presentation by a representative of Jenoptik Jena (GDR) reported on the design and technical parameters of the MFK-6 Multispectral Camera and the MSP-4 Multispectral Projector developed by Jena and the Institute for Space Research at the USSR Academy of Sciences under the sponsorship of Intercosmos. The unit was used in Soyez 22 and takes 4 visible and 2 infrared pictures simultaneously. D. Mischev (Bulgaria), the Chairman of the session reported that Bulgaria has used the camera in an aircraft with results of high quality pictures. The camera with the color mixing projector for extracting visual information from the high quality multi-band photography obtained seems to be a remarkable instrument.

Two papers were presented on sea ice. They were "Scatterometer and Imaging Radar Results of Sea Ice" by a joint Canadian and US group and "The Sea Ice Discrimination by Means of Passive and Active Microwave Observations" by a group from the USSR Academy of Sciences. Neither detailed reprints were available to this observer, nor was I present at this session. Unfortunately I chose to attend the session on space-based power systems for Earth. In this session some papers tried to show the feasibility of converting solar energy to micro-

waves for energy transmission to Earth. Even with projected technological advances, the analyses presented seemed to me unrealistic from both an economic and environmental point of view.

The sense of the program devoted to space (material) processing indicated that the greatest interest was on growing crystals in a zero gravity field. Apparently this concept has one of the greatest possibilities of economic viability. However, surface tension effects induced by temperature gradient impose convective motions (the Marangoni effect). This effect presents the fascinating theoretical and experimental challenge of balancing or offsetting this surface tension force if the zero gravity experiments are to be effective. These efforts are just beginning.

It would appear appropriate to close the technical aspect of this article with some brief comments on the Conference held to present the East European cosmonauts to the Press. Asked about the difficulties in adjusting to a non-gravitational field, the cosmonauts agreed that initially it was difficult to accommodate but that their special training and practice allowed them to adjust. In fact, after a long stay in space, the real adjustment problems to the Earth's gravitational field were noted. Leonov commented that a journey to Mars is feasible, but that interplanetary flights belong to the future. The cosmonauts stressed the somewhat political element of international cooperation on manned space missions, particularly among the socialistic countries.

Roy Gibson (UK), Director of ESA, was elected the Federation's new president replacing Dr. Marcel Barrère of ONERA (France). The new Vice-Presidents are: L.I. Sedov (USSR), Prof. S. Saito (Japan), R. Monti (Italy), Dr. E. Hollax (FRG), and Dr. J. Grey (US).

The Guggenheim International Astronautics Award for 1979 went to C.C. Kraft, Jr., Director of NASA's Johnson Space Center, for directing the US manned space flight programs. The Emil Memorial Award for international cooperation in space was awarded to G.S. Lunney of NASA and K.D. Bushuyev of Moscow's Institute of Space Research for their management of the Apollo-Soyuz test project.

In closing, I would like to congratulate Chernyi and Monti for accumulating an engrossing set of papers and enticing most competent and responsible people to deliver papers, chair sessions, etc. Dubrovnik offered some of the finest resort hotel and other accommodations for a conference that I have seen. Further, the scenery in the area is outstanding. These features are together enticing and detracting as was evidenced at the XXIX Congress of the International Astronautical Federation. (Irvin Glassman, Center for Environmental Studies, Princeton Univ., Princeton, NJ)

SPACE SCIENCE IN SWEDEN

Sweden supports a very respectable space program both through its participation in the European Space Agency (ESA) and through national programs that in several instances involve bilateral cooperation with other countries. The Swedish Board for Space Activities (SBSA), under the Ministry of Industry, is the central authority responsible for funding all government-sponsored space activities both national and international. In addition to the Ministry of Industry, the Ministries of Education, Communication, Foreign Affairs, and Housing and Planning are represented on this Board. The Board has three advisory committees: science, applications, and remote sensing, all of which include representatives of government, industry, universities, and research institutes as well as the Swedish Space Corporation (SSC). The SSC is a nonprofit quasi-governmental institution that operates as a private corporation handling the executive management functions of the Swedish space program for the SBSA. Among these functions are management of the Swedish sounding rocket and balloon launching range, Esrange, near Kiruna; technical execution of the space science, remote sensing and materials programs of the SBSA; and providing technical experts to ESA as required. The actual funding of space programs to research institutes, industries and the SSC is in the form of contracts let by the SBSA.

There is in addition to the SBSA and SSC an Association of Swedish Space Scientists (SRS) composed of active space scientists who provide a forum for discussions on scientific problems and joint

projects within the scientific program. In effect, they provide an *ad hoc* advisory capability for the various official advisory committees to the SBSA. The Swedish space budget for fiscal year 1977 included $15.5 million for ESA contributions (2.7% of the total contributions to the ESA budget) and $6.5 million for the national programs. The national budget for space programs, however, is actually larger than indicated by the above figure as only equipment that flies in space is included in this. Funding for test equipment, ground computers, laboratory facilities, salaries, and telescopes, for example, comes from various other sources.

Sweden participates in the basic and scientific research programs of ESA as well as in the technologically oriented programs such as OTS (telecommunications satellite), Marots (maritime communications satellite), Meteosat (weather satellite), and the Ariane launcher. The technical program participation is via two international consortiums—STAR and MESH—with the industrial organizations of Telefonaktiebolaget L.M. Ericsson and Saab-Scania AB being the respective representatives. Bilateral scientific cooperation between Sweden and NASA involves participation in the International Sun-Earth Explorer Satellite, the Orbiting Solar Observatory 8, and the Jupiter Orbiter among others. Official bilateral programs are also underway with the Soviet Union via the Soviet Academy of Sciences, France via the French space agency CNES (Centre National d'Etudes Spatiales), and Austria. Other cooperative efforts are carried out on a more or less *ad hoc* basis with Belgium, Denmark, Finland, FRG, the Netherlands, Norway, Switzerland, and the UK, primarily through balloon and sounding rocket campaigns.

The national scientific activities of the various Swedish research groups fall into four basic categories: 1) Magnetospheric and ionospheric physics—in particular the measurements of charged particles and electric and magnetic fields using sounding rockets, balloons, and satellites. The main groups involved in these programs are the Kiruna Geophysical Institute, the Department of Plasma Physics of the Royal Institute of Technology, and the Uppsala Ionospheric Observatory. 2) Upper atmospheric physics—specifically atmospheric processes and composition between 80 and 150 km at high latitudes using sounding rockets. The main groups involved in this research are the Institute of Meteorology, Stockholm University, and the Uppsala Ionospheric Observatory. 3) Astrophysics—with emphasis on studies of solar and stellar uv and ir radiation using satellite and balloon experiments on an international cooperation basis. The Astronomical Institute, Lund University, and the Stockholm Observatory are the primary institutions involved in these studies. 4) Material sciences—in particular solidification processes of metals and diffusion processes in liquid metals under zero-*g* conditions using sounding rockets. The major groups involved in this research are the Department of Casting of Metals, Royal Institute of Technology, and the Department of Physics at the Chalmers Institute of Technology.

Several satellite, balloon, and sounding rocket programs currently underway in Sweden are outlined in the following paragraphs and may be taken as typical of the types of projects being pursued in the Swedish space program. The Kiruna Geophysical Institute has a particle spectrometer on board the ESA GEOS 1 and 2 scientific satellites that will measure electrons and protons in the 0.3-20 keV energy range. Extensive software programs have been developed making possible the determination of pitch angle distribution and energy spectra. GEOS 2 attained orbit successfully in the summer of 1978, and data are currently being analyzed by the Institute.

The Soviet Prognoz 7, launched 31 October, carried a Swedish-built particle experiment consisting of three mass spectometers covering the energy range of 0.2-16 keV and three other energy-per-charge (E/q) spectometers for the detection of electrons and positive ions in the 0.03-40-keV energy range. The orbit of the Prognoz 7 satellite is highly elliptical (apogee 203,000 km, perigee 483 km) with an inclination of 65° that will enable measurement of auroral particles over the auroral zone and cusp regions at fairly high altitudes (3000-20,000 km). The Kiruna Geophysical Institute and Swedish Space Corporation were responsible for designing and building the experiment. Preliminary studies for a new Swedish-built magnetospheric satellite, M-Sat, have been initiated in cooperation with the USSR.

Other future satellite programs include participation by the Astronomical Institute in Lund in the dust detector experiment onboard the NASA Jupiter Orbiter; studies of the vestibular function with the Space Sled; and studies of solidification of metals during zero-*g* conditions. The latter two experiments will be flown on the first Spacelab.

National sounding rocket experiments have been carried out in Sweden since 1961, most of them being international cooperative programs. The sounding rocket activities are mainly centered around physical and chemical investigations of the upper atmosphere and charged particle, electric field, and plasma measurements of the ionosphere. Owing to the geographical location of the sounding rocket launch facility (68°N, 21°E), studies of the aurora and other high latitude phenomena are of particular interest. Several examples of planned rocket experiments for 1979-80 follow. Substorm-GEOS will involve launching three rockets in rapid sequence and in coordination with the GEOS 2 satellite to study charged particles and electric fields during different phases of substorm activity. The Ba-GEOS will involve studies of the effect of a barium ion jet released from a rocket at about 400 km. The GEOS 2 mass spectrometer will be utilized for detection of the barium ions. PIRAT (Pointed IR Astronomical Telescope) is an experiment for photometric observations of extended celestial gas and dust clouds using a liquid helium-cooled telescope.

An international balloon project known as SBARMO-79 is scheduled for the summer of 1979. Some 36 balloon flights will be performed from northern Scandinavia during the period carrying detectors to measure auroral x-rays, magnetic and electric fields, vlf-emissions, and atmospheric infrasonic waves. The Swedish experiments will be provided by the Royal Institute of Technology and include measurements of electric fields in the auroral zone of ionospheric origin. Sweden has also been participating in a balloon project known as BIRAP with the Netherlands in which a 60-cm telescope is used for long-wavelength infrared studies of contracting dust and gas clouds. The scientific aim is to attain a better insight into the formation and evolution of stars. The principal Swedish investigator is the Stockholm Observatory. Two launchings have taken place in 1978 and further launchings are planned for 1979.

Sweden is becoming increasingly interested in remote sensing of earth resources and environment. Land mapping, air and water pollution detection, ice surveillance, oil spill surveillance, and sea ice mapping are examples of programs underway in this area. The SSC has installed a Landsat station at Esrange which will be integrated into the Earthnet system of ESA. In another area of satellite applications, the SSC performed the study work for a Nordic area television broadcast and telecommunications system—the so-called NORDSAT. A decision to implement such a system is now under consideration by the Scandinavian countries involved.

Several of the space research institutions mentioned in this article were visited by the author and will be reported on in more detail in subsequent articles. One of the notable observations made while visiting the Swedish research institutes is that everyone involved in space science and technology is very familiar with the works of other groups and close cooperation exists among these groups. This situation may be largely due to the wide representation on the SBSA advisory committees and the SRS by researchers from the universities, institutes, and industry. (Robert W. Rostron)

SPACE PHYSICS AT THE SWEDISH ROYAL INSTITUTE OF TECHNOLOGY

The activities of the Space Physics Group of the Department of Plasma Physics at the Royal Institute of Technology (KTH), Stockholm, are primarily concentrated on the plasma physics of the ionosphere and magnetosphere with particular emphasis on the role of electric fields. These activities include both theoretical and experimental work with the latter conducted both in space and in a laboratory which is well endowed with all of the modern equipment that would make any experimental physicist envious. The space physics research is carried out in close contact with laboratory plasma physics experiments that have traditionally characterized the research of this Department. This is an asset that appears to be beneficial for progress in both fields.

The theoretical research in space physics at the Institute covers a wide range of physical problems of the ionosphere, magnetosphere, solar wind, solar atmosphere, and other cosmic plasmas. In magnetospheric studies, the major

interest is attached to the behavior of electric fields, and models of the field distribution and associated plasma flow are under development. The electric current systems in the ionosphere and the magnetosphere are examined with relation to their effects on the plasma in the upper ionosphere where they may create density depletions and local space charge sheaths. The conditions for the existence and of the processes of formation of space charge sheaths and other types of magnetic-field aligned electric fields are also under study. Various aspects of these theoretical studies are supplemented by laboratory simulations and corresponding measurements.

Rocket-borne experimental packages have been a part of the space science program for over ten years. These experimental activities also concentrate on studies of electric field and plasma parameters using a double probe technique (measurement of the potential difference between two conducting electrodes immersed in a plasma). This technique was originally developed for dc measurements, but it has been modified to operate in special modes for intermittent determinations of electron temperature and density along the rocket's flight path. During the period 1978 and 1979, the group is involved in some eight flights from Esrange (the Swedish rocket range), the Andoya range in Norway, and Cape Parry in Canada. Four of the flight experiments will be carried out in conjunction with the GEOS 2 scientific satellite of the European Space Agency (ESA). In addition to the rocket-borne experiments, the Department makes electric field measurements in the upper atmosphere using balloon-borne equipment. Winter balloon flights are providing interesting correlations between visible auroral arcs, electric fields, and x-ray precipitation. The Space Physics Group is also participating in electric field experiments on several satellites including the International Sun Earth Explorer and the forthcoming EXOS-B. They are collaborating with the Univ. of Tokyo on the latter experiment.

Since many of the key problems of understanding the ionosphere and magnetosphere raise questions of fundamental plasma physics, several research projects are being carried out in the laboratory to provide direct correlation with the space programs. Among these are studies of the phenomenon of electric double layers in current-carrying plasmas and of the generation and diagnostics of collisionless magnetized plasmas and their interaction with solid bodies, neutral gases, and magnetic fields.

The phenomenon of electric double layers refers to the condition in which potential discontinuities exist in plasmas. In certain cases these layers are visible, e.g., in an arc discharge. The phenomenon can occur in both low and high density plasmas and arises in a number of ways. In space physics, the double layer phenomenon has been invoked to explain solar flares and acceleration of auroral electrons. Recent electric field measurements in satellite orbits above the auroral region have also given evidence of localized space charge regions with large electric fields (another definition of double layer). Experiments and numerical simulations have shown that one condition for the formation of double layers or potential discontinuities is that the electron drift velocity must exceed the thermal electron velocity. Torven and Anderson of the Institute's Plasma Physics Department have been working in the field of electric double layers for many years and recently have found conclusive evidence of double layers in a magnetized plasma column through direct observation. Their technique is outlined briefly in the following paragraphs.

The observations of the double layer were in the form of a visible boundary which divided a plasma into a cathode and anode discharge. The plasma was maintained by a dc-arc discharge in mercury vapor and the plasma column confined by an axial magnetic field variable between 50 and 1500 G from a pair of Helmholtz coils. A schematic of the apparatus is shown in Figure 1. The plasma was maintained by the source to provide a single-ended plasma inflow along the magnetic field with plasma source currents up to 40 amp attainable between the cathode and the hollow electrode E_1. The plasma passed through both electrode and a second aperture in the plate E_2 into the vacuum chamber. The vapor pressure in the vacuum chamber was kept on an order of magnitude lower than in the source, and resulted in formation of a plasma column between E_2 and the anode, A. If the anode was left floating, most of the electrons were reflected in an anode sheath, and a quiescent and current-free plasma column was formed with an axial electric field. The

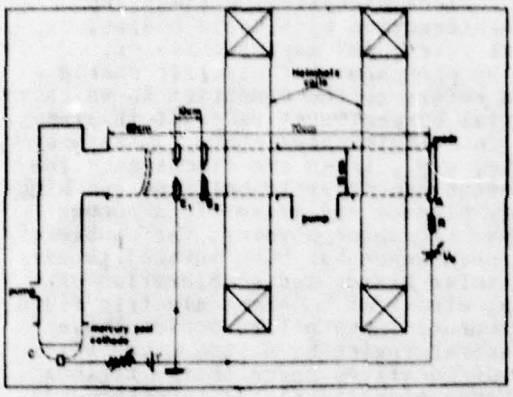


Fig. 1

field was directed towards A. The electron temperature equaled that in the dc arc, and the electron gas was distributed along the column in an approximate Boltzmann configuration so that the density decreased by typically a factor of 2 between E_2 and A. A magnetic field of 100 G provided by the Helmholtz coils gave an electron radius of gyration of 0.3 mm. The ion gyro radius was larger than the column diameter and the ions were confined by a radial electric field (not shown in Fig. 1). The electron number density was proportional to the plasma source current with an electron number density of 10^{15} m^{-3} being used. This value, which gave a plasma Debye length of 0.35 mm, refers to the plasma density on the low potential side of the formed double layer as discussed below. The mercury atom number density was 5×10^{18} m^{-3}.

Three axially movable probe filaments that could be heated to electron emission temperature were used for the diagnostics. The emission current of the probes could be adjusted so that their floating potential equalled the plasma potential. Plasma potential variations from dc up to 400 kHz could be followed.

The plasma current increased exponentially when the anode potential, V_A, was increased from the floating potential to the plasma potential. This occurred since the electron reflecting-voltage drop over the ion-rich anode sheath decreased. The current tended to saturate when V_A reached the plasma potential with a further increase in V_A giving rise to an electron-rich anode sheath that reflected the positive ions. When V_A reached a value of about 25 V, the anode sheath was converted into a double layer which assumed an approximately stationary position a few centimeters from the anode. The double layer could then be moved to any new stationary position between E_2 and A by a further increase in the external voltage, U_0. Once the layer was formed, the discharge current was no longer saturated and the current, which was between 25 and 30 mA for positions close to A, increased to 57 mA for a position halfway between E_2 and A. The layer could be observed as a visible boundary that divided the column into a cathode plasma, maintained by the plasma source, and an anode plasma, formed between the layer and the anode (Fig. 2). The layer voltage was

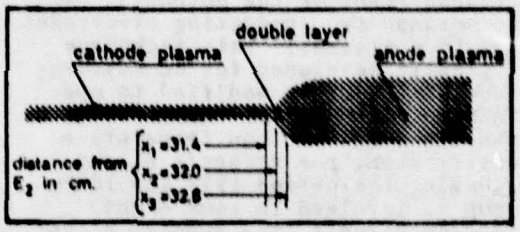


Fig. 2

found to fluctuate by up to 20%, and these fluctuations propagated in the anode plasma. The layer also exhibited an axial motion back and forth with amplitudes somewhat larger than the layer thickness.

The above results are preliminary, and Torven and Anderson are continuing new variations of their technique. Meanwhile, the theorists are attempting to correlate the observed double layer results with various magnetospheric phenomena.

Another ground-based plasma physics experimental program underway, with a bearing on space physics, is the study of plasma flows in a curved magnetic field. Two unpredicted phenomena have been observed: First, a plasma beam was injected into a curved magnetic field and deflected in the direction opposite to which the field was curved, and second, it contracted into a flat slab in the plane of curvature of the magnetic field. These phenomena have importance in the studies of plasma injection in space and solar physics as well as in-

jection into magnetic bottles utilized in controlled fusion. In the case described here, the plasma was produced by means of a conical theta-pinch gun and studied by means of high-speed photography, electric and magnetic probes, ion analyzers, and spectroscopy. It was found that a fraction of the traverse electric field $\bar{E} = -v \times \bar{B}$, induced when the beam enters the curved magnetic field, was propagated upstream and caused the reverse deflection by $\bar{E} \times \bar{B}$ drift. The upstream propagation of the transverse electric field is due to electron currents. The contraction of the plasma beam into a flat slab is not yet understood. Energetically, the interaction phenomenon is an example of an energy transfer process in a plasma, whereby kinetic energy is transferred from the ions to the electrons and can even produce beams of energetic electrons. In space physics, the phenomenon could have far-reaching consequences in that space plasmas often have a more or less beam character and move between regions with varying curvature of the magnetic field, e.g., entering the dipole field near a cosmic body or a curved field at the boundary of a magnetosphere. In cases in which the field changes abruptly, considerable electric fields parallel to the magnetic field could arise. These could accelerate beams of runaway electrons, both upstream and downstream. It is possible that the phenomenon of energetic auroral rays could be understood by this mechanism.

The KTH has many other equally interesting and relevant investigations in plasma and space physics underway, and they certainly pull their share in enhancing the Swedish space program as well as continuing their long-standing contributions to basic plasma research pioneered by the granddaddy of them all, Professor Hannes Alfven who still retains a chair at the Institute. (Robert W. Rostron)

ONAL REPORTS

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

SYSTEMS SCIENCES

R&M AT MOD

Reminiscent of Mark Twain's famous remark about the weather, people have known for more than a generation that it is no use having a piece of equipment that doesn't work when you need it, and that reliability and maintainability are terribly important and should be given more attention than they receive conventionally. Still, when push comes to shove, it is hard for a procurement officer to opt for lower performance and/or greater expense when the thing works beautifully in demonstration, and everyone is terribly optimistic about how it is always going to work in the future. Then catastrophic failures occur in the field, and we start a new cycle of directives ensuring reliability and maintainability during procurement, which directives are gradually eroded once again.

Reliability is also a big area of academic interest, with journals and books and the like devoted to it. Reliability theorists talk about MTBF (Mean Time Between Failures, which is the time constant of an assumed exponential process) and the Weibull distribution, a fancy density function which fits some of their models nicely. But these models do not solve the fundamental problem of the military: how does one achieve optimum cost/effectiveness in respect to reliability and maintainability? For example, by replacing the magnetron in a certain airborne radar with a traveling wave tube, one can increase the reliability of this subsystem at the expense of a decrease in performance (specifically a decrease in detection range). One must first train procurers to be alert to this kind of possibility; and second develop techniques for determing whether the possibility should be followed up after it has been suggested.

The Ministry of Defence (corresponding to our DoD) has recently tackled this problem head-on. A two-year study was commissioned, with support from both sides of MOD, namely the operational and the procurement. From the former, an RAF office at the three-star level, and from the latter, a group from Air Systems, established the study under Group Captain Donald Steward (RAF) as

team leader with Peter G. Reich (pronounced the Scottish way, "Reech") as scientific advisor. The study is now completed, and its final report will be issued shortly under the title "Report of the Reliability and Costing Study Group." The report doesn't use the phrase "Reliability and Costing" very much—rather it talks about Reliability and Maintainability—but the three-star office under which they operated is called "Reliability and Costing Steering Group."

I met Reich in his office at 97 High Holborn Street in London, near the British Museum—and it is a wonder that 97 High Holborn Street isn't on display in the Museum; but office space in London is hard to come by, and the headquarters at Whitehall isn't nearly big enough. He pointed out that the study was rather extensive. There was only a six-man in-house team for the two years, but there were also study contracts to 8 firms to analyze 20 subsystems from 7 types of aircraft.

Unlikely as it may seem, the study did actually come up with some conclusions and some implementable recommendations. First the good news: one can get a good return on investment (in R&M) if one places the money shrewdly. The bad news: it is not possible to make generalities, and it is not possible to analyze systems in this way, only subsystems (a typical system is an F4J airplane with all its equipment including its load of missiles; the subsystems then include things like the hydraulics, the VHF transceivers, the propulsion). Some subsystems aren't good places to invest and others are. Furthermore it is necessary to be very clear on the distinctions between the two basic criteria: savings in support cost on the one hand and gains in operational effectiveness on the other, which affect respectively the numerator and denominator of the cost/effectiveness ratio. It is also necessary to be clear on the distinction between investment costs (including production and modification, and including things designed to improve R&M) and support costs (namely ground support, test, maintenance, and spare parts supplies).

Finally, discounting can have an incredibly strong effect on costs. Typically, ten years elapse between the time when the weapon system is a gleam in someone's eye and the time when it becomes operational; and another fifteen years elapse before it is finally phased out (this is not extreme—Phantoms have been operational for fifteen years and are still going strong). If inflation proceeds at 10% (or equivalently if we assume a 10% discount rate), $1 becomes 20¢ after 15 years or 12¢ after 20 years. If one is comparing an R&D cost before the system becomes operational with an R&M saving near the end of the operational life, it may not be clear just how the comparison should be made!

Every subsystem is a special case. For example, the AWG-10 Radar manufactured by Westinghouse as the AI radar on the Phantom had modifications made by the manufacturer to increase R&M. The return in cost was less than one-to-one for the expense of the changes, but there was a marked increase in the operational effectiveness as measured by detection capability; that is, the maximum detection capability was not changed, but the average detection capability achieved operationally was significantly increased, which meant a considerable improvement in cost/effectiveness as a result of the expenditures for R&M.

In the course of the study they talked extensively to the US military. The USN has had considerable unfortunate experiences with the reliability of the F40, and was most interested. The USAF had been "running scared," Reich told me, in connection with the F15. They knew how to fix them, but not how to prevent them from breaking down. Eventually they got the reliability of this weapon system up to par.

A final conclusion is that for better R&M one needs better data systems. For example, in many cases the MTBF is calculated from statistics which involve dividing the total failures into the total hours; but the resulting data may be misleading because it is not known during how many of those hours the subsystem was actually turned on.

My conclusion from listening to all of the above was that no matter how often a problem has been studied in the past, and how intractable it may seem to be, there can still be a lot of profit in taking a new look at it by a competent systems analysis team that is also thoroughly familiar with the substantive technicalities. (Robert E. Machol)

NEWS & NOTES

EINSTEIN CENTENARY SYMPOSIUM

To commemorate the birth of Albert Einstein on 14 March 1879, the scientific Community in Israel are convening the Jerusalem Einstein Centennial Symposium on 14-23 March 1979. Organized by the Israel Academy of Sciences and Humanities, Hebrew University of Jerusalem, Van Leer Jerusalem Foundation, The Jerusalem Foundation, and the Aspen Institute for Humanistic Studies, the Symposium has 8 Israeli Honorary Sponsors and 17 International ones, including the National Academy of Sciences (US). The Opening Ceremony under the auspices of the President of Israel will include an address by Sir Isaiah Berlin, President of the British Academy, and a concert by Isaac Stern and the Israel Chamber Orchestra.

The remaining fourteen Sessions will cover the following: Einstein's Scientific Contributions—Historical Perspectives; Reception of Einstein's Scientific Ideas; Einstein's Impact on Scholarship and Sciences; Einstein and His Work (Lectures in Hebrew); Opening of Einstein Exhibit; Einstein and Developments in the Jewish World; Einstein's Impact on Modern Thought; Einstein and the Culture of Our Time; Einstein—the Coherency of his Life and Work; Einstein and the Nuclear Age; Unification: Aims and Principles; General Relativity and Cosmology; Gauge Theories of Gravity and Its Enlargements; Working with Einstein—Reminiscences by Associates and Assistants; Quantum Chromodynamics; Gauge Theories of Weak and Electromagnetic Interactions and Flavor Dynamics; and Unification Theories.

The speakers in these Sessions are mostly internationally known persons in the world of Science, Arts and the Humanities. The social program includes dinner at the Knesset, and receptions by the Mayor of Jerusalem and the President of Israel.

REVIEW JOURNAL

As pointed out by one of our Liaison Scientists, researchers in the United States are frequently looking for review articles on various subjects and occasionally, we are made aware of such articles that appear in European journals. Such is the case for electrical engineers. The Institution of Electrical and Electronic Engineers (UK) each year publishes the *IEE Reviews* as a special issue of the *Proceedings IEE*. In the 1978 *Special Issue* (Vol. 125, No. 11R November 1978: PIEEAH 125 (11R) 1075-1194), the following reviews may be of interest to some of our readers:

"Alphanumeric display," by G.F. Weston (23 pgs); "Electronically scanned antenna systems," by M.F. Radford (12 pgs); "Thermoelectric power generation," by D.M. Rowe (23 pgs); "Permanent magnets," by J.E. Gould (14 pgs); "Air insulation at large spacings," by B. Jones and R.T. Waters (24 pgs); and "Marine electrical installations," by D. Gray (17 pgs).

Although the *IEE Reviews* are automatically supplied to *Proceedings IEE* and *Records* subscribers, it may be purchased separately at the single-copy price ($24.00). Photocopies of individual papers can be supplied from the IEE Library at 10 p. (~20¢) a page (postage extra).

ONRL NEWS

Dr. James H. Schulman, Acting Technical Director of the Office of Naval Research, Arlington, VA, and formerly Chief Scientist of ONRL from July 1974 to November 1977, retired from government service 31 January 1979. We wish him much happiness in what we expect shall be a "busy" retirement.

We bid farewell and smooth sailing to Dr. Vern Smiley, Liaison Scientist for Physics (Optics), who has returned to his joint appointment in the Univ. of Nevada System with the Desert Research Institute as Research Professor and the Physics Department as Professor of Physics.

PERSONAL

At Heriot-Watt Univ., Edinburgh, Dr. Colin Davidson, Senior Lecturer in the Electrical and Electronics Engineering Department, has been appointed Head of the Department from 1 January 1979 until 31 July 1983.

Dr. Gordon Hobday, Chairman of Boots (Pharmaceuticals), has been nominated as the new Chancellor of the Univ. of

Nottingham, in succession to Sir Francis Hill, who has resigned after seven years.

Dr. Christopher Lance, Reader in Pure Mathematics at Manchester Univ., has been appointed the Chair of Pure Mathematics at Leeds Univ. from 1 October.

Sir James Lighthill, Lucasian Professor of Mathematics at Cambridge Univ. has been appointed Provost of University College, London, in succession to Lord Annan, who is to become Vice-Chancellor of the University of London. Sir James will take up his appointment 1 October 1979.

OBITUARY

Prof. Kenneth Walton, Vice-Principal of the Univ. of Aberdeen and Professor of Geography, died 4 January at the age of 55. He was appointed to the Chair of Geography in 1965 after having served as Senior Lecturer and Reader, and was made Vice-Principal in 1977. He is perhaps best known for his books, The Highlands and Islands of Scotland (1961) and The Arid Zones (1969), although he published many articles on physical geography in various journals.

ONRL REPORTS

C-8-78 EUROPEAN UNDERSEA BIOMEDICAL SOCIETY 4TH ANNUAL SCIENTIFIC MEETING by R. Goad

The 4th Annual Scientific Meeting of the European Undersea Biomedical Society was held in Luxembourg on the 12th and 13th of October 1978. This report summarizes the meeting which was concerned with the Medical Aspects of Diving Accidents, and reviews the 20 papers that were given. Presentations were divided into topics relating to one of the four following areas: 1) Unconsciousness of the Diver in the Water, 2) Diagnosis of Decompression Illnesses, 3) Treatment of Decompression Illnesses, and 4) Coincidental Injury or Illness While at Raised Environmental Pressure.

C-12-78 PROGRESS IN CARDIOLOGY by J.C. LaRoque

An international conference of cardiologists gathered to present data and discuss the present status of thinking in four major areas of cardiology. In valvular heart disease, there are numerous problems related to the presence of an implanted valve in the body. Mortality curves are highly favorable, however, when compared with the natural history of unoperated valve disease. Porcine heterografts are the wave of the future. The echocardiogram has substantially advanced diagnosis in this area, but it has many limitations which are still being discovered. Congenital heart disease patients are in many cases surviving into adult ages, presenting numerous new problems in management. Though anatomy may be corrected, physiology is not completely corrected. In coronary artery disease the classic question persists: whether thrombosis precedes or follows myocardial infarction. Only 55% of a recent post-mortem series showed thrombosis, implying some other physiologic cause may underlie at least 45% of infarctions. Coronary spasm may occur in 100% of patients with unstable angina. Large clinical trials to limit infarct size are being begun in humans, following the demonstration that this is feasible in dogs, and that precordial mapping is a reliable measure of infarct size in humans. Electrophysiologic techniques have dramatically increased our understanding of rhythm and conduction disturbances. The mechanism of producing and sustaining an arrhythmia can be worked out exactly in many patients with supra-ventricular tachycardia (SVT), ventricular tachycardia (VT), and Wolff-Parkinson-White (WPW) syndrome. Medical management of arrhythmias, however, still escapes a completely rational approach, in spite of numerous new drugs available. Electrophysiologic precision has also increased the opportunities for surgical treatment: VT and SVT with concealed bypass tracts may now be sometimes cured surgically, as well as the WPW syndrome. Congestive cardiomyopathy has been discovered to be associated with high titres of coxsackie virus: Anti-viral therapy may be developed in the future. Obstructive cardiomyopathy has been shown to have an abnormal but characteristic appearance on heart muscle biopsy. Sudden death remains the most important problem in this group, and high risk families have been identified.

R-7-78 SYSTEM DESIGN AND SOFTWARE ENGINEERING METHODOLOGIES IN EU EUROPE by D.C. Rummler, P.A. Santoni, H.G. Steubing, and R.J. Pariseau

This report is the result of a survey conducted during 1978 of systems design and software engineering methodologies at various academic institutions, industrial facilities and governmental research establishments in the United Kingdom, France, and Germany. Specific activities surveyed include computer-based system requirements derivation system, design specification and program implementation methodologies, concepts and tools.

R-11-78 FLAT PANEL DISPLAY TECHNOLOGY IN EUROPE by D.C. Rummler, J. Silva, A. Nedoluha, and H. Whitted

This report is the result of a survey of Flat Panel Display technologies in early 1978. Countries visited included the United Kingdom, France, and FRG. Selected industrial and governmental research establishments were surveyed for developments in emissive (gas discharge, light emitting diode, electroluminescence) and subtractive (liquid crystal; electrophoretic, electrochromics) display technologies. Significant new applications of these flat panel technologies are also identified.

R-12-78 EUROPEAN DREDGING—A REVIEW OF THE STATE OF THE ART by J.F. Hoffman

The state-of-the-art of dredging in Europe is described. The details are on a three-month on-site investigation in the countries of Belgium, the UK, France, Germany, the Netherlands, and Scotland. Information was obtained during conferences involving more than 40 persons. Visited were two dredging firms, one manufacturer of dredging equipment, three universities, six laboratories concerned with the hydraulics and/or sedimentation in harbors, eight port authorities, and three miscellaneous federal agencies. New dredging technology—modifications to old dredging technology as well as dredging practices in selected European ports is discussed. The facilities and capabilities of the hydraulic laboratories visited are described.