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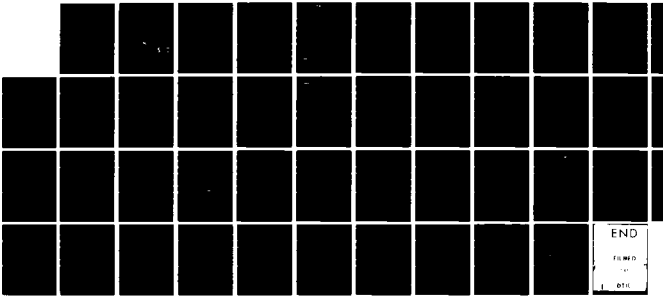

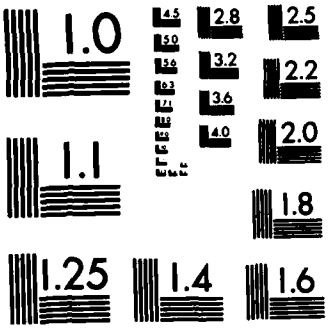

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edited by Robert L. Carovillano and Don J. Peters

31 October 1982 Volume 36, No. 10

ACOUSTICS

COMPUTER SCIENCES

MATERIAL SCIENCES

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ACOUSTICS

LABORATOIRE DE MÉCANIQUE ET D'ACOUSTIQUE (CNRS LMA), MARSEILLE

LMA, operated directly by the CNRS (Centre National de la Recherche Scientifique), is probably the foremost acoustics laboratory in France. It was founded in 1941 as the Centre de Recherche Scientifique et Maritime (CSIRM), drawing largely on staff from the former Laboratoire d'Etudes de la Marine Nationale at Toulon, a naval laboratory that was closed as a result of the German occupation of France during World War II. CSIRM was split in 1963, the corrosion section becoming the Laboratoire de Chimie Bactérienne (LCB), and the acoustics and vibration sections becoming the Centre de Recherches Physiques (CRP); at that time it moved to new quarters in the suburb of Saint Marguerite, about 5 km east of the center of Marseille. The laboratory again changed its name in 1973, when Dr. B. Nayroles became director.

During a visit to the laboratory in July 1982, the Director-Adjoint, Mr. A. Bergassoli, explained the organization. The laboratory has about 68 scientists (chercheurs), about 62 supporting staff (ITA - ingénieurs, techniciens, administratifs), and a few students. The Mechanical Department is headed by Dr. Y. Jullien, the Acoustics Department by Dr. G. Gazhanes. In each department about half the work is theoretical and fundamental research and half is applied. There is a computer group known as "Archiméde," headed by Mme. F. Nayroles, who reports directly to the administration.

The sections in the Mechanical Department are Applied Mathematics, under J. Argémi; Dynamics of Structures, partly under G. Delfosse and partly under Y. Jullien; and a small radiation group under R. Bouc. In the Acoustics Department there are Ultrasonics, under G. Gazhanes; Psychoacoustics and Computer Music, under J.C. Risset; Propagation and the Environment, under M. Foti, an area in which Bergassoli was doing some work; and Active Acoustic Absorbers and Acoustic Antennas, projects run by Nayroles.

The laboratory is not primarily a teaching institution, but by arrangement with the Université d'Aix-Marseille II, whose science campus is at Luminy 5 km to the east, LMA is responsible for the 3^{me} Cycle d'Acoustique, comprising the DEA (Diplome d'Etudes Approfondies, corresponding roughly to a US master's degree), the Doctorat de Spécialité, and the Doctorat d'Ingénieur. Several of the scientists and engineers of LMA conduct formal classes, and the practical work takes place with one of the research teams. The contact between the leaders of the various research teams at LMA and the full-time university science faculty is regarded as indispensable. There were 10 foreign students at the laboratory, mostly supported by their own governments. The degree programs are coordinated by Jullien.

Almost all the major experimental facilities are in separate buildings, so that experiments will not interfere with each other. Some of the buildings were specially built, others adapted to new uses as the programs of the laboratory have changed. For example, in an anechoic room the psychoacoustics group is studying impulsive noises, and in a program in cooperation with Dr. Bertram Scharf (Northeastern Univ.) Mr. G. Canevet is testing the ability to discriminate the direction of a tone-burst masked by another noise (which may be a pure tone or band-limited noise). The initial experiments have been recorded manually, but an automated system is being set up.

Particularly interesting is a large reverberant room in which there are no parallel surfaces and suspended "clouds" are used to produce a properly diffuse sound field. There is a replaceable wall between the room and a smaller reverberant room to enable transmission loss of various construction materials to be measured. A special floor is used to check the effect of impact sounds. Another large room is set up for active absorption experiments down to 60 Hz . In another large room there was a scale model of a highway interchange. Foti, who is in charge of the section, said that as the only acoustics laboratory in the south LMA had become heavily involved in consulting, measurements standardization, and regulation efforts. Having helped other laboratories to set up their own facilities, LMA is now moving back towards more basic research, including ventilating systems. However, under the regional plan it will maintain the present facilities and continue to make measurements. For example, LMA has been involved in the planning stages of the Marseille metro system and the road tunnel under the Vieux Port; earlier it was concerned with the Croix Rousse tunnel in Lyon.

Gazhanes discussed the four main areas of work of the ultrasonics group, which employs 18 people, 5 of them scientists and 3 students. A target recognition project involves tomography and includes a study of resonances of elastic spheres in water and spectroscopic methods. There is a project on three types of propagation in a heterogeneous medium: a diaphysical medium such as water with controlled air bubbles, a periodic medium such as can be obtained with composites, and a stratified medium. Gazhanes' group is interested in the dispersion of the speed of sound as a function of frequency and is also using impedographic methods. A third effort is concerned with acoustic imaging, including acoustic holography, a study of acoustics antennas, and spectral filtering. The fourth area involves ultrasonic transducers, such as a wide-band 15-KHz to 500-KHz transducer for the diaphysical measurements and another from 1 to 5-MHz

for spectroscopy. Some of the transducers are marketed under license by the Societe AID in Meyland (near Grenoble). An apparatus for measuring acoustic flux for medical applications had also been demonstrated, though I did not learn whether it had been marketed commercially. Among the facilities is a large shallow tank with a sandy bottom for propagation experiments; it uses an array of 15 receivers, ceramic cylinders 2 mm in diameter. A hybrid system with 32 receivers and analog-digital processing is under development. The use of acoustic interferometry for the detection of corrosion in concrete bridge piles is being studied.

Nayroles showed me the new laboratory being completed for measurements of active damping. This is long-term project with the ultimate objective of developing technology for sound absorption or vibration control over a wide frequency band. There are two main areas of investigation, one in active absorption in wave guides such as ventilation ducts or pipelines, the other, active mechanical absorption for use in buildings. A project on detection of incident sound in a tube has the objective of separating in real time the turbulent and acoustic part of the signal. The effect of turbulence can be reduced by 9 dB with an array of eight microphones. As good control of acoustic sources is needed, a real-time correlator is used to perform the convolution necessary for the control of a loudspeaker and a numerical simulation of a wide band absorbing system is being set up. For active mechanical absorption experiments, a system for counter excitation, with 16 independent harmonic signals whose amplitude and phase can be controlled, has been constructed.

Dr. P. Filipi talked about two projects in which he is engaged. One is on interactions between fluids and solids, in which he is studying rib-stiffened plates, the other on acoustic propagation in the environment. He and Mlle. D. Habault are developing a mathematical model of the ground to calculate the diffraction of sound over composite soils and around thin screens; it involves the measurement of properties, particularly impedance.

Dr. D. Arfib discussed the computer music work he is doing in the psychoacoustics group with Prof. J.C. Risset (whose primary affiliation is with the university). Arfib is studying the possibilities of nonlinear distortion and of additive synthesis for percussive sounds, quasivocal sounds, and inharmonic sounds.

Mr. J. Basso showed me the facilities of the seismic protection group, which is headed by Mr. Delfosse. Marseille is in an area of seismic activity, so the seismic work is of considerable importance locally. The group has developed a series of isolators to be placed between the foundations and the ground floor of new buildings; the isolators are rigid vertically and flexible horizontally and are used to diminish the resonant frequency. They consist of laminated layers of rubber and steel plates bonded together and are marketed under the name "GAPEC" by the Societé ERA in Marseille. The group is now turning its attention to existing buildings and the isolation of things inside, particularly electrical switching systems. It has a large servo-controlled vibration table for simulation experiments on a scale of 1:8, and for test excitation they have been using a recording of seismic activity from Taft, California, in 1952, with a peak acceleration of 0.1 g.

G.L. Wilson

The Pennsylvania State University

COMPUTER SCIENCES

CONFERENCE ON SYNCHRONIZATION, CONTROL, AND COMMUNICATION IN DISTRIBUTED COMPUTING SYSTEMS

As computing systems have become distributed over wide areas in recent years the importance of communication has increased and with it the need for synchronization and control. The conference held on 20 to 24 September 1982 at Polytechnic of Central London provided an opportunity for computer scientists of many countries to discuss theoretical and practical aspects of the problems involved. The conference was sponsored by Polytechnic of Central London and the Institut de Recherche en Informatique et en Automatique, France. The 17 speakers discussed programming and hardware issues resulting from the physical dispersal of computing systems. Some speakers proposed formal and theoretical solutions to problems, others discussed models, and others discussed systems in being or in the process of being implemented. A representative sample of the papers will be summarized.

Professor J. P. Verjus (Rennes Univ. France) gave an introductory talk on synchronization and communication in distributed computing systems. He used the example of cars entering and leaving a parking lot under different physical constraints, for example, one gate serving the two functions with the resulting communication problems of control of car entry. Verjus said that the two principal reasons for providing synchronization tools in a distributed information system are concurrence in sharing resources or data and cooperation for proper execution of the application. He assumed a distributed system over a set of separate sites, each having its own private memory. It was assumed that when messages are sent they are neither altered nor lost, for any two sites the sending order is the same as the receiving order, and the failure of a site is

detected and signaled to all sites attempting to communicate with it.

Using the parking lot analogy Verjus introduced some possible techniques to cope with variability of transmission delays along communication channels, the multiplicity of decision making centers, and the possibility of site failures.

Three talks were given by Prof. E. P. Jensen (Carnegie-Mellon Univ.). In the first two he gave a general approach to the design of a distributed computing system and in the third he described the Archons project, a funded research project specifically on decentralized or multilateral management in a computing system.

Jensen's first paper on "The Implications of Physical Dispersal on Operating Systems" endeavored to draw a clear picture of the relative advantages of a centralized computer and a network. A centralized computer can have system-wide executive control but limits the kind of processing that can be embedded in remote input-output subsystems. On the other hand, a network imposes little restriction on the physical dispersal of processing but cannot achieve global executive control and its benefits. A compromise between the two extremes is needed for some applications of computing systems such as real-time control of ships and factories. The performance of nearly all conventional executive resources management concepts and mechanisms depends on assumptions about communication delays and sequencing that are valid when the communication mechanism is shared primary memory. However, when primary memory is physically partitioned and interprocessor communication is by input-output there is a major quantitative increase in the mean and variance of delays due in part to the protocols needed to manage packet sequencing and for error detection and correction.

New operating system concepts are needed that can be met by a decentralized computer. In such a system intermediate steps of a computation may be probabilistic. The behavior and the outcome of classical centralized computing is also somewhat probabilistic due to faults and errors but in unanticipated and uncontrolled ways. On the other hand decentralized computers will face nondeterminism as their normal operational mode and thus will be designed to deal with the nondeterminism explicitly, systematically, and to their advantage. Certain parameters usually considered to be constants will be recognized as variables, and probabilities of events previously thought to be zero or one will be seen to have continuous distributions.

In his second paper Jensen discussed "Decentralized Control of Computer Systems." Generally computer systems are considered to be distributed on the basis of decentralized user access, system geography, processing, or data. The aspect that is least frequently decentralized is execution time resource management and control.

The historical development of software has resulted in a centralized bias. This was due to the high cost of processors in the beginning and later, as processor hardware became less costly, multiple processors were connected to shared main memory because most of the uniprocessor software concepts and structures could be successfully retained with minimal modification. Many of the premises on which traditional operating systems were based are now taken for granted.

A new conceptual model is presented in which the primitive active entity is an activity. A resource management activity is decentralized to a degree determined by the number of entities that perform it and the relationship among those entities. Control is a special case of resource management. Control of an activity consists of certain resource management activities performed by one or more entities at a level below that activity. The lower-level control activities require a consistent state, which in turn is maintained at a still lower level and the process continues.

An activity whose consistency is enforced by a unique lower level entity has totally centralized control. When there are multiple such entities, control is decentralized to an extent depending on their number and how they interact.

In the model, decentralization is based on the notion of multilateral resource management, which is a function of the following factors:

(1) The extent to which all the responsible managers must contribute to an activity before it is complete.

(2) The parity of the managers involved in the activity.

(3) The number of managers associated with the activity.

(4) The average percentage of the other managers with which each cooperates.

(5) The number of resources in each intersection of managerial scope.

The model distinguishes multilateral management forms on the basis of two factors, consentaneity, defined as the extent to which a particular activity for a resource is carried out by all its managers together with or without any real concurrency; and equipollence, defined as the degree of equality with which authority and responsibility are distributed across the multiple managers associated with a particular activity.

The Archons project, which was the subject of Jensen's third talk, is a research project at Carnegie-Mellon University specifically oriented toward the general ideas presented in the first two of his papers. The research is on multilateral management of operating system resources. The management is global for the entire computer system despite inaccurate and incomplete information about nonlocal parts of the operating system.

There are three kinds of research in the Archons project: operating systems, architecture, and experimental systems. At present the project is 1 year into the first two areas and is entering the functional specification phase of the third. The primary applications for the research are military real time command and control.

The architecture has the following characteristics: (1) multicomputer with constituent application subsystems having disjoint primary memories and communication by physical input-output; (2) heterogeneity in which the application subsystems may be heterogeneous or homogeneous, general or special purpose, and contain any number of processors, each interconnected in any way; (3) a global bus system with every application subsystem connected to a pool of autonomous buses up to 1000 meters long (buses are bit-serial with 10 Mbps data rate each); (4) separation of application and system processing with a system resource management for each application subsystem. Most system management takes place in these units.

System resource management is structured in the following dimensions: (1) functionally resident in the system resource management units versus the application subsystems; (2) assignment of system resource management across nodes; (3) layering of the functionality within the system resource management units; and (4) functional partitioning of each layer in a system resource management unit.

Prof. Brian Spratt (Director, Computing Laboratory, Univ. of Kent) spoke on "Control and Management Issues in an Operational Local Area Network." The Computing Laboratory provides central computer services to 1300 users; serves the academic faculty and students for eight degree courses in computer science and computer systems engineering; and provides research support for work in languages, data bases, software tools, and local and wide area operating systems and networks.

In setting up the system the Kent University faculty considered Cambridge Ring, Ethernet, and Central Switch (X25) as possible architectures. Because of the cost and inflexibility of the X25 switch and the comparative difficulty of getting information about Ethernet, the Cambridge ring system was chosen.

The Kent Ring Project was approved in May 1978 to build and evaluate a Cambridge ring and to examine its feasibility for all communications. Evaluation was completed in May 1979 with a good rating in reliability, maintenance, and extendability. Kent has a second ring for testing and for source-tested spare components.

From the beginning of 1980, the main services provided by the Computing Laboratory have been based on the ring. For the first 6 months there was a single host, the ICL 2960. Since then a Digital Equipment Coorporation VAX11/780 running the Unix operating system has been added as a second host. The system provides a common family of terminals that can access either host. The terminals are connected to the ring by means of terminal concentrator processors and are in various buildings on the campus. The ring has a gateway in the form of a PDP-11 system that connects the local system to remote computing facilities at the University of London with a CDC7600, and the University of Oxford with an ICL2980 using leased PTT lines.

The protocols are based on the basic block or packet protocol devised by Cambridge University.

The laboratory managers have concluded that the system provides a good basis for future service, research, and teaching. They believe it is better to buy than to build components for standard uses. They also believe that universities should both invent and prove systems and the wide-area communications play a vital role.

Two papers were given on the language Pascal. Dr. Ian Abramsky (Univ. of London) presented a paper entitled "Pascal-M: A Language for Distributed Systems." He described the features of a dialect of Pascal designed to facilitate type-secure programming of systems of communicating processes, based on synchronized message-passing without shared memory. It is unusual in that the channels of communication, called mailboxes, are separated from processes, thus allowing nondeterministic pairing of senders and receivers. Mailbox identifications can be transmitted in messages, which allows initially established connections between processes to be varied dynamically. Each mailbox has a message type and the Pascal-M compiler type checks every message to ensure that it is type secure. The first use of the language has been in system programming; the language implementation at present allows the description of the operating system of a single-processor machine. Extensions are being made to allow message-sending across machine boundaries in a multi-processor work station and between work stations in an information network. The design of the language owes much to other languages devoted to message passing between communicating sequential processes.

"Distributed Path Pascal" was the title of the paper given by Dr. Roy H. Campbell (Univ. of Illinois). Path Pascal combines path expressions, abstract data types, and Pascal into a practical programming language for distributed systems. The high-level language includes objects for encapsulation, processes for concurrency, path expressions for synchronization, and interrupt processes. It contains high-level constructs for synchronization and coordination of asynchronous systems and currently runs on several computers. Remote objects support the construction of distributed systems that are both modular and configuration independent. Path Pascal has supported operating system, network, and simulation model software development.

The processes and shared data abstractions of Path Pascal suffice for the specification of many distributed software systems. The programmer requires little knowledge of data transmissions, physical location of processes, or network configurations when constructing concurrent distributed application software. Path Pascal encourages methods of successive refinement for such applications while allowing arbitrary communication between processes of the coupled systems.

Campbell's presentation described the motivation for the language extensions, the programming of distributed software on networks of computers, and a technique to verify the synchronization and deadlock properties of Path Pascal programs.

"An Approach to the Construction of Parallel Programs" was the subject of a paper given by J. P. Banatre (Beaulieau Univ., France). Given a problem P, the following principles should be followed in order to build a parallel solution of P: (1) Analyze P and isolate subproblems $P_1,\ldots,P_n$ (2) Analyze logical dependencies between the P_i's (3) Express P_i's together with those dependencies, and (4) Delay as long as possible implementation choices.

Banatre discussed the following process-cooperation schemes: independent processes, recursive composition of parallel processes, a data-driven cooperation scheme, and a more complex cooperation scheme, distant processes. He concluded with a presentation of recent work on semiautomatic construction of parallel programs illustrating how to derive parallel programs from functional specifications.

J.S. Banino (Inst. National de Recherche en Informatique et en Automatique [INRIA], France) presented a paper on Chorus. Chorus is a distributed system in which the active entities, called actors, execute according to the following model of computation: An actor is activated on reception of a message at one of its ports. The incoming message triggers the execution of a processing step by the actor. In a given actor, processing steps are executed one after another.

The paper described a mechanism designed to implement a service with high availability. The service is by a server actor (the master), which executes processing steps for client actors. The master server is coupled with another identical server, the slave, which is installed on another site and simultaneously runs the same processing steps with a small delay, but with outputs not effective so long as the master executes correctly. In case of a fault detected at the master site, the slave actor dynamically switches to the master mode and replaces the previous master. Then a new slave may be generated at a third site. The dynamic reconfiguration is not seen by the clients.

The Delta System was described by Dr. G. LeLann (INRIA). Lelann gave some lessons learned from a real experiment in the area of distributed computing systems. Basic design concepts were introduced, and design principles derived from such concepts were applied to the construction of Delta, a locally distributed computing system built between 1979 and 1981 at INRIA. The Delta executive software is now being partially rewritten for performance improvement by Compagnie Intertechnique, which will make Delta systems commercially available by 1983.

Dr. P. T. Wilkinson (National Physical Lab., Middlesex, UK) described "The Demos Multiple Processor" project, which is being carried out jointly by the NPL and Scicon Ltd. The project explores the boundary between closely coupled systems such as array processors or shared memory multiple processors on the one hand and more loosely coupled distributed systems consisting of independent computers interconnected by some type of communications network on the other.

The target hardware architecture consists of a number of identical computer subsystems (processor, memory, and various peripheral devices) interconnected by a localized, very high speed communication system. It is usually referred to as a multicomputer organization; an advantage is that standard computer hardware can be used, only the communication mechanism requires special development. In the case of the Demos prototype, a high-speed parallel ring is used to join Intel 8086 microprocessors (up to a maximum of 256).

One of the main objectives of the project was to explore the use of the "high-level-language, single-virtual-machine" approach to the development of applications software for multicomputers, using some suitable concurrent programming language as the starting point. A key feature common to many languages of this type is the notion of "process", which allows the application requirement to be expressed as a number of independently progressing (i.e., parallel) threads of activity to which processing units can then be assigned. A key feature distinguishing one such concurrent programming language from another is the nature of the mechanisms whereby the processes can intercommunicate and synchronize their activities.

While languages using message passing for the above purpose might appear best suited to a non-shared-memory organization, the one actually chosen for Demos was Concurrent Pascal, which uses the procedure-oriented monitor mechanism. The talk covered the reasons for the choice and the nature of the software support needed to produce Concurrent Pascal programs for the Demos multicomputer. In particular, it has been necessary to develop a remote-monitor-call mechanism so that the modules of a Concurrent Pascal application program can be divided among the component elements of the multicomputer.

A general feature determining the suitability of an application task for multiple processor hardware is the ability to decompose the task into process modules of sufficient complexity, given the significant process context switching and interaction overhead inherent with such a system. One outcome of the Demos project is a better understanding of the overheads for the kind of system described, and Wilkinson concluded by discussing some of the results obtained and their implications for the multicomputer approach.

There were a number of other very good papers presented but those briefly discussed above are representative of the best. This was the second in what may well become a series of seminars sponsored by Polytechnic of Central London and INRIA.

J.F. Blackburn

ONR London

6TH INTERNATIONAL CONFERENCE ON COMPUTER COMMUNICATION

"Pathways to the Information Society" was the theme of the 6th International Conference on Computer Communication, held 7-10 September 1982 in London, England. British Telecom was host to the conference, which was the sixth in the biennial series sponsored by the International Council for Computer Communication (ICCC). John S. Whyte, engineer-in-chief and managing director of major systems for British Telecom, was conference chairman.

In his opening remarks the Duke of Kent, patron of the event, referred to the important role the United Kingdom has played in the development of computing and communications systems. He mentioned the invention of the computer by Charles Babbage 150 years ago, the development of Pulse Code modulation, and the proposal for geostationary satellites for use in transoceanic communication. Dr. Douglas F. Parkhill, president of ICCC, was unable to attend but his remarks were read by Prof. Philip Enslow, executive vice president. Other examples of British contributions to the computing field were given: The electronic valve; the Turing machine; EDSAC, the first operational electronic computer; the magnetic drum; the cathode-ray tube; index registers; packet switching; videotext; and teletext.

Dr. Ian Ross, president of Bell Telephone Laboratories, spoke of microelectronics and software. Over the last decade the number of components on a silicon chip has doubled each year. Meanwhile the cost has dropped from between 10 and 20 dollars to 0.01 cents per circuit. Such progress is expected to continue with megabit memories becoming available in 1983. The possibility of using gallium arsenide instead of silicon for certain kinds of chips and the promise of Josephson junction technology offer opportunities for continued progress.

Software, which provides the intelligence and control for hardware and makes it more flexible, is a critical element in the success of the development and use of ever more sophisticated systems. Bell Telephone uses 2700 software controlled switching systems, which account for 6 million transactions per hour with only 0.001% down time. There are 18 million lines of code in use and the system interfaces with 200 million people. The health of future computer communication depends on maintenance and reliability.

The Bell system has installed fiber-optic transmission lines in a number of locations, the longest is 650 miles in length. They are looking toward 1 to 2 gigabits per channel. The integration of photonics and electronics is expected in the future. Photonics has the advantage of faster switching speed (1 picosecond) but is larger and requires more power than electronics. Future success will depend on reliability and usability, the melding of man and machine more than on growth of technology.

Four parallel streams of papers were presented in the technical sessions. The author attended mainly the sessions on distributed systems and systems interconnection, which are reviewed briefly here.

D. A. Winscom Clarke (International Computers, Australia) spoke on "The Influence of Network Bandwidth on the Design of Distributed Database Systems." The need for interactions with humans imposes practical limits on the acceptable response times for computing systems. When an application program is separated from one or more data-base managers by communication links, the delays imposed may make certain design techniques impractical. By estimating such overheads, we can conclude under what circumstances software technology is satisfactory and when fresh methods are needed.

The data-base management systems in service today are based on the concept of single record access. Clarke showed that such software technology can be used to implement a distributed data base with a number of servers provided they are connected by a high-speed local area network. When a slower wide area network is used, available technology cannot support the secure synchronized updating of a distributed data base with multiple servers. Such a facility will be available only when the data-base-manager servers can support more powerful multi-record access predicates. Even then, secure asynchronous updating will be needed to achieve acceptable performance and a number of theoretical difficulties will require solutions.

"A Communication Oriented Operating System Kernel for a Fully Distributed Architecture" was the subject of a paper by F. E. Schmidtke (Siemans, FRG). He described the basic concept of a distributed microcomputer

network currently being implemented as a prototype system. Taking into account recent progress in network technology and computer interconnection, system software is becoming more important. Its primary task is to make the benefits of computer networks available to its users without concern for configuration and allocation problems. The network should appear to a user as a single powerful machine. Schmidtke's network-operating-system approach tries to tackle such basic problems as decentralized network organization, functional decomposition, interprocess communication, and allocation mechanisms, using ideas recently advanced by other researchers. Major unanswered questions related to distributed systems include management of distributed data bases, programming techniques, and user interfaces.

S. Obana, Y. Urano and K. Suzuki (Kokusai Denshin Denwa Company, Japan) presented a paper on "The Integration of Distributed Heterogeneous Database Systems based on the Entity-relationship Model." They proposed a virtualization technique based on the entity-relationship model (a common conceptual model of the network needed to solve the problem of heterogeneity) for integrating worldwide distributed heterogeneous data bases and showed its applicability to existing data-base systems operating in Kokusai Denshin Denwa.

For the purpose of solving the heterogeneity problem and the data distribution problem, Obana, Urano and Suzuki discussed the network architecture of the distributed data-base system from the viewpoints of data-base technique and communication technique. They introduced the concept of the virtualization of data-base management systems and users and proposed the symmetric five-layered schema structure as an actual technique for the virtualization. They adopted the entity-relationship model to represent the conceptual scheme in the five-layered schema structure and developed the common database access protocol. Thus far they have implemented an experimental system that handles the heterogeneity problem. They are now approaching the data distribution problem and are constructing a system that will provide the advanced service.

B. M. Wood (Computer Analysts and Programmers Ltd, UK) discussed "Open Systems Interconnection-Basic Concepts and Current Status." Wood's paper provided an introduction to the standards under development for it through a review of the reference model for open systems interconnection and of the concepts and principles it introduces. The model is a set of open systems interconnected by some medium for the transmission of data. A system is defined as one or more computers and the software, peripherals, terminals, human operators, physical processes, and means of data transfer that go with them to make up a single information processing unit.

The layers of the model are the following:

(1) The physical layer, which provides a model for the interface to the physical media, controlling bit transmission between systems, and providing for the activation, deactivation and, where necessary, the linking of the data circuits to provide physical connections.
(2) The data link layer, which supports data-link connections. It controls data transfer over physical connections, detects and, if necessary, corrects errors in the data transferred and allows for the transfer of requests to link data circuits from the network layer to the physical layer.
(3) The network layer, which supports network connections and ensures that the characteristics of the connections are independent of the underlying data link and physical services except in the quality of service provided. The layer provides relaying and routing, so that end-to-end connections can be established between transport entities in systems that cannot be directly linked by data-link connections.
(4) The transport layer, which supports transport connection. It provides transport addresses within the end systems.
5) The session layer, which supports session connections allowing the establishment, control, and termination of dialogues between application processes.
(6) The presentation layer, which resolves differences in the representations of information used by application entities.
(7) The application layer.

The UNIVERSE Project, which was discussed by five speakers, will be the subject of a later ESN article but a brief summary is given here.

The Universities Extended Ring and Satellite Experiment (UNIVERSE) Project is designed to investigate the use of concatenated Cambridge rings and small dish satellite earth stations accessing the Orbital Test Satellite. Both metropolitan transmission at Mbps speeds and wide-area terrestrial transmission at Kbps speeds are incorporated. UNIVERSE has participants from four academic establishments (Rutherford Appleton Laboratory, Cambridge University, Loughborough University and University College London), from Industry (GEC-Marconi Research Research and Logica Ltd), and from British Telecom.

The UNIVERSE communication system has four components: the Satellite System, the Cambridge Rings, the High Speed Terrestrial Link, and the X25 Networks. The aims of the project are (1) to measure the performance of the system for the types of traffic likely to be encountered in practice, (2) to develop procedures to ensure the utility of the system for computer-computer and terminal-computer interaction, (3) to investigate the utility of the concatenation of Mbps satellite links and local networks for business communications, and (4) to develop more appropriate components and bridges for optimising a system of this type.

The conference was the largest ever held by the ICCC, with 1,600 in attendance. They came from all over the world and included delegates from Austria, Australia, Belgium, Brazil, Canada, Denmark, Finland, France, India, Indonesia, Ireland, Israel, Italy, Japan, Luxembourg, Malaysia, the Netherlands, New Zealand, Norway, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, the United States, USSR, and West Germany.

One hundred seventy papers covering virtually all aspects of computer communication were presented. The quality of the papers was high and the interest of the delegates was evident.

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THE UNIVERSE PROJECT

This report is based on papers presented during the 6th International Conference on Computer Communication held in London on 7 to 10 September 1982.

The Universities Extended Ring and Satellite Experiment (UNIVERSE) is a project to investigate the use of concatenated Cambridge rings and small dish satellite earth stations accessing the orbital test satellite (OTS). Participants in the project are the Rutherford Appleton Laboratory (RAL), Cambridge University (CU), Loughborough University (LU), University College London (UCL), GEC-Marconi Research (MRL), Logica Ltd., and British Telecom (BT). Funds come from the Department of Industry, the Science and Engineering Research Council (SERC), British Telecom, GEC-Marconi, and Logica. Both metropolitan transmission rates at Mbps and wide-area terrestrial transmission at Kbps rates are incorporated.

UNIVERSE is designed to investigate the facilities that must be developed to allow business communication over a concatenation of terrestrial and satellite networks. To carry out the work small earth stations are established at all participants' premises, except for Logica, which can communicate at 1 Mbps via the OTS. There will be one to three Cambridge rings capable of a local user data bandwidth of 4 Mbps at each site. The Cambridge rings are connected to a variety of service hosts-local servers, computers driving the earth stations, and computers containing gateways to the other networks.

The Basic Configuration

There are four components of the communication systems: (1) the satellite system (SS), (2) the Cambridge rings (CR), (3) the high-speed terrestrial links (HTS), and (4) the X25 networks.

Four types of gateways or bridges are under development or in use to connect the various networks: (1) satellite bridge (SB) between earth station and ring, (2) ring bridge (RB) between rings, (3) X25 gateway (XG) between the X25 network and the rings, and (4) terrestrial half bridge (THB) between the ring and the high speed terrestrial link (peculiar to UCL and Logica). Figure 1 shows the configuration.

The Satellite Network

The four components of the network are the OTS satellite, the earth station, the station interface module (SIM), and the satellite bridge computer. The UNIVERSE project will use the wide band module A of the OTS satellite, taking a 5-MHz frequency share of the channel. Other experiments will use different parts of band A or the narrow band module B, with its 5 MHz circularly polarized channels. The rest of the earth station and the SIM equipment are compatible with that of the Satellite Transmission Experiment Linking Laboratories (STELLA) project.

The earth stations, which are supplied by Marconi, have 3-m dishes and can operate with both linearly and circularly polarized beams. Data are transmitted using a 2-Mbps modem with half-rate encoding to give a 1-Mbps data rate.

The SIM is a Motorola 6800-based device, which does the framing, timing, multiplexing, demultiplexing, and synchronization of the data stream to the earth.

The data are packetized by the Link Driving Computer (LDC), a 512-Kbyte GEC 4065 computer. It interfaces the Cambridge ring, SIM, and the X25 networks. In the SIM the data are put into high-level data link control (HDLC) format packets. A master earth station allocates slots in a frame for each transmitting earth station. The HDLC address can be designated for one or all destinations. It is possible to multiplex HDLC packets for several destinations in one transmission slot.

The Cambridge Rings

The Cambridge ring used in the UNIVERSE operates at 10 Mbps, with 38 bit minipackets containing two data bytes, a source and a destination data byte, and six control bits. A simple parity error check is used to protect the data.

For the purposes of UNIVERSE, all data are sent in basic blocks (BB); one type of BB has a 2-minipacket header consisting of a single minipacket that describes the type and the length (up to 1K minipackets); a second minipacket has a 12-bit port header. After the data there is a sum check.

A second type of BB is sent as a complete datagram and has two minipackets for each source and destination in addition to the route.

The High Speed Terrestrial Links

Researchers at Loughborough University are investigating the use of optical fibers as replacements for lengths of Cambridge ring up to 1 km. The electronics must be designed to multiplex and demultiplex the signals onto single fibers because the ring transmission uses two pairs of balanced transmission lines.

Logica and UCL are investigating three methods of using transverse-screened cables: (1) use of several pairs to make a node at Logica part of a UCL ring, (2) use of existing proprietary hardware, with special modems to connect ring bridges at UCL and Logica, and (3) development of special hardware with work starting in late 1982.

The X.25 Nets

The Public Network run by British Telecom (BT) and the network operated by the UK Science and Engineering Research Council (SERCNET) are being used. They use medium speed connections to the sites (2.4 to 9.6 Kbps).

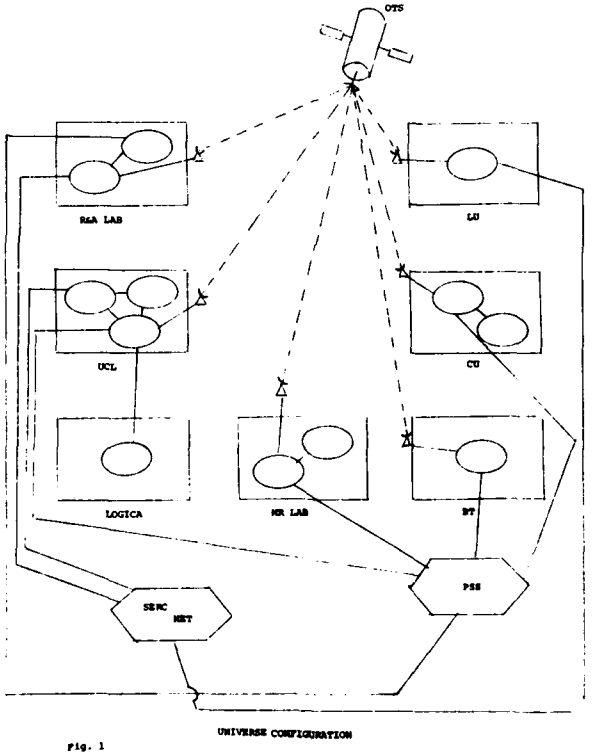
The Gateways

The four types of gateways or bridges operate similarly. They are the ring bridges (based on Motorola 68000 with Motorola 6809s as ring interfaces), the satellite bridges (based on GEC 4065 with Motorola 6800 interface to the earth station and Intel 8086 as interface to the ring), terrestrial half bridges (based on HDLC-Type block structures), and X25 bridges (based on Intel 8086 computers).

In each of the gateways or bridges a client machine makes a connection to a remote service via a local name server. The name server either recognizes the remote service or has to initiate a dialogue with a remote name server (with known address) to determine the current address. The appropriate routing information is then set up in the bridge and a return address is sent to the client system. By concatenating the procedure, virtual routes with return paths can be set up. It is necessary, however, to hold some status information in each bridge. Alternatively single datagrams can be sent across the routes.

Common Servers

To allow a minimum of important services to be standardized it is necessary to have sufficient standardization in several of the services available on each ring. In this category are the satellite bridge, ring bridge, X25 bridge, error logger, name server, time server, boot server, and exerciser/echoer.



UNIVERSE CONFIGURATION

Fig. 1

Protocol Architecture

The unit of communication is the basic block (BB), which contains up to 2048 bytes of data preceded by a route field. The route field contains a port number (8-bit source and

destination-ring addresses are carried by the minipackets making up the block). The port number indicates the destination within a machine connected to a particular ring station. It may correspond to a process or have a meaning similar to the X25 logical channel number.

The single shot protocol (SSP) consists of a request block (SSPREQ) to a host eliciting a reply (SSPRPLY). It is used for simple transactions such as a name lookup on a name server and requesting the time of day from a time server. The SSP sets up a single path from the receiver to the sender of the SSPREQ.

The initial connection protocol (OPEN and OPENACK) is similar to SSP but is used to set up connections to remote services. Such remote services may employ higher level protocols for further communication. The initial connection protocol sets up two paths, one in each direction between the sender of the OPEN and the receiver.

The byte stream protocol (BSP) is a higher level protocol that may be built on top of basic blocks and provides error correction and flow control. It is used over the UNIVERSE network in an end-to-end manner. Bridges have no knowledge of BSP states. An extended version of BSP called transport service byte stream protocol (TSBSP) provides transport service facilities.

Three kinds of objects are connected to the ring: clients, servers, and name servers. A client is a machine, usually a computer, which wants to make use of a service provided by another machine, a server. Servers include file servers, time servers, and compiler servers. Although a name server is a type of server, it is considered separately because it provides the means for clients to find the addresses of other servers. A client only has symbolic names for services. To find the corresponding station and port the client sends a name lookup request containing the name as a string to its local name server. The name server replies with the service's address.

The client proceeds to contact the service by sending an OPEN request block to the supplied address, quoting a port in the client to be used for the reply. The server determines a port that the client should use for the rest of the conversation. The port number is returned to the client in an OPENACK block.

If a client wishes to use a service provided on another ring, the procedure is much the same as in the single-ring case just described. The name sent to the name server may be prefixed with a site identifier, and the client may notice some differences in the network behavior such as extra delays before transactions are completed.

If the name server knows the global address of a requested service but does not believe a path exists to that address, the site number, ring number, host, and port are passed to the bridge in an address insertion request. This causes the bridge to allocate a port dynamically and associate it with the given address. The bridge passes the port number back to the name server in an address insertion reply. The name server then passes this, along with the ring address of the bridge, back to the client in its normal reply to a name lookup. The client now sends its OPEN request to this port in the bridge. The port has the property that an OPEN sent to it is transformed into a BRIDGEOPEN block by inserting the global address supplied previously by the name server.

The BRIDGEOPEN is now passed between bridges, each inspecting the address to find the next bridge. Each bridge remembers the reply port number given in the OPEN or BRIDGEOPEN and replaces it with a port number that it allocates on its outgoing side. The return path is then ready for the OPENACK. The last bridge before the destination changes the BRIDGEOPEN back to an OPEN so that the server has no need to deal with blocks containing global addresses. The OPENACK is then sent by the server back to the bridge, which changes the destination port number and reply port number, the destination port being changed to that of the next bridge in the backward path and the reply number being changed to that of another dynamically allocated port on the current bridge. This is repeated at each bridge so that by the time the OPENACK reaches the client a complete forward path has been created.

In case the name server does not know the global address of an off-site service, it must find the address by asking a name server on the remote site. This can be done by performing an address insertion request to the satellite bridge quoting the global address of the remote name server. Addresses for each remote site are known by every name server. An SSP transaction with the remote name server can then be performed in order to acquire the global address of the service.

The project will serve the following important aims:

(1) Measure the performance of the system for the types of traffic likely to be encountered in practice.

(2) Develop procedures to ensure the utility of the system for computer-computer and terminal-computer interaction.

(3) Investigate the utility of the concatenation of Mbps satellite links and local networks for business communications.

(4) Develop more appropriate components and bridges for optimizing a system of this type.

The system will have applicability in providing computer-computer service traffic for research users at all the participating locations. The concatenation of local networks and small earth station satellite systems will have important implications for business communication.

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MATERIAL SCIENCES

3RD INTERNATIONAL CONGRESS ON HYDROGEN AND MATERIALS

This was the fourth in a series of meetings that began in 1967 as a mostly French conference with a few invited US papers. The succeeding international conferences, in 1972, 1977, and 1982, were held under the chairmanship of Prof. Pierre Azou of the Ecole Centrale des Artes et Manufactures, Chetenay Malabry, France. Sponsoring or cooperating organizations, in addition to the ecole, were l'Institute Superieur des Materiaux et de la Construction Mécanique, le Commissariat al'Energie Atomique, le Groupement pour l'Avancement de la Mécanique Industrielle, la Societe Francaise de Métallurgie, the International Association for Hydrogen Energy, la Centre National de la Recherche Scientifique, and la Societe Air Liquide.

There were 159 papers accepted and printed in the 2-volume conference proceedings. The session titles describe the scope of the congress: Metal-Hydrogen Bonding and Hydrides, Influence of Hydrogen on Physical Properties, Surface-Hydrogen Interaction, Diffusion, Trapping, Influence of Hydrogen on Mechanical Properties, Embrittlement by Hydrogen Gas, Fatigue and Stress Corrosion, Microstructure Effects, and Industrial Implications. All of the 39 French papers were given (and published) in French; nearly all other papers were in English, the only other language permitted. French law prohibits the use of English by French scientists at conferences in France.

Nearly half the papers dealt with basic matters of hydrogen-metal interactions including surface reactions, hydrogen diffusion and permeation, metal hydrides, and trapping of hydrogen. Many of the other papers attempted to weave such basic considerations into the discussion. The emphasis was on the behavior of hydrogen as an interstitial solute and as a gas-phase (molecular H_2) constituent in iron and iron-base alloys that do not form hydrides; other alloy systems received less attention. The remaining papers dealt with various technological consequences of interactions, such as hydrogen embrittlement, hydrogen storage in metals, stress corrosion cracking, corrosion fatigue, and industrial implications of such processes.

The effect of oxide layers on the permeation of hydrogen is receiving emphasis now because of the potential use of hydrogen as a fuel and as a heat-transfer medium in advanced portable and stationary engines and power systems. Despite this, only two papers dealt directly with the subject. Tison, Menut and Fidelle of the CEA (France) investigated the effects of oxide layers on low alloy steels and austenitic stainless steels at temperatures from 25 to 260°C. They concluded that for low alloy steels, which are primarily ferritic, the surface oxide inhibits dissociation of the H_2 molecule, thus impeding its entry, and in addition impedes movement of the hydrogen, reducing the permeability considerably below that of oxide-free specimens. The permeability of austenitic stainless steel was found to be inherently so low that the presence of an oxide surface film did not significantly influence permeability. Battacharyya (I.I.T., Chicago) and Stephens (NASA - Lewis) investigated hydrogen permeabilities of seven iron-nickel superalloys and a cobalt-base superalloy at 650 to 870°C. They found that the Fe-Ni alloys, specifically 19-9DL, had good permeation resistance and that Cr, Al, and Nb are important with respect to permeation resistance. Chromium and Al can help maintain oxide stability in a hot, reducing atmosphere. Additions of oxidizing substances such as CO_2 to the H_2 gas were not investigated.

Trapping is a term used to cover all the ways by which hydrogen can be removed from interstitial solution while retained within the alloy, such as by trapping in dislocations, in second phase or inclusion interfaces, in grain boundaries, in voids, and even as hydrides. It is now appreciated that trapping can greatly influence permeability and embrittlement by taking part of the hydrogen out of circulation, thus rendering it ineffective, or by concentrating hydrogen at critical points in the microstructure, making it more effective. More papers dealt with this subject than at the previous conference, and the developments of both theory and experiment have enhanced prediction as well as understanding of the effects of microstructure and defect structure of metal lattices on the correlation between hydrogen content, resultant embrittlement, and hydrogen diffusivity and permeability. A paper by G.M. Pressouyre of the Creusot-Loire Research Center (France) showed how one can semiquantitatively correlate the occurrence of manganese sulfide inclusions with the hydrogen embrittlement susceptibility of a steel using Pressouyre's trap theory of hydrogen embrittlement.

The storage of hydrogen involves the ultimate in trapping effects, and the approach has been to find metal alloy systems of light weight, high hydrogen absorption capacity, rapid hydrogen uptake at reasonable temperatures, good stability at storage temperatures, and easy expulsion of hydrogen without unreasonably high temperatures and without degradation of the absorbent alloy. The basic investigations needed include studies of hydride properties, electronic properties of both the unhydrided alloy and its hydrides, the interaction energetics between hydrogen and the alloy, effects of impurities, and fracture

and hydrogen degradation effects over a broad range of temperatures, to mention only a few. A number of papers related to such topics; for example, L. Schlapbach (Lab. fur Festkorperphysik, ETHZ, Zurich) and Achard and Percheron-Guegan (CNRS, France) discussed the effects of aluminum substitution for Ni in $LaNi_5$, a promising reversible hydride storage medium. A major problem of such media is loss of storage capacity due to formation of oxides after many adsorption-desorption cycles with "dirty" hydrogen (contaminated by O_2 or H_2O). This results in part from a property of such intermetallic compounds that activates the surface to promote hydrogen absorption, namely the oxygen-chemisorption-induced segregation of La to the surface. Substitution of Al for part of the Ni reduced the rate of oxide formation while interfering minimally with the absorption speed.

Hydrogen embrittlement of ferritic and martensitic steels is a well studied but poorly understood phenomenon, and literally dozens of papers dealt with various facets of the problem both phenomenologically and mechanically as well as from very basic points of view. A controversial point is the mechanism whereby interstitial hydrogen causes cracks to grow in ferritic and martensitic low alloy steels and ferritic iron alloys. Among other possibilities, hydrogen may reduce the tensile cleavage resistance directly, or it may indirectly reduce cracking resistance by simultaneously decreasing the flow stress and restricting slip to narrow bands at the tips of cracks. The answer is not yet available, but some papers presented results of fundamental studies of effects of solute hydrogen on plastic flow properties. H. Wada and K. Sakamoto (Tokyo Univ.) measured the effects of electrolytic cathodic charging on zone-refined iron over a range of strain rates and temperatures. Cathodic charging at 195°K while straining at rates below $8X10^{-5}$ per second caused up to a 50% decrease in flow stress, whereas at rates above $5X10^{-4}$ per second charging caused about a 10% increase in the strain rate. When charging was stopped at $8X10^{-5}$ per second strain rate, the flow stress rapidly increased, eventually exceeding the hydrogen-free value for that strain. Specimens tested after charging had higher flow stress than hydrogen-free specimens. At higher temperatures the effects were less marked, and the effect of charging during straining at all the strain rates investigated was to increase the flow stress. The authors concluded that hydrogen in solid solution intrinsically hardens pure iron and that the softening observed during active cathodic charging results from generation of edge dislocations at the surface.

E. Lunarska and J. Wokulski (Inst. of Physical Chemistry, Warsaw) examined effects of cathodic charging on single crystal iron whiskers of two growth directions (thus stress axes), <111> and <110>, with different crystallographic side faces. The results were complex. The authors concluded that hydrogen intrinsically reduced flow stress in solid solution and tended to restrict or hamper cross slip. They specifically rejected the proposal mentioned above that softening might have been caused by generation of dislocations at the surface by active cathodic charging.

Y. Felefli, W. Dahl and K.W. Lange (Technical Univ., Aachen, FRG) noted that cathodic charging during straining reduces flow stress in very pure iron, increases flow stress in less pure iron, and attempted some critical experiments to explain the phenomenon. The experiments involved measurements of effects of strain aging on the yield behavior and flow stress in iron with less than 1 atomic ppm C+N and iron with 60 atom ppm C+N, with and without cathodic charging during testing and strain aging. They concluded that the results could best be explained by hypothesizing that hydrogen in solid solution reduces the Fe-Fe bond strength and that the hardening and strain aging effects in both purities of Fe resulted from hydrogen-dislocation interactions and H-N and H-C pair formation. The softening and the increased propensity for cleavage could be attributed to Fe-Fe bond weakening in the absence of other reactions. Further softening or aging (during continuous cathodic charging) in the ultrapure Fe was attributed to the filling of vacancies around the dislocations, causing a reduction in dislocation-vacancy interaction energy.

Evidence has accumulated in recent years that many types of environmental degradation in aluminum alloys, such as stress corrosion cracking (SCC), are caused by hydrogen embrittlement, and that aluminum shows hydrogen solubility, diffusion, and permeation effects analogous in many respects to those of iron alloys. N.J.H. Holroyd and D. Hardie (Alcan International, Banbury, UK, and Univ. of Newcastle-Upon-Tyne) showed that room-temperature preexposure to seawater causes a residual embrittlement of 7017 and 7049 alloys in inert environment tests that can be removed (at room temperature) only by straining the specimen at very low strain rates, and not by standing for prolonged periods even in vacuum. If the preexposure is at 70°C, however, recovery occurs at room temperature on standing for a time in laboratory air, without the need for straining. The necessity for straining in the recovery from room temperature preexposure embrittlement was interpreted as implying dislocation transport of hydrogen away from the sites of embrittlement. Such is not true of all Al-Zn-Mg alloys; some recover on standing at room temperature without slow straining. R.A.H. Edwards (Technical Univ. of Delft, The Netherlands) studied the effects of hydrogen charging on Al-6Zn-3Mg high purity alloy that had been stripped of its oxide surface layer and gold coated. Specimens were cathodically charged for up to a few hundred hours at

various potentials, then dried and tested. The gold coating prevented corrosion attack, so the considerable embrittlement effects were evidently due to hydrogen. Other specimens were exposed to tritiated water, then cleaned, sealed in tubes of scintillation liquid, and broken to allow measurements of fracture surface grain boundary coverage by tritium. There was considerable accumulation of tritium on the boundaries, probably in the form of Mg^3H (analogous to the hydride). Several such papers seemed to prove that true hydrogen embrittlement by diffusion occurs in aluminum alloys and may be a mechanism for SCC.

Zirconium alloys are used for fuel-rod assemblies in nuclear reactors where embrittlement by internal hydride formation is a major problem. C.E. Ells, et al. (Chalk River Nuclear Labs., Ontario) studied hydride decomposition kinetics in Zr-2.5Nb and found that the application of a tensile stress while holding at the decomposition temperature retards decomposition. Also, decomposition was slower than expected when the hydrogen concentration was 60ppm (wt.), compared to results with lower contents and for Zircaloy-4, but the results were not explained. The stress effect is intuitively understandable because the release (by tensile stress) of the inherent compressive misfit stress of the hydride precipitate reduces its Gibb free energy, tending to decrease the driving energy for decomposition. K. Nuttall (Whiteshell Nuclear Research Establishment, Pinawa, Manitoba) found that hydrides in Zr-2.5Nb tubing had a primarily longitudinal orientation creating marked anisotropy in crack growth susceptibility, easy and brittle longitudinal cracking, making circumferential cracking difficult and primarily ductile. This was somewhat unexpected, as stress-induced precipitation occurs ahead of the crack with hydrides normally oriented perpendicular to the applied stress. It was discovered that in this case a strong crystallographic anisotropy precluded hydride orientations perpendicular to the longitudinal tube axis, thus making circumferential cracking difficult.

Titanium alloys are important in the chemical processing industry and in aerospace, and particularly in the latter are used at very high strength levels such that hydrogen embrittlement and stress corrosion cracking may be troublesome. Titanium alloys form hydrides similar to zirconium alloys but are less prone to do so. T. Enjo and T. Kuroda (Welding Research Institute, Osaka Univ.) studied the hydride precipitation behavior and consequent fracture behavior of Ti-6A1-4V alloy at very high hydrogen contents, simulating the localized conditions in weldments where locally high hydrogen contents may occur. They could correlate internal friction behavior with hydrogen in solution and hydride precipitate occurrence. At hydrogen contents of 3500 ppm (wt.), for example, additional beta phase is stabilized and the normally ductile beta phase is embrittled by hydrides, whereas the alpha phase remains ductile. The fracture morphology was controlled by the amount and microstructural distribution of hydrides, so the results are too complex to summarize easily. Interestingly, alpha-beta interface cracking was observed at 120 ppm but not at the very high hydrogen concentrations.

D. Hardie, et al. (Univ. of Newcastle-Upon-Tyne) studied the role of hydrogen in stress-corrosion cracking of commercially pure titanium in methanol-HC1. Preexposure in the solution without stress followed by slow straining to failure resulted in the appearance of dark-etching grain boundaries to a depth approximately equal to the expected hydrogen diffusion depth, intergranular cracking, and transgranular cleavage with fluting, similar to SCC. The reduction in area decreased with decreasing strain rate. If such a failed specimen was aged at room temperature for 60 days, no dark etching effect occurred. Such observations made in direct SCC experiments support a hydrogen embrittlement model for SCC in methanol-HC1 solutions, rather than the anodic-active-path dissolution model usually proposed.

D. Meyn (Naval Research Lab., Washington, DC) correlated microstructural crack propagation mechanisms with hydrogen contents and the type of stressing in annealed Ti-6A1-4V. He concluded that under steady-rate sustained load cracking hydrogen accelerates crack growth by causing alpha-beta interface cracking, possibly because of hydride precipitation. Under fatigue and other transient or non-steady-state conditions such as during peak load holds during fatigue, hydrogen enhances cleavage. In the latter case, hydride precipitation seems less likely to be the cause, judging from what is known about effects of stress and hydrogen concentration on hydride precipitation habits.

Other metals and their alloys discussed included magnesium, nickel, niobium, vanadium, tantalum, uranium, and palladium. Most investigators of such materials used them as ideal systems for the study of hydrogen-metal interactions per se, except for magnesium, where more practical ends were served.

Azou closed the conference, noting that research into hydrogen-metal interactions and hydrogen embrittlement is taking place in nearly every part of the world and involves huge sums of money in related materials problems. He called for the formation of an international organization to systematize the ever-increasing number of hydrogen-related conferences and symposia, and suggested that the next 5-yearly conference might be held in another country.

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IV CONFERENCE ON SUPERCONDUCTIVITY IN d- AND f- BAND METALS

The fourth in a series of conferences on d- and f- band superconductivity was held in Karlsruhe, West Germany, from 28 to 30 June 1982. The conference attracted some 250 attendees from about a dozen countries.

Background

The first conference on superconductivity of d- and f- band metals took place at Rochester University in 1971. A second Rochester conference in 1976 highlighted the discovery of high T_c ternary compounds, where T_c is the superconductivity transition temperature. Energy band theorists were prominent at the conference as theoretical calculations of T_c were being made from first principles. The third conference was at the University of California at San Diego in 1979. The fourth conference, reported here, was broader than previous conferences and included selected topics, such as organic superconductors and superconducting ceramics, not involving d- or f- band electrons.

Summary

Twenty-four of the 55 oral presentations were from the US, 10 were from the FRG, 6 were from Switzerland, and the remainder were by scientists from eight other countries. Of the 10 scheduled sessions 2 were devoted to the intermetallic compounds of the A15 phase, ternary compounds, and theory. The others dealt with new materials: Raman scattering, localization, and less common compounds. The presence of some 250 participants attested to the continuing scientific interest in the subject matter.

While T_c has not been increased one iota over the maximum of 23°K (Nb_3Ge) established 10 years ago, the applications of newly developed preparational and diagnostic techniques are allowing the materials scientist to probe the fine details that govern the growth of high T_c phases, i.e., the role of the oxides of the B-element (A_3B compounds) in the low-temperature growth of the A15 phase of Nb_3Ge. The convergence of diverse experimental techniques such as tunneling, Raman scattering, and neutron scattering has yielded a consistent picture of the phonon spectra of elements and alloys, data of great importance to microscopic theory.

The improvements in techniques for accurate first-principles energy-band calculations coupled with the dramatic increase in available computing power have produced significant advances in the calculation of the parameters that govern superconductivity. The improvements are such that theorists are now telling the experimentalists which alloys and compounds they should make, e.g., if MoN could be formed in the B1(NaCl) crystal structure it would have a T_c value of 28 to 30°K. The suggestion by a theorist prompted an aside by one of my colleagues, "Yes, but it doesn't form." The same statement could have been made 10 years ago with respect to nearly stoichiometric Nb_3Ga (T_c = 20°K) and Nb_3Ge (T_c = 23°K). G. Webb, then of the Radio Corporation of America (RCA), showed how to make the high T_c, nonequilibrium phases of Nb_3Ga; nonequilibrium phases of the high T_c materials are now made routinely. Energy band calculations also predict higher T_c Chevrel phases.

The development of current microscopic theory was reviewed by C.M. Varma (Bell Labs), who showed that original predictions by McMillian of a maximum T_c of about 30 to 40°K are not justified. Besides the reviews, some new theoretical concepts were introduced for electron pairing, e.g., heavy Fermions, bipolarons, a rebirth of acoustic plasmons (Demons), and pairing in K-space.

Among new materials the emphasis was on magnetic superconductors; no new high T_c A15, or Chevrel phases were reported. There were reports of new materials that are magnetic (ferromagnetic) in the normal state yet enter the superconducting state at low temperatures, e.g., Y_9Co_7 orders magnetically at 6°K and becomes superconducting at 3°K. Can ferromagnetism and superconductivity coexist in a single-phase material? Theory and experiment say yes. What is the nature of this coexistent state? The question motivates much theoretical and experimental work.

Selected Highlights-The A15 Compounds

A comparison with previous d- and f-band conferences indicates that, after nearly 30 years of intensive investigation, knowledge of this class of compounds has reached a high degree of sophistication. In general, the agreement between theoretical calculations of physical parameters and experiment is quite good. Present work emphasizes the use of diagnostic techniques such as tunneling, neutron diffraction, and Raman-scattering to probe details of the phonon spectra of known superconducting transition metals and A15 compounds. Such data are essential for understanding the electron-phonon coupling in the systems that determines T_c. Geballe noted the excellent agreement in the phonon dispersion curve of Nb as measured by the above three techniques.

Work on the A15 compounds described at the conference emphasized structural (electronic and phononic) studies of new phases. The failure of Nb_3Si to live up to its empirically predicted high T_c (~28 to 30°K) and the failure to find higher T_c values in Nb_3Ge are attributed to the fact that single phase,

well-ordered, stoichiometric compounds have yet to be fabricated. Thus, detailed studies of the growth process of the A15 phase in sputtered films are important for the attainment of true stoichiometry without which complete atomic ordering is impossible. A study by J.R. Gavalar (Westinghouse) emphasized the role of oxides of the B element (A_3B compound) in promoting the low temperature growth of the A15 phase of high T_c systems.

One cannot help being impressed by the quantity and quality of the heat capacity data currently being obtained at several laboratories. The accurate data obtained at higher temperatures (A. Junod, Geneva) and magnetic field (G.R. Steward, Los Alamos) have shown good agreement between experiment and band theory calculations with regard to the electronic density of states (DOS) and with energy-gap values as measured by tunneling techniques. The data allow one to use existing theories to derive values of the microscopic parameters important for superconductivity. It is concluded from these data that the electron-phonon coupling parameter, λ, is governed mainly by the electron DOS. Where the correlation is not so obvious, as in V_3Ga, one suspects the presence of spin fluctuations. (The author believes that magnetic effects, due to the incipient magnetism of V, were alluded to in the early work of Hulm et al. on V-based A15 compounds.) With regard to specific heat, even theorists are becoming involved. The new high magnetic field data (H=18T) yielded a value for γ, the coefficient of the linear term in the specific heat, about one-third the value of previous data, i.e., 35 versus 96MJ/Mole-K^2, and the data showed an unusual kink in the slope of the C/T versus T^2 plot (G.R. Steward, B. Cort and G.W. Webb, Phys. Rev. 324 3841, 1981). W.E. Picket and B.M. Klein (NRL) used experimental values for the phonon spectrum and their theoretical DOS function to explain the kink.

My impression is that for the past 5 years the A15 compounds have served as a test-bed for verifying the essential correctness of the theoretical models and calculations with no substantive changes in concepts with regard to the mechanisms leading to higher T_c values.

Ternary Compounds

R.N. Shelton (Ames Laboratory) noted that "a remarkable increase of interest in ternary superconductors has occurred within the past decade." The importance attributed to ternary systems by B. Matthias (Univ. of California, San Diego) was that therein lay hope for high T_c values. Progress in raising T_c values in the ternary systems seems to be running parallel to that observed for the A15 compounds Nb_3Sn (18°K,1953), which involved a wait of almost 20 years for Nb_3Ga (20°K), and Nb_3Ge (23°K). The discovery in 1972 that a Chevrel phase compound $PbMo_6S_8$ had a T_c of 14.5°K gave rise to the hope that a breakthrough of the 23°K value would soon occur. At the fourth conference, some 10 years later, theorists H. Nole and O.K. Anderson (Max-Planck Institute, Stuttgart) summed up the situation: "Today more than 100 of these ternary molybdenum chalcogineds (Chevrel phases) are known. Still, however, no compound has been found with a T_c or critical field higher than that of $PbMo_6S_8$". It is interesting to note that Shelton, while suggesting ways to find structures favorable for superconductivity, did not stress high T_c values per se. Nohl and Anderson, on the other hand, on the basis of their band calculations, stated that the best chance for high T_c values is with Chevrel phases which have just below 22 electrons per cluster ($PbMo_6S_8$ has 22 electrons per cluster).

In the author's opinion Shelton's paper properly reflected the situation with regard to research in the area of ternaries. That is, the emphasis is on quality material synthesis and characterization and not on the development per se of new insights into the basic physics of high T_c superconductors.

Reentry Superconductors

Shelton identified four systems of reentry superconductors, the Mo_6S_8, Rh_4B_4, Fe_2Si_5 systems and the rare earth stannides. Reentrant superconductivity is a misnomer used to describe the following behavior. As the sample is cooled from room temperature it enters the superconductivity state at Tc1. Upon further cooling the sample reenters a normally conducting (R=0) state at another characteristic temperature Tc2. The low-temperature state (T<Tc2) is one where long-range magnetic order is known to exist. The close interplay between magnetism and superconductivity is a feature that has stimulated much theoretical and experimental activity. It is now fairly well accepted that superconductivity and antiferromagnetic order can coexist. But what about ferromagnetism? Yang et al. (Univ. of California, San Diego) described their study of the pseudoternary system $Ho(Rh_{1-x}Ir_x)_4B_4$. They stated that ferromagnetic ordering destroys the superconducting state for values of x between 0.07 and 0.2. Magnetic ordering is inferred from neutron scattering data and indicates that superconductivity can coexist with antiferromagnetic ordering but not with ferromagnetic ordering in this system. In the case of $ErRh_4B_4$, neutron-scattering studies (Sinha et al., Phys Rev Letts 48, 950 [1982]) as well as

data on ternary rare earth compounds presented at the conference suggested that superconductivity and long-range ferromagnetism coexist with a sinusoidally modulated structure.

Tunneling studies have been brought to bear on the problem. C.P. Umbach and A.M. Goldman (Univ. of Minnesota) reported the first tunneling data for a magnetic superconductor, sputtered films of $ErRh_4B_4$. The data revealed new features such as the temperature-dependent, zero-bias resistance and a splitting of the Fraunhofer-like pattern of the magnetic field dependence of the dc Josephson current. Goldman speculated that such effects are consistent with the existence of the domain structure found in neutron-scattering experiments on single crystals of $ErRh_4B_4$. H. Mook, Jr., et al. (Oak Ridge National Laboratory, Argonne National Laboratory, and the Univ. of California, San Diego) reported on neutron scattering studies on a number of ternary compounds $(Er_{1-x}Ho_x)(Ir_{1-y}Rh_y)_4B_4$ that show that the magnetic transitions vary from a simple mean field transition to complicated behavior near Tc2. Theorists have attributed the existence of this state to either spin-spin exchange or polarization of the conduction electron spins induced by the magnetization via S-f interaction.

The question of the coexistence of superconductivity on long-range magnetic ordering is of great fundamental interest. In rare cases, the magnetic ordering occurs before the superconducting transition. Sarkission (Imperial Col., London) reported on Y_9Co_7 where magnetic order comes at 6°K and superconductivity at 3°K. It is believed that superconductivity and magnetic ordering coexist between 3 and 5°K. The nature of the coexistence state is unknown but clearly the order parameter will have an inhomogeneous spatial variation. As noted above (Yang et al.) the pseudoternary also orders magnetically at temperatures higher than the superconducting transition.

Heterostructures

The improvement in techniques to prepare thin-film structures is being exploited to produce new superconducting systems and to produce tunnel junctions to obtain information on the phonon structure of new superconductors. M.B. Brodsky (Argonne National Lab.) reported that very thin films (1 to 2nm) of Cr and Pd had been grown with Au or Ag in epitaxial metal film sandwiches. Surprisingly, one such Ag/Pd/Ag and several Au/Cr/Au sandwiches form a superconducting composite with T_c values as high as 3°K. The relatively high Hc2 values, 71 kOe, for Au/Pd/Au at 1°K and 41 kOe for Au/Cr/Au are expected on the basis of the high resistivities and large DOS. It was speculated that p-wave pairing may be operative in these structures where the individual constituents, by themselves, are not superconductors. Other groups reported on the use of two-component structures to obtain tunneling data on such heterostructures as Nb/Cu and NbTa. J. M. Rowell (Bell Telephone Labs) reported on a collaborative study with the Kernforschungscentrum Karlsruhe group on Nb/Ta superlattices prepared by molecular beam epitaxy. Here one can lay down alternate layers of Nb and Ta by oscillating the sapphire substrate above the sputtering guns. The films grow as single crystals by epitaxy with the sapphire. The superstructures are used to probe the tunneling density of states and the electronic mean free path as functions of layer thickness, i.e., superlattice period. Tunneling studies of structures of Nb/Cu with individual layers in the range 8 to 5,000 Å with total thickness ~ 1 micron were also reported by Falco and Schueller (Argonne National Lab). The studies allow one to determine the phonon spectra, $\alpha^2(\omega)F(\omega)$, as a function of layer thickness and the effect of interfacial scattering.

New Superconductors

D. Jerome (Orsay) gave a presentation on organic superconductors, and there were several talks on the $BaPb_{1-x}Bi_xO_3$ superconducting perovskite. Jerome's talk impressed the author with the scope and thoroughness of the effort (see Sci. American, July 1982). While the author does not share Jerome's optimism that one can attain high T_c values via the quasi-one dimensional nature of such compounds, Jerome's arguments appear to be sound.

In 1975, the ceramic material $BaPb_{1-x}Bi_xO_3$ was discovered, by workers outside the mainstream of research on superconducting materials, to be a high T_c superconductor (T_c~13°K). A.W. Sleight, J.L. Gillson, and P.E. Bierstadt, then at Dupont, were studying the metal insulation transitions in perovskite compounds when they found that for values of x between 0.05 and 0.3 the system exhibited superconductivity with T_c increasing with increasing x. For values of x > 0.3 the system is semiconducting. The relatively high value of T_c, especially for a system containing no transition metal elements, is of great fundamental and technological interest. Methfessel, (Ruhr University, Bochum) in his review "The Irregular Superconductivity of $BaPb_{1-x}Bi_xO_3$," emphasized that the complete phase diagram of the system is unknown and that discussions of the system based on the pseudobinary approach neglect the complicated chemistry involved. The high T_c accompanied with a vanishingly

small γ (coefficient of the linear term in the specific heat), and the reported absence of the specific heat anomaly at T_c all add to the mystery regarding the cause of the observed superconductivity. Speculations have focused on nonphononic causes for electric pairing. Energy-band calculations by Matthias and Hamann (Bell Labs) reported at the conference confirmed the belief that d- electrons do not play a role in the observed superconductivity.

Theoretical Overviews

B. Klein (B. Klein & W.E. Pickett, Naval Research Laboratory, Washington, DC) gave a comprehensive review of band calculations of superconducting parameters in d- and f- band metals, documenting the great advances in calculating the parameters that govern superconductivity in elements and compounds. He stressed that, although the band theorists have come a long way, there is a need to improve energy-band techniques to handle materials with narrow peaks in the DOS at the Fermi level and to develop more sophisticated techniques to deal with defects so that comparisons with experiment will be more meaningful. He noted that if MoN could be formed in the B1 crystal structure it should have $T_c \sim 30°K$. Thus again, theorists are predicting new high T_c materials.

C.M. Varma (Bell Labs.) gave an overview of the theoretical aspects to the question, "What factors limit the superconducting transition temperature?" His remarks covered the thinking that has evolved since McMillian first raised the question some 15 years ago. McMillian used empirical data to evaluate the microscopic parameters of the theory and said that for A15 compounds $T_c^{max} \sim 40°K$. Varma pointed out that McMillian's limit on the el-ph coupling parameter, λ, had been removed in the work of Allen and Dynes and that T_c seems to be well described by J. Rowell's simple formula $T_c = \theta/20(\lambda-0.25)$, where θ is the Debye temperature. He concluded that the hope for higher T_c^{max} values resides solely on the plot of T_c^{max} versus time straight line with slope of 3°K per decade.

In his summary of the meeting M.L. Cohen (Univ. of California, Berkeley) noted that some of the newer materials are focusing attention on new, or older, less popular mechanisms for superconductivity such as pairing in K-space rather than real space, bipolarons and pairing, heavy fermions, and acoustical plasmons (demons). Concerning band calculations he noted that the experimentalists are now accepting theoretical work as valid input to their research.

Poster Session

There were approximately 60 poster presentations, 29 of which were from German institutions. The US had 13, Switzerland 5, and the remaining 12 were contributed by scientists from 8 different countries. The A15 compounds, ternary compounds, and transition-metal elements and alloys accounted for about five-sixths of the posters.

Discussions with the Julich group about their data and reasons for believing that $EuMo_6S_8$, a Chevrel phase compound, is not a bulk superconductor were particularly informative. Early reports that $EuMo_6S_8$, which is not a superconductor at ambient pressure, becomes superconducting at higher pressures, were confirmed by ac magnetic susceptibility measurements as a function of pressure and temperature. The behavior of the diamagnetic signal as a function of pressure below 12 Kbar caused them to investigate the superconducting transition by means of dc magnetization measurements. No evidence for bulk superconductivity was observed and the superconductivity seen by the ac technique was attributed to shielding by supercurrents induced in a minor superconducting phase present as an impurity.

A poster by a group from the University of Houston presented resistivity and ac-x data as functions of pressure and temperature. The disappearance of the magnetic signal at 43 Kbar while still permitting detection of a measurable decrease in resistance forced the workers to the same conclusion, i.e., $EuMo_6S_8$ is not a bulk superconductor. However, a poster by the University of California, San Diego group displayed data on the transition temperatures and upper critical magnetic field as a function of pressure for the pseudo-ternary $Yb_{1.2-x}Eu_xMo_6S_8$ system Here the addition of Eu ($x<0.45$) enhances the Hc2 value at low temperatures (i.e. Hc2 exceeds that of $Yb_{1.2}Mo_6S_8$). Pressure decreases the T_c of $Yb_{1.2}Mo_6S_8$; however, as Eu is substituted while the T_c at P = 1 atm decreases, the pressure effect becomes positive and superconductivity can even be induced in those compounds that are not superconducting at ambient pressures (P = 1 atm). From a detailed analysis of the data, B.M. Maples et al. (Univ. of California, San Diego) concluded that $EuMo_6S_8$ is indeed a bulk superconductor. I found it interesting that three scientists, all products of Matthias's institute at the University of California, San Diego (Maples; P. Chu, Univ. Houston; R.W. McCallum, Julich) investigating, in essence, the same system, do not agree on the nature of the superconductivity in that system. In a way it highlights the problems of relating the response from measurements of the incremental and initial magnetic susceptibility by the ac mutual inductance technique to detailed properties of the sample. This seems to be especially so in the case where pressure is used as an additional parameter!

Concluding Remarks

Although the meeting lacked the extraordinary interest that accompanied the new high T_c compounds of the 1971 conference and the new relatively high T_c tenaries and reentry superconductors of the 1976 conference, the balance between the young and not-so-young investigators, the improvements in both theoretical and experimental techniques, and the widening of the scope of the conference made it scientifically rewarding.

B. Klein

NRL

FOURTH EUROPEAN CONFERENCE ON FRACTURE (ECF4)

ECF4, organized by Prof. K.L. Maurer on behalf of the European Group on Fracture (EGF), was held at the Institut für Metallkunde and Werkstoffprüfung, Montanuniversität Leoben, Austria, on 22 to 24 September 1982. The conference title was "Fracture and the Role of Microstructure." No US research was presented.

Dr. H. Holzer, chancellor of the University of Leoben, welcomed the 196 registrants. He pointed out that the university, which has 1,500 students, is continuing its tradition of producing metallurgy and mining engineers. Management of materials resources, petroleum engineering, and ceramics engineering have also been introduced into the curriculum.

Dr. René Labbens (Creusot-Loire), president of the EGF, opened the conference. He stated that the formation of a European group concentrating on fracture was a major decision and that this conference, dealing with microstructural effects on fracture and fatigue, was a step towards fundamental understanding of fracturing. Labbens had previously done research on fracture mechanics at Lehigh University with Prof. G.R. Irwin.

On the evening preceding the opening of the conference, Prof. K.J. Miller (Univ. of Sheffield) lectured on his involvement with fracturing processes on a global scale as part of "The International Karakoram Project" relating to the origin of the Himalayas (see the book: Continents in Collision, K.J. Miller, Royal Geographical Society, 1982). The Karakoram Project was a cooperative seismological research effort among Great Britain, India, Pakistan, and The People's Republic of China (PRC). The Karakoram region, near the geographical intersection of India, Pakistan, and PRC, is an interesting and dangerous area. Mainly because of the movement of the Indian subcontinent in a northern, slightly eastern direction, there is a continuing fracturing of material from the depths of the continental plates up to the upheaved terrain on which roads and buildings are precariously engineered. Structures regularly collapse and have to be rebuilt. Avalanches are as natural as load drops in the deformation behavior of steel, and the two are not unrelated (see R.W. Armstrong, C.S. Coffey, and W.L. Elban, "Adiabatic Heating at a Dislocation Pile-Up Avalanche", Acta Metall., 1982, in press).

There were parallel sessions on (1) Fracture and Fracture Toughness and (2) Fatigue. Two volumes of preprints were distributed (Editors: K.L. Maurer and F.E. Matzer, Publisher: Engineering Materials Advisory Services Ltd., Warley, West Midlands, B64 6PH, UK). Copies of the proceedings are available from Prof. K.L. Maurer at Leoben.

A brief description of several presentations is given here. The main impression gained was that considerable detailed measurements were being made of the brittle fracture and fatigue behavior of many practical engineering alloys. The conference preprints should be valuable to workers in the field.

Fracture and Fracture Toughness:

Prof. T. Varga (Technical Univ. of Vienna) discussed the considerable emphasis on measurement of the crack opening displacement (COD) produced by controlled fracturing tests. The interest is in macroscopic cracks introduced into various materials. New measurement techniques were described. The crack openings produce so-called stretch zones preceding rapid crack growth. There is some question of the validity of the (historical) concept that a constant cleavage-fracture stress is required for failure at the crack tip for cleavage fracturing of even the most brittle materials.

In work described by Dr. G. Jolley (Salford Univ.) and P. Hopkins on "The Significance of Crack Tip Blunting (Stretch Zones) in Fracture Toughness Specimens", scanning electron microscopy (SEM) observations were made of the inclined stretch zones at the initial fracturing regions of HY80 steel specimens of relatively low inclusion content. A "Talysurf" profilometer was used to measure the width and height of the residual plastic stretch zone remaining on either half of a fractured specimen. Stretch zones of the order of 0.2 mm long with angles of inclination on the order of 20° to the original crack surface were measured. A related paper, "Ductile Fracture Mechanisms of Structural Steels," by J. Lereim (Det Norske Veritas) dealt with macroscopic and microscopic measurements of delamination at inclusions on a millimeter scale along the rolling direction (RD) in plates of ordinary ship-hull steels. In the fracture mechanics test, the height of splitting at inclusions was measured along the RD oriented orthogonally to the induced crack plane. The COD for the overall stretch zone was determined by the ductile fracture of the delaminated ligaments holding the specimen together. The ligaments appeared to fail by plane-strain deformation. A model

relating the COD to conventional tensile test results assumed that the stress-strain description represents the deformation behavior of a single ligament.

C.P. You (Univ. of Cambridge) presented a paper with J.F. Knott on "Ductile Fracture in High Strength Structural Steels." The COD was greater for HY80 steel than for HY130 material. This result was attributed to greater localization of plastic deformation in HY130. Pronounced fracturing occurred in shear bands between inclusions in HY130 and this was proposed to involve significant work hardening. Deformation was more widely spread and fracture occurred by void coalescence in HY80. The COD measurements were by SEM examination of metallographically sectioned specimens and by infiltrating an elastomeric material into stretched specimens. The dependence of the COD measurements on the ratio of crack length to specimen thickness was attributed to an increasing importance to the fracturing process of stress triaxiality produced by plastic deformation in thinner specimens.

G. Michot (Lab. de Physique des Solide, École des Mines, Nancy), A. George, and G. Champier described "Dislocations Developed Around Crack Tips in Silicon and their Influence on Fracture Toughness." The authors proposed that silicon is an excellent material for fundamental studies of brittle fracture. The constitutive relations for dislocation movement are well developed for the material. Controlled low densities of dislocations can be introduced within crystals and directly observed by x-ray diffraction topography. A major observation was that dislocations introduced at crack tips in silicon appear to increase the stress intensity required for fracture by shielding the crack tip stress field within the material rather than by physically blunting the crack tip. D.A. Curry (Central Electricity Generation Board) pointed out that the microscale description seems to be analogous to the accepted macroscopic description that a residual stress is present at the crack tip upon unloading a deformed specimen. In the same fundamental vein, M. Pfuff (GKSS-Forschungszentrum GmbH) described his research on a "Dislocation Theoretical Approach to the Brittle-to-Ductile Transition in Metals." In his work, the continuum mechanical model of a crack with a strip-type plastic zone at the crack tip (described previously by Dugdale; Bilby, Cottrell, and Swinden; and Yokobori and Ichikawa) was modified to allow for a dislocation-free zone immediately at the crack tip. The length of the zone was equated to the length of a Frank-Read source for nucleating dislocations in the zone across the gap from the crack. By considering the change of elastic and plastic energies for crack extension, a rapid increase of the theoretical fracture mechanics stress intensity with temperature above the brittle-to-ductile transition temperature was predicted.

In the subsession on "Crack Growth Resistance," the principal emphasis was on determining the R-resistance curves for plasticity-affected crack tip extension in the testing of relatively ductile materials. As an example, B.Voss (Fraunhofer-Inst. für Werkstoffmechanik) presented a paper co-authored with J.G. Blauel on the "Experimental Determination of Crack Growth Resistance Curves." A single-specimen partial-unloading-compliance method for determining the work done for crack growth, and the direct current potential drop method for crack extension, were combined to determine the plastic work for crack extension at various crack sizes on a single specimen. W. Schmitt (Fraunhofer Inst.) spoke about his work with D. Siegele and T. Hollstein on the "Numerical Analysis of Elastic-Plastic Fracture Mechanics Experiments." Items of concern were to use elastic-plastic finite element calculations for bridging the gap between the mechanical behavior of actual engineering components and experimental results obtained on small laboratory specimens. An additional aim is to handle practical three-dimensional problems.

In the "Microstructure and Fracture Toughness" subsession, consideration was given to the fracture-toughness properties of weld metals. J.H. Tweed (Univ. of Cambridge) described his work with J.F. Knott on "Microstructure-Toughness Relationships in C-Mn Weld Metal." The material studied related to North Sea offshore structures. The role of inclusions on fracture behavior was followed in terms of their direct fracturing effect and their influence on determining the total transformation microstructures of the weld material. The inclusions affect the austenitic grain size and nucleate acicular ferrite within the austenitic grains. Large inclusions occur at prior delta grain boundaries that become a portion of the total austenitic grain boundary area. The soft grain boundary ferrite underwent considerable strain hardening until the carbide structures cracked leading to total fracture. The initial sources of fracture were traced by river-line patterns to spherical inclusions, identified by energy-dispersive analysis of x-rays to contain manganese, silicon, sulfur, and titanium. Other inclusions contained calcium and potassium. L. Devillers and B. Marandet (Inst. de Recherches de la Sidérurgie Française) reported similar results in "Fracture Toughness and Microstructure of Submerged Arc-Welded Weld Metal." The weld metal is used on pipeline steel. The project was done in cooperation with The Welding Institute at Cambridge. The importance of the oxygen content in the weld was monitored as it ranged between an acceptable 40×10^{-3} weight percent, associated with aluminum oxide inclusions, to an unacceptable concentration of 80×10^{-3} weight percent, associated with oxide inclusions containing aluminum, silicon, and manganese.

Other papers in the session included: "Influence of Microstructure on the Fracture Toughness of Tempered Martensitic Alloy Steels," by S. Slatcher and J.F. Knott; "Scatter in the Cleavage Fracture Toughness of A533B Plate", by D.A. Curry, I. Milne and K.N. Akhurst; "The Cleavage Fracture Strength in a Bainitic Microstructure", by H. Kotilainen (Imatran Voima Co., Finland); "The Influence of Steel Microstructure on Dynamic Fracture Toughness", J. Buchar, Z. Knésl, and Z. Bilek (CSSR Inst. of Physical Metallurgy); "Reasons for the Appearance of (Delamination) Separations in HSLA-Steels", by K. Kühne, H. Dünnewald, and W. Dahl (RWTH Aachen); "The Cause of Separations and their Effect on Fracture Behavior," by B. Engl and A. Fuchs (Hoesch Hüttenwerke AG); and "Analysis of Fracture Surfaces of Molybdenum", by R. Eck, I. Jäger, and E. Pink (Montanuniversität Leoben and Erich-Schmid-Inst. für Festkörperphysik, Leoben).

Fatigue

The subsession "Crack Initiation" began with "Persistent Slip Bands Induced by Fatigue in a Nickel Base Superalloy," by J.N. Vincent and L. Rémy (Centre des Matériaux de l'École des Mines de Paris). Slip-band and cracking observations were made on the nickel-chromium-aluminum-hafnium alloy MAR-M-004 having a large grain size. Although work on copper by H. Mughrabi (Stuttgart) showed that the critical plastic strain required to produce persistent slip bands (PSBs) establishes a lower limit for the observation of a fatigue limit stress, it is lower in MAR-M-004 than that for PSB formation. K.J. Miller summarized considerations relating to the extension of fracture mechanics to the role of small cracks on fatigue properties. The Coffin-Manson relationship for the cyclic strain-to-failure dependence on the number of cycles should be obeyed. At low cyclic stress intensities, crack growth might be negligible or even negative. At small crack sizes, the fatigue-limit stress provides a high stress cutoff for the extension of the Griffith-Irwin equation to small crack sizes. G. Lütjering (Technische Univ., Hamburg-Harburg) stated that microscopic observations associated with PSBs showed that cracks were not always present in materials but were produced by plastic deformation processes.

K. Schulte (DFVLR Inst. für Werkstoffforschung) presented the paper "The Influence of Incoherent Particles on Fatigue Crack Propagation under Variable Amplitude Loading in High-Strength Aluminum Alloys." Alloys of type 7075-T6 and 7475-T761 were studied under flight simulation conditions with large deformations Crack-growth rates versus stress-intensity amplitudes were interpreted in terms of precipitate decohesion and cracking. D. Rhodes (formerly Univ. of London, now at GKSS-Forschungszentrum) described his work with K.J. Nix and J.C. Radon on "Void - Coalescence during Fatigue Crack Growth" in a project involving engineers and metallurgists. Aluminum-copper alloys in the 2000 series and aluminum-zinc-magnesium-copper alloys, such as 7010-T76, were tested to establish the crack growth rate-stress intensity amplitude relationship. With the TEMSCAN electron microscope operating in the SEM mode, fatigue striations as small as 0.1 μm could be clearly resolved at 150,000x and, operating in a TEM mode, bands of high and low dislocation densities within the material were matched with the striation spacings.

L. Guerra Rosa (CEMUL-Inst. Superior Técnico, Portugal) presented the paper "Effects of Plasticity and Strain Rate on Fatigue Crack Growth," co-authored with C. Moura Branco and J.C. Radon. The sizes of plastic zones in fatigued steel were measured by Vickers microhardness testing at 0.2N load and by the extent of crack growth upon compression testing in fatigue of specimens prestrained by the application of a single compressive load. R. Pippan (Erich-Schmid-Inst. für Festkörperphysik, Leoben) described his work with H.P. Stüwe on "The Temperature Field Surrounding the Fatigue Crack Tip." Liquid crystals were used to show the heating effect in steel. The plastic work per cycle was proportional to the stress-intensity amplitude raised to the fourth power. A.F. Blom (Royal Inst. of Technology, Stockholm) described his work with A. Hadrboletz and B. Weiss (Univ. of Vienna) on "Numerical and Experimental Determination of Stress Intensity Factors in a 20 kHz Resonance System." With their method of determining fatigue-crack growth-stress intensities at high frequency, threshold data can be determined 500 times more quickly. M. Prodan (Swiss Federal Inst. for Reactor Research) and J.C. Radon presented the paper "Fractography and the Shape of Part-Through Cracks," an investigation of the leak-before-fracture condition of fine-grained steel pressure vessel material. K. Pedersen discussed "The Effect of Grain Structure on Fatigue Life of Age Hardening Aluminum (-Magnesium-Silicon) Alloys," co-authored with O. Helgeland and O. Lohne (SINTEF, Dept. of Metallurgy, Norway). A pronounced effect of grain size on material toughness was found in push-pull fatigue despite the lack of any significant effect on the yield strength. For all aging treatments, large grains on the surface led to relatively easier crack initiation.

Two related papers were given by W. Hoffelner (Brown Boveri Central Laboratory, Baden): "Fatigue and Fracture Mechanics of a Wrought Ni-Base Alloy," co-authored with R.B. Scarlin and K.N. Melton, and "On the Interaction of High-Cycle-Fatigue and Creep in the Cast Nickel-Base Superalloy IN 738 LC," co-authored with H. Schmidt. Creep, fatigue, and fracture-mechanics tests were described and correlated with microstructural and fractographic observations. The creep-fracture strain was determined as a function of the

Larson-Miller parameter involving temperature and time-to-rupture. Combined creep and fatigue-crack-growth rates were determined on the basis that creep-crack growth occurred during the time held at stress for individual cycles while fatigue-crack growth occurred during the loading-unloading period. In discussion of the paper, T.V. Duggan (Portsmouth Polytechnic) said he had found the effect of a minor cyclic stress superposed on a creep test could be very great.

Other papers in the Fatigue session were "The Fatigue Limit of Steel Wires as Determined by the Fatigue Threshold (ΔK_{TH}) and the Surface Properties," by I. Verpoest, A. Deruyttere and E. Aernoudt (Katholieke Univ. Leuven); "The Role of Induced Phase Transformations on Fatigue Processes in AISI 304L," by Y. Katz, A. Bussiba and H. Mathias (Nuclear Research Center-Negev, Israel); "The Effect of inclusions on the Environmentally Accelerated Cyclic Crack Growth of Reactor Pressure Vessel Steels in Simulated LWR Environments," by K. Törrönen, M. Kemppainen, H. Hänninen and S. Salonen (Technical Research Center of Finland, VVT); "Corrosion Fatigue Cracking Behavior of Austenitic Stainless Steels in Chloride Solutions at Room Temperature," by H. Schmidt, B. Weiss, and R. Stickler (University of Vienna); "Three-Dimensional Fractography," by B. Bauer, M. Fripan and V. Smolej (Max-Planck-Inst. für Metallforschung, Stuttgart); "Direct Visual Registration of Crack Extension in Ceramic Materials at Elevated Temperatures," by A. Bornhauser, K. Kromp, H. Schmid, and R.F. Pabst (Max-Planck-Institut für Metallforschung); and "Nucleation and Growth of Thermal Fatigue Cracks in Chemically Inhomogeneous Tool Steel," by L. Kosec, F. Kosel, and F. Vodopivec (Slovenian Ironworks, Metallurgical Inst., Yugoslavia).

R.W. Armstrong

ONR London

NEW SEMICONDUCTOR GROWTH PROCESS HOLDS GREAT PROMISE FOR FINNISH FIRM

The Lohja Corporation employs 4,000 people, which by Finnish standards makes it moderately large. The product lines include cement, lime, concrete, minerals, chemicals, building units, and electronics and are organized into five industrial divisions. A pending reorganization will remove a display technology group from the electronics division to form a separate division. At present the display technology group, headed by Dr. Tuomo Suntola (vice president), employs 50 people in R&D plus 15 in a new pilot production facility.

The Lohja electroluminescence facility in Espoo (a suburb of Helsinki) was visited on 17 September 1982. Suntola and senior scientist Runar Törnqvist described the process, devices, and development plans for the atomic layer epitaxy (ALE) approach to electroluminescent displays.

The efficacy of the ALE process derives from its extreme simplicity. The substrate temperature, the uniformity of the temperature, and the rate of deposition of the reactants are all relatively unimportant. Nevertheless, highly uniform, large-area (e.g., 20" x 20") films can be formed; not a single optical fringe could be detected. Of even greater significance, the film thickness can be controlled easily and precisely to within a single monolayer or atomic-lattice constant.

The method involves the evaporation of the cationic reactant (e.g., Zn) onto a clean 580°C substrate followed by a vacuum purge in which all except the first atomic monolayer of the cation species sublimes. The operation is followed by a similar deposition of the anionic reactant species (e.g., S), which is also followed by a vacuum purge in which all but one layer of the deposited anion sublimes. The sequence is repeated at a cycle time of 2 to 3 sec with an ensuing growth rate of 1 μm/hr, which is equivalent to the growth rate of MBE processes. Precise control of film thickness is accomplished by merely counting deposition-purge cycles.

The exact mechanism by which the process works is not known. It appears that within a given range of substrate temperatures Zn-Zn bonds are unstable as are S-S bonds, and therefore sublimation occurs freely and rapidly. Zn-S bonds, however, appear to be much more stable at the same temperature and therefore the monolayer growth process is precise and controlled.

As the process is carried out in a vacuum chamber approaching about 10^{-6} Torr before evaporation, one would expect comparatively serious contamination, especially by oxygen. Instead, intentional doping is the problem; it seems to be virtually impossible intentionally to incorporate dopants into the layers during growth. The Lohja researchers can grow ZnTe, ZnSe, and ZnS, but they have not been able to grow ZnO. They have had their samples analyzed by two separate SIMS groups for impurities but none was found. They did not know, however, what type of ion beam was used in the SIMS machine, its vacuum level, or its sensitivity to any given element.

In addition to the compounds of Zn made by the ALE process are Al_2O_3, Ta_2O_5, $InSn_xO_y$, TiN, TiO, and $TiAlO_3$. As the initial main product line being developed to exploit ALE is that of electroluminescent displays, a compatible deposition means must be found to deposit transparent electrical conductors and to provide pinhole-free thin electrical insulators for conductor crossover points. $InSn_xO_y$ is primarily used for transparent conductors whereas Al_2O_3 is used for crossover insulators and device passivation. The $InSn_xO_y$ films are

also useful on window panes in cold climates because they are transparent to the visible spectrum but impede the reradiation of heat to the outside.

ZnS and ZnSe grown by other methods have virtually always been characterized by (perhaps native) n-type impurities. The ALE process apparently grows intrinsically pure material into which any impurities must be diffused or ion implanted. As both ZnSe and ZnS are projected to possess very high charge carrier velocities at high electric fields, pursuit of such approaches in the US may be warranted.

Life testing of the ZnS electroluminescent displays under high temperatures and in steam environments has been underway for nearly 2 years. Pinhole punch-through failures seem to be nonexistent. The most common failure appears to be by the electromigration of the soft $InSn_xO_y$ transparent metallic conductors. The mechanism is also well known in electroluminescent displays made by other methods. $InSn_xO_y$ has yet another problem; its electrical conductivity is too low to permit the fabrication of a large area display with high resolution. GaN is also a transparent material that exhibits high electrical conductivity when deposited by conventional vapor phase epitaxy (VPE) techniques. At the suggestion of the author, Lohja plans to investigate the usefulness of GaN, as it should be ideally suited to the ALE process. The conductivity of GaN as produced by the conventional VPE technique is believed to originate as a native defect characterized by nitrogen vacancies in the crystal lattice. The ALE process, however, may eliminate such "conducting" vacancies and provide a semi-insulating material of high band gap capable of blue light emission.

By alternating cation or anion reactant species, ternary or quaternary compounds can be synthesized and the color of the electroluminescent display can be tailored precisely to suit the application.

Lohja has heretofore been too occupied with establishing a competitive position in the electroluminescent display market to investigate the epitaxial growth of single crystalline semiconductor films by the technique, but they know of no barriers to such application. As others have recently established that high-quality single crystalline epitaxial films of silicon can be grown on ultraclean silicon substrates at temperatures as low as 400°C, the comparatively low substrate temperatures required in the ALE process should be no impediment. To ensure ultraclean starting surfaces, however, an ultrahigh vacuum deposition system such as is routinely used by the MBE community may be required. If single crystalline compound semiconductor films can, indeed, be grown by the process, it should be an ideal method to grow heterojunctions such as are required by the new high-electron mobility transistors (HEMT) or for superlattice or modulation-doped semiconductor structures not involving elemental semiconductor films exceeding one atomic layer. As the surface chemistry involved in the ALE process is not fully understood, it is not known whether IV-IV compounds can be grown.

The ALE technique might be used as an analytic tool for surface science research. If, in fact, impurities do not adhere to a surface in which there are no pinholes or vacancies when held at certain temperatures, interface (surface) states may be examined better and heterojunction interface state densities significantly reduced.

In the first commercial application of ALE process devices, scheduled for early 1983, the Helsinki airport will be configured with information display boards with alphanumeric panels built of Lohja-developed ZnS modules approximately 4" x 2" in size.

In summary, the ALE technique seems destined to have a major impact on monochromal electroluminescent flat panel displays. As knowledge is gained in understanding the factors present in intrinsically excluding impurities and experience with broader bandgap materials develops, the process may also have a major impact on flat multi-panel color displays, compound semiconductors, superlattice and modulation doped materials, and electronic devices involving heterojunctions.

M.N. Yoder

ONR London

MATHEMATICS

THE WORKING MATHEMATICS GROUP

The Working Mathematics Group consists of volunteers from British educational and industrial institutions established in 1976 and dedicated to providing a two-way flow of information among the institutions. The industrialists and teachers produce instructional materials showing mathematics in action in actual applications. The group states that its aim is to promote an "evolution" of mathematics education at the secondary level toward skills and knowledge relevant to industrial employment. It maintains that a drastic change in mathematics education is not feasible because of many factors, including the examination system used in the UK and the backgrounds of teachers currently in the educational system.

Considering the examination system first, it should be noted that formal examinations at the secondary level now effectively determine what is taught and how it is taught, at least to students in the upper 75% of academic ability. While the group has no official power to effect changes in the examinations, it is attempting to

change attitudes of mathematics examination boards and, at the teacher level, make appropriate learning materials available to schools at a low cost. But changes in the boards will probably take time.

The second major factor, the shortage of suitably qualified mathematics teachers, is due in large part to the way teachers themselves are educated. Many secondary-level mathematics teachers have never experienced real applied mathematical problem solving. For this reason, the Working Mathematics Group has chosen to develop self-instructional materials for direct use by mathematics students. It has been observed that the materials also provide cost-effective, in-service training for the teachers using them.

Initially the group comprised just two small teams writing self-instructional materials. One team concentrated on examples from industry, primarily from the engineering field, while the other concerned itself with mathematics related to finance and insurance. The number of topics covered by the teams has steadily increased, to include a wide variety of mathematics applications accessible at the secondary level. The spectrum of units presently available from the group touches students in the 15-20-year age range. A sample of the units available is:

Mathematics of Finance
Transportation Models
Mathematics and the Telegraph Pole
Mathematics and Hydrology
Stability of Structures
Critical Path Analysis
Elements of Control Theory
Investment
Simulation
Stock Control

A unit is essentially a study booklet, usually about 50 pages long. It is designed to provide about 3 hours of study for an average student from the target population. The units are published as good-quality offset litho master sheets and are available to local education authorities, groups of schools, and industry training programs under a £50 license that grants the right to reproduce and distribute an unlimited number of copies for 2½ years.

I have reviewed a section of the Stability of Structures unit, called "Yacht Design," designed for "A-level" (18+ years of age) courses. The unit is well written and should be of great interest to most mathematics students. Using the design of a stable sailboat as the "carrier problem," the unit introduces approximate integration methods (including the trapezoid rule and Simpson's rule), the resolution of forces and moments of forces, and the center of mass concept. It contains many practical examples using numerical methods, a large number of problems (with solutions), and a self test covering the material presented (with solutions). It is enjoyable reading, even for a professional already in a mathematical field.

With such an active publication program, the group's achievements are impressive, especially when one considers that the writing members are all volunteers, giving their spare time to the activity. All have regular, full-time jobs. The Working Mathematics Group is funded by donations from industry (especially companies represented in the group), from the Department of Industry, and from the Leverhulme Trust. The group, accustomed to operating on a tight budget, is now faced with survival problems due to reduced funding from industrial donors in recent years. According to Dr. Michael Gould (with the group), who recently visited the ONR-London offices, they are anxious to make international contacts and to cooperate with groups undertaking similar projects elsewhere. The type of collaboration that might be possible, if funding were available, was described by Dr. Jeanne Agnew (Math. Dept., Oklahoma State Univ.), who also attended the meeting at ONR London. Agnew has developed a senior level mathematics course at Oklahoma State that uses industrial case studies. The approach, described in "A Case-Study Course in Applied Mathematics using Regional Industries", Am. Math. Monthly, 87 (1980), is similar to that being used by the Working Mathematics Group.

Anyone wishing to make contact with the group may do so through Dr. Michael Gould, The Working Mathematics Group, 152-154 High Street, Uckfield, Sussex TN22 1AT.

D.R. Barr

ONR London

MEDICAL SCIENCES

AN AUTONOMOUS CAPSULE FOR TRANSMITTING INTESTINAL SIGNALS

A standard method for recording intestinal motility directly is to insert wires with miniature electrical and pressure sensors into the patient; the wires may be introduced via the mouth or nose. Though the technique is often useful, it is disagreeable to patients, and it is practically impossible to explore the entire tract. At the Institut National de la Sante et de la Recherche Medical (INSERM), Centre de Recherches Nucléaires, Strasbourg, a French team has produced a transmitter capsule that can be swallowed by the patient, be "commanded" from outside, and send continuous signals as it moves through the tract. The capsule promises to be of diagnostic significance in bowel pathologies, and the large amounts of data that can be obtained from it should lead to better models of bowel activities. J.F. Grenier was the principal medical investigator, and he was supported by F. Crenner,

A. Lambert, J.C. Schang, and S. Schmitt. The device has been reported at one meeting in the US; later this year, a published description will appear in Motility of the Digestive Tract (Raven Press).

Superficially, the capsule resembles a bullet; it is 10 mm in diameter, 25 mm long, weighs 4.7 g, and has hemispherical ends. Two small hinged arms are attached to one end of the capsule; they serve as the mechanical means for controlling its progress through the tract. Each arm has two springs; one has just enough force to keep the capsule in good contact with the tissue; a second "closing" spring brings the arm back into the capsule body and hastens evacuation of the capsule. There is an ingenious arrangement of wires for exercising telecontrol. When the capsule is at the desired recording place in the bowel, a magnetic field signal is sent to a switch on a micro-furnace. The furnace melts the polyethylene wire holding the arms, and they then open and hold the capsule in place. After about 30 hours, another wire holding the second spring will have been resorbed by the luminal environment, and the arms move back into the capsule. Colonic transit times in humans vary from 12 to 48 hours; the capsule stays in the stomach from 1 to 5 hours. After retrieval in the feces, the capsule can be sterilized, fitted with new batteries, and used again.

The electronics configuration uses standard miniature op amps and oscillators, but many problems had to be solved involving sealing, signal sensors, and the specific chips that are used. Mechanical action of the intestine is recorded by means of a tiny ferromagnet on one of the arms, which changes the inductance of a coil and eventually appears as a change in oscillator frequency. With a current drain of 800 mA, the unit operates for about 35 hours on two silver-oxide batteries. Transmission distance of the FM signals is about a meter, so for some situations the patient may wear a light receiver and retransmitter system. There are no inordinately expensive elements in the capsule or in its associated computer and recorders, so routine use is contemplated.

Extensive trials of the transmitter capsule have been run on dogs and there are now some data from humans. Human signals of interest include the basic slow waves (8 to 20 cycles/minute) of the intestine, the spikes that indicate contractions, and the more or less regular mechanical "mixing" waves that work the intraluminal material. Though the capsule may move even with its arms extended, its progress is much slower than the regular slow waves, and the investigators believe that the quality of the signals is not seriously affected by the movement of the capsule. Much baseline recording development work must be done, and there will undoubtedly be some adjustments in bandwidth and other operating parameters for the capsule.

Besides the obvious clinical use of autonomous transmitters, such devices could provide data for advanced signal analysis. For example, abnormal spike bursts can be detected semiautomatically and plotted on a graph. There are also various possibilities for detecting the relationship between regular intestinal signals and clinical indications. The INSERM group already uses "stretch" displays to facilitate interpretation of signals. The figure shows a recording of capsule signals from a dog.

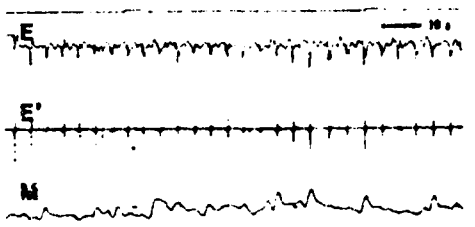

Fig. 1: Recording obtained in the jejunum of a dog. E: electrical activity, time constant 1 s., 1V/cm. E': electrical activity, time constant 0.03 s., 0.2 mV/cm. M: mechanical activity, DC recording, 2-mm variation in diameter of the bowel per cm on the paper, contractions towards top.

N.A. Bond, Jr.

ONR London

HEALING OF BONES AND OTHER TISSUE BY ELECTRIC CURRENT

As early as 1953, Yusuda performed basic experiments on the piezoelectricity of bone in which it was demonstrated that electrical charges are present on the opposite surfaces of a loaded bone, the concave surface being negatively charged and the convex surface positively charged. Since that time, many researchers, notably orthopedic surgeons, electrochemists, and biophysicists have sought to develop different techniques to stimulate the healing of fractures in bones by the direct application of electric current across the site of the break. As is usually the case, interested scientists began looking at other tissue types to stimulate with electric current and soon efforts were being made to enhance the healing of soft tissue wounds and regenerate nerves.

In the early 1970s C.A. Bassett (Columbia Univ.), C.T. Brighton (Univ. of Pennsylvania) and other orthopedists began experimental trials on humans using electromagnetic fields to achieve healing of fractures that otherwise would not heal. Thus began a new wave of basic and clinical research into how and why electromagnetic energy stimulates tissue growth and repair. The research community grew

slowly but steadily and in 1980 the Bioelectric Repair and Growth Society (BRAGS) was formed to provide a common meeting ground and platform for information exchange for physicians, biologists, engineers, physicists, and others actively engaged in such multidisciplinary research. BRAGS held its first annual meeting in Philadelphia in 1981. The second, held in Oxford, UK, on 20 to 22 September 1982, is the basis for this report.

The meeting, with approximately 170 attendees, dealt with about 6 major topics in 12 oral and 3 poster sessions. The general topic areas were bone fracture healing (in animals and humans), in vivo studies with cell or tissue cultures, electromagnetic (EM) field distributions (theoretical and measured), electrical properties of bone, membrane transport and electrochemistry, and nerve regeneration. In all, 95 papers were presented.

The stimulation of tissue growth appears to occur most effectively when pulsed electric current is caused to flow through the tissue at the point where the growth is desired. There are two methods of bringing such flow about: (1) by direct application via implanted or attached electrodes, (2) through induction of current in the tissue using external Helmholtz coils generating a pulsed magnetic field. The two techniques have formed the basis for two different camps each seeking to show that their method is superior. To a non-physician, it seems on first glance that the current-induction technique would be the preferred one as it is entirely noninvasive and merely calls for placing the coil around the limb or body portion to be healed. The direct current method involves insertion of one of the electrodes (usually the cathode) into the tissue. The anode often is simply attached to the skin, but in some cases it may also be implanted.

By far the principal clinical use of electrical stimulation has been in the treatment of bone fracture nonunions (i.e., fractures that would not heal or rejoin over an extended period of time) and in the treatment of nontraumatic avascular necrosis of the head of the femur. If untreated the latter condition, which primarily affects young adults, leads to a collapse of the head of the femur, degenerative arthritis, and significant disability. Few operative procedures have been found to be successful. Both Bassett, the acknowledged leader of the pulsed-magnetic field (PMF) induction method, and Brighton, the chief proponent of the direct-current camp, have reported encouraging results when electrical stimulation was used as an adjustment to other treatment modalities for avascular necrosis of the femural head. With only a few hundred patients treated for the condition, results thus far must be viewed as tentative.

In the case of ununited bone fractures, however, the picture is much clearer. Eleven papers were presented in which it was shown that thousands of patients in the United States, Europe, and other parts of the world have been successfully treated for nonunions by electrical stimulation using both direct and induced current. In a large number of the cases, as Bassett, Schink, and Mitchell reported, the individuals had repeated, unsuccessful operative attempts to produce union of the fracture, including internal and external metallic fixation, bone grafts, or combinations of such methods. Some had failed to heal for as long as 2 to 3 years.

Supporting the clinical uses of electric stimulation is an increasing amount of basic research aimed at elucidating the mechanisms underlying the healing and regenerative processes. To understand the processes, it is necessary to study mechanisms taking place at the cellular level. The movement of calcium into bone and its dependence on hormones was studied and reported on by Guy and Weld (Univ. of Louisville) while Kurenstein and co-workers (Weizmann Inst. Israel) gave results of their work with bone-cell cultures in which they studied the effects of pulsed fields on the intracellular level of cyclic AMP and DNA. They found that only the cells that are sensitive to prostaglandin - E_2 respond to low-field stimulation, in which case they get a 1.3-fold increase in DNA synthesis. Liboff, Williams, Strong, and Wistar (Naval Medical Research Inst. [NMRI], Bethesda) got as much as a twofold increase (compared to controls) in DNA synthesis as evidenced by the uptake of tritiated thymidine. They used cultured human foreskin fibroblasts. Liboff and Halverston (also at NMRI) reported on a new procedure for electrically stimulating cells in culture. Their technique has several advantages among which are: (1) the capability of simultaneously studying many cluster plates, (2) mimicking the waveshapes produced by the pulsed electromagnetic field coils, (3) easy control of frequencies, and (4) the accurate characterization of the charge density being applied to the cell surface. It was evident from these and other papers that much attention is being given not only to cellular mechanisms directly involved in the tissue repair process but to possible secondary effects on enzyme function, normal cell metabolism, and side effects on internal organs incidentally exposed to pulsatile currents.

Often when mention is made of the side effects of electromagnetic fields it is assumed that such effects are negative. However, synergistic effects can occur in positive as well as negative directions. Pilla, Norton, and Tansman, (Mt. Sinai School of Medicine) reported on a study in which pulsating electromagnetically induced current (PEMIC), when combined with the immunomodulating drug, Pyran copolymer, proved to be an effective tumor growth inhibitor in mice. The study involved observing survival times of mice implanted with B16 melanoma. The median survival time for control animals was seven weeks and was not affected by PEMIC or Pyran alone. However, treatment with PEMIC in

combination with Pyran increased survival time to 10 weeks in 100% of treated mice. This was considered a significant reduction in tumor growth rate and may be due to enhancement of immune response. The PEMIC levels used were not hyperthermic and may lead to new considerations of the use of electromagnetic fields in cancer therapy. This represents a spin-off in this area of research.

Finally, mention must be made of the research in which attempts are being made to regenerate nerve tissue. If we are to achieve the ultimate regeneration of human limbs, we must first learn to regenerate nerves. Without innervation, new muscle or bone tissue would be almost useless as there would be no "wires" over which control signals could be sent from the central control panel, the brain. Equally important, however, is the fact that thus far no one has reported any significant regrowth of muscle and/or bony tissue at amputated stumps of mammals unless extra nerve tissue was implanted and induced to grow. ONR contractor Dr. Betty Sisken, who was program chairperson for the BRAGS meeting, reported on her work involving nerve regeneration both in vitro and in situ (in amputated rat limbs). Sisken has been able to induce partial limb regeneration in embryonic, young, and adult stages of such nonregenerating species of vertebrates as chick, rat, opossum, and frog. The most efective method seems to be augmentation of nerve supply to the amputated stump and then appliction of direct current alone in combination with injections of nerve growth factor (NGF). The preliminary results of her laboratory work indicate that the addition of bimetallic electrodes and neural tissue implants appears to stimulate new bone formation, both at the end of the cut bone and in the soft tissue around the bone stump. What remains is to find the correct conditions to effect correct differentiation and controlled growth of the new tissue. Perhaps, then, we can look forward to regeneration of severed toes, hands, arms, legs, etc. Surely the innovative research of the forward-looking scientists gathered at the BRAGS meeting points in this direction.

T.C. Rozzell

ONR Arlington

MEDICALLY ORIENTED PAPERS AT ICASSP '82

The International Conference on Acoustics, Speech, and Signal Processing (ICASSP), held in Paris on 3 to 6 May 1982, was one of the largest European scientific congresses of the year. The proceedings, published by the IEEE in three volumes, run to some 2,100 pages. A few of the many papers of interest to the medical community are summarized here.

B. Chalamond (CHRU, Hôpital du Bocage, Dijon, France) described French research on semiautomatic edge detection in the human femur. When a hip prosthesis is fitted it is necessary to have an accurate definition of the inner surface of the femur, as the spherical prosthesis head is screwed onto a "tail" piece of metal that is cemented to the medullary canal surface. P. Chiguin, another French researcher, had previously proposed a systematic process for optimal fitting of the human femur by means of roentgenograms, and the work at Dijon continues toward the realization of the Chiguin approach. In the present setup, x-ray pictures are first digitized into 512/512 bytes and a moving-window scanner examines each row to establish the edges of the femur. For the left edge, the window moves from left to right and a cumulative-sums statistical detector is used; for the right edge, the window moves from right to left. The medullary canal edges, of course, will be inside the bone edges, and this a priori information can be used in setting up the canal edge detector. A Bayesian edge procedure is run on each row. Finally, a nonlinear "smoother" operates on the row medians and presumably eliminates canal outliers and part of the noise. Though the whole scheme depends on several soft estimates of variability parameters, it seems to work well with the intrinsically noisy X-ray material. Chalamond showed a graph that illustrated how the system produced a sharp canal edge from a fairly flat prior distribution and rather scrappy data. For practical use, the French team stated that the canal detector works "... with a good precision."

An advanced spectral representation scheme for cardiac data was presented by an American team (C.L. Nikias, Univ. of Connecticut; P.D. Scott, SUNY Buffalo; and J.H. Siegel, Univ. of Maryland Dept. of Surgery, Baltimore). During a normal heartbeat, a single wavefront moves endocardially-to-epicardially. If the heart pattern is aberrant, there may be signs of either a single reversed-direction wavefront or multiple fragmented wavefronts. The detection of such secondary patterns is clinically important, because when such patterns are fairly stable they are indicative of arrhythmia, which in turn is a risk factor for surgical procedures such as coronary artery bypass.

The signal analysis of such wavefronts with plunge electrodes is hampered by many constraints such as the medium, the wavelength range, the temporal features, and the noise characteristics. Nevertheless, Nikias and his colleagues were able to demonstrate that their system could pick up and display aberrant waveforms. Both simulator and experimental animal tests were run. As in other work described at the conference, the statistical model used a prediction window. In the model, parameters were sought to minimize covariance recursion errors by the least squares requirement; hence the "CLS" label for the method.

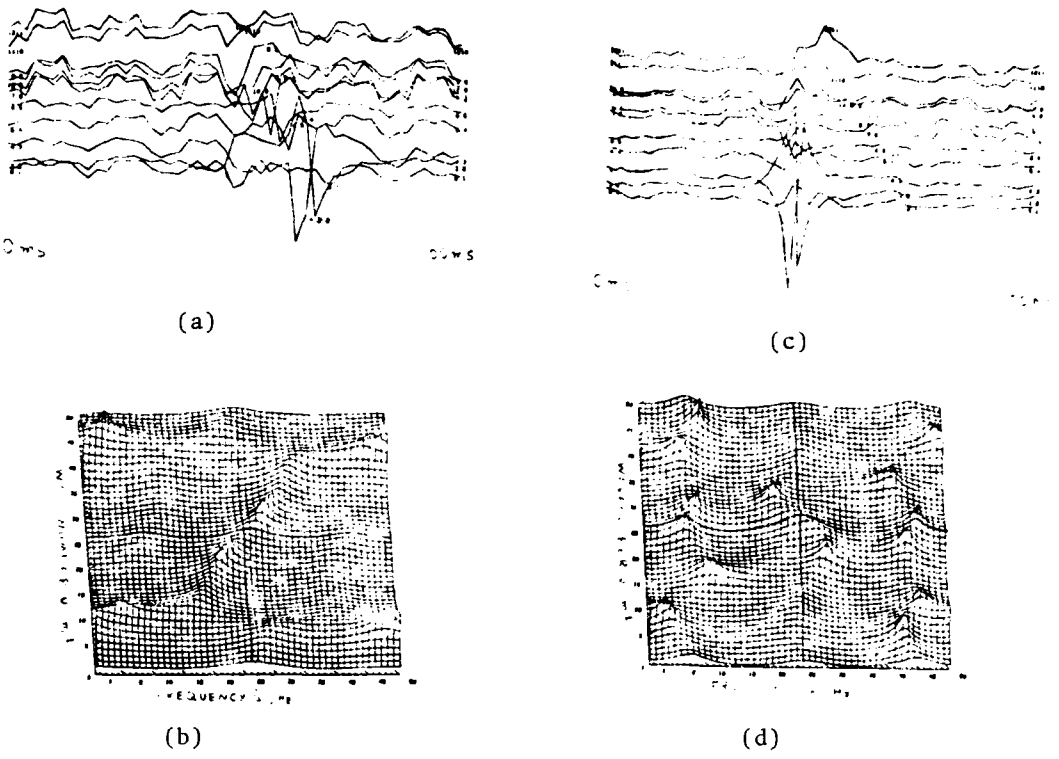

Fig. 1 Aberrant cardial wavefronts, cooled canine preparation.

Nikias showed some beautiful pictures of cardiac wave spectra produced by the system. For instance, when a typical wavefront from a canine preparation is depicted by the CLS model, the peaked wavefront is evident, and the slope of the peak gives the velocity of the wave.

When the myocardium of the canine preparation was cooled, thus producing aberrant electrical activity, the CLS system again picked up the aberrant waves and displayed them in an accessible format. The data record shown in Figure 1(a), when put through CLS processing, gave the display shown in 1(b), in which a single "wrong-way" (epicardially-to-endocardially) wavefront is shown. From the data of 1(c), CLS yields five aberrant wavefronts and displays them as in 1(d), with three fronts moving in the normal direction and two in the opposite direction. The velocities of the wavefronts can be estimated from the graph. According to the authors, this type of decomposition simply cannot be done reliably from inspection of the raw spectral recordings.

A group of French researchers described their methods for analyzing human breath sounds from a tracheal microphone pickup. The clinical motivation was that physical analysis of breath sounds might assist in medical diagnosis or therapeutic performance. Theoretically, signal analysis might help in the formulation of more detailed models of breath sound origin in human airways. Once the models were available, critical sites of disease might be determined by noninvasive methods. The investigators were G. Charbonneau and M. Sudrand (Institut d'Electronique Fondamentale, Paris) and J.L. Racineux and E. Tuchais (Centre Hospitalier and Clinique de Pneumonologie, Angers). They used 15 normal and 15 asthmatic (non-crisis) subjects for standardization tests.

A special (0 to 2000 Hz) microphone was held on the tracheal anterior triangle by means of an attaching lead; the signal went through a high-pass filter and sonometer and into an FM tape recorder. The whole system had a flat response from 0 to about 1200 Hz. Recorded signals were digitized and run through an FFT, with separate spectra calculated for inspiration and expiration and for two flow rates (0.5 and 1 liter/s). To explore the differences between asthmatics and normals, four parameters were taken: bandwidth, mean frequency, the signal integrated over 60 to 1260 Hz, and the frequency at the arbitrary threshold of 0.1 of peak value.

For both asthmatics and normals, the increased flow rate caused more amplitude in the higher frequencies. There may be an

individually determined threshold flow rate; at higher rates the high frequencies become more significant. Asthmatics have markedly different spectra for inspiration and expiration, whereas normals have about the same spectra. Asthmatics also displayed more deviations from the fitted frequency and amplitude time functions, suggesting that the sound-originating sources are under less control. The breath-sound domain seems to be a good place for further validation of semiautomatic discriminant schemes.

J.R. Deller (Electrical Engineering, Illinois Inst. of Technology, Chicago) described a system for analyzing glottal volume velocity data and presented a feature-vector plot of results on 20 subjects (9 normal, 11 pathological). With measurements of glottal "jitter" (variances in time of arrival of pulses) and "shimmer" (variation of glottal pulse amplitudes), and with the fitting of several timing coefficients, a feature vector was derived for each subject.

In a feature 3-space, Deller found excellent discrimination among normal and pathological subjects; he puts his data on a negative-log spatial plot and finds that the pathological subjects are not only separated from the normal ones, but the two "worst" pathologicals (squamous cell cancer and glottic cancer) are those that appear closest to the origin. Deller also remarked that in this type of feature-space presentation, a therapist might trace the therapeutic progress of a given patient as his or her feature vector changed over time.

Various schemes for aiding deaf people, and especially for teaching deaf children, were reported by European research teams. At the IBM-France Scientific Center in Paris, M.D. di Benedetto, F. Desombes, B. Mericaldo, and J.P. Tubach have been working on a lip-reading aid. The labial image is often difficult or impossible to "translate"; for example, a voiced "p", "b", or "m" will look alike even to an expert lip reader. IBM-France's approach is to supplement the labial image with information keys. It has been known for some years that a supplementary marking system can disambignate the labial picture stimuli. One such system is "cued speech", wherein eight hand-shape signals and four hand-position signals can resolve labial stimuli into useful consonant-vowel units. Several projects in various countries have tried to process a speaker's voice automatically in real time so as to provide something resembling cued speech. For example, one American project has experimented with special spectacles onto which the supplementary cues are instantaneously projected.

The IBM-France analysis starts by digitizing the speech signal and using a Hamming window to compute several parameters. Then the speech signal continuum is segmented into five categories, which previous research had related to such phoneme classes as fricatives, sonorants, occlusions, and silence. During a "system training" phase, human speakers uttered simple sentences for which the correct phonetic translation was known in advance; an algorithm computed the best match between the standard phonetic transcription and the computed segments. There could be several segments for each phonetic unit, as the signal analysis proceeded in a one-way fashion, and when a parameter vector was matched with a phoneme it could happen that several other vectors ended up in the same phonemic category.

When the system started to run, a speech input was received, the window was computed and compared with a stored set of prototype windows, and a distance function was computed. The shortest distance resulted in the phoneme-like classification.

Ten supplementary information keys resulted that were considerably different from those used in cued speech. As the IBM-France system is developed further, there will be more additions and adjustments to the key structure. Some promising early validation runs have been performed already. After "training the system" on 52 short sentences from three speakers, a set of relatively long (25 phonemes) sentences was presented. The automatic discriminator made better than 60% correct choices of the known phonetic units, and from the "keys" standpoint the success-of-match rate was about 70%. Experts have observed that to be practical, an aiding key device would have to achieve 80% or better correct phonemic recognitions; the IBM-France scheme is perhaps within sight of that goal.

At the Royal National Institute for the Deaf (RNID) in London, a visual feedback system for the speech of deaf children has been developed and made commercially available in Britain. For a long time it has been known that a deaf child's growth in the use of written language is severely impeded by lack of access to spoken language, with the result that by the time he reaches high school a profoundly deaf child is some 5 or more years behind a normally hearing counterpart. The technological approach has been to furnish visual patterns of speech to the deaf student and to shape the associated speech behaviors by means of the visual display. Many devices using card frames and oscilloscopes were built during the 1960s, and as minicomputers and dedicated microprocessor cards became economically feasible in the 1970s, the technical developments and opportunities became more exciting.

The RNID approach is to provide a special speech display for hobby microcomputers of the Apple or Radio Shack class. Such equipment is cheap, mass produced, easy to maintain, and it already is found in many schools. Such advantages support the idea that we can avoid the technical and economic problems of the earlier card-frame systems. In the RNID system now under evaluation, pitch and energy components of the speech signal are computed and displayed by means of a special computer card,

while memory and hard copy storage considerations can be managed through the ordinary computer operating system. For example, amplitude can be coded by means of gray scale levels, dot density, or color. About 20 systems have been produced for trial in Britain, and the tests of the system and the software are continuing.

J.M. Pardo (Escuela Técnica Superior de Ingenieros de Telecommunicación, Madrid) designed a system for training deaf children to make correct vowel sounds. There is a target sound that the student should imitate, say the sound of "a". This is represented by a stored wave shape. When a student tries to make the target sound, the wave shape he or she emits is shown instantly on a video screen, along with the desired target wave. The student tries to make his or her sound approximate more closely the stored correct wave function. The computer recognizes satisfactory performance by means of a distance measure. A face on the display frowns until a criterion sound is reached and then smiles. Performance steadily improves over 13 practice sessions for all the vowels, with "u" showing the most remarkable improvement. As in the RNID case, part of the appeal of the system is that it is relatively simple and cheap.

Medical understanding and treatment of acute epileptic patients may be helped by a reliable method of defining the epileptogenic focus during seizures. To track the propagation of pulses along neural pathways, N.J.I. Mars (Medical Data Processing Dept., Univ. of Leiden, Netherlands) proposed a new application of the "mutual information" measure between nonlinear processes. Eventually the method may be suitable for EEG applications. Mars has already shown that, in both experimental dogs and humans with known foci (from surgery), localizations can be facilitated.

The papers discussed here show how active the medical signal analysis area is and also how tantalizing it is. More techniques are being reported for getting signals into a workable vector format, real time computations are becoming practical in many areas, and costs are dropping as computer memory size increases. A great number of the projects seem to be coming close to a complexity barrier. That is, when ordinary statistical schemes and detectors are applied to large data sets of complex biological or speech signals, some real achievements in classification and aiding are realized, but it may be difficult to improve "hit rates" very much over the initial successes that come from the simple but rapid processing of large amounts of data. In some cases, the inclusion of more information such as transition probabilities may be enough to increase performance up to useful levels; but in others, a really effective signal analysis may have to wait for better understanding of the basic processes involved.

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OPERATIONS RESEARCH

OPERATIONS RESEARCH AT IABG

The Industrieanlagen-Betriebsgesellschaft (IABG), which may be translated "Industrial Facilities Operating Company," is in Ottobrunn, near Munich, West Germany. Founded in 1961 by a joint agreement between the FRG Ministry of Defense and the West-German aerospace industry, it is owned indirectly by the government through a government-owned holding company. The legal and financial arrangement allows IABG to conduct studies and evaluations for both private and public clients while maintaining a neutral and unbiased point of view. A wide range of technical and scientific projects relating to various engineering disciplines as well as systems analysis, computer science, management science, and operations research are undertaken at IABG. The company claims to have more professional workers in systems analysis and operations research than any comparable organization in western Europe. This report contains an overview of major activities and discussions of several individual operations research projects, based on interviews and materials provided the author during a recent visit to IABG.

Systems analysis at IABG includes optimization of the operational capabilities of weapons systems. The results are used for analyses of long-term demand for weapons systems, formulation of future military missions, determination of optimal system mixes, assessment of the cost-effectiveness of systems, and improvement of tactical doctrines. A war-gaming facility is used to interrelate military decision making and analytical assessments. Military technology study teams investigate proposals concerning weapon systems from many points of view, including control, sensor technology, human factors, vulnerability, maintenance, and development costs. The groups are also involved in technological forecasting in an attempt to anticipate development trends. Because of their involvement in the support of planning decisions, the military technology groups perform a key function in the relationship between the Ministry of Defense and the manufacturers who develop new material. Thus, the activities of the groups are analogous to the systems engineering work done by the British Royal Establishments (such as the Royal Aircraft Establishment [RAE] and Royal Armament Research and Development Establishment [RARDE]), by Centre de Documentation de l'Armement [CELAR] in France, and by the Systems Engineering Group [SEG] and Center for Naval Analysis [CNA] for the US Air Force and Navy, respectively.

Systems analysis is also used for nonmilitary projects at IABG. One area is manpower modeling for personnel planning, utilization, and organization. This includes determining

requirements as functions of recruitment and promotion strategies, assessing training programs and requirements, and predicting personnel requirements from social, economic, and technological forecasts. IABG has recently been involved in reviewing public health systems such as organizational analyses of hospitals and studies of the use of medical services. The company analysts have also made studies of university training programs, environmental protection measures (especially projection of environmental impacts, assessment of recycling measures, and development of an environmental research data bank), and studies connected with regional planning by various local government bodies (including regional population projections, population mobility studies, investment planning for transportation services, and analyses of rent control and subsidy proposals).

IABG is devoting much effort to assessing the reliability and performance of various hardware systems, mostly in connection with aerospace development. It has several laboratories in which full-scale systems of considerable size (such as aircraft wings) and complexity (such as satellites) can be tested. The engineering tests are often supplemented with computer simulations and analytical investigations. The laboratories are equipped to simulate various environments, such as a 3-m space simulation chamber. Applications include assessments of structural strength of vehicles, construction and design characteristics, materials technology and testing, acoustics, hydraulics, inertial and other precision equipment, electromagnetic compatibility, magnetic field simulation, reliability and maintainability, space simulation, operational field trials and passive protection.

The company has a manpower planning group of professionals with diverse backgrounds (social science, engineering, mathematics, computer science, physics, economics, and psychology) that provides advice and assistance to large employing organizations, industries, government agencies, and regional bodies. Dr. Rolfe Lepping, a member of the group, described some of his recent work. Lepping is primarily concerned with optimal management of manpower systems viewed as a whole. He deals with stocks and flows of people rather than with individual employees. His analyses involve use of Markov-chain, geometric, and network-flow models to study problems of recruitment, promotion, and career planning in large organizations. One such study concerned the determination of an objective age-grade structure of noncommissioned officers in the German Air Force. That organization manages about 100 different occupational groups, each having different stocks of several grades of noncommissioned officers. The problem was to bring about a similar promotion flow through the grade structure for each group. The system was modeled as a network-flow problem for which a stationary ("ideal") structure was found.

Dr. D. Gebhardt described his work on a statistical test procedure for the accuracy of missiles, based on hit patterns. The null hypothesis under test is that a square d units on a side will contain a missile impact with probability 0.5. Gebhardt assumes the missile impacts are at points (X,Y) in a Cartesian coordinate system, that the square "target" has sides parallel to the axes with its center at the origin. He further assumes that X and Y are independent normal with zero means and variances σ_x^2 and σ_y^2, respectively. Using an approach similar to the Aspin-Welch approximation for the Behrens-Fisher problem, Gebhardt gives a test in terms of $s^2 = \Sigma(x_i^2 + y_i^2)/n$, where n missile impacts $(x_1, y_1), \ldots, (x_n, y_n)$ have been observed. If we let $\sigma^2 = \sigma_x^2 + \sigma_y^2$ and $\lambda = \sigma_y / \sigma_x$, then ms^2/σ^2 is distributed approximately as chi-square with $m = n(1 + \lambda^2)^2/(1+\lambda^4)$ degrees of freedom. The hypothesis of 0.5 probability of impact within the square target allows one to give σ as a function of d. Thus a critical value $s_\alpha(\lambda)$ can be found such that the null hypothesis is rejected whenever $s \geq s_\alpha$ for a size α test. Gebhardt shows that the operating characteristics of the test are fairly insensitive to variations in λ, and he suggests that a value be estimated by personnel familiar with the missile system under test. He also shows that the uniformly most powerful test for the situation, which could be based on a weighted average of Σx_i^2 and Σy_i^2, is sensitive to the choice of λ and thus argues in favor of basing the test on the slightly more variable statistic s^2. Gebhardt has derived the power function for this test where alternative hypotheses are given in terms of the length of sides of a square that will contain a missile impact with probability 0.5. His approach can be adapted fairly easily to other than square target shapes.

Dr. Gerhard Schroeter has been working for several years on coverage problems with applications to standard artillery doctrines and to new technologies such as guided weapons and submunitions projectiles. He is also interested in weapons mix problems such as the following: for given cost, maximize a weighted sum of targets that can be engaged. The solutions for various scenarios give interesting insights into tradeoffs among system parameters. For example, various limitations of mortars become evident in situations requiring concentration of fire, according to Schroeter. As much of Schroeter's work has appeared in journals published in the English language, it is not reviewed further here. The following list of papers will give the reader an appreciation of Schroeter's interests:

"Probability of Kill and Expected Destroyed Value if the Underlying Distributions are Rotationally Symmetric", Operations Research, 24 (1976);

"The Application of the Hankel Transformation to Spherically Symmetric Coverage Problems", Journal of Applied Probability. 17 (1980);

"Expected Coverage of a Randomly Located Target by Multiple Independent Salvos", Operations Research, 28 (1980); and

"The Variance of the Coverage of a Randomly Located Area Target by a Salvo of Weapons", Naval Research Logistics Quarterly, 29 (1982).

In summary, IABG is a large research facility doing significant work on development of operations research theory and applications. It conducts diverse studies for military, government, and industrial customers. As IABG is not engaged in product development and has no commercial interests of its own, it can be presumed that the conclusions reached in its studies are completely objective. I was told that IABG considers its neutrality towards both the private and public sectors to be an essential factor of its organization. IABG is also careful to maintain confidentiality in its work with its clients.

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PHYSICS

EIGHTH INTERNATIONAL CONFERENCE ON NUMERICAL METHODS IN FLUID DYNAMICS

From 28 June to 2 July 1982 Aachen was the site of the Eighth International Conference on Numerical Methods in Fluid Dynamics, organized by Professor Egon Krause of the Rhine-Westphalen Technische Hochschule (RWTH) Aerodynamics Institute. About 200 participants heard 6 invited lectures and 60 contributed papers, of which the selection committee had allocated 25 from the US and 10 from the USSR. Four Soviet authors were unable to attend, and their places were filled with substitute papers given by western authors. All papers were in English. Bound proceedings will be published by Springer-Verlag within the next few months.

Most of the research reported (over two-thirds of the papers) was motivated by airplane design considerations; NASA laboratories alone accounted for 10 of these. The most popular theme was a transonic flow over airfoils, a problem that has obvious applicability to all supersonic aircraft and to many commercial aircraft that fly so close to Mach 1 that some of the airflow is supersonic. Transonic flow introduces significant mathematical difficulty because the boundary conditions needed to solve the supersonic part of the flow differ from those in the subsonic part. Twenty years ago calculations simulated flow over a single airfoil; today the whole airplane can be modeled. Improvements in both hardware and software have reduced computer running times by two orders of magnitude, with a resulting saving of billions of dollars in design and operating costs, as noted by W.F. Ballhaus, Jr. (NASA Ames) in the opening invited lecture.

Among other areas of research were general gas dynamics problems, explosions, turbulence, combustion, rotating flows, and flows in pipes and channels. Almost all the papers emphasized computational techniques rather than results. Many of the calculations took hours to run on the largest scientific computers (a sizable minority of authors used Cray machines), so minimization of running times and core requirements received much emphasis.

Not unexpectedly, many of the most impressive results were reported in papers by US authors. As preprints (and in some cases reprints of previously published articles) are readily available and the institutions themselves are close to American readers, I omit specific mention of the papers and restrict myself to brief descriptions of a few of the non-US papers.

The second invited lecture of the conference was given by P.I. Shushkin (Computing Center, USSR Academy of Sciences, Moscow). A review of published work on the subject of blast waves in gaseous media, it included no original results and in fact stressed one-dimensional calculations with comparatively little mention of multidimensional problems. Thus it appeared to continue the Soviet practice so much in evidence in 1980 at the Seventh ICNMFD, which took place at Stanford, of collecting as much information as possible from western workers while offering little or nothing in return. Still, among the more than 100 papers we cited, Shushkin reviewed a number by Soviet authors that might otherwise have gone unnoticed by western scientists. Moreover, the paper given subsequently by Y.I. Shokin, (Inst. of Theoretical and Applied Mechanics, Novosibirsk), described work carried out within the past 2 years and to some extent not previously published. It reported use of the "method of differential approximation" to lay down a nonuniform grid to avoid or minimize time-step restrictions by adapting the grid to the flow. Basically, the idea is that in regions of expansion, for any time step δt, it is possible to find a distribution of mesh points for which a given difference scheme is stable, while in regions of compression there is an

inherent upper limit on δt given by the time required for waves to break.

Leonhard Kleiser (Kernforschungszentrum, Karlsruhe, FGR) described spectral simulations of the transition from laminar to turbulent states in plane Poiseuille flow. He has succeeded in modeling the "vibrating ribbon" Poiseuille flow experiments of Nishioka et al. The model requires a three-dimensional description and particular attention to maintaining the incompressibility and boundary conditions of the discretized equations. The numerical results are in impressive agreement through the early (weakly nonlinear) stages of development. Although the coarseness of discretization (32 x 32 x 41 elements) militates against the possibility of obtaining detailed agreement with experiment in the stage of fully developed turbulence, the work is a valuable step toward unraveling the problems associated with the onset of turbulence.

E.F.F. Botta (Univ. of Groningen) and A.E.P. Veldman (National Aerospace Lab., Amsterdam) described a method for iterative solution of convective-diffusion equations (e.g., the time independent Navier-Stokes equation). When the matrix resulting from discretization is not diagonally dominant, as occurs for central-difference approximations in the large-Reynolds-number limit, conventional iterative methods exhibit convergence difficulties. Botta and Veldman adapted results from the method of successive overrelaxation (SOR) for equations with constant coefficients to equations with coefficients that vary across the mesh. For linear systems, the speed of the local-relaxation technique is comparable with SOR, but for nonlinear systems they are up to two orders of magnitude faster.

Kazuhiro Nakahashi (National Aerospace Lab., Japan) reported on a technique for calculating supersonic two-dimensional chemically reactive flow through the exhaust nozzle of a rocket-propulsion system. Usually most of the computation cost is incurred by the kinetics package, which solves the ordinary differential equations describing chemical processes. These are stiff (i.e., they contain nearly balanced large source and sink terms whose net effect is a slow change in the species number) and are usually solved implicitly while the fluid equations are integrated using explicit methods to reduce storage requirements. Such systems are ill conditioned because of the difference in form between the fluid and rate equations. Nakahashi's method consists of explicit differencing of the radial derivatives in the fluid equations and linearization of the chemistry equations, together with a uniform implicit treatment of the axial (timelike) terms in both fluid and chemistry equations. The resulting method is especially efficient when a large number of chemical species are present.

In addition to the scientific sessions, the organizers arranged excursions to the German nuclear research center at Julich, to the town of Monschau (Montjoy) 25 miles south of Aachen, and to the Aerodynamics Institute at the RWTH. The institute was for many years (until 1930) under the direction of Theodore von Karman. In addition to the expected work on airplane design, it is involved in studies of airflow around stadiums and other buildings and flows in valves. We were shown two wind tunnels and a water tunnel, along with numerous displays, models, and experiments.

The conference ended Friday. On Saturday, a one-day workshop was held at the Aerodynamics Institute on multigrid methods. This is a class of techniques for iterative solution of elliptic equations based on obtaining a crude approximate solution on a coarse grid, using that as the initial guess for a solution on a somewhat finer grid and so on through successive refinements until the desired degree of accuracy is attained. Approximately 40 persons took part, about half from various German universities, with the remainder being foreign scientists who had come for the ICNMFD. Multigrid methods have been improved to the point where they are now among the fastest and most robust (problem-dependent) techniques for solving elliptic equations.

The ninth conference in the series was to have been held in Poland. At the banquet Thursday evening, however, it was announced that "owing to changed circumstances" the steering committee had voted to move the site of the 1984 meeting to the south of France, at a location to be determined later. The move followed by 2 months the decision by the US government to suspend scientific exchanges with Poland. The organization of the 1984 meeting will be under the direction of Prof. Soubbaramayer of the University of California.

D.L. Book

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NEW ASPECTS OF ION BEAMS IN BRITAIN

The UK Institute of Physics hosted a 1-day meeting on ion beam machines in London on 30 September 1982. The meeting was sponsored by the Atomic Collisions in Solids group and organized by Dr. C.J. Clipstone of the Gillette Corporate R&D Laboratory in Reading, England. The purpose of the meeting was to bring British scientists and engineers up to date on the latest developments in the field and to provide a forum for discussion of related new concepts. Forty-one persons attended.

Ion-beam machining has been in use in both the semiconductor and specialized metal fabrication industries for a number of years. Almost universally ion machining or milling has used chemically inert gas ion beams that mill materials indiscriminately by simple momentum transfer. As lithographic resolution

requirements for the semiconductor industry became increasingly stringent, preferentially selective atom-by-atom (almost) removal of a particular layer or region was needed. The selective milling requirement has led to the development of machines using noninert gas ions whose chemical-potential activity is selectively exploited; the activity frequently dwarfs the action of the purely physical-kinetic interaction of inert ions. The machines so developed are known as reactive-ion-etching or reactive-ion-milling machines. Through meetings such as the one discussed here the precision-engineering industry is becoming increasingly aware of the potential of ion beams for component machining and surface processing such as texturing, smoothing, and cleaning. Whereas laser and electron-beam processing removes material by thermal evaporation (frequently carburizing the surface), reactive ion etching removes material regardless of hardness and almost always achieves a higher quality of cleanliness, surface finish, grooves, cuts, and holes. (The cleanliness is exploited in new surface-analysis techniques described later in this article.) As it has been shown that ion-beam machining provides superior surfaces the industry is now moving to develop means of providing economical stock removal rates.

Peter Byers (Whickham Engineering) described new experimental ion implantation machines that incorporate novel features. Among the features are both pre- and post-separation acceleration, variable ion source-to-isotope-separation magnet distance, and variable control of the physical shape of the magnetic pole piece. The added flexibility results in less dispersion of the ion beam as acceleration energy or isotopic species is changed.

Dr. J.R.A. Cleaver (Dept. of Engineering, Cambridge Univ.) described a new approach to a high brightness ion source. His source was a heated tungsten needle whose exposed exterior was covered by a liquid of the desired ion species. By using surface tension and capillary action, the exposed exterior of the needle was kept supplied from a heated reservoir. A control-acceleration electrode concentrically positioned near the tip of the needle provided a field-effect-like emitting action to remove ions from the point source. Ion beam current densities of 10^6 A/cm²/steradian were achieved. Applications include micromachining, resist layer exposure, and direct writing of selective ion implantation into semiconductors. A comparatively long lens system achieves a resolution-dispersion of 1,000 Å on target.

In a paper that could have far-reaching effects in the electronic device fabrication industry, Dr. Peter Hemment (Univ. of Surrey) described his recent work on "Dosimetry Errors, Control, and Reproducibility of Dopant Implants." He began by analyzing the mass separator region of a typical ion implanter and showed how the separation process itself leads to a relatively high-pressure region near the magnet. The region creates a high probability

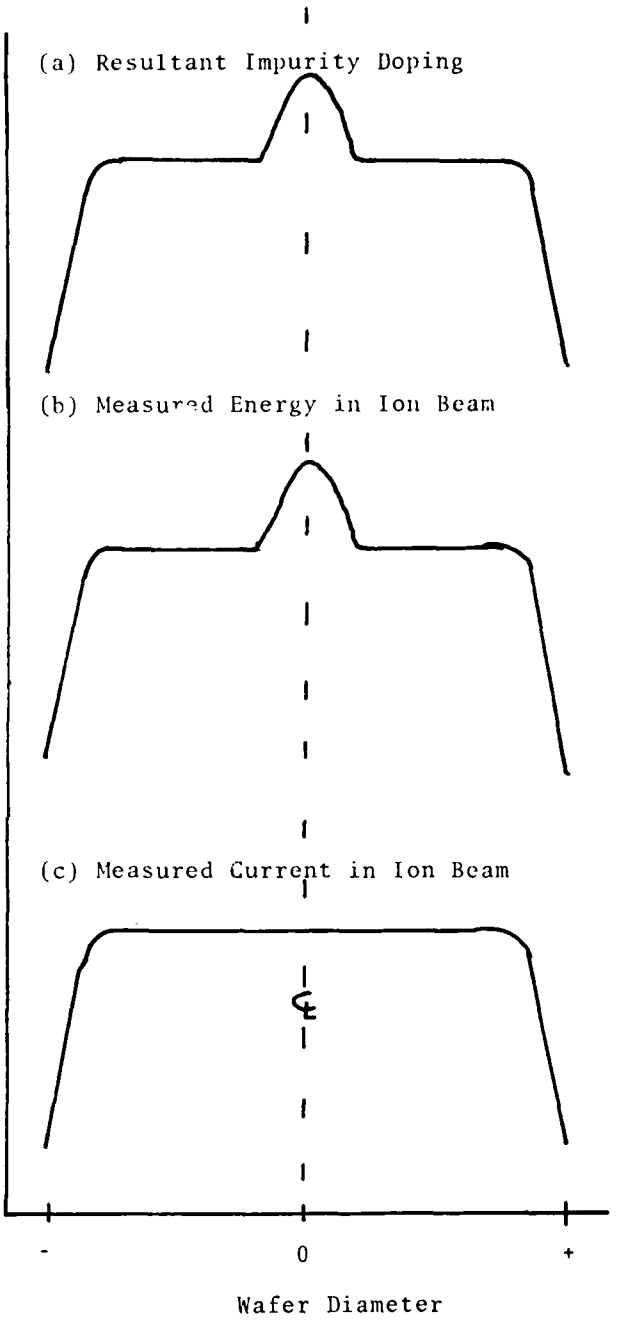

Figure 1. Resultant Radial Distributions

of collisions and the collisions, in turn, create differently charged ions and secondary electrons. The electrons can recombine with ions to produce neutral particles. Although the neutral particles (of the same isotope as the

desired ion) are equally effective as impurity dopants in the semiconductor, their distribution in the semiconductor wafer presents a problem. To implant a large-area wafer uniformly with a small diameter ion beam, the ion beam typically is electrostatically defocused or electrostatically scanned. As the neutral particles respond to neither electrostatic nor magnetic fields, they are neither defocused nor scanned. As a result, the center of the wafer typically receives a large dose (fluence) of neutrals in addition to the ions. Subsequent impurity implantation profiles are shown in Figure 1(a). Using a calorimeter to profile the total energy deposited by the scanned beam as a function of wafer diameter produced the profile in Figure 1(b), whereas a Faraday cup profile of beam current is shown in Figure 1(c). Rutherford backscatter analysis of the semiconductor wafers confirmed the profile shown in Figure 1(a). (The horizontal scale has been expanded around the centerline to illustrate the effect.) Techniques for reducing the magnitude of the neutral beam include post-separation acceleration and greater pumping in the region of the separator. Techniques for reducing the effects of nonuniformity caused by the neutral particles include physical rotation and translation of the sample. The errors that can accrue by using the conventional ∫idt method for determining total dose are readily apparent in Figure 1.

Even though reactive ion etching can be highly selective, there are situations in which a multitude of sometimes unknown materials must be precisely removed from a surface (e.g., semiconductor surface cleaning). In such an operation it would be convenient if the cleaning process could be remotely monitored continuously. A.J. Dixon (Thor Research) has investigated the trajectories of secondary electrons emitted from a semiconductor surface in the presence of an intense magnetic field. The secondary electrons can be generated either by an ion beam or by UV illumination. Dixon's findings have enabled him to design and build a new type of instrument for both machining and analyzing a semiconductor surface (Fig. 2). The surrounding 7.7 Tesla superconducting magnet that creates magnetic field lines is not shown in the figure. The secondary electrons are emitted from the surface of the sample when it is struck with ions from a fast atom sputtering source or flooded with UV illumination. The energy of the emitted secondary electrons is a function of the chemical composition of the surface monolayers; this energy determines the orbital diameter of the cyclotron-like motion and hence the ultimate resolution of the instrument. The instrument is basically a surface-sensitive device and can be used in various ways. Its chemical sensitivity is thought to be equivalent to that of a secondary ion mass spectroscopy machine with the added advantage that in the UV flood mode no surface damage or carburizing effects are present. As a scanning electron microscope it offers an enormous depth of field, but lateral resolution is limited to no better than 0.15 μm. It can be used also as an AUGER machine, an ion beam miller, and a photoelectron spectromicroscope. As a surface tool it also provides chemical contrast in two dimensions and bandstructure analysis. It may well aid scientists in analyzing surface states and oxide semiconductor interfaces.

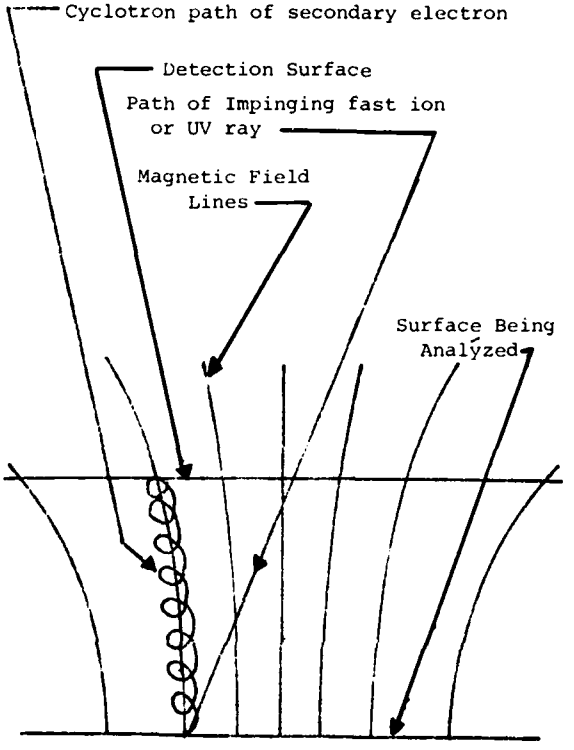

Figure 2. Surface Analysis Technique

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Solitons '82: The Scott Russell Centenary Conference: Part II

A review of the Solitons '82 Conference, begun in the September issue of ESN, is completed. Last month, applications to hydrodynamics and electronics were considered. Here, some of the contributions to condensed-matter physics are reviewed and applications in other areas are noted. The report concludes with a few general observations on the research presented at the conference.

Condensed-matter physics

Much of the material presented at the conference in this area was concerned with solitons generated in two types of potential fields. One is periodic in some position or phase variable and describes chains of interacting particles such as atoms in a crystal lattice. In the case of crystals, the solitons may represent such things as dislocations or deformations that move through the periodic structure. The associated continuum spectrum is represented by harmonic vibrations of atoms in the lattice (the phonon field). Such solitons are determined from the Sine-Gordon equation (see Part I) or a variant of it. The other type of potential is a double well describing two metastable states that the system may exist in or condense into. The bistable orientation of molecular bonds or the phase of a material are examples of quantities described by this ϕ^4 potential. The name and notation derive from the order of the polynomial in the position or phase variable that describes the double well. Examples of both types of solitons were discussed.

A problem of particular interest in epitaxy is the layering of a crystal lattice of one material on top of a substrate of a second material when the lattice spacings for the two are different. Imagine a long, oscillating line of hills and valleys as a gravitational analogue of the periodic potential of the substrate. The overlay is then represented by a line of masses resting on the rippled surface and connected by springs with equilibrium lengths slightly different from the hill-to-hill spacing. Starting from one mass oscillating in a valley and moving along the line, the shift in equilibrium position accumulates until either two or no masses will be found in a particular valley. The sudden change represents a dislocation soliton driven by the potential mismatch of layered materials. As reviewed by J. A. Kramhansl (Cornell Univ.), the problem can be treated by including in the Hamiltonian terms for the stretching of the overlay to accommodate the periodic structure of the substrate, the interaction of the overlay with the substrate, and the driving by a nonlinear chemical potential. The resulting Sine-Gordon equation yields soliton solutions that describe the displacement dislocations and phonon field of the overlay.

M. Payrard and M. Remoissent (Laboratoire d'Optique du Réseau Cristallin, Dijon, France) studied how the shape of the substrate potential changed the kink solitons that describe the dislocations. (Kink solitons differ from the "bumps" described in the first part of this report. A bump leaves the medium undisturbed after it passes so that the dependent variable has the same asymptotic value in front of and behind the soliton. A kink is characterized by different values of the dependent variable on either side. Kinks are therefore described by tanh functions rather than sech functions.) They studied a one-dimensional atomic chain with a new type of nonlinear, periodic-substrate potential

$$(13) \qquad V(\phi,r)=(1-r)^2\,\frac{1-\cos\phi}{1+r^2+2r\cos\phi}\ .$$

In Eq. (13), the phase ϕ represents the position along the chain, changing by 2π between atoms. By varying r between -1 and +1 (with r=0 representing Sine-Gordon), they determined that the shape of the substrate potential was particularly important for modeling physical systems where discreteness effects were involved. When the potential became sharp, even large amplitude kinks could be pinned to the lattice.

Remoissenet collaborated with S.N. Pnevmatikos and N. Flytzanis (Univ. of Crete) in an analytical and numerical study of a diatomic chain with a quartic interaction potential for nearest neighbors. In the continuum approximation (replacing the differences of neighboring atom positions by differentials in the Hamiltonian), the equations of motion for the two different atoms could be decoupled. Both acoustic modes (motion along the chain) and optical modes (motion transverse to the chain) were studied. The acoustic modes were described by a Modified Boussinesq (MBQ) equation of the form

$$(14) \qquad U_{tt}=C^2U_{xx}+q(U^3)_{xx}+hU_{xxxx}\ ,$$

where C, q, and h are constants. (Similarity solutions of the MBQ equation were reported by G.R.W. Quispel, H.W. Capel, and coworkers [Instituut Lorentz, Leiden].) The optical modes were described by a cubic-nonlinear Schrödinger equation. Both equations yielded analytical solutions that were then used as initial conditions for numerical studies of the discrete chain. Stable, long-lived solitons of both types that appeared to decouple at long times were observed.

Another example of the Sine-Gordon equation in solid-state physics was discussed by Dr. Lin Lei (Inst. of Physics, Chinese Academy of Sciences, Beijing). He described a new method of generating solitons in nematic liquid crystals. Solitons in liquid crystals immersed in electric and magnetic fields have been studied for about 15 years. Lin Lei showed that Sine-Gordon solitons are possible in field-free liquid crystals provided a shear force is applied by sliding the plates which sandwich the nematic. In this research, the soliton is a traveling domain wall separating regions in which the crystals have different alignments. Such solitons are visible to the naked eye when placed between crossed polarizers. Lei described recent experiments with the liquid-crystal MBBA that were in good agreement with his analysis.

Polyacetylene $(CH)_x$, the simplest linear-conducting, conjugated polymer, has a number of intriguing properties that can be explained by soliton theory. The material is a shiny, grey, flexible film that conducts electricity. As a light and cheap semiconductor, it has applications to electrochemical displays, batteries, and synthetic metals. Chains of CH about 4 Å apart form into fibrils that are separated from each other by about 2,000 Å. The open structure allows easy access of doping atoms to the chain. Doping provides controlled variation of resistivity from about 10^{-12} to about 10^{4} $(ohm\text{-}cm)^{-1}$, thereby spanning the range from insulators to metals.

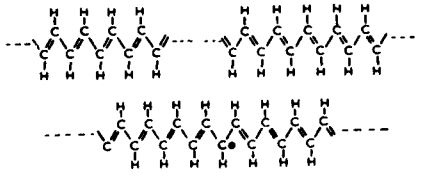

Fig. 3

The "trans" form of polyacetylene (Fig. 3 top) is of particular interest because it has two energy-degenerate configurations: a dimerized pattern of alternating single and double bonds (A) and its mirror image (B). Because the energies of the two states are the same, soliton excitations can exist in the form of a moving domain wall separating the A and B regions. A.R. Bishop (Los Alamos National Lab.) described models for the coupled electron-phonon excitations in which the two ground states are represented by the two wells of a ϕ^4 potential where positive and negative values of ϕ correspond to bond displacements towards A and B. The system Hamiltonian includes terms for the hopping energy of electrons between CH units, electron creation and annihilation, and the strain on the CH units. Kink solitons (bottom of Fig. 3) and polarons (kink, antikink coupled states that have the same asymptotic bond pattern on both sides of the defect) were obtained analytically. The analysis demonstrated the existence of electronic midgap states between the valence and conduction bands that could be occupied at low energy investment. The results provide explanation for mobile defects observed in undoped $(CH)_x$ and the high conductance of doped defects.

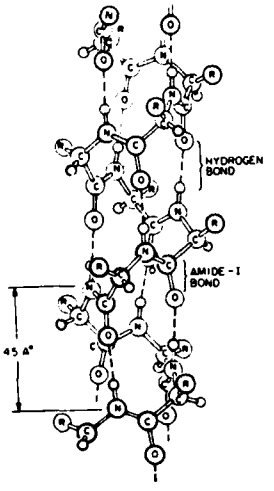

Fig. 4

Alwyn Scott (Los Alamos National Lab.), one of the meeting organizers, did not present his work formally but provided copies of his research papers on electron-phonon phenomena in the α helix of DNA (Fig. 4). Scott has refined a model proposed by Davydov (Phys. Scr. 20, p387,[1979]) to describe how the amide-I bond (appearing in every peptide group of every protein) stores and transports biological energy by means of longitudinal sound waves on the helix. In addition to the helix proper, the response of three longitudinal spines (the hydrogen bonds that hold the protein in helical form) had to be considered. The complex structure led to a complicated set of coupled equations related to the nonlinear Schrödinger equation that was solved numerically (Phys. Lett. 86A, p60,[1981]). The calculations were initiated by assuming that two 0.205 eV amide-I quanta were created from the 0.49 eV of biochemical energy released by hydrolysis of ATP into ADP. Soliton formation was observed when the hydrogen-bond anharmonicity (the change in amide-I bond energy per unit extension of the hydrogen bond) was chosen to be the same as independently calculated by other researchers. Scott suggested that the Davydov solitons play important roles in muscular contraction and the sensitivity of living organisms to low-intensity, nonionizing electromagnetic radiation. Most recently, he has demonstrated an impressively close correlation between the laser-Raman spectra of biologically active E. coli bacteria

and the spectrum predicted from the internal vibrations of Davydov solitons.

Other Topics

D. J. Wallace (Univ. of Edinburgh) used soliton theory to study the properties of interfaces between regions of two distinct thermodynamic phases. The two phases are represented by minima in a ϕ^4 potential of the form $a\phi^4+b\phi^2+c\phi$ where $\phi(x)$ is the fluid density and x measures the distance from the interface. When c=0, a first-order phase transition (for example a liquid-vapor transition) is modeled and a kink soliton divides the two phases. Wallace showed that his analysis could be made to agree with experiments on sulfur hexaflouride in the critical region provided the statistical-mechanical partition function was corrected for surface-tension effects. When $c\neq 0$, the upper state is metastable. Wallace made calculations in spherical geometry with negative c and a radially dependent ϕ to determine the critical bubble size responsible for boiling in a superheated (and therefore metastable) liquid.

Two papers on soliton solutions in general relativity were presented. Dr. Anna Curir (Univ. of Oxford) applied the inverse scattering transform to the solution of Einstein's field equations. A solitonic gravity wave propagating from the cosmological singularity of the Big Bang towards infinity was obtained. The soliton gave rise to a perturbed region inside the light cone in such a way that the region exterior to the light cone remained unperturbed.

Astronomically closer to home, B. Roberts (Univ. of St. Andrews) discussed the possibility of solitons occurring in magnetic flux tubes in the solar photosphere. Roberts believes that such solitons may explain large inhomogeneities observed in x-ray photographs of the solar corona. Although a complex variety of dispersive magnetoacoustic modes can exist in the sun's atmosphere, only the simplest one-dimensional modes were considered by Roberts. The equilibrium was described by an isolated flux tube along the z direction containing a parallel magnetic field. The field is zero outside the flux tube. Gravity is everywhere ignored. Linear stability theory yields both sausage and kink instabilities each with fast and slow modes. The solitons arise from a multiple-scale analysis of the nonlinear MHD equations. The equation of motion can be written in the form

$$(15)\quad 0=V_t+C_TV_z+\beta VV_z+\alpha C_T\left[\frac{1}{\pi}\int_{-\infty}^{\infty}\frac{V(z',t)dz'}{z'-z}\right]_{zz}$$

Here, α and β are constants, V is the fluid velocity, and

$$(16)\quad C_T=C_oV_a/(C_o^2+V_a^2)^{\frac{1}{2}}\ .$$

In Eq.(16), V_a is the Alfven speed and C_o is the sound speed inside the slab. Equation (15) is a form of the Benjamin-Ono equation. Solutions of the equation were discussed by Dr. Mark Ablowitz (Clarkson College). The Benjamin-Ono 1-soliton solution looks like a "knee-cap" bulge that moves along in the flux tube at about 7 km/s in the photosphere.

Concluding Remarks

The Solitons '82 Conference indicated important applications of soliton theory to a number of areas of physical science including hydrodynamics, electronics, and condensed-matter physics. However, reports on direct experimental observation of solitons were scarce. Only Dr. Osborne described sufficiently detailed experimental measurements to characterize the observed internal water waves as solitonic. He observed that the wave propagation velocities were proportional to their amplitude, that particle velocities tended not to reverse in time, and that the disturbances preserved their character while propagating over many wavelengths. The properties were identified with those expected from KdV solitons. For Osborne, the major question was not identification of solitonic behavior but determination of the initial disturbance from which the solitons could grow. The computer techniques he developed for the purpose may be important for determining the sites for sea-based structures.

Many authors discussed experimental observations that could be explained by the presence of solitons but did not directly characterize them. Christiansen demonstrated impressive agreement between theory and experiment for the dc current-voltage characteristics of Josephson junctions when each current branch was associated with a specific number of solitons bouncing back and forth between electrodes. Kodama referred to observations of picosecond optical pulse narrowing in agreement with his analysis but he did not present experimental results. Scott's analysis of vibrations in the DNA helix demonstrated good agreement with observations of the laser-Raman spectra of living cells. Krumhansl mentioned experiments using a rare gas atomic layer on a carbon substrate in which stable dislocations formed spontaneously above a certain temperature. Although the behavior was in agreement with the type of soliton analyses carried out by Payrard, Remoissent, Pnevmatikos, and Flytzanis, Krumhansl stated that nonsolitonic explanations were possible. Bishop's soliton theory for the electrical characteristics of polyacetylene can explain experimental results. However, Arnold Glick (Weizmann Inst., Rehovot, Israel) has just published (Phys. Rev. Lett. 49, p804[1982]) a

nonsolitonic theory that explains the electronic midband structure on the basis of the electromagnetic interaction between chains.

Computational difficulties can interfere with establishing the solitonic nature of physical phenomena. A number of the mathematical papers presented formal solutions to various soliton equations. The solutions display conservation laws and other fundamental properties that contribute to a basic understanding of the physical system. However, except for the simplest solutions to the most basic equations, formal solutions are not easily cast in an algebraically explicit form. From a physicist's point of view, the equations governing a particular physical system should be sufficiently complex to model all important phenomena. To use available analytic solutions, one must simplify the governing equations to the point where their adequacy for modeling the physical situation is questionable. However, the analytic solutions can be used as initial conditions for numerical solutions of equations that contain all necessary complications. In this way, computational time and expenses can be minimized and the applicability of numerical solutions increased. Such a procedure was followed by several researchers to demonstrate that long-lived solitons may exist. Unfortunately, it cannot be used to determine if solitons would have grown spontaneously from the continuum, as their existence is assumed at the start of calculation.

Another limitation associated with numerical solutions is the number of spatial dimensions that can be considered. With the exception of Norman Zabusky's computer modeling of soliton-like behavior of vortex structures (carried out at the Naval Research Laboratory under ONR sponsorship), numerical calculations were limited to one spatial dimension. Although dictated by computing time and cost, 1-D calculations may be inadequate for a complete understanding of phenomena such as defect growth in crystals that are inherently multidimensional.

In summary, the conference presented a good balance of papers dealing with mathematical properties and applications to physics. The United States contributed strongly in both areas. A number of the mathematical "stars" in this field are from American universities: Mark Ablowitz and D. J. Kaup (Clarkson College, Potsdam, NY) and J. Bona (Univ. Chicago). The American computational and applications area was represented by several researchers at Los Alamos National Laboratory: A. R. Bishop, P. Lomdahl and A. C. Scott. Canada, China, Denmark, France, Japan, the Netherlands and the United Kingdom were well represented. Contributers from the Soviet Union concentrated on the more esoteric and formal problems such as multidimensional equations and gauge equivalence rather than "down-to-earth" applications.

Are solitons real physical entities? Apparently they are in some physical systems. And in other systems where their presence is questionable, the techniques of soliton theory represent powerful tools for understanding nonlinear phenomena. These are impressive accomplishments for a science little more than a decade old.

D. Mosher

ONR London

STATISTICS

THE 15TH EUROPEAN MEETING OF STATISTICIANS

The meeting, organized by the Bernouli Society for Mathematical Statistics and Probability and the Italian Statistical Society, was held on the campus of the University of Palermo 13-17 September 1982. Approximately 125 papers, split about evenly between invited and contributed papers, were delivered to over 400 attendees. The meetings featured special sessions on a number of topics, including robust statistical methods, achievements and opportunities in applied probability, boundary-crossing problems in sequential analysis, and stochastic processes.

In two lectures jointly entitled "Achievements and Opportunities in Applied Probability," J.F.C. Kingman (Oxford Univ.) reviewed applied probability and then projected future developments in the subject. Kingman commented that applied probability grew up as an array of separate activities as scientists concerned with particular phenomena involving chance developed ad hoc methods of analysis. Gradually the connections among different areas were realized, but not before basic methods such as the Poisson process had been repeatedly rediscovered. The realization that common models were involved in different applications was widely apparent in the 1950s and was marked by the publication of the classic books by Feller, Doob, and Bartlett. Kingman surveyed the challenges in probabilistic analysis and the tools that are being developed to meet them. There has been a change of emphasis from the early days, when problems were rapidly reduced to analytic form (Kolmogorov differential equations, for example), to the modern pursuit of Chung's dictum, "The process is the thing." Several times Kingman expressed his view that in an analysis one should attempt to stay close to the probability concepts involved rather than immediately resorting to pure analysis. He mentioned a number of applications and techniques and made comments about their future importance. A sample follows:

Genetics - an old area in which scientific progress is leading to significant new problems.

Biotechnology - a merger of the engineering and genetic sciences will provide future challenges.

Martingales - need to be taken more seriously by applied probabilists; look for martingales (or approximate ones) in your problem, then exploit appropriate identities.

Lattice processes - there has been too much work here; it is difficult to relate them usefully to continuous processes.

A number of presentations were on nonparametric statistics. J. Durbin (London School of Economics) discussed "Asymptotic Significance Points for the Kolmogorov-Smirnov (K-S) Test when Parameters are Estimated." He considered a test of H_o: $F(x) = F(x;\theta)$, where the parameter vector θ is estimated by an efficient estimator $\hat{\theta}$. The test is based on the process $y_n(x) = \sqrt{n}\ [F_n(x) - F(x;\hat{\theta})]$, which converges in distribution to a zero mean Gaussian process with a covariance kernel different from that for cases not involving estimation of a parameter. Durbin viewed the one-sided K-S test in terms of the non-Markov process y(x) and developed expressions for the first passage density, in the form $p(x) = b(x) \cdot f(x)$, for a differentiable boundary a(x); $o<x<1$, where

$$b^2(x) = \lim_{s \uparrow x} \frac{1}{x-s} E[I(s,y) \{a(s)-y(s)\} | y(x) = a(x)],$$

where I is an indicator function that is zero on a sample path. Durbin approximated b by

$$\hat{b}(x) = \lim_{s \uparrow x} \frac{\hat{b}(s,x)}{x-s}, \text{ where } \hat{b}(s,x) \text{ is given by}$$

the above conditional expectation in the case of Brownian motion with a straight line boundary, not considering any previous crossings. He showed comparisons of values given by the approximate method with those from an exact (numerical) method (also given by Durbin, in 1967) for scalar θ. The comparisons suggest the approximation is good and should lead to useful extensions of the K-S test procedure.

The most exciting developments discussed at the meeting were in the area of robust statistics. R. Welsch (MIT) reviewed "Diagnostics, Stable Inference, and Robust Regression." He described current work in detecting outliers, determining influential observations (points whose removal from the sample would affect the inferences markedly), and leverage points (observations whose fitted values are largely determined by the corresponding response values). Welsch discussed bounded influence regression (Kunser and Welsch, JASA (1982)) and problems that occur where there are large "clumps" of outliers. He cited the need for diagnostic tools for their detection with high "breakdown" protection, especially in the early stages of analysis. In the later, "confirmatory" stages of analysis, it is still desirable to use estimators that are resistant to data problems, but more emphasis should be placed on efficiency. This leads to a search for efficient stable inference procedures such that no small subset of the data is overly influential in the inferences drawn from the data.

A few of the other papers presented at the Palermo meeting that dealt with robust statistics were:

"Robustness Against Violation of the Assumption of Independence," F. Hampel (Erdg. Techn. Hoch, Zurich),

"Robust Estimators of Regression Parameters and Their Asymptotic Relations," J. Jurecková (Charles Univ, Prague),

"Robust Smoothing of Time Series via M-smoothers," W. Härdle (Univ. Heidelberg) and P. Tuan (Univ. Grenoble),

"Infinitesimal Robustness of M-estimators for Regression." E. Ronchetti (ETH-Zentrum, Zurich) and P. Rousseeuw (Brussels),

D. R. Barr

ONR London

NEWS & NOTES

COLOR IN LOFARGRAMS -- A NEGATIVE RESULT

A lofargram is a visual aid for tracking passive sonar signals. In the usual lofargram, a succession of spectral rows or lines is painted on a raster display. The human operator scans the recent series of cycles in order to discern signals. Spectral dots on each raster line are intensity modulated, so that a strong target signal appears as a line or string of dots. Various signal processing schemes are used to enhance the presentation.

Over the years, proposals have been made to include color in complex displays, and as long ago as 1976 the British armed forces were experimenting with color in lofargrams. Recently, the work done in the late 1970's at Plessey Electronics Systems Research, Romsey, Hampshire, has been declassified, and the results were announced at a NATO Agard Conference in April 1982 (Agard Proceedings No. 329). J. Metcalfe of Plessey was the reporting investigator.

After some preliminary work with color scales and preference values, the Plessey researchers established four color sets as being the most promising: green-red, a TRACOR scale, red-green, and blue-red. A green-blue (known to be nonpreferred) and monochrome green were used as controls. Thus, there were six color scales, expected to vary from best to worst. A realistic lofargram simulator displayed

seven segments, with each segment being 64 dots wide and 200 dots high, and with controlled white noise. Three segments had noise only and four segments had target signals plus noise. Seven different signal amplitudes were sampled, and operators had to find the signals and classify them into one of four types. The performance criteria included the amplitude levels of first detection and of first classification.

Results were quite clear: color did not improve detection or classification performance appreciably on any criterion. In fact, differences between best and worst of the six color sets were always less than 1 db. Apparently the S/N ratio is so potent a variable that it overrides other display features such as color. One can imagine displays where color would be an appealing, useful, and even decisive feature, but the lofargram apparently is not one of these.

N.A. Bond, Jr.

ONR London

DISCUSSION MEETING: "EARLY STAGES OF DECOMPOSITION OF ALLOYS"

Experimental and theoretical aspects of the subject are to be discussed in detail at a small conference at the International Haus Sonnenberg near St. Andreasberg/Harz, West Germany, on 19 to 23 September, 1983. The organizers are P. Haasen (Inst. für Metallphysik der Universität Göttingen, Hospitalstrasse 12, D-3400 Göttingen), R. Wagner (GKSS-Research Center, Geesthacht), and V. Gerold (Max-Planck-Inst. für Metallforschung, Seestrasse 92, D-7000 Stuttgart 1). F.-D. Wöhler, Göttingen, is scientific secretary for the conference at which attendance is to be limited to less than 70 specialists.

Methods of investigation and models for understanding the early stages of diffusive processes during alloy decomposition will be considered in detail. Particular emphasis will be given to refinements of classical nucleation and growth mechanisms as well as to the process of spinodal decomposition. Discontinuous precipitation, eutectoid, and massive transformations will be considered. Field ion microscopy-atom probe, transmission electron microscopy, and scattering methods involving x-rays and neutrons are among the experimental techniques to be described.

Of special interest to researchers in the general area are recent achievements made with "time-of-flight" and "imaging-atom-probe" additions to the method of field ion microscopy (see, for example, the book Field Ion Microscopy, R. Wagner, Springer-Verlag, Berlin, 1982, volume 6 in the series "Crystals: Growth, Properties and Applications," edited by H.C. Freyhardt, Göttingen). In a separate poster presentation at the conference "High Temperature Alloys for Gas Turbines 1982," 4 to 6 October, Liege, Belgium, K.M. Delargy and G.D.W. Smith (Oxford Univ.) presented excellent results on the "Phase Composition and Phase Stability of Alloy IN 939" as obtained with the several techniques of atom probe time of flight mass spectrometry, field emission, scanning transmission electron microscopy, x-ray microanalysis, and electron probe microanalysis whereby time-resolved transformations of microstructures were observed on the scale of 2 nm and single atoms were identified chemically.

R.W. Armstrong

ONR London

SHORT WAVELENGTH LASER

A laser operating in the x-ray regime would provide a means to increase profoundly our knowledge of molecular structure and chemistry. The wave coherence of the laser beam would make possible the construction of x-ray holograms recording the 3-dimensional structure of atoms in molecules. Presently, diffraction patterns produced by incoherent x-ray sources provide 2-dimensional information that must be unfolded by computer in conjunction with guesses about the 3-d structure. The difficulties and ambiguities associated with diffraction analysis of complex molecular structures such as DNA would be eliminated by viewing x-ray holograms illuminated by a visible-light laser through a microscope to obtain a magnified, three-dimensional image of the molecule. X-ray energies are required to view the atomic scale because resolution is limited by the wavelength of the illuminating radiation. X-radiation also penetrates metals more deeply than longer wavelength radiations and therefore has potential advantages over visible or near IR lasers in some defense applications.

There are several reasons why a coherent x-ray source is difficult to create. The lasing transition must be a high-energy excited state so that its decay produces x-ray photons. As the spontaneous decay of such states may be as short as 10^{-15} s, rapid pumping is needed for the required population inversion. Unlike visible and near-visible radiation, x-rays cannot be reflected at the boundaries of the lasing medium. Because the beam must then be developed in a single pass of the radiation through the medium, a high density of lasing atoms is required. These facts of nature conspire to require a very high incident power density to pump the population inversion. Currently, researchers are experimenting with

transitions about 10 times less energetic and longer in wavelength than desired for applications. During the past year, the acknowledged leader in the short-wavelength laser race was a 182 Å transition for which gain was demonstrated at the University of Hull (ESN 36-7, [1982]). In that research, a Nd-glass laser beam was focused in a line onto a carbon target. The inversion was produced in C^{+2} as the expanding plasma cooled and recombined. A paper presented in September at the 4th International Symposium on Gas Flow and Chemical Lasers in Stresa, Italy, that reported gain at a shorter wavelength is described below. (The symposium as a whole will be reported on in a forthcoming ESN.)

G. Jamelot and coworkers at the Université Paris Sud and the Ecole Polytechnique observed gain at 105.7 Å for a 3d-5f transition in lithium-like (10-times ionized) aluminum. A 100-J, 20-ns CO_2-laser pulse was line focused onto an aluminum target to 10^{12} W/cm². Spectrographs viewed the target-ablation plasma longitudinally (end on) and transversely (from the side). By masking off part of the laser beam, the plasma length could be varied continuously from 0.2 to 7 mm. Relative to the surrounding lines, the intensity of the 105.7 Å line varied strongly with length. The variation of line intensity with length was used to calculate absorption coefficients for a number of emission lines. The absorption coefficients were positive for the surrounding lines but negative for the 105.7 Å line, indicating a gain of 1 cm^{-1}. Gain was observed with the 20-ns pulse at all points on the plasma density profile. When a 2-ns pulse of the same energy was used, inversion was not observed near the target axis but was observed in the lower-density region 75 μm off axis and beyond. The results indicate a miximum density for inversion.

The experimental results were corroborated by analysis. The rate equations for Al^{+10} and Al^{+11} with radiative and electron-collisional transitions were solved assuming a 1-keV electron temperature. The calculations predicted population inversion for the 105.7-Å transition at plasma densities below 10^{19} cm^{-3}, a density consistent with the gain profiles of both the 2- and 20-ns experiments.

D. Mosher

ONR London

FIRE PROTECTION FROM CARBON-FIBER MATERIALS

Panotex carbon-fiber garments and coverings, manufactured in the UK, must be among the world's best protections against fire. A human in a heavy fire suit, for example, can withstand temperatures of up to 1500°F for short periods; the outer skin of the suit is of aluminized Panotex, and there are several inner layers of woven or knitted Panotex mixed with other materials. Dressed in this garment, rescue workers could literally walk in the flames of a petroleum fire. The padding is thin enough for the operator to handle tools and to insert them easily into pockets on the outside of the suit. Lighter suits can provide protection of up to several hundred degrees. The key to the protection is the Panotex fiber material itself, which has been developed by Universal Carbon Fibres Ltd., Knaphill, Surrey (UK). Though very thin, cloths made from Panotex fibers are intrinsically resistant to most acids, alkalis, and solvents, and unlike KEVLAR and other materials now used in fire suits, Panotex will not soften or melt at temperatures in the 500-degree range. In addition to the garment applications, Panotex fabrics are also reported to be useful in the fire protection of furniture, aircraft seats, walls, and electrical cables.

N.A. Bond, Jr.

ONR London

POLYMER DOSING OF SEWAGE

When certain water-soluble polymers of high molecular weight are added to water, the flow rate of the resulting solution in a pipe may increase. It is believed that the macromolecules in solution affect turbulence formation and thus reduce drag. This well-known property of polymers has been applied for several years to a sewage system in Bristol, England. As in many cities, Bristol's sewage drains are normally adequate, but in heavy rainstorms the additional load can cause flooding, and even slight improvements in carrying capacity may mean the difference between adequate and inadequate sewage disposal. The storm peak load may be several times the dry weather flow. The Bristol experience shows that capacity can be increased by 25% or more in a 300-mm pipe serving 10,000 people and that the costs of providing the dosing equipment and the polymer additives themselves are quite low relative to building a new sewer.

The Bristol people have tried various ways of injecting the polymer and have concluded

that an automatic dry-powder injector plant is the most practical for their 300-mm sewage pipes. Chemical costs per year for polyethyleneoxide (polyrx WSR-301) are on the order of several hundred UK pounds per main pipe, and the automatic injection plant costs about 10,000 pounds. All the tests so far done on the treated effluent suggest that the polymer levels would never reach biologically significant levels.

N.A. Bond, Jr.

ONR London

A CONTROVERSIAL SELECTION TEST FOR PILOTS

European defense ministries differ sharply in their opinions about the Defense Motivation Test (DMT), a projective test instrument. Several air forces, notably those in Scandinavia and West Germany, have used the test for some years. The test is called projective because the important aspect of a subject's response to a test item is not whether he gets the "right" answer, but rather his "personal style" in approaching the task. As an illustration, in one item a picture of a boy holding a violin is briefly flashed on a screen and the test subject has to draw what he can remember from the short exposure. DMT protagonists claim that those testees who can reproduce the boy's figure rather accurately are more apt to be accident free and to be successful pilots. If a subject devotes much attention to a second and threatening human figure in the scene, that focus is taken as a negative indicator.

Public and professional controversy over the DMT flared again recently when a University of London professor announced at the British Association for the Advancement of Science meeting that the DMT had "predicted" 13 out of 14 trainee deaths in the Swedish Air Force. Out of a total of 229 Swedish trainees, 14 were killed in air accidents, and a study of the records showed that 13 of these had unsatisfactory DMT scores; however, the fraction of accidents among the entire set of unsatisfactories was not disclosed. In fact, normal score distributions and complete "hit rate" data for the DMT are remarkably difficult to find. Test manuals, scoring procedures, and reliability coefficients are also not fully standardized or reported and are often closely held by the using military agency.

The Royal Air Force (UK) concluded a couple of years ago that the DMT made no additional contribution to the ordinary intellectual and sensori-motor test battery. The French Air Force also evaluated the DMT and rejected it. At present, the situation seems to be that some countries are strongly devoted to the test, others reject it as near quackery, and a thorough evaluation that could satisfy nearly everybody has never been carried out. There may be certain similarities to the "Rorschach boom" of some 30 years ago. In the 1950s, many clinicians administered the Rorschach test and claimed to find the scores useful; projective scoring techniques were taught routinely to graduate students in psychology and psychiatry. Over the years, however, as the results from study after study became available, it was gradually realized that Rorschach scores were unreliable and invalid, and the test is now little more than a curiosity pursued by a few specialists. Most of the rich psychoanalytic conjectures about the projective meaning of Rorschach responses are now forgotten.

Certainly this would be a good time to ventilate and to validate the DMT. If aspects of the test measure up to the usual psychometric standards, many countries could take it seriously as a possible selection instrument. Perhaps an international validation study, say in several European countries, would be desirable. With the fairly large annual cadet inputs, definitive studies could be made in a couple of years. Whether or not the DMT turned out to be accepted or discredited, an international validation effort itself should produce better understanding of the pilot selection process, and there would probably be some surprises in the way that conventional selection instruments "stand up."

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BRITISH CONTRACEPTION FOLLOWUP

Male sterilization is the safest form of contraception and is nearly 10 times as effective as "the pill." That conclusion comes from the Department of Community Medicine at Oxford University, which recruited 17,000 British married women in 1968-74 and has followed up their pregnancies ever since. The failure rate of male sterilization was only 0.02%, compared to 0.13% for female sterilization and 0.16% for oral contraceptives. In the study, failure rate was taken as the number of unplanned pregnancies divided by person years of use.

The rhythm method had the highest failure rate, 15.5%, with chemical contraception following closely at 11.9%. Because all the women in the sample were enrolled at British family planning clinics, their cooperativeness and willingness to follow instructions were probably higher than in most contraception surveys. In any event, the failure rates cited in the Oxford study were low compared to those in other developed countries and are probably representative of what can be expected under optimal conditions.

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EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Dr. A.K. Jonscher	Dept. of Physics Chelsea College London,UK	NOSC San Diego (12/13 October 1982) NSWC White Oak (October 1982)
Dr. G. Ottaviani	Physics Institute Modena, Italy	NRL (15 November 1982)
Dr. W.G. Price	Dept. of Mech. Eng., Brunel Univ., Uxbridge, UK	DTNSRDC ONR Arlington USNA Annapolis NPS Monterey (All October 1982)

ONRL REPORTS

C-1-82 NATO AGARD Conference on "Propagation Effects on ECM-Resistant Systems *in Communication and Navigation*," by J.M. Goodman

The 30th symposium of the Electromagnetic Wave Propagation Panel of NATO/AGARD was held from 24 to 28 May 1982 in Copenhagen, Denmark. A discussion of the proceedings is contained herein along with appropriate clarifications and personal reflections. The conference dealt with various issues related to the ECM-resistant systems in communications and navigation with special emphasis upon propagation influences. Contributed and review papers covered propagation effects and limitations, system adaptation, and the interaction of specified systems with the environment. The report also describes a concluding round table discussion in general terms.

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