SERC BULLETIN

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IN THIS ISSUE

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The Science and Engineering Research Council is one of five research councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through the provision of grants and studentships and by the facilities which its own establishments provide for academic research.

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SERC ***Annual Report*** (available from PRU, SERC Swindon Office; price £6.00) gives a full statement of current Council policies together with appendices on grants, awards, membership of committees and financial expenditure. ***SERC Bulletin***, which is normally published three times a year, summarises the Council's policies, programmes and reports.

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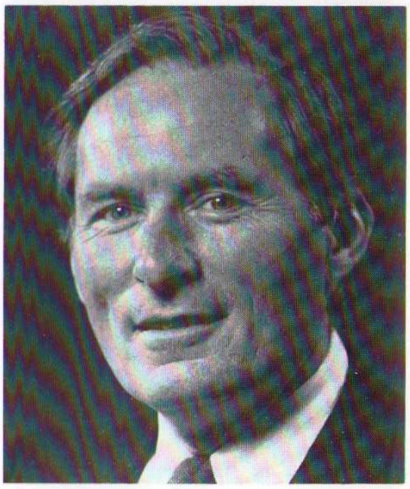
Sir Alec Merrison, 1924 - 1989

The death of Sir Alec Merrison FRS on 19 February 1989 at the age of 64 brought to an end a career of extraordinary success and diversity. A physicist educated at King's College, London, he carried out research in nuclear physics at Harwell and Liverpool University. From there in 1958 he went to CERN, where he headed a group which carried out a series of key experiments, including the dramatic observation of the direct decay of pions to electrons.



Sir Alec Merrison, FRS

In 1962 he was appointed the first Director of Daresbury Laboratory, where he headed the design and construction of the 4 GeV electron synchrotron NINA. Commissioned in record time, this provided the basis for an important range of experiments in particle physics. He left in 1969 to become Vice Chancellor of Bristol University, a position he held for 15 years.

There seemed to be no limit to the range of his activities, in and out of nuclear physics: Chairman of a study into the causes of failure of box-girder bridges, Chairman of a Royal Commission on the NHS, Chairman of the ABRC, President of the CERN Council, President of the Institute of Physics, a Director of Lloyds Bank, a Governor of the Bristol Old Vic Trust, etc, etc.

To all these activities he brought his talents of outstanding leadership, judgement, and robust common sense. A born deflator of stuffed shirts, he inspired total commitment and loyalty in all those who worked with him. Above all he brought a sense of full-blooded enjoyment and fun which he shared with all around him.

Dr R G P Voss
Head of Engineering Division
SERC Swindon Office

Congratulations to ...

... the following on their election as Fellows of the Royal Society on 16 March:

Professor A J Cain (Liverpool University), former member of the Biological Sciences Committee;
Dr M S Child (Oxford University), former member of the Science Board Computing Committee;
Professor A G Davies (University College London), former member of the Chemistry Committee;
Dr D Hull (Cambridge University), former Chairman of the Polymer Engineering Subcommittee and member of the former Polymer Engineering Management Committee and Materials Committee;
Professor J P Simons (Nottingham University), former member of the Laser Facility and Chemistry Committees.

Front cover picture

The die drawing laboratory at Leeds University, where the Polymer Physics Group has come up with exciting new developments in oriented polymers. A biaxially oriented tube of bright yellow polyethylene is made by drawing through a die followed by an expanding mandrel. See page 12.

Council commentary

Engineering strategy

At its last meeting of 1988, the Council discussed a strategy document from its Engineering Board. The Board had wished to take stock of the expanding area of its interests and had concluded that its overall objectives should be unchanged and that their attainment should be through the continuing use of planned, coordinated and managed programmes. These objectives are:

□ providing high-quality, highly trained, postgraduate manpower;
□ supporting excellence and stimulating innovative ideas;
□ identifying and supporting coordinated research programmes in selected areas of high national priorities;
□ supporting research in collaboration with industry, with appropriate technology transfer.

New IGDS programmes

The Integrated Graduate Development Scheme (IGDS) allows graduate students in employment to deepen and extend their technical knowledge by attending a coherent programme of short courses at postgraduate level (see *SERC Bulletin* Volume 3 No 12, Autumn 1988). The IGDS was pioneered by SERC in 1980 and has since proved that it has a ready market. At its December meeting, the Council approved a further six programmes. They are:

Liverpool University, Liverpool Polytechnic, University of Manchester Institute of Science and Technology: *Process and manufacturing engineering;*

Manchester Polytechnic: *Polymer engineering;*

Brunel University, Loughborough University: *Packaging technology;*

Durham University, Newcastle University, Newcastle Polytechnic, Sunderland Polytechnic, Teeside Polytechnic: *Manufacturing systems engineering with marketing;*

Sheffield University, Sheffield Polytechnic: *Metal-based technologies;*

Queen's University of Belfast, University of Ulster: *Advanced manufacturing technology.*

Four programmes are already in operation and approval has been given for a total of 12. The Council is conscious that, given funds, this scheme could be expanded dramatically; it is equally clear, however, that having promoted this important innovation, it is impossible for SERC to bear the sole burden of a truly national provision of training of this type and it is therefore encouraged that the Department of Trade and Industry (DTI) and the Training Agency are willing to take part in financing appropriate parts of the scheme.

Research fellowships for 1989

The Council approved 18 awards to start in 1989 under its Advanced Fellowship scheme. These had been selected from a field of applications showing a very high quality. Of the 76 applications received, 34 were ranked 'alpha'.

The Council's Senior Fellowships scheme has been operating at a level of two awards annually for some years. The Council has decided to raise this to three, funding the increase by restricting to salary-only the value of each award, and asking the Fellows' host institutions to bear the salary-related costs.

International organisations

The Council approved payments for the coming year relating to UK membership of the following international bodies:

□ EISCAT, the European Incoherent Scatter association, which conducts research in the atmosphere and ionosphere using radar techniques.

□ ESF, the European Science Foundation, to which all UK Research Councils belong, and which promotes collaborative studies among its 18 member nations.

□ ILL, the Laue-Langevin Institute, which houses facilities for research using neutron beams, in which the UK is an equal partner with France and West Germany.

□ ESA, the European Space Agency, for which SERC is responsible for that part of the UK contribution which relates to the Science Programme of ESA.

Recent large grants

Approval has been received from the Department of Education and Science for the following new research grants:

Southampton University for setting up a very high field nuclear magnetic resonance facility for biological research — £520,000 over four years.

Cambridge University for a centre for research in molecular recognition — £733,000 over four years.

Forward Look

At its February meeting, the Council finalised its Forward look submission to ABRC and agreed working allocations for its programmes in the financial year 1989-90. Both these exercises took into account the additional funds that had been allocated to the science budget by Government in the most recent public expenditure survey (see *SERC Bulletin* Volume 4 No 1, Spring 1989: Supplement). The Council also approved a number of new commitments including notably the 1989 contribution to the European Synchrotron Radiation Facility and grants to support a second group of four Interdisciplinary Research Centres (see page 4).

'Foot and mouth' virus

The Chairman reported that the structure of the foot-and-mouth disease virus has been determined at close to atomic resolution by X-ray diffraction using the SRS at Daresbury Laboratory. The work was carried out by a group from the Laboratory of Molecular Biophysics at Oxford University and Wellcome Biotech led by Dr D Stuart of Oxford University. The project was initially supported by an SERC Exploratory Agreement and was continued under an 'umbrella' grant to the Laboratory of Molecular Biophysics from the Medical Research Council.

Anglo-Australian Telescope

At its March meeting, the Council approved payment of £1,227,000 as the UK contribution for 1989-90 to the Anglo-Australian Telescope Board (AATB), which operates under an agreement between the Governments of the UK and Australia. The Council also welcomed the annual report of the AATB for 1987-88, which contained scientific highlights of the year and instrumentation developments, as well as reporting on the main event of the year: the incorporation of the 1.2-metre Schmidt Telescope into the Anglo-Australian Observatory.

DELPHI solenoid

The DELPHI solenoid, the world's largest superconducting magnet constructed at the Rutherford Appleton Laboratory for the Large Electron Positron Collider at CERN (see page 9), is now operational in the underground experiment hall. The Chairman reported to the Council that it had reached the specified magnetic field of 1.2 Tesla and the definitive field plot had been completed satisfactorily. RAL would shortly be handing over responsibility for the coil to CERN.

Four new interdisciplinary research centres announced

SERC announced, after the February Council meeting, that a further four Interdisciplinary Research Centres (IRCs) were being set up. The new IRCs are in:

- **High performance materials (Birmingham University and University College of Swansea);**
- **Polymer science and technology (Leeds, Bradford and Durham Universities);**
- **Process simulation, integration and control (Imperial College and University College London); and**
- **Optical and laser-related science and technology (Southampton University and UCL).**

The four new centres are in addition to the five existing IRCs which the Council established during 1988 (see *SERC Bulletin* Volume 3 No11, Summer 1988 and Volume 4 No 1, Spring 1989). This latest addition represents continued investment by the Council in selected topics of basic and strategic importance which require simultaneous involvement of several disciplines.

The Council's awards are subject to approval by the Department of Education and Science, and further discussion with the institutions concerned.

The establishment of these four centres arises from some 44 bids for centres in seven strategic areas of science and engineering. The quality of the bids was high and many were excellent. It is the Council's intention that, within its limited existing funds, at least some of those proposals of the highest quality which could not be funded as IRCs should be supported by other means.

The Council is able to fund this latest group of IRCs from the extra funds allocated to SERC in the Science Budget, as announced by the Secretary of State in February; the total funding is £40.6 million over a six-year period (see *SERC Bulletin* Volume 4 No 1, Spring 1989: Supplement). The Council is at present considering how a further group of IRCs might be established in a year's time, and in what topics. However for any such endeavour it would require extra funds.

High performance materials

(Director: to be appointed)

An Interdisciplinary Research Centre in Materials for high performance applications, which will have its prime site at Birmingham, will bring together staff from the Departments of Metallurgy and Materials, Mechanical Engineering, Chemical Engineering and Engineering Production at Birmingham University, and the Department of Materials Engineering at the University College of Swansea, and will liaise closely with related research in mechanical design, electronics and surface engineering in the two Universities.

The IRC will focus primarily on the development of metals and metal matrix composites, and ceramics and ceramic matrix composites, in the immediate context of materials processing and manufacturing technologies, to meet the current and future needs of the aerospace, automobile, power generation and other industries. The IRC programme places heavy emphasis on a design-driven approach to materials development, with close involvement of supplier and user industries in programme implementation.

The proposed main building for the High Performance Materials IRC, at Birmingham University.

In order to achieve the integration of materials development with processing and manufacturing technologies, the IRC will carry out both 'foundation' and 'targeted' programmes. Foundation programmes in advanced manufacturing technologies, computer-aided materials engineering and property and microstructure assessment, will provide the knowledge, understanding and enabling technologies for transfer to targeted programmes, aimed at evolving specific new materials or products, driven by engineering requirements, over a two to ten year time-scale.

The IRC will provide a national focus for research in materials for high performance applications and will encourage collaborative programmes with academics from other academic groups and industry.

Polymer science and technology

(Director: Professor I M Ward FRS)

An IRC in polymer science and technology is to be set up at Leeds, Bradford and Durham Universities. The principal objectives of this centre will be to establish a focal point for the future development of polymer science and technology in the UK, to interface academic and industrial research in the field effectively and to provide a more substantial flow of trained polymer scientists and technologists. A substantial programme of wholly novel research is proposed which will build upon the recognised strengths of the consortium in polymer chemistry, physics and process engineering. This will cover the synthesis, characterisation and application of dendritic polymers, polymer networks, novel liquid crystalline materials and new conducting, piezo- and pyro-electric polymers. It is also planned to investigate the physics of ionic transport in polymers, scale up laboratory production of novel materials to commercially significant quantities, produce and investigate the physical properties of a range of polymer composite materials, and model and develop new polymer processing operations.

The work of the IRC will not only be of fundamental interest; much of it will be of significance to the industrial sector and it is planned to carry out some research jointly with companies. The IRC will also collaborate widely with other academic institutions throughout the UK.

Professor I M Ward FRS, Director of the Polymer Science and Technology IRC.

Process simulation, integration and control

(Director: Professor R W H Sargent F Eng)

The IRC in process simulation, integration and control is to be based at Imperial College of Science, Technology and Medicine, London. The IRC is a joint venture with the Agricultural and Food Research Council. Collaboration will be mainly between the Chemical Engineering Department and two groups within the Electrical Engineering Department, together with the SERC Centre for Biochemical Engineering at University College London.

Research will be directed as an integrated systems approach to all aspects of design, control and management in the process industries. The main emphasis will be on

Professor R W H Sargent F Eng, Director of the Process Simulation, Integration and Control IRC.

the development of methodology for process modelling, design, control and company-wide information and management systems. The research will be underpinned by the study of underlying theory and development of appropriate numerical methods and computer software tools.

The Centre aims to create a strong national research programme linking work in higher education institutions and industry with accompanying technology transfers. This will be achieved through a strong management structure with industrial participation.

Imperial College bases its Centre on a foundation of expertise built up over many years. The groups concerned are internationally renowned having developed, among other things, the chemical engineering processing software package called SPEEDUP, used internationally in both the academic and industrial worlds. The Centre will be able to build on current interdepartmental collaboration and the strong existing industrial and technology base. This will rapidly lead to radical changes in the design of processes, especially in the vital areas of batch processing and the processing of food.

Optical and laser-related science and technology

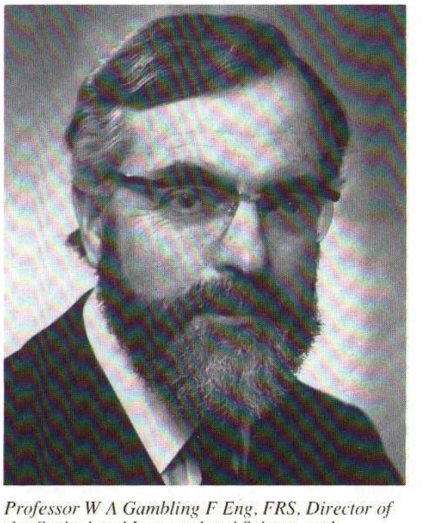
(Director: Professor W A Gambling FRS, F Eng)

The optical and laser-related science and technology IRC is to be based on the existing long-standing collaboration between groups in the Electronics and Physics Departments at Southampton University and the Electronic and Electrical Engineering Departments at University College London. There are new collaborations with the Physics and Chemistry Departments at Sussex University and electrochemists at Southampton, in the form of joint projects involving the ion beam facilities at Sussex. Further new collaborations are planned with the Physics and Electrical Engineering Departments at King's College, London, and Physics Departments at Kent and Oxford Universities. The Institute of Sound and Vibration Research at Southampton and the Centre for Applied Microbiology Research at Porton Down may also contribute.

The major objectives of the IRC are:

- ☐ To develop new miniature solid-state lasers for applications in communications, information systems and consumer products. The new lasers would have considerable advantages over existing diode lasers, being cheaper, more compact, more reliable, and capable of operation at visible wavelengths and kilowatt peak power;
- ☐ to establish an infrastructure and long-term capability for sophisticated and novel material processing;
- ☐ to marry together expertise in guided-wave optics with expertise in the traditional laser field in order to make significant progress in nonlinear optics, femtosecond pulse generation and transmission, optical switching, optical sensing, and optical signal processing;
- ☐ to identify applications for realistic solid-state light sources and the wide range of optical components, devices and systems which will result from the IRC programme with a view to long-term commercial exploitation.

The IRC will build on the good record for innovative advances in optical research at Southampton and extend the strong research base at Southampton and UCL. This base covers fundamental physics, chemistry, biochemistry and electronics; optical and laser materials fabrication, fibre fabrication and biochemical materials. It extends also to special fibres, active and passive devices based on fibres, and optical biosensors.



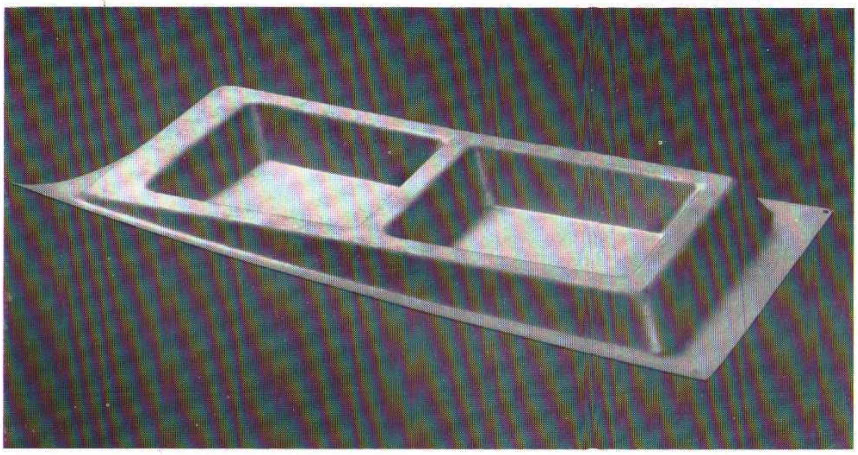
Professor W A Gambling F Eng, FRS, Director of the Optical and Laser-related Science and Technology IRC.

New LINK Programmes

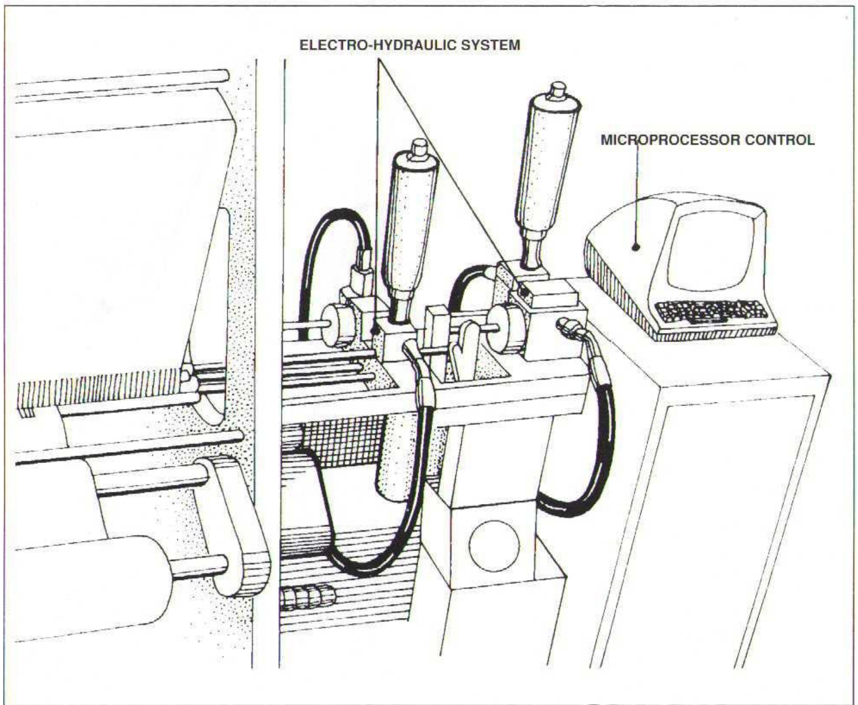
Six further programmes under the LINK Initiative have recently been announced. This brings the total number of approved programmes to 15 (see box on page 7). Brief details of the new programmes which involve SERC collaboration are given below.

Structural composites

This £40-million programme supported by SERC, Department of Trade and Industry (DTI), and industry aims to develop advanced composite materials of lower density but increased strength and stiffness, improved damage tolerance, and enhanced performance. Primary topics include new and improved polymeric, metallic and ceramic matrix composite materials and their associated surface, joining and processing technology; the integration of the scientific understanding of properties of materials with the design and manufacturing processes associated with specific applications; the development of practical non-destructive inspection techniques and lifetime prediction methods.



Superplastically formed module door made by British Aerospace from BP's metal matrix composites. (Photo: BP).



An electronic warp knitting machine to provide quick changeover times for manufacture of fabrics is being developed at Leeds University under the High Speed Machinery initiative.

For further information contact Richard Lindgren, telephone 0793 411109, at SERC Swindon Office, or the LINK Structural Composites Programme Secretariat, Department of Trade and Industry, Ashdown House, 123 Victoria Street, London SW1E 6RB; telephone 01-215 6305.

Ventilation, air conditioning and refrigeration

This £3-million programme funded by SERC, DTI and industry aims both to encourage the transfer of new technology into this relatively traditional area, and to enhance understanding of component interaction, and thus optimise performance of total systems. Primary topics include generation and transmission of sound, building environmental performance, control technology and fault diagnosis, heat transfer, novel refrigeration cycles and refrigerants, and design of advanced turbo-machinery.

For further information contact Sue Charlesworth, telephone 0793 411487, or the LINK VACR Programme Secretariat, telephone 0793 411335, at SERC Swindon Office.

Design of high speed machinery

High speed manufacturing machinery, capable of high quality outputs and rapid responses to variable market demands, has applications across all industrial sectors. This £20-million programme, supported by SERC, DTI and industry, aims to promote the design, construction and utilisation of such machines. Key themes in this programme are microprocessor-controlled electrical motors; cams, linkages, mechanisms and computer simulations; sensors, transducers, and feedback systems; enabling technology including safety, reliability, and noise and vibration; computer control of machines and processors.

For further information contact Louise Johnson, telephone 0793 411117, or the LINK Design of High Speed Machinery Programme Secretariat, telephone 0793 411425, at SERC Swindon Office.

Protein engineering

This £8-million programme is supported by SERC, DTI, AFRC, the Medical Research Council (MRC), the Ministry of Defence and industry. The programme aims to develop the systematic ability to design proteins rationally with new or improved properties, and to advance the understanding of structural properties and the rules governing structure and function and biological activity. Main topics within this programme include tertiary structure determination, protein structure/function relationships, and mutagenesis and expression of proteins.

For further information contact Neil Viner, telephone 0793 411279, at SERC Swindon Office, or the LINK Protein Engineering Programme Secretariat, Biotechnology Unit, Laboratory of the Government Chemist, Queen's Road, Teddington, Mddx TW11 OLY; telephone 01-943 7358.

Biochemical engineering

Biochemical engineering is concerned with the exploitation of biotechnology through the development and operation of industrial-scale equipment and processes.

This £15-million programme, which is sponsored by SERC, DTI and industry, will consist of a range of collaborative projects between equipment manufacturers, bioprocess companies and higher education institutions. Primary topics include innovative downstream processing, fermentation, process control and asepsis, containment and the environment.

For further information contact Neil Viner, telephone 0793 411279, at SERC Swindon Office.

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The sixth new programme, which does not involve SERC, has been announced in **Food Processing Science**.

Contact points are: The Laboratory of the Government Chemist, Queen's Road, Teddington, Mddx TW11 OLY, telephone 01-943 7000, and the Ministry of Agriculture, Fisheries and Food, 17 Smith Square, London SW1P 3HX; telephone 01-238 5544.

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A programme in **Nanotechnology** was announced last year, initially supported by DTI and industry (see also page 8). It aims to support research into ultra-precision engineering to nanometric tolerances. SERC has now joined this programme as a participant. The total value of the programme, including the SERC contribution, has increased to £15 million. Key areas which will be supported by SERC are sub-surface damage in nano-machined structures; isotropic and anisotropic etch mechanisms; ion beam/target interactions; nano-joining and bonding; non-destructive evaluation of nanostructures.

For further information contact Stuart Ward, telephone 0793 411173, at SERC Swindon Office, or the LINK Nanotechnology Programme Secretariat, National Physical Laboratory, Teddington, Mddx TW11 0LW; telephone 01-943 6258.

LINK general aims

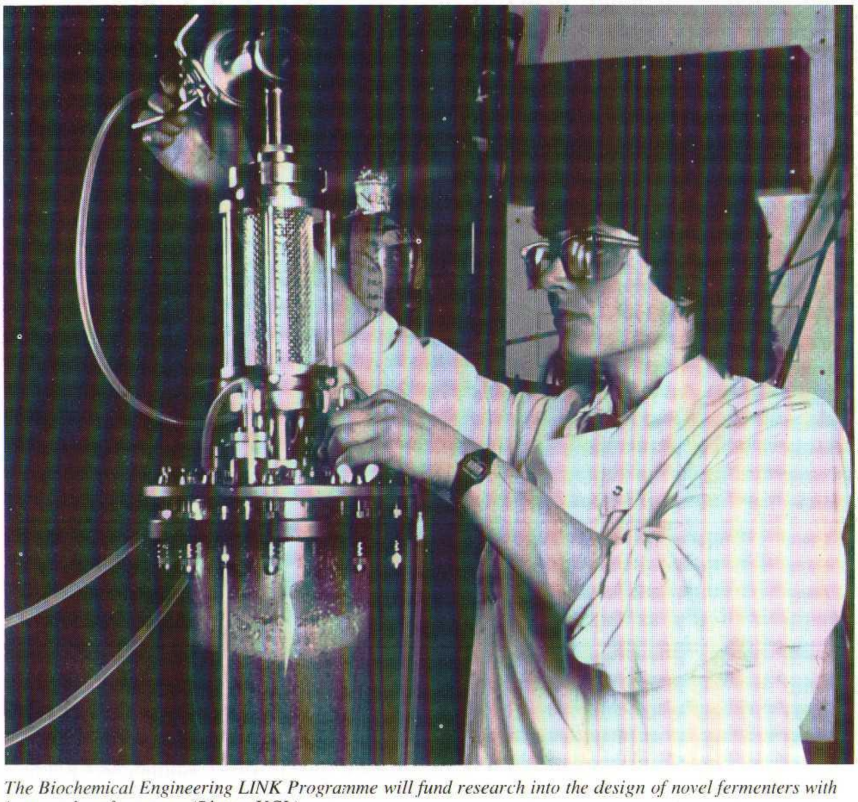
The LINK Initiative aims overall to encourage strategic research of medium-term industrial significance, increased industrial investment in such R&D and, by strengthening links between industry and the science base, improve transfer of new technology into industry. LINK operates by supporting collaborative pre-competition research projects involving industry and the scientific community. Up to 50% of the cost of these projects is available from government sources.

LINK programmes announced last year are:

Programme	Value £ million	Sponsors
Molecular Electronics	20.0	SERC, DTI, MOD, industry
Advanced Semiconductor Materials	24.0	DTI, SERC, industry
Eukaryotic Genetic Engineering	4.4	SERC, DTI, industry
Industrial Measurement Systems	21.8	SERC, DTI, industry
Biotransformations	4.0	DTI, SERC, industry
Selective Drug Delivery and Targeting	3.0	SERC, MRC, DTI, industry
Personal Communications	12.7	DTI, SERC, industry
Construction Maintenance and Refurbishment	3.0	SERC, DOE, industry
Nanotechnology	15.0	DTI, SERC, industry

For further general information regarding the LINK Initiative contact:

Stuart Ward
LINK Çoordinator, telephone 0793 411173, or
Paul Tomsen
LINK Unit, telephone 0793 411162, both at SERC Swindon Office.



The Biochemical Engineering LINK Programme will fund research into the design of novel fermenters with improved performance. (Photo: UCL).

Nanotechnology study panel

Nanotechnology is a term generally used to describe ultra-precise engineering, to a scale where dimensions are measured in nanometres (1 nm=10^{-9}m). It is a generic topic, with implications in many scientific and engineering disciplines, and this very breadth created problems for SERC in seeking to assess what support it should provide. In consequence the Nanotechnology Study Panel was established in 1988 with membership drawn to reflect both industrial and academic viewpoints and to cover a wide range of interested disciplines.

The Panel defined nanotechnology as:

"The ultra-precision engineering of materials where dimensions or tolerances in the range 0.1 nm-100 nm are critical but not determined by the sizes of the atoms or molecules concerned."

Current activity

Nanotechnology involves the ability to position and control tools and materials to appropriate dimensions, the manufacture of surfaces and structures to nanometric tolerances, and the subsequent evaluation and characterisation of the components to confirm that tolerances have been met.

The Panel noted that there was a high level of activity in Japan, including the Yoshida nano-mechanism ERATO Project, and in the USA, particularly in the major centres at Cornell and Berkeley, and were concerned that there was little parallel for this in the UK.

Much of the current UK activity is supported by the Department of Trade and Industry through the National Physical Laboratory, both through in-house research and through the LINK Programme in nanotechnology announced last year (see *SERC Bulletin* Volume 3 No 12, Autumn 1988). SERC was found to be supporting a considerable number of relevant grants, but in the context of other initiatives and with little or no formal contact between the groups involved. There was certainly scope for extracting information from these studies for the benefit of the nanotechnology community.

Topics appropriate to SERC

As well as noting the relevance of some existing studies, the Panel identified several areas where a lack of basic understanding was beginning to impede progress and where little or no work was under way in the UK. These were:

☐ evaluation of sub-surface damage resulting from nano-machining and of the consequent implications for surface stability;

☐ the detailed mechanisms operating in isotropic and anisotropic chemical etching techniques and their relationship to microstructure;

☐ the 'mechanics' of interaction between the target and both focused and low energy ion beams;

☐ techniques for the non-destructive evaluation of nanostructures;

☐ techniques for nano-bonding and joining.

Nanotechnology is a subject of rapidly growing importance with significant industrial potential. The Panel thought it essential for SERC to support work in the areas that it had identified. In its report, which was presented in December 1988, the Panel recommended that:

☐ SERC make appropriate provision to support work in the topics identified above;

☐ SERC become a partner in the current LINK Programme in nanotechnology and funnel its resources for nanotechnology through this;

☐ a coordinator be appointed to interface between groups working in nanotechnology, including those whose work is supported under existing initiatives, and also to interface between SERC and the LINK Programme.

Following subsequent discussions within SERC, this report has been accepted by the Council. SERC has become a partner in the LINK Programme, contributing £1.5 million over five years to support work in the topics identified by the Panel (see also page 7). A coordinator is to be appointed to oversee SERC activity in nanotechnology, which will be located within the Materials Science and Engineering Commission.

For further information regarding SERC support for nanotechnology, contact: Stuart Ward (telephone 0793 411173) at SERC Swindon Office.

Dr D A Melford F Eng
Chairman
Nanotechnology Study Panel

An example of the use of showered ion beams for ultra-precision forming of a diamond stylus. Left: a nominally hemispheric tip with radius about 5 microns — the smallest that can be made accurately by conventional lapping and polishing. Right: the stylus sharpened to an extremely fine point (radius about 15 nanometres) under the action of controlled ion bombardment and simultaneous rotation about the axis of symmetry. (Photo: Warwick University).

A future for the UK in CERN

The announcement that the UK is to remain a member of CERN, made by SERC Chairman Professor William Mitchell to the CERN Council in December 1988 (*SERC Bulletin* Volume 4 No 1, Spring 1989), came as a great relief to British particle physicists. Uncertainty created by the recommendations of the 1984 Kendrew Report, that the UK should withdraw from CERN unless its annual financial contribution could be substantially reduced, was heightened when adverse movements in exchange rates in the immediately following years produced instead a steep rise in the UK contribution. At the UK's instigation the CERN Council commissioned a review by an independent international committee chaired by Professor A Abragam, which reported in December 1987. Reforms negotiated during 1988, arising from the Abragam recommendations, contributed in large measure to the Government's decision, writes David Thomas, head of SERC's Nuclear Physics Division.

A major reform has been agreed in the method of assessing the annual contributions of member states to the CERN budget. The new algorithm relates contributions more closely to the current wealth of each country, and has the effect of stabilising each country's contributions in its own currency — apart from any real or inflationary changes in the CERN budget itself. For the UK, there is likely to be a dramatic reduction of almost 20% from the high of £55 million in 1988 to about £45 million a year from 1990 onwards — a level that should be little affected by future movements in exchange rates, although it will continue to be affected by any change in the net national income of the UK relative to that of other CERN member states. An 'early departure' scheme and limitations on recruitment will reduce CERN staff by 15% over eight years. Significant savings on personnel costs will be achieved from 1992 onwards. Services to visiting scientists are being improved. Changes are being implemented in financial procedures, in personnel management and in the management structure. New approaches to the participation of scientists from non-member states in CERN programmes are being studied, with the objective of increasing the total resources available and reducing the proportion of the costs borne by member states. All these measures are expected to lead to improvements in efficiency and/or further reductions in costs without damage to the scientific programmes.

It is expected that the first collisions of electrons and positrons will be achieved in the 27-kilometre circular LEP (large electron-positron) collider sometime this Summer, and the first data are expected to be recorded in the four major LEP experimental arrays. UK particle physicists are involved in three of these, code-named ALEPH, DELPHI and OPAL. Over the past seven years, the efforts of half the UK high-energy physics community and £27 million of SERC funds have been devoted to the design and construction of the UK contributions to the experimental equipment. In addition, the 6-metre diameter superconducting DELPHI solenoid was constructed at RAL, under contract to CERN (see page 3 and *SERC Bulletin* Volume 3 No 11, Summer 1988).

The first stage of the LEP programme, with scheduled energies of 50 GeV per beam, is likely to last for three to four years. During this period, the physics region explored will be that close to the Z° — the mediator of the neutral weak interaction. The presence of the Z° increases the electron-positron cross-section by two to three orders of magnitude so that event rates of several million per year may be expected. The physics that can be explored ranges from searches for evidence of the missing 'top' quark and the Higgs scalar boson to establishing the number of lepton families (at present three are known — electron, muon and tau, each with its own neutrino). Even more exciting is the challenging prospect of the discovery of new particles or effects not encompassed by the "standard model".

The LEP experiments each have a different emphasis. They will all detect both charged and neutral particles, but their abilities to identify the particles and their spatial and energy resolutions are different, as are the techniques used in their construction.

LEP is not the only scientific programme at CERN, of course. There is still a flourishing programme at the SPS (Super Proton Synchrotron). This has now become an extremely versatile machine being able to operate in several modes: as a protron-synchrotron for fixed target physics, as a heavy ion accelerator and as a proton-antiproton ($p\bar{p}$) collider (as well as an injector to LEP). There is some UK involvement in all these areas, the largest effort being on the upgraded UA1 and UA2 $p\bar{p}$ collider experiments. The systematics of the Z° and $W\pm$ particles discovered in 1983 are being studied with much higher statistics and resolution, and new particles are being searched for. One of the most exciting results from CERN in 1987-88 involved a UK group at the SPS, where for the first time a non-zero result for the CP violation parameter ε'/ε was obtained. The result is in line with expectations of the standard model and is a sensitive test. Another area of activity at CERN is at LEAR, the low energy antiproton ring. Here two experiments have UK involvement and are just being installed; one is studying CP violation in K-meson decay and the other is studying meson resonances. Both use innovative techniques.

CERN is no longer the exclusive domain of particle physicists. The SPS has been successfully used to collide heavy ions (such as oxygen and sulphur) at energies of up to 200 GeV/nucleon. There are plans to use even heavier ions in an attempt to produce and study the predicted quark-gluon plasma state of matter. Increasing numbers of nuclear structure physicists are becoming involved in these experiments, although UK involvement is currently confined to a group from Birmingham.

The scientific prospects have never been brighter for some 130 UK physicists and 60 SERC-supported students whose research is focused on CERN.

Dr D V Thomas
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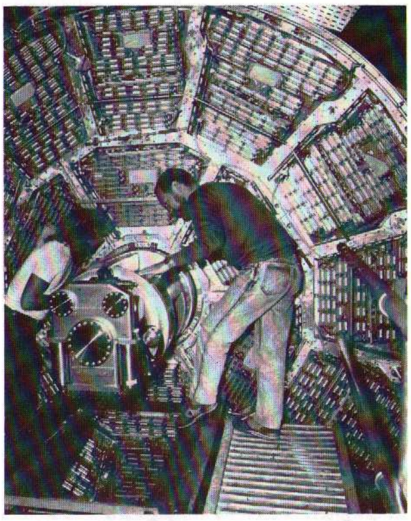
SERC Swindon Office



The successful final assembly of the ALEPH central detectors for CERN's large electron-positron collider. The large cylindrical time projection chamber is shown equipped with readout electronics on its end-plate, and the inner tracking chamber (built at Imperial College) fully inserted along its axis. (Photo: CERN).

Hybrid Monte Carlo and parallel processing with transputers

A new computer simulation technique known as 'Hybrid Monte Carlo' has made feasible numerical calculations in quantum systems involving many fermions. It was developed on the Meiko Computing Surface at Edinburgh University, which is partly funded by an SERC cooperative research grant. It is, writes Brian Pendleton of Edinburgh University and himself an SERC Advanced Fellow, a good example of the use of parallel processing techniques.

Many problems in classical physics are too complex to be amenable to analytic solution. The most powerful techniques developed for solving these problems are those of numerical simulation.

Computer simulations are performed by creating an artificial world inside the computer and measuring quantities of interest during the evolution of the system in computer time. For example, in condensed matter physics the technique of molecular dynamics (MD) uses large computers to integrate Newton's equations for the system of interest.

In statistical physics, Monte Carlo (MC) techniques use random numbers to generate typical configurations of the system inside the computer. By 'typical' we mean those configurations which are most likely to occur when the system is in equilibrium with itself and its surroundings. Averaging over typical configurations we obtain many interesting properties of the bulk material.

In both MD and MC simulations we represent the state of the system in the computer by a set of numbers — for example, the instantaneous positions and momenta of the molecules interacting with each other in liquid. Many interesting quantum systems include fermions (particles of half-integer spin). Unfortunately, due to the Pauli exclusion principle, the state of a fermion is not easily represented by an ordinary number and the usual computer simulations do not generalise. We have developed a simulation technique which takes the best features of MD and MC simulations and combines them into an algorithm which allows us to simulate quantum systems involving fermions quite readily. Fortunately, we can describe the basic features of this Hybrid Monte Carlo algorithm (HMC) for classical systems.

Numerical integration of Newton's equations for large systems is computationally intensive. To avoid truncation errors, one must step forward in time very slowly and it can take a long time for anything to happen. Our solution to this problem is to randomise the system's momenta occasionally and to combine the resulting 'hybrid molecular dynamics' with a Monte Carlo step. We integrate Newton's equations approximately using a large time-step and use a random selection criterion (based on the system's energy) to decide whether or not to include the current state of the system in our set of 'typical' configurations. The approximate integration scheme must satisfy a few crucial properties, but can be quite crude.

The main application of HMC is to quantum systems containing electrons, protons, and quarks. Once we have dealt with the Pauli principle, the equations of motions of fermion systems are highly complicated, but we do not have to solve them exactly: the Monte Carlo step takes care of the errors automatically.

We tested HMC on the problem of a simple harmonic oscillator in a heat bath for which we wrote a simple Pascal program. The method worked so well that we developed it for a much more complicated system: the quantum electrodynamics (QED) of strong electric charges. This required a more powerful machine; we used the Meiko Computing Surface, a large parallel computer constructed from many Inmos Transputers. QED is particularly suited to parallel processing as one can divide space and time into a lattice of points. By using the parallel processing facilities built into the occam programming language, one can perform an efficient HMC simulation. Each processor knows the state of its own local region of space-time and broadcasts this information to its neighbours. The results of our simulations were extremely encouraging and the project has developed into a large research effort on strongly coupled QED at Edinburgh University.

HMC has become the favoured calculational technique for most large quantum systems involving interacting fermions. A hot-bed of research where HMC has found favour is in the race to find a theory of high temperature superconductors. Here one simulates models of interacting electrons moving around the crystal lattice. Many groups world-wide are performing calculations in Quantum Chromodynamics (QCD) which describes the interaction of quarks and gluons inside the proton. For instance HMC is playing a central role in the US Department of Energy's 'Grand Challenge' programme to find a supercomputer solution to QCD.

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Drs Bowler and Kenway with a compute board from the Meiko Computing Surface at Edinburgh

Probing the scissors mode

A recent experiment at Daresbury's Nuclear Structure Facility (NSF) has helped to resolve a conflict between two different theories of the collective motion of neutrons in nuclei. In this article, Dave Warner of Daresbury Laboratory and Bob Chapman of Manchester University explain how it was done.

Nuclear physicists have known for a long time that many of the low-lying states of atomic nuclei stem from collective excitations which involve the correlated motion of neutrons and protons. These excitations can often be described in terms of the rotations and/or vibrations of a nucleus with a relatively well defined shape. The lowest energy excitations of this type involve quadrupole shape oscillations where the neutrons and protons move together (in phase), while at higher excitation energies, shape oscillations occur where the neutrons and protons move out of phase (isovector modes). If the neutron and proton mass distributions separate in this way, collective motion of a dipole type becomes possible. The best known example is the 'giant' electric dipole resonance which can be viewed as a translational oscillation of neutrons versus protons. In a nucleus where the equilibrium shape is ellipsoidal, the oscillation can take place along either the major or the minor axis of the ellipse, giving rise to a double-humped excitation spectrum (figure 1a). The intensity is greater for vibrations at right angles to the symmetry axis, because these may occur along either of the two minor axes.

Recently, world-wide attention has focused on the prediction of a new magnetic dipole mode in which the neutrons and protons perform rotational rather than translational oscillations (figure 1b). In effect, this is an oscillation in the angle between the symmetry axes of the neutron and proton ellipsoids which resembles the opening and closing of a pair of scissors; hence this excitation has been dubbed the 'scissors mode'. The first experimental data supporting the existence of the new scissors mode were obtained in the nucleus gadolinium-156 by electron scattering and, since then, many other examples have been located, in both rare earth and actinide nuclei. However, even as the new data were being obtained, an alternative explanation for them was proposed, based on the motion of two protons in specific orbits of high angular momentum (j).

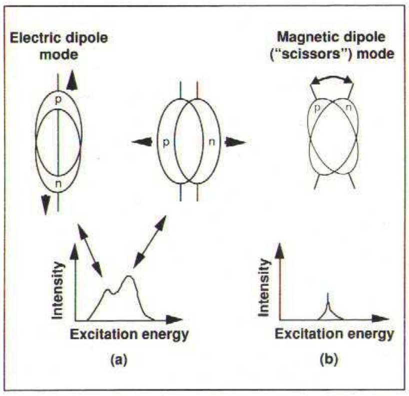

Figure 1: (a) The electric dipole mode and (b) the magnetic dipole mode of nuclear collective motion.

Ambiguity resolved

The ambiguity between these interpretations has now been largely resolved by a group of physicists from Manchester University, Daresbury Laboratory and the Niels Bohr Institute. The principle of their experiment, which was done at the NSF using the magnetic spectrometer, is illustrated in figure 2. The chosen target nucleus, holmium-165, has a single proton in one of the high angular momentum orbits of interest. By removing another proton from the holmium-165, dysprosium-164 nuclei are produced in states with *two* protons in the high-j orbits. The experimenters aimed first to locate these states and secondly to find out whether they corresponded to those excited most strongly in the electron scattering experiments.

The unique combination at Daresbury of a tritium beam and a high precision magnetic spectrometer was ideally suited to this task. The single proton was picked up from the holmium-165 in a collision with a triton to yield dysprosium-164 and an alpha-particle; the alpha-particle's energy is related to the two-proton state being studied. Alpha-particles emitted from the target at a chosen angle were bent by the spectrometer in a curved path using the strong magnetic fields produced by its three dipole magnets. The alphas were then brought to a focus in a gas-filled detector half a metre in length which identified them in terms of both their position on the focal plane (giving their energy) and their subsequent energy loss in the gas. With additional information from an angular distribution measurement, it was then possible to identify uniquely the energy of the two-proton state of interest in dysprosium-164.

An example of the energy spectrum of the emitted alpha-particles is shown in figure 2. The areas shaded black correspond to the two-proton state and reveal the location of a rotational band built on the basic configuration at an energy of 2.56 MeV. The relative intensities of the states in the band, their relative energy spacings and the measured angular distribution all give clues to the underlying structure. The states observed at lower excitation energy (to the right in figure 2) are well understood and stem from different configurations.

In the earlier electron scattering experiments the strongest excitations, which were postulated to be due to the scissors mode, were located at 3.1 MeV. This region of excitation energy lies to the left of the shaded band in figure 2, and the NSF measurements obviously reveal little or no proton transfer strength in this region. In the reaction studied, which involves the transfer of only one proton, there should indeed be little or no population of the collective scissors mode states, as that would require the rearrangement of many neutrons and protons. Thus the collective scissors mode description remains a plausible explanation for one or more of the states seen previously in electron scattering experiments.

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Daresbury Laboratory

Dr R Chapman
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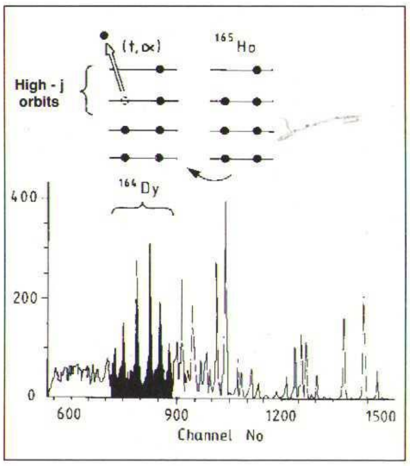

Figure 2: Alpha-particle spectrum showing the particular states populated in dysprosium-164 in the reaction.

Developments in oriented polymers

It is well known that the properties of polymers can be changed by fabrication processes, such as drawing or rolling, which introduce controlled degrees of molecular orientation. A simple example is the drawing of synthetic fibres like nylon or polyester to produce a desirable improvement in stiffness, strength and recovery from strain. Conventional processes, however, produce at best materials with a modulus in the preferred direction at least an order of magnitude less than the theoretical value calculated for a fully extended polymer along the molecular chain direction (figure 1). Recognition of this discrepancy between achievement and theory has stimulated considerable research, leading over recent years to exciting new developments in oriented polymers. The research is described here by Professor Ian Ward of Leeds University, recently appointed Director of the new Interdisciplinary Research Centre in Polymer Science and Technology (see page 4).

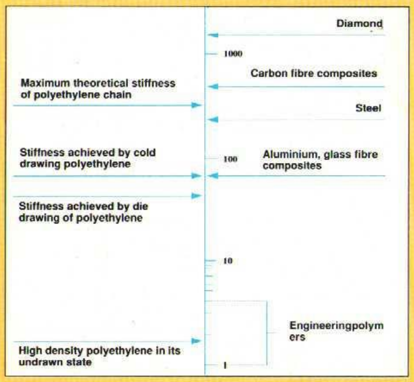

Figure 1: Comparative stiffness of typical high modulus materials.

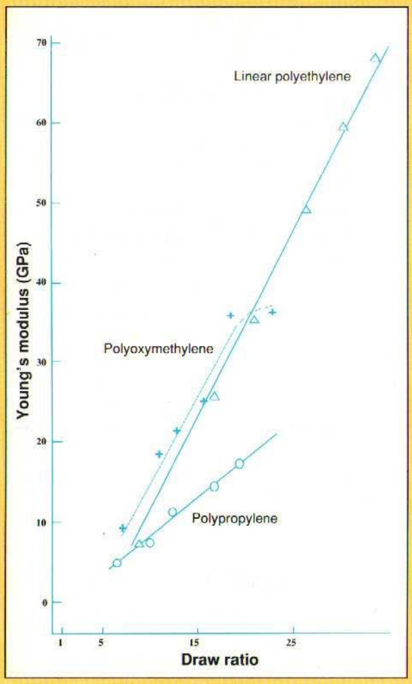

Figure 2: Young's modulus as function of draw ratio for polymers of high modulus.

Polyethylene particularly has been the subject of extensive investigation using various techniques such as controlled crystallisation from the melt followed by hot drawing, hydrostatic and ram extrusion, drawing of fibres from low-concentration solution, all of which can produce highly oriented materials. These investigations have confirmed that highly oriented molecular structures with significantly increased stiffness and other desirable characteristics are indeed possible. Of the various techniques examined, solid-state deformation processes initially appeared to offer the broadest base for scientific study. For this reason the Polymer Physics Group at Leeds University has for several years concentrated its efforts on the development of such processes, and studies of the structure and properties of the oriented polymers which can be produced.

Initial research on polyethylene showed that the widely held view of a 'natural draw ratio' in the general range 4-10:1 for common polymers was not correct. It was demonstrated that extremely high draw ratios of at least 30:1 could be obtained by careful control of polymer molecular weight, initial morphology and drawing conditions. Furthermore, it was shown that there is a unique linear relationship between the Young's modulus and the draw ratio for a range of different polymers (figure 2).

The conditions of draw required to achieve 'effective drawing' in which folded polymer chains uncoil and move relative to each other to produce finally an oriented structure of extended chains have to be closely defined for each polymer. Extensive investigation of the molecular orientation and morphology confirmed that fundamental structural changes take place during the drawing process resulting in a final structure consisting of highly crystalline regions linked by polymer chains or intercrystalline bridges, in which the disordered amorphous regions are also more ordered than in polymers drawn to low draw ratios.

As expected, these structural modifications give rise to substantial changes in the properties of highly drawn fibre or film. In polyethylene, Young's moduli at room temperature comparable with glass or aluminium have been achieved and, with the low density (0.96), give high specific modulus values compared with other materials (table 1). Yarn strengths are significantly increased to greater than 1.0 GPa (about 10 grams per denier), combined with 4-5% extensibility, which gives a yarn that does not exhibit the brittleness associated with other stiff fibres. It can therefore be safely handled and processed into yarn or fabric structures.

Characteristics of the highly oriented polyethylene structure in addition to increased strength and modulus include improved thermal stability and low shrinkage up to about 110° C; extremely low permeability to gases such as oxygen, helium and water vapour; and outstanding resistance to mineral acids, alkalis and solvents together with improved resistance to sunlight degradation. Spinning of high molecular weight materials in the form of low concentration gels is a further exciting development. When subjected to the same high-ratio draw processes as those for melt-spun fibres, high molecular weight polyethylene fibres attain 2.5-3.0 GPa strengths and 70-100 GPa tensile modulus, with other properties similar to the melt spun fibres. These outstanding values serve to illustrate the potential of this new technology.

Various applications have been evaluated for the melt-spun high modulus polyethylene (HMPE) yarns, to exploit their unique combination of stiffness, strength, high energy absorption, chemical resistance and lightness. In addition to industrial yarn and fabric uses, the reinforcement of matrices, both polymeric and cementous, has shown considerable promise, since the HMPE fibres incorporated into relatively brittle matrices impart ductility to the composite. Cement panels reinforced with HMPE fibres have been shown to be much less brittle than their asbestos-reinforced equivalents; extensive investigations with polyester or epoxy resin systems have shown that composites containing HMPE fibres, unlike equivalent combinations based on carbon, or glass fibres, do not shatter on impact but can withstand several impact tests before failure. Moreover, recent work with HMPE fibres in combination with glass and with carbon fibres indicates considerable potential for such hybrid composites, which may be used to obtain optimum properties in terms of performance, price and weight.

The significant improvement in impact resistance imparted by HMPE is now being exploited in dentures made of polymethylmethacrylate where clinical trials have shown that incorporation of HMPE fabric into the denture greatly reduces the incidence of breakage, with no adverse effects on denture appearance or wearer comfort.

For situations where bonding between fibre and resin matrix is important, the inherent poor adhesion normally associated with polyethylene can be markedly improved by plasma treatment of the fibre. Recent work has also shown that major improvements, including a dramatic reduction of creep, can be achieved by cross-linking the oriented structure using electron or gamma irradiation. High draw techniques on high density polyethylene (HDPE) polymers, in combination with plasma and electron radiation, can be used to produce monofils, multifilament yarns and tapes with the general properties outlined in table 2.

Further research at Leeds has shown that the principles established for fibre drawing can also be applied to produce oriented materials of larger cross-section. An important development is a die-drawing process in which a billet of isotropic polymer is pulled under controlled conditions through a converging die to produce rods, tubes, sheets and other profiles (see front cover picture). This process has been applied to a wide range of polymers, including HDPE; polypropylene (PP); polyoxymethylene (POM); polyester (PE); polyvinylidene fluoride (PVDF); polyvinylchloride (PVC) and polyetheretherketone (PEEK), with valuable results. The conditions required for effective drawing and the degree of drawing achieved vary with the particular polymer but in all cases beneficial effects have been obtained due to the increased molecular orientation.

The property enhancement achieved by die-drawing is not necessarily confined to increases in stiffness and strength, although in polyolefins and polyacetal, where high draw ratios are possible, these are significant, and moduli of 20 GPa (similar to wood, cement and bone) can be achieved. For example, die-drawn HDPE rods have been shown to be effective non-corrosive reinforcements in concrete, and expanded tubes in HDPE exhibit significantly improved hoop-strengths combined with greatly improved gas permeability and excellent chemical resistance. Clear tubes of both uniaxially and biaxially oriented polyester with outstanding toughness and gas-barrier properties have been produced. In PVDF, products with significant improvements in piezo-electric characteristics have already been commercially exploited in sensitive detector systems.

These developments have generated considerable commercial interest and collaborative research projects are in progress on various aspects of particular interest to individual industrial concerns. The die-drawing rig installed at Leeds has been used to investigate conditions for particular polymers and to produce practical sized samples for evaluation. At present a major research project is underway to develop a continuous die-drawing process using melt-extruded polymer rather than solid billets.

Although the industrial potential of these developments is considerable, and has been actively exploited by the British Technology Group in terms of licensing agreements, the important benefits to fundamental polymer science should not be underestimated. Over the years, investigations into many aspects of oriented polymers have taken place. These include studies of processing conditions for different polymers; properties of oriented materials under various conditions; end-use evaluation of products; deformation and fracture characteristics; computer modelling of processes etc. These researches have not only produced a comprehensive theoretical understanding of the processing, structure and properties of oriented materials but have also provided excellent training and experience for postgraduate students, research fellows and others.

Figure 3: Monofil, multifilament and tape samples in UHMPE.

The role of SERC over several years has been fundamental to these activities. The development of the die-drawing process was actively encouraged by the former Polymer Engineering Directorate, who provided support for the construction of a prototype production rig. The design and installation of this facility has enabled the scientific principles to be translated into operation. Furthermore, the production of samples of suitable size and in adequate quantity has proved invaluable in stimulating industrial interest and enabling their active involvement in these developments. In addition, an SERC rolling grant funded by the Materials Science and Engineering Commission has provided an excellent underpinning of these activities, encouraging new developments both in terms of exploring the fundamental science and in initiating new lines of investigation. The financial support and practical encouragement provided by SERC and BTG for the work at Leeds over many years is gratefully acknowledged.

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Table 1: Modulus values achieved by synthetic fibres and other materials

Material	Modulus (GPa)	Specific gravity	Specific modulus
Carbon fibre (RAE Farnborough)	420	2.00	210
Kevlar 49	127	1.45	88
Polyethylene (ultra-high modulus)	60	0.97	62
Kevlar 29	59	1.44	41
Steel	210	7.80	27
Aluminium	71	2.71	26
'E' -glass fibre	63	2.54	25
Polypropylene	7	0.91	8
Polypropylene ($\lambda = 25$)	20	0.91	22

Table 2: Characteristics of high-modulus polyethylene products

- Low specific gravity (0.96)
- Low moisture absorption (<0.01%)
- High specific modulus
- High strength and extensibility
- Good thermal stability over working range
- Good energy absorption
- High thermal conductivity in oriented direction
- Excellent chemical resistance
- Low oxygen permeability
- Good weathering resistance
- Excellent electrical properties
- Low friction

Initiative in new materials

An Initiative in the Synthesis and Evaluation of Materials for the 21st Century has been approved by the Materials Science and Engineering Commission (see *SERC Bulletin*, Volume 3 No 12, Autumn 1988), writes Sue Chambers of the Commission's Secretariat.

The aim of the Initiative is to support and encourage both basic and strategic research into the synthesis and evaluation of new and improved materials selected for their interesting and potentially valuable properties. The scope of the Initiative is wide, covering both organic and inorganic materials. Materials of interest would be, for example, those synthesised for their thermal and mechanical properties (such as advanced structural materials, polymer composites, metal matrix composites, ceramics, reinforced carbons and hard coatings); those synthesised for their electrical, magnetic and optical properties (such as semiconductors, non-linear optical materials, magneto-optical materials, molecular and polymeric conductors and thin films), and those synthesised for their chemical properties (such as water-soluble polymers and microporous crystalline and amorphous solids). Some of these areas are covered by more focused Initiatives (for example, Molecular Electronics) and in these cases the new initiative will be used to support initial proposals with a greater emphasis on synthesis.

Platelet crystals of an extremely hard ceramic — TiB2 — synthesised by carbothermic reduction. TiB2 could have applications in, for example the production of advanced armour, wear parts and electrode materials. (Photo: ICI Advanced Materials).

Although the strength of synthetic chemistry in the UK is widely recognised, the synthesis of novel materials has not been a major preoccupation of British chemists and so an important part of the Initiative will be to encourage greater involvement by chemists in this new and burgeoning field. If the UK is to feature as a major force in exciting new developments in the field of advanced materials and take advantage of the vast potential market which can be exploited by the use of new materials, it is essential that the physical sciences community be more oriented towards material research in the future.

For any programme to be supported under the Initiative, synthesis of new materials must be integrated with their characterisation and/or evaluation. The formation of collaborative groups involving scientists and engineers with expertise in synthesis and processing, and those with expertise in the characterisation and evaluation of the properties of materials will be encouraged. Collaboration with industry will also be encouraged and it is envisaged that a series of workshops with a major input from industry will aid this interaction. It is likely that the first workshop will cover aspects of ceramics.

The Initiative now falls within the remit of the Materials Science and Engineering Commission, although the Commission and the Science Board have jointly agreed to commit at least £800,000 to the Initiative for the current session. A further sum arising from expected new money to SERC is currently under discussion. It is expected that it will be possible beyond the current session to expand the programme, but this will depend upon the availability of funds which are, as yet, undetermined.

A Management Panel has been set up to oversee the Initiative, with members drawn from the academic and industrial communities and whose expertise covers a broad spectrum of materials. **Professor Allan Underhill** (Department of Chemistry, University College of North Wales, Bangor) who acted as Coordinator to the programme while it was under development, will continue as Coordinator to the Initiative. Professor Underhill has been at Bangor for over 20 years and has research interests in the areas of low-dimensional solids with unusual properties and conducting polymers. Although the Initiative has only recently been formally approved, it has been developed with pump-priming funds over the past two years. During this period a demand, totalling £5 million for 87 research grant applications involving 97 different scientists, was received and 28 grants have been awarded totalling £1.36 million. A demand totalling £1.8 million for 23 research grant applications was received for the 15 September 1988 closing date.

Professor Allan Underhill

The grants awarded over the pump-priming period have covered a broad spectrum of materials. Examples include the synthesis and characterisation of new magnetic and conducting materials (£70,600 awarded to Dr P D Battle and Dr T C Gibb of Leeds University and Dr M Kilner, Dr M R Bryce and Dr D Parker of Durham University); bulky selenide complexes: chemistry and materials preparation (£29,150 awarded to Dr M Bochmann of East Anglia University) and fundamentals of the formation of tin (IV) oxide films by MOCVD (£43,055 awarded to Dr P G Harrison of Nottingham University).

Further information can be obtained from SERC Swindon Office (telephone 0793 411110) or from:
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Dr Susan Chambers
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Electrochemical sensor for detection of hydrogen

Quantitative detection of hydrogen is of considerable importance in a variety of industrial situations, such as metal refining, in nuclear reactors and in many chemical processes, where a warning of the presence of hydrogen is desirable because of its explosive reaction with oxygen. There is therefore great demand for a robust, reliable, convenient and inexpensive hydrogen sensor. Dr Derek Fray of Cambridge University describes the development of such a sensor.

A variety of industrial situations, such as the synthesis of ammonia, methanol and other chemicals, petroleum refining, the manufacture of semiconductors, chemical reduction, corrosion control and general metallurgical purposes, require the detection and measurement of hydrogen. In metal processing, for example, hydrogen easily dissolves, as a result of interaction with moisture in the atmosphere, in the liquid alloys of iron, aluminium, copper and so on. When the metal solidifies during casting, the hydrogen solubility decreases dramatically leading to the formation of porosity, which adversely affects the mechanical properties of the metal. Once formed, porosity is difficult to eliminate, and so it is sometimes crucial to detect and control hydrogen levels before casting special alloys. In nuclear reactors, controlling the levels of hydrogen in liquid sodium coolant is important in order to avoid blockage or poor heat transfer or corrosion of structural materials. In many chemical processes, hydrogen monitoring can be used to improve process control, and to detect corrosion in pipework.

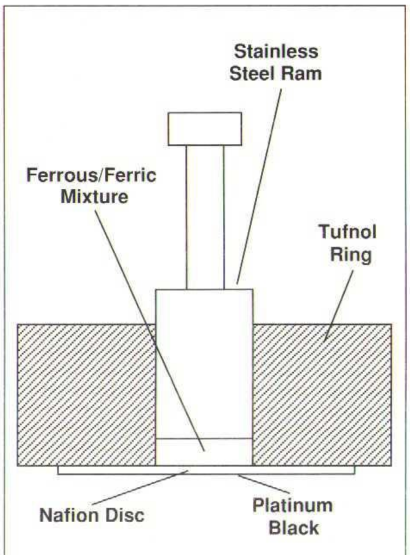

Figure 1: Schematic diagram of hydrogen sensor.

Conventional analytical techniques are not entirely adequate in the detection and monitoring of hydrogen, but gas sensors based on solid-state galvanic cells have a remarkable potential for meeting the very demanding criteria of ruggedness, reliability, simplicity of operation, quick and selective response, low energy consumption, low cost and compatibility with microelectronics.

In the Department of Materials Science and Metallurgy at Cambridge, a hydrogen sensor has been developed by the author and Professor David Morris, a visiting fellow from the University of New Brunswick, Canada. The operating principle is based upon a simple thermodynamic concept: that a concentration gradient of a species across an ionic conductor results in a potential which can be detected by a high-impedence voltmeter. The physical arrangement is shown in figure 1 and the sensor may be represented by:

$$H_2 | H^+ \text{conductor} | H_{2\,(ref)}$$

The potential (E), mentioned above, is given by the Nernst equation

$$-ZEF = RT\ln \frac{P_{H_2\,(ref)}}{P_{H_2}}$$

where $P_{H_2\,(ref)}$ represents the partial pressure of hydrogen of the reference mixture, P_{H_2} is the partial pressure of hydrogen at the sensing electrode, R is the gas constant, T is the temperature, F is Faraday's constant and Z are the units of charge carried. As the hydrogen conductor, Nafion (per-fluorocarbon sulphonic acid) was used and the reference hydrogen concentration was given by a mixture of ferrous and ferric ions in which the following equilibrium occurred:

$$2H^+_{(Nafion)} + 2Fe^{2+} \leftrightarrow 2Fe^{3+} + H_{2(g)}$$

The results showed that the sensor gave the theoretical Nernstian response for hydrogen or deuterium down to 50 ppm in argon. For hydrogen in reactive gases, it proved necessary to insert a palladium silver diaphragm between the Nafion and the gas.

By placing the sensor against a steel substrate it proved possible to detect the hydrogen generated by a corrosion reaction on the other side of the steel. The arrangement for carrying this type of measurement on gas or oil pipe lines is shown in figure 2. As Nafion is only stable up to 200°C, any measurement on molten metals can only be achieved by equilibrating an inert gas with hydrogen in the molten metal and exposing it to the sensor at ambient temperature; this has been successfully achieved using molten aluminium, copper and steel.

The sensor was partly developed under a grant from the former Materials Committee (now the Materials Science and Engineering Commission). Overall, it has been used in the laboratory to measure hydrogen in gases, solid and liquid metals and aqueous solutions. The invention is the subject of patent application in which the rights have been assigned to British Technology Group for commercial exploitation. The sensor has been licensed to Cormon Ltd for the exploitation of the device in corrosion monitoring and British Steel Corporation is carrying out plant trials using the device for the measurement of hydrogen in molten steel.

Dr D J Fray
Department of Materials Science and Metallurgy
Cambridge University

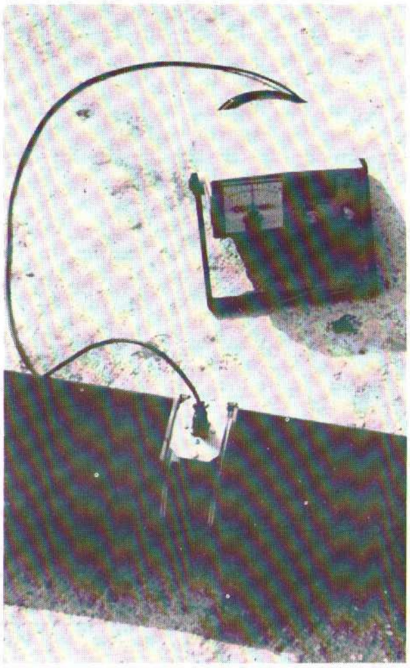

Figure 2: Sensor attached to a steel pipe.

The context of conditioning

The image of a dog in one of Pavlov's conditioning experiments is familiar to generations of psychology students. But recent research, writes Professor Nicholas Mackintosh of Cambridge University, shows a much more complex picture than that presented by Pavlov.

Pavlov's dog stands, restrained by a set of straps attached to a wooden frame, facing a one-way screen through which he can be observed by the experimenter. A bowl into which meat can be delivered sits on a table in front of him, and a tube attached to a fistula in his cheek collects drops of saliva in a graduated cylinder. The diagram in figure 1 does not even bother to show the metronome whose ticking will serve as the conditional stimulus (CS) signalling the delivery of the US or unconditional stimulus (the meat). But as everyone knows, after a certain number of conditioning trials, the dog will show that he has associated CS and US by salivating profusely whenever the metronome starts to tick.

But the CS forms only a small fraction of the total pattern of stimulation impinging on the dog when food is delivered. Might not these other stimuli, which together form the context in which conditioning trials occur, become associated with the delivery of food? If so, what would we expect to happen if the metronome was set to tick in a quite different context — in the animal's living quarters or in a different experimental room with no harness, one-way screen etc? Equally, in the dog's experience, the metronome has meant food only in this particular context. Will he necessarily assume that it continues to mean food if it starts ticking elsewhere? This too raises the possibility, although for rather different reasons, that conditional responding will be confined to the context in which conditioning occurs.

Rather surprisingly, for these questions have both practical and theoretical significance, until recently little more than anecdotal evidence has been available to answer them, and depending on which anecdote you chose to listen to, you could believe either that conditioning transferred perfectly wherever the CS was presented, or that it would be disrupted by seemingly trivial changes in context. According to our experiments, the truth is both simpler and subtler. The learned association between CS and US can indeed transfer perfectly from one context to another, but at the same time contextual stimuli do become associated with the US during the course of conditioning and these associations will contribute to the level of conditional responding to the CS observed by the experimenter.

Two of our experiments on conditioned fear in rats illustrate the point. Their design is illustrated in the box opposite. In both experiments, rats alternate between two distinctive conditioning chambers, on odd days receiving conditioning trials in context 1 to an auditory CS paired with a brief, mild shock (0.5 sec, 0.5 ma). The rats have been trained, in both chambers, to press a lever for occasional pellets of food, and conditioning to this CS is measured by the extent to which its presentation suppresses lever pressing. As can be seen in figure 2, conditioning occurs rapidly, and within a few trials the rats have stopped lever-pressing whenever the CS is turned on. In the next phase of the experiment, the CS is tested, without the US, over a series of extinction trials, either in the context where conditioning occurred (Group Same) or in the second chamber where the rats have been placed on alternate days (Group Diff). In this first experiment, as can be seen in the table, no CS or US had been presented during these alternate sessions in the second chamber. As can also be seen in figure 2, when the auditory CS is now presented there, conditioning is severely disrupted, although when, after a few days, rats in Group Diff are returned to the conditioning context, their fear of the CS is immediately, if briefly, restored.

In this experiment, therefore, the effects of conditioning seem largely confined to the context where it was established. The results of a second experiment help to explain why. As can be seen in the table, there is only one change in the design: here, during the initial alternate sessions in context 2, rats receive conditioning trials but to a quite different CS, a flashing light, paired with the same mild shock. But this difference is enough to change the results completely. Now, as can be seen in figure 3, when the auditory CS is tested in context 2, there is no loss of fear: even though this CS has been paired with shock only in context 1, there is essentially perfect retrieval of the CS-US association when it is presented in a different context. Why, then, did conditioning apparently fail to transfer from one context to the other in the first experiment? the simplest explanation is that contextual stimuli themselves become associated with the USs which occur in their presence, and that the moderate level of conditioning which results is enough to augment or potentiate the level of responding to a discrete CS. In the second experiment, Group Diff was tested in a context just as well associated with the delivery of shock as that in which the auditory CS had been conditioned, and there was no loss of conditioning. In the first, Group Diff was tested in a context that had no association with shock, and lacking its normal background potentiation, responding to the CS was apparently disrupted.

We have confirmed these findings with other conditioning preparations, appetitive as well as aversive, instrumental as well as Pavlovian, and have ruled out the possibility that the greater generalisation of conditioning from one context to another, when both contexts are associated with the US, could arise because the occurrence of a salient event like a US in both contexts somehow makes them seem more similar. We have also used other ways of manipulating the context of conditioning. One variant is to use the animal's pharmacological state as context.

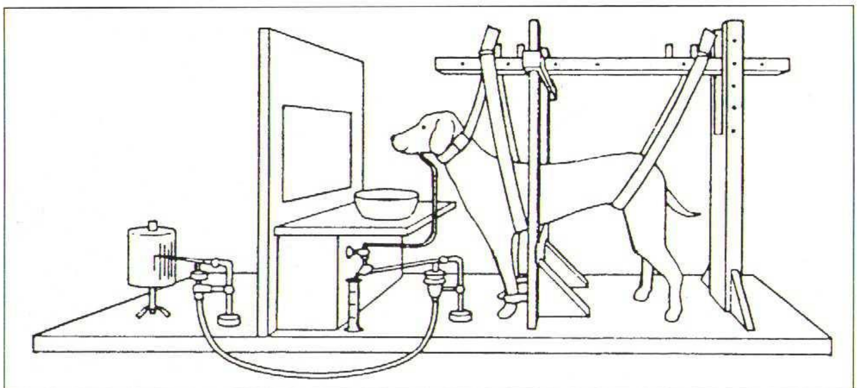

Figure 1: A dog in one of Pavlov's conditioning experiments.

Experiments on 'state-dependency' have shown that conditioning established under the influence of a drug may not be manifested if the animal is tested in the undrugged state (and *vice versa*). But in our experiments, this state dependency disappears when animals receive conditioning trials to two distinct CSs, one paired with the US on days when they have received the drug, the other paired with the US on drug-free days. Now conditioning transfers perfectly when each CS is tested in the opposite state. There is no evidence that retrieval of the CS-US association is dependent on reinstatement of the pharmacological state holding at the time the association was first established.

That the association between a CS and US — the knowledge that the CS predicts the US — can be retrieved regardless of a change of context or of pharmacological state, contradicts some received opinion. But the fact that, in spite of this, the level of responding to a CS may be markedly affected by the status of the context in which it is presented, may have important practical consequences. Certain psychological treatments for anxiety, for example, are assumed to work by extinguishing a previously conditioned anxiety state. If this treatment takes place in a secluded office, where pains are taken to ensure that patients are relaxed and unthreatened, we run the risk that when they return to the world where they learnt their anxiety, it will be reinstated. The test phase of figure 2 illustrates what we can expect to happen when anxiety is conditioned in a threatening place and extinguished in a place of safety: it will be restored as soon as one returns to the threatening environment.

Experiment 1

Conditioning	Extinction	Test
Group Same		
C1: CS → shock **C2: nothing**	**C1: CS alone**	**C1: CS alone**
Group Diff		
C1: CS → shock **C2: nothing**	**C2: CS alone**	**C1: CS alone**

Experiment 2

Conditioning	Extinction	Test
Group Same		
C1: Auditory CS → shock **C2: Visual CS → shock**	**C1: Auditory CS alone**	**C1: Auditory CS alone**
Group Diff		
C1: Auditory CS → shock **C2: Visual CS → shock**	**C2: Auditory CS alone**	**C1: Auditory CS alone**

C1 and C2 refer to two different experimental chambers or contexts.

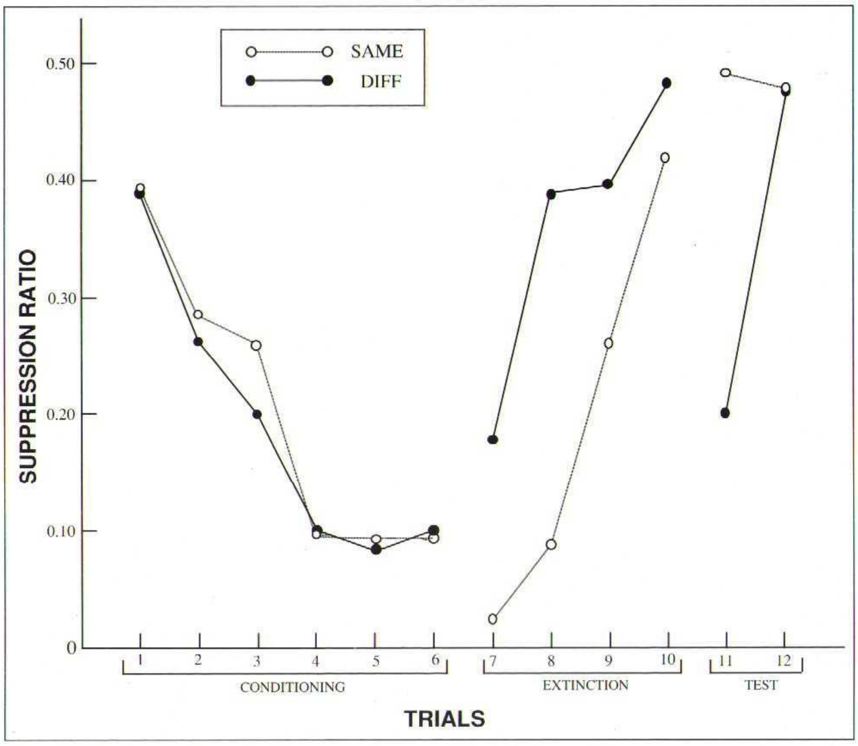

Figure 2: The first panel (conditioning) shows the acquisition of conditioned fear in two groups of rats to a CS paired with a brief, mild shock US. Fear is measured by the extent to which the CS suppresses lever-pressing for food: a suppression ratio of .50 indicates equal rates of lever-pressing in the presence and absence of the CS: no conditioning; one of .00 indicates the complete suppression of lever-pressing by the CS. In the extinction phase, the CS is presented for four trials without the US, for Group Same in the chamber where they were originally conditioned, for Group Diff in the second chamber. On the final two test trials, both groups are presented with the CS (without US) in the original conditioning chamber.

Professor N J Mackintosh
Department of Experimental Psychology
Cambridge University

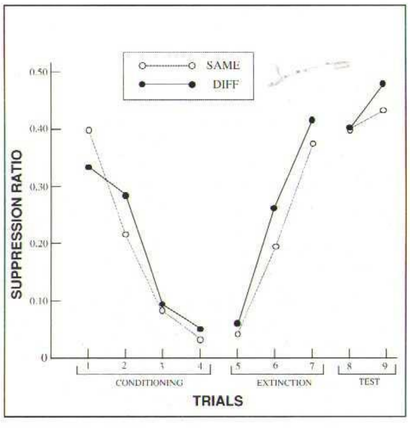

Figure 3: Results of the second experiment shown in the table. All details as for figure 2.

Krypton fluoride laser R&D at RAL

A research and development programme at the Rutherford Appleton Laboratory's Central Laser Facility that will lead to designs for uniquely high powered lasers was approved in principle by the Science Board at its April meeting. The lasers will be a development of the existing highly successful SPRITE system which is already available to users at RAL along with the world-leading VULCAN laser, writes Phil Rumsby of RAL.

SPRITE uses a new type of laser technology pioneered at the laboratory over the last few years. It operates with a mixture of gases as the active laser medium in place of glass as used in VULCAN. The advantage of working with this gas laser technology is that both capital and running costs are significantly reduced because of the cheaper material cost and higher efficiency — for example, the new developments are expected to lead to lasers with an efficiency of 1% or 2% compared with the 0.1% efficiency of VULCAN.

In addition, the new lasers will generate ultraviolet light directly whereas glass lasers make infrared light which then has to be converted to ultraviolet light in order to be useful for scientific experiments. Glass lasers are also far more susceptible to damage and prone to non-linear effects or distortion.

Ultra high power

Gas lasers using krypton-fluoride have been around for some years now, but their usefulness in terms of high performance laser facilities has been limited by difficulties of producing pulses of short enough duration. These problems have now been solved by RAL's SPRITE group who have shown that pulses from a KrF laser can efficiently pump a new type of gas laser known as a Raman amplifier. The Raman amplifier uses methane as the active medium and permits a sequence of KrF pulses to be efficiently combined in order to give the required short pulse duration and ultra high power for successful scientific target experiments. With the recent endorsement by the Science Board, the stage is set for the new technology's next development.

The VULCAN neodymium glass laser will continue to serve the scientific community well for many years to come. The research and development programme will lead to ultra high power lasers which could be in use by 1994 and could outperform VULCAN by a large factor, enabling UK scientists to maintain a world leading position in research using very high performance lasers.

Dr P T Rumsby
Rutherford Appleton Laboratory

Scientific results from the Cray

A report has recently been produced describing the scientific results from the first 18 months of operation of the Joint Research Council's Cray X-MP/48. The report is based on response to letters sent to all grant holders and describes a variety of existing research programmes which have benefited from the processing power of the X-MP/48.

The Cray X-MP/48 supercomputer operated for the Advisory Board for the Research Councils has been in use since April 1987 (see *SERC Bulletin* Volume 3 No 9, Autumn 1987). The reliability and performance of the machine have been exceptionally high and have led to a steady reduction in maintenance time. About 450 processor hours are delivered to users each week.

Dr Roger Evans being interviewed by Gargy Patel of BBC Radio Oxford at the press briefing on the Cray results in March.

The true scientific achievements will emerge only after the first round of three-year grants reaches fruition but here are some highlights from preliminary reports.

Protein crystallography — Simulated annealing and molecular dynamics have been used to speed the refinement of experimental crystallographic data. A 3.3Å resolution structure of rabbit serum transferrin shows for the first time the peptide chains connecting the halves of the bi-lobal molecule.

Bioreductive drug design — The fact that cancer cells have a reduced blood supply is being exploited by designing chemotherapeutic drugs which are active only when reduced.

Environmental sciences — The Cray X-MP is providing new, detailed models of the Antarctic Ocean, the North Sea, the upper atmosphere and global meteorology.

Epidemiology — The power of the Cray X-MP makes it possible to construct bias-free analyses of the clustering and geographical distribution of certain human cancers.

Computational fluid dynamics — New insights into the fundamental behaviour of turbulent fluids are being gained by sophisticated numerical modelling.

Structural engineering — Detailed models are being constructed for the elastic-plastic behaviour and crack propagation in tough pressure vessel steels.

Atomic physics — The power of all four Cray processors has been linked together to extend the range of atoms that can be modelled and to increase the accuracy of atomic collision cross-sections.

Particle accelerator physics — Previous objections to the use of lasers to drive high field particle accelerators have been removed by the discovery of a new non-linear self-focusing effect.

The report, *Scientific results from Cray*, is being sent to all Cray grant holders; anyone else wanting a copy should contact Linda Miles (0235-445790 or LMILES@UK.AC.RL.IB).

Roger Evans
Atlas Computing Centre
Rutherford Appleton Laboratory

A new probe for the atmosphere

At Capel Dewi, in a valley just five miles outside Aberystwyth, in Dyfed, Wales, an impressive array of 64 TV-style antennas can be seen, each one standing 5 metres high and 3 metres wide. This represents the first phase in the commissioning of the Mesopheric, Stratospheric, and Tropospheric Radar, a new SERC facility which will probe and monitor the Earth's middle atmosphere. This includes the troposphere, extending to about 10 kilometres; the stratosphere, occupying the next 30-40 km; and the mesophere, which extends to about 85 km above ground. The development of this facility, due to come 'on stream' towards the end of 1989, is a joint project between Rutherford Appleton Laboratory and the Physics Department of the University College of Wales, Aberystwyth, write Lance Thomas of Aberystwyth and Tony Hall and David Llewellyn-Jones.of RAL.

At the Capel Dewi site there is much evidence of the demanding activity required to prepare the site for the erection of a further 336 four-element Yagi antennas occupying a total area of 140,000 square metres. The power from five 25-kilowatt radio frequency transmitters is to be distributed to the antennas by a system of power dividers and a labyrinth of precisely cut cables. Arrangements are also made for introducing, by means of a system of relays, additional phase-delaying cable lengths for directing the beam at angles up to 12° about the vertical in two orthogonal planes. The returned signals, up to 6000 per second, are received in a high-performance receiver, then averaged and demodulated under the control of a dedicated computer which also spectrally analyses the data for the estimation of Doppler shifts and hence wind velocities.

The radar operates at a frequency of 46.5 MHz and the present 64-element array, powered by two of the transmitters, can detect useful echoes up to an altitude of 16 kilometres, spanning the troposphere and the lower stratosphere. The enlarged 400-element system will extend this altitude range to 30 km and also provide data for the mesopheric region between 60 and 85 km.

The radar system is designed to observe mean and small-scale atmospheric motions, including atmospheric waves and turbulence, as well as mesoscale features such as fronts and the jet stream. Research studies of these phenomena following the commissioning of the system are being planned by the Department of Physics at UCW, and by other university groups. A particularly interesting feature of the Aberystwyth plan is to coordinate the radar measurements with those of atmospheric structure and composition carried out with the Lidar systems of the department.

In addition to these research studies, the radar has applications in mesoscale meteorology and also in the aviation industry. For example, studies of turbulence and severe wind shear, which represent hazards to aircraft flights, are of vital importance. Also, the information gained on upper level winds could be useful in reducing fuel consumption for commercial airlines.

The importance to aviation was recently underlined by the fact that in the USA it has been announced that operational ST radars (rather simpler than the SERC facility) will be erected at 47 of the country's busiest airports with the purpose of enabling air traffic controllers to warn pilots of potentially disastrous wind conditions.

This new MST Radar has attracted considerable interest from scientists abroad. This was demonstrated at the International MST Radar Workshop held in November 1988, in Kyoto, Japan, where it was agreed that the next International Workshop should be held at Aberystwyth in two years' time, when the visitors will be able to see for themselves this recent addition to SERC's armoury of research facilities.

Professor Lance Thomas
(MST Radar Project Scientist)
University College of Wales, Aberystwyth

A J Hall and D T Llewellyn-Jones
Rutherford Appleton Laboratory

The SERC MST Radar antenna array, near Aberystwyth. Each antenna is a four-element Yagi, standing five metres high. The array will eventually comprise 400 antennas.

The management of technological change

The joint Economic and Social Research Council-SERC Committee is seeking good new proposals for its initiative in the successful management of technological change. It is particularly interested in supporting comparative studies of how competing countries manage technological change, and the career patterns of scientists and engineers in UK business and industry, writes Dr Maggie Wilson of the Committee's Secretariat.

The Joint ESRC-SERC Committee launched the initiative in 1986 because it felt that Britain needed to be more effective in the way it managed the exploitation of technology. The research specification invited applications in five main areas of interest:

☐ Qualified scientists and engineers in business
☐ The implementation of technology
☐ Technology in the service sector
☐ Environmental and societal constraints on technical change
☐ Production management.

More than 120 responses were received from which about one third were selected to proceed to the next stage.

A follow-up invitation was circulated in early 1988 to encourage applications with particular reference to:

☐ Technological change — strategic factors
☐ Technological change — human factors
☐ The implications of new technologies.

Some two dozen grants have now been funded and the Committee's current grants are listed below.

Continued on page 21.

Joint ESRC-SERC Committee: current grants

The impact of new manufacturing technologies on the manufacturing/marketing interface within the firm *(Department of Management, Bath University; Management Centre, Bradford University)*

Implementation of new technology in the polymer process industry *(Management Centre and Department of Mechanical Engineering, Bradford University)*

Investment in advanced manufacturing technology: benefits and justifications *(Management Centre, Bradford University)*

Electronic-funds-transfer at point of sale: operational marketing and organisational determinants of success *(Department of Business Studies and Research Centre for Social Sciences, Edinburgh University)*

New firms in the biotechnology industry: a study of innovation and growth *(Department of Business Organisation, Heriot-Watt University; Department of Management Science, University of Manchester Institute of Science and Technology:UMIST)*

The social organisation of police work and information technology *(Department of Sociology and Department of Behaviour in Organisations, Lancaster University)*

Social and technical formulation of expert knowledge for technological decisions *(Centre for Science Studies and Science Policy, Lancaster University)*

The management and diffusion of innovation in new and improved materials and processes *(Department of Economics, Department of Science and Technology, and PREST, Manchester University)*

Strategic innovations in the financial services sector. The role and management of computing expertise *(Department of Business Studies, Napier Polytechnic of Edinburgh; Research Centre for Social Sciences and Department of Computing Science, Edinburgh University)*

Exploring user mental models of advanced manufacturing processes *(Department of Production Engineering/Production Management, Nottingham University)*

Strategic and R&D decision-making in biotechnology *(Systems Department, Open University)*

R&D strategies and the management of technological change in a period of rapid restructuring *(Department of Technology and Department of Design Technology, Open University)*

Worker support for technical change and its implications for the management of technological change *(Policy Studies Institute)*

Creating and retaining qualified women scientists and engineers *(Policy Studies Institute)*

Human centred system development *(Department of Computer Studies and Department of Applied Social Studies, Sheffield Polytechnic)*

Manufacturing organisation for computer integrated technologies *(Management Department, Sheffield Polytechnic; Centre for Business Research, Brighton Polytechnic)*

The changing character of managerial roles and organisational structure in IT-based enterprise *(Department of Sociology and Department of Management Studies, Southampton University)*

The structure of new product teams: a pilot study *(Department of Technology and Business Studies, Department of Mechanics of Materials and Department of Psychology, Strathclyde University)*

The identification of training needs in technology management *(Department of Technology and Business Studies, Strathclyde University; Centre of Business Research, Brighton Polytechnic; Department of Technology Faculty, Open University)*

Management and organisational integration in relation to new technologies *(Science Policy Research Unit (SPRU), Sussex University)*

Environmental regulation technical change and the energy sector *(SPRU, Sussex University)*

The integration of R&D strategy and business strategy *(Department of Management Sciences, UMIST)*

Human factors in design and implementation of CAPM: systems for total quality control *(Cardiff Business School, University College, Cardiff)*

Implementation of process technology *(Department of Industrial and Business Science, Warwick University)*

SERC-DTI Information Technology Advisory Board

SERC and Department of Trade and Industry (DTI) announced in February the membership of the new joint advisory structure that coordinates their support for information technology (IT). The new structure is made up of a number of committees and subcommittees dealing with specialised areas of IT, such as microelectronics design and systems engineering. These all report to the Information Technology Advisory Board (ITAB) chaired by Dr Nigel Horne of STC (see *SERC Bulletin* Volume 3 No 12, Autumn 1988). Each committee will have about a dozen expert members, drawn about evenly from industrial and academic backgrounds.

ITAB is the senior body in the new advisory structure and provides strategic advice across the full range of DTI and SERC it interests. More specialised advice will be given by four second level Advisory Committees which each deal with a particular area of the technology. The Committees cover, respectively:

- ☐ Devices
- ☐ Systems Architecture
- ☐ Systems Engineering
- ☐ Control and Instrumentation (a working group only at the present).

Subcommittees report to each Advisory Committee and are responsible for the detailed oversight of specific support programmes and for the assessment of individual project proposals.

SERC is responsible for support of research, education and training in universities and polytechnics. Its expenditure on IT research, education and training in the current academic year is expected to be about £42 million.

DTI aims to improve the working of UK IT markets; to increase awareness and use of IT and international standards; to increase pre-competitive research in advanced IT; and to improve the supply of skilled IT manpower to industry. DTI expenditure on IT research and awareness in 1988-89 is expected to be £59 million.

SERC and DTI have worked together for a number of years on various IT collaborative research programmes, including the Joint Optoelectronics Research Scheme (JOERS), the Alvey Programme, several LINK programmes and now on the national Information Engineering Advanced Technology Programme. The new joint advisory committee arrangements will strengthen the effectiveness of this cooperation, and help the coordination of national programmes with European research programmes, such as ESPRIT.

Continued from page 20

The Committee's research support tends at present to be biased towards social science departments with an interest in technology; so far, few truly interdisciplinary projects have emerged involving scientists or engineers and social scientists in work of mutual interest. The Committee would, therefore, like to encourage applications from scientists and engineers with an interest in the social and economic impacts of their work.

History and remit of the Committee

The Joint Committee was set up in 1968 in response to the Swann Report (*The flow into employment of scientists, engineers and technologists*, Cmnd 3760). The report had found that there was a mismatch between the whole pattern of science-based education in Britain and the national need for such graduates in industry and the public services. "Jobs in industry", said the report, "coincide only exceptionally with the education disciplines in which scientists and technologists are prepared."

The two Councils accordingly agreed to set up a joint advisory committee to "advise on the provision for postgraduate training in cross-discipline areas of concern to both Councils and on the award of postgraduate studentships in these areas." In its early years, the Committee concentrated on encouraging a small number of departments to provide the broader type of postgraduate training envisaged by Lord Swann's report.

Early in 1973 a reconstituted committee met with a mandate to continue the work of its predecessor, and it made a further report (*Blending the natural and social sciences*) in 1975. The most important of its recommendations was that the Committee should have the power to award research grants. In October 1975, it became a standing Committee of the two Councils, with a remit covering support of interdisciplinary research as well as postgraduate training. In 1980 it accepted responsibility for award of the Board's Total Technology research studentships in addition to its long-standing responsibility for the Council's graduate schools.

The activities of the Committee can be summarised as follows:

a. the provision of postgraduate studentships for advanced courses and PhD programmes that integrate the social sciences and engineering;

b. the encouragement and support of similarly broad research, and its application;

c. the broadening of the horizons of research students in either science and engineering or social science subjects, particularly in respect of employment opportunities.

In 1983 the work of the Committee was reviewed by the Chairmen of the two Councils. They recommended that the Committee should evolve new and more sharply defined areas of interest, such as, for example, the management of industrial change. The Committee already supported some postgraduate education and research related to technological management, and followed this recommendation by increasingly slanting its activities in this direction.

This culminated in the launch of the research initiative in the management of technological change, which far from being mounted just for a limited period, is still active and the Committee is still interested in receiving proposals in any of the areas outlined on the previous page.

Dr A M Wilson
SERC Swindon Office
(telephone 0793 411238)

Science consultant for Teaching Company

The Teaching Company Directorate has given consultant Dr Neil Cryer special responsibility for setting up programmes in the science disciplines.

The Teaching Company Scheme started in 1974. It has the twin aims of transferring advanced ideas from the academic world to industry while helping the ablest graduates achieve a flying start in an industrial or commercial career. How the Teaching Company mechanism works is described in the box.

The Scheme has now grown to the stage where there are over 350 live programmes. It was originally targeted at manufacturing industry, where it has had a significant impact. Recently, it has diversified into fields such as management (with encouragement and funds from the Economic and Social Research Council: ESRC) and information technology. There are also a few programmes concerned with the application in industry of the results of pure science research. Examples include a recently started programme between Randox Laboratories Ltd of Crumlin, Co Antrim, and the Department of Biochemistry at Queen's University, Belfast. Randox is a small firm manufacturing diagnostic clinical chemistry kits and enzymes for medical and veterinary diagnostics. The aim is to expand the company's product range by developing new diagnostic kits based on enzyme-linked immunosorbent assay technology — a field in which Queen's University is expert. A highly successful Teaching Company partnership between the Physics Department of Kent University and Sifam Ltd of Torquay provides another example. In this case, the collaboration is applying expertise in opto-electronics to the development of a completely novel system for measuring current for protection and metering purposes in transmission and distribution systems. This is of great interest to power utilities and major electricity users.

Contact points:

Dr Neil Cryer, Lansdowne, Fishers Hill, Hook Heath, Woking Surrey GU22 0QF Telephone 0483 740 423.

Teaching Company Directorate, Sudbury House, London Road, Faringdon, Oxon SN7 8AA Telephone 0367 22822.

***Dr Neil Cryer** joined the Teaching Company Directorate in February 1989. He has spent periods at Chelsea College, Bristol University and Royal Holloway and Bedford New College. His research interests have included far infrared spectroscopy, polymers, the use of laser scattering and electron microscopy. More recently he has concentrated on the applications of electronics and microprocessors, and in this connection has undertaken consultancies with industry. He has also written a number of books on the more popular aspects of computing.*

The success of these programmes has led to a recognition that the Teaching Company may be a potent mechanism for realising the industrial potential of research carried out in pure science departments. Consequently, following discussions with SERC's Science Board, it has been agreed that some more science-based programmes should be started.

Neil Cryer, a physicist, was recently appointed by the Teaching Company Directorate to spearhead the drive for science-based programmes. He will be responsible for promoting the Scheme to science departments, stimulating ideas, advising proposers and carrying out the initial evaluation of potential programmes. He has already started a series of contacts with selected researchers, initiative coordinators, and SERC committee members and secretaries. There are no preconceptions about the disciplines in which these new programmes will be found but, clearly, the Science Board's strategic initiatives may well provide a rich source of ideas.

Neil Cryer will be pleased to hear from you if you want to know more. Alternatively, you can contact the Teaching Company Directorate's office in Faringdon.

John Monniot
Assistant Director
Teaching Company Directorate

The Teaching Company Scheme

Since its inception, the Scheme has helped to link hundreds of companies of all sizes with academic teams in institutes of higher education all over the UK. In operation, each company is partnered by a university or polytechnic group with relevant specialist expertise.

Each partnership is called a Teaching Company Programme. It works in one or more project areas identified by the company as essential to improving its effectiveness and central to its future, but beyond its existing resources. Academics participate in the Programme by being involved with company managers in the joint supervision and direction of the work of a group of high quality young graduates.

The graduates become Teaching Company Associates. They are appointed by the academic Department concerned and are paid full industrial salaries to work for two years on the specified projects. Usually several Associates are employed over the lifetime of a Programme. A common arrangement is for two or three Associates to be employed for the first and second years, and two or three more for the second and third years, giving an overlapping 2-4-2 or 3-6-3 pattern.

Each Programme is funded jointly by the participating company and Government through a Teaching Company grant. The Scheme is currently sponsored by SERC, the Department of Trade and Industry, ESRC and the Northern Ireland Department of Economic Development.

SERC-DTI biotechnology collaboration

SERC and the Department of Trade and Industry (DTI) have strengthened their collaboration in biotechnology by setting up a single advisory structure. A new Biotechnology Joint Advisory Body (BJAB) will deal with the entire range of DTI and SERC interests in biotechnology, including training, research, international liaison, technology transfer, regulation and the climate for investment.

The membership of the BJAB consists of senior academic and industrial members in roughly equal numbers. Existing committees of SERC and DTI are being rationalised and consolidated in the new advisory structure. The Agricultural and Food Research Council and the Medical Research Council may also be represented in the new advisory structure.

A Senior Director of Biotechnology is to be appointed to coordinate the activities of both bodies, acting on the advice of the JAB, and will be responsible for:

□ the development and presentation of policy options to the BJAB;

□ the implementation of the Board's policy and strategy decisions, working through officials of SERC and DTI; and

□ liaison with agencies whose interests in biotechnology impinge upon the SERC-DTI activity.

Announcing the new structure in February, Professor William Mitchell, Chairman of SERC, said: "This decision would not only create a new integrated joint advisory structure for biotechnology and lead to improved oversight of the programme, but would enable even closer collaboration between the strategic basic research supported by SERC and transfer of its output through DTI into industry and the market place.

"Providing intellectual input into this important high-technology sector of UK industry is one aspect of SERC's wealth-creation role, a role which has recently been supported by the House of Lords Select Committee on Science and Technology Interim Report on Agricultural and Food Research."

Dr Ron Coleman, Chief Engineer and Scientist of DTI, said: "Since the early days of the SERC Biotechnology Directorate and the DTI Biotechnology Unit, both organisations have worked hard to ensure complementary programmes of research and consistent approach to industry.

"These new arrangements will strengthen the collaboration and are very timely now that the pace is quickening towards the commercialisation of biotechnology. We can benefit from the UK's excellent research base only if attention is given also to such critical topics as technology transfer, training, regulation, international liaison and public perception. Establishing a single source of advice for the whole activity in SERC and DTI makes a great deal of sense. There will be further benefit if AFRC and MRC come alongside."

The DTI leads for the Government in encouraging the industrial exploitation of biotechnology and ensuring liaison within the Government through the Interdepartmental Committee on Biotechnology. DTI set up, in 1982, a Biotechnology Unit in the Laboratory of the Government Chemist to manage a programme of research with companies, technology transfer and awareness raising. The annual expenditure by DTI on these activities rose from £0.5 million in 1981-82 to £6 million in 1987-88.

SERC's Biotechnology Directorate has, since it was set up in 1981, initiated and funded scientific programmes covering most of the key areas of biotechnology and involving more than 30 different academic institutions. Total SERC provision for the Biotechnology Directorate over the five-year period 1982-87 has been some £13.5 million.

SERC has recently reviewed its Biotechnology Directorate through a panel chaired by Professor Tom Blundell FRS and has accepted the panel's recommendations (see *SERC Bulletin* Volume 4 No 1, Spring 1989). The panel concluded that the Directorate, under the leadership of Dr Geoff Potter, had made significant achievements in the support of biotechnology research. These included progress in scientific and engineering research, fostering links between disciplines, encouraging industrial involvement in collaborative pre-competitive research programmes, transferring results from basic research to industry and providing trained manpower to meet national needs.

Dr Potter, who was SERC's Director for Biotechnology since the Directorate was set up, retired in February to take up a new career as Director of Industrial Development at Warwick University. A new Director for Biotechnology is to be appointed.

Some new publications from SERC

Biotechnology

Biobulletin, the Biotechnology Directorate's newsletter and *Directory of research in biotechnology, October 1988*: copies of both are available from Sue Cooper, Swindon Office (0793 411495).

Molecular recognition

Copies of the Biological Sciences Committee's newly launched *MRI News* are available from Dr Colin Miles, Swindon Office (0793 411446).

Chemistry

Copies of *Current grants in chemistry October 1988* and *Chemistry Committee report and statistics review 1987-88* are both available from Kate Reading, Swindon Office (0793 411360).

Process engineering

Copies of the Process Engineering Committee's *Grants current at 1 July 1988* and *Reports on projects June 1988* are both available from Brenda Fallows, Swindon Office (0793 411449).

Environment

A guide to EC research funding for the construction and transport industries has been prepared for the Environment Committee by Professor G Fleming and M Gregory of Strathclyde University. Copies are available from Steve Cann, Swindon Office (0793 411493).

Engineering Board

Copies of *Engineering Board strategy* are available from Ian Maxwell, Swindon Office (0793 411429) (see page 3).

Radiowave propagation in bad weather

The 24th Appleton Lecture of the Institute of Electrical Engineers was given in January by John Norbury of the Rutherford Appleton Laboratory under this title. He explained how 'bad weather' in the lower atmosphere, together with varying conditions in the ionosphere, can have significant effects on electromagnetic waves, and how this has led engineers and scientists to detailed theoretical study and experimentation. Here, Dr Norbury gives some highlights from his lecture.

Although the British are obsessed with weather as a topic of conversation and are generally of the opinion that it is wet nearly all the time, a more detailed investigation of the climate shows that rain is actually a fairly infrequent occurrence. For example, it only rains for 6% of the time in London. This is fortunate as it can have a fairly severe effect on radio transmission in the gigahertz part of the radio spectrum.

Optical transmissions and radio signals are identical in their basic characteristics, in that they are both manifestations of electromagnetic waves. However the associated frequencies (or wavelengths) differ dramatically. Whereas the optical region of the spectrum spans less than one order of magnitude, the radio spectrum extends over more than ten decades.

The visual perception of bad weather and the performance of radio systems is quite closely correlated but significant differences do exist.

The graph of the scattering cross-section of a sphere helps to explain some of these differences (figure1). The cross-section has been drawn so that it is normalised on both axes. On the vertical axis the cross-section is divided by the physically projected area (ie the optical value) and on the horizontal scale it is expressed as a function of the ratio of sphere diameter to wavelength. The curve is divided into three regions: (1) Rayleigh (proportional to the fourth power of the wavelength), Mie (or resonant) and (3) optical.

Raindrops approximate to spheres and have diameters ranging between 0.1 and 6 millimetres. Thus if the wavelength is long compared with a raindrop diameter, then the apparent radio cross-section of a drop is small and has little effect. Traditional television transmissions (BBC and ITV) in the 400 to 800 MHz band have wavelengths greater than 35 centimetres and are thus hardly affected by rain. However the frequencies used for the new satellite broadcasting systems (ASTRA and British Satellite Broadcasting) at 12 and 17 GHz have wavelengths comparable with rain drop diameters. Planners of these systems must make allowance for the rainfall climate. It is perhaps surprising that the UK has far less heavy rainfall than many other parts of Europe. In Northern Italy, for instance, the power margin required to overcome rain effects is several times greater than in Great Britain.

The same figure 1 also explains why fog affects our ability to see, whereas radio waves are largely unattenuated. As fog particles have sizes from about 1 to 40 microns, comparable with visual wavelengths, the scattering and resulting attenuation of optical transmissions is large. However to the very much longer radio waves, more than five orders of magnitude greater, fog particles appear to be minute.

Although fog in itself does not cause a problem for radio waves, the meteorological circumstances which create fog can have a detrimental effect. Under normal conditions the pressure, temperature and humidity of the atmosphere decrease with increasing height. However in calm anticyclonic weather, inversions can occur through radiative night time cooling of the atmosphere near the ground. These inversions, which tend to produce sharp discontinuities in the radio refractivity profile of the troposphere in the first few hundred metres, act as a partial mirror to radiowaves. Figure 2 shows a field strength contour plot of radiowaves at 1 GHz produced by a transmitter situated just below a strong over-water layer. Near the surface, trapping the radiowaves below the duct produces much greater field strengths at large distances from the transmitter. This enhancement can cause interference between communication networks using similar frequencies at different geographic locations. Television interference from mainland Europe, in strong anticyclonic conditions, is caused by this ducting mechanism. On the other hand, the reduction in field strength above the duct can give rise to radar holes.

It is difficult to condense the contents of one hour's talk into a page; these examples can only give a flavour. It is, however, important to understand the contribution made by the study of radio science and radio meteorology to the implementation and understanding of modern radio communication systems. Without such an insight, the reliability of these systems would be much degraded.

Dr J R Norbury
Rutherford Appleton Laboratory

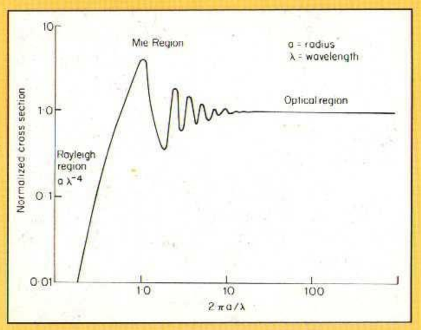

Figure 1: Cross-section of sphere.

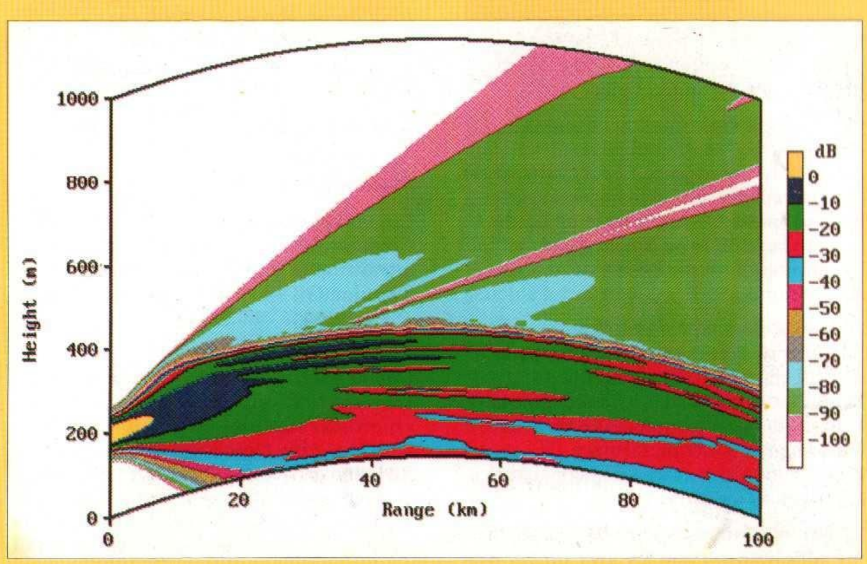

Figure 2: Signal strength plot of radiowaves in tropospheric ducting conditions.