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SCIENCE & ENGINEERING RESEARCH COUNCIL

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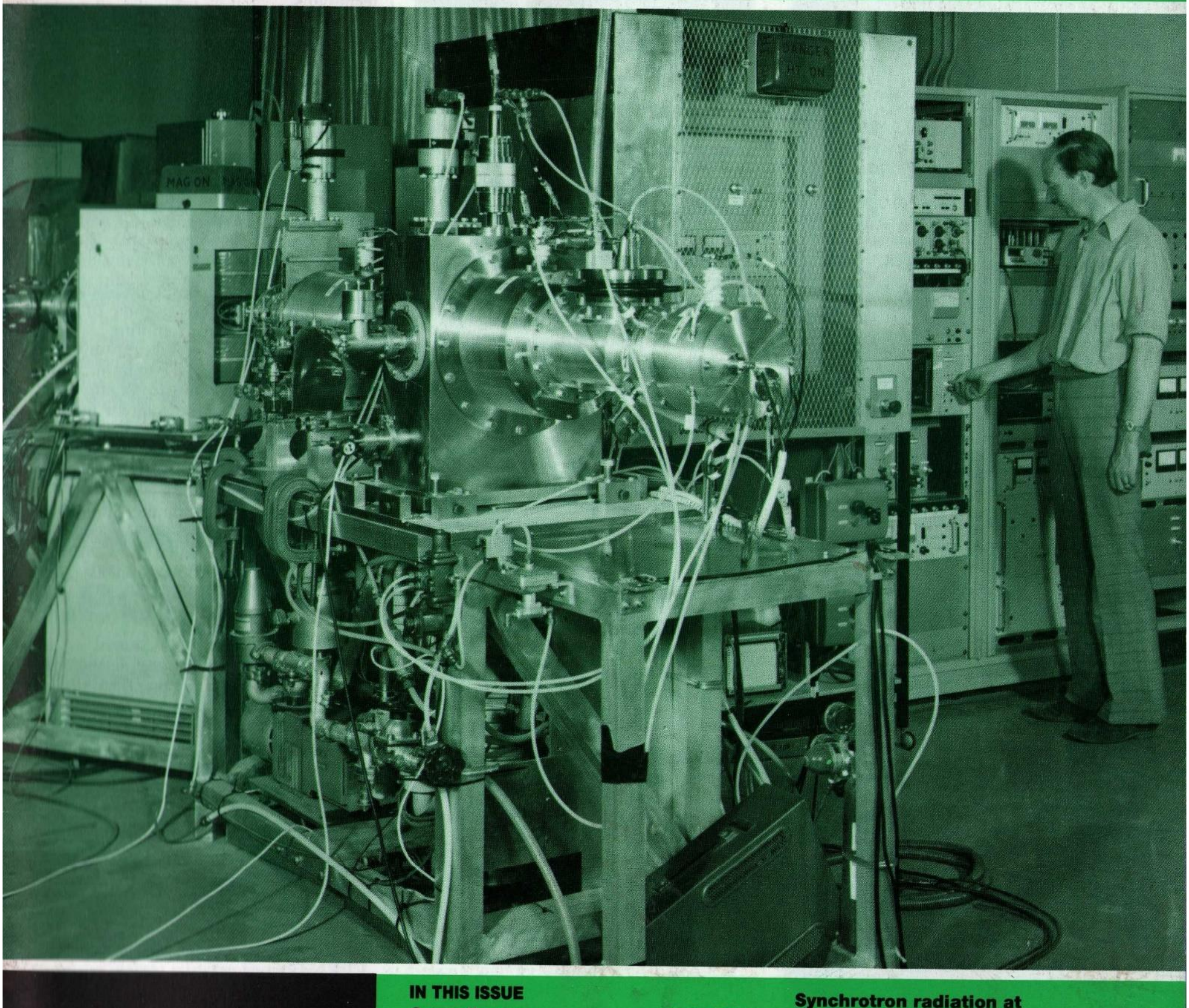

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The Science and Engineering Research Council is one of five research councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through 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 HMSO Bookshops) 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, summaries the Council's policies, programmes and reports.

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Front cover picture

Tests being carried out on the ion source now installed on the Nuclear Structure Facility at Daresbury Laboratory. The beams extracted from the ion source are mass-analysed by a dipole magnet shown in the background. The NSF has recently accelerated its fiftieth different beam species... ***see page 18.***

Council Commentary

Allocation for 1986-87

In March, Council decided on the allocation of funding to its various activities for the financial year 1986-87. A problem was caused by the currency exchange rates which had altered markedly since last November, when nominal rates were fixed by the Treasury. The effect of these changes, particularly the fall in sterling against leading European currencies in which Council pays most of its overseas subscriptions, is a loss on paper of several million pounds.

Supercomputer

The ABRC has now approved, subject to Treasury approval, the purchase of a Cray XMP-48 'supercomputer' and has asked SERC to house and operate the machine. At its meeting in March, Council approved the recommendation that the new machine should be sited in the Atlas Centre at Chilton, under the control of the Council's Director of Computing.

Instrumentation needs for science

The Council has considered a report from its Science Board on present deficiencies in advanced instrumentation in university departments. The Science Board has concluded that in its area of responsibility some £20 million per annum for five years is needed to update the equipment to a reasonable level. Council has asked its other Boards to conduct similar surveys and to determine their needs for advanced equipment.

Visit to ILL and CERN

Council held its May meeting at the Institut Laue-Langevin in Grenoble, a jointly-funded French-German-British laboratory providing neutron beams for university scientists to study biological, chemical, physics and material science problems. Council saw some of the work under way at ILL, and also visited CERN in Geneva.

An initiative in interfaces and catalysis

The Council endorsed a proposal from the Science Board to launch a programme of research under the title 'Interfaces and Catalysis'. The programme aims to allow recent advances in the science of surfaces to be applied to the solution of problems in heterogeneous catalysis, in order to extend the understanding and the scope of this industrially important area of technology.

ISIS: another partner

The Council welcomed Sweden's intention to join the international consortium centred on the spallation neutron source, ISIS, at the Rutherford Appleton Laboratory, allowing Swedish scientists to join the UK, France and Italy in planning the future support and exploitation of ISIS.

ESF 'networks'

The European Science Foundation (ESF) has set up a programme of 'networks' aimed at promoting communication and collaboration within the European scientific community in a specific field. Some networks may ultimately lead to proposals for major cooperative projects. To launch 'networks', the ESF will support a series of seminars, workshops and small-scale collaborations in the selected areas for two-year periods. A common fund has been set up by ESF to finance this launching phase to which the Council has agreed to contribute £50,000.

Retirements

At its July meeting, the Council recorded its thanks for past services to Mr G R Hall CBE, FEng (Brighton Polytechnic) and Professor J J Turner (Nottingham University) who were retiring having served for four years, and to Dr M W Holdgate CB (Department of the Environment) who is resigning because of the pressure of increased duties in the Department.

CERN review

At a special meeting in February, the CERN Council set up a review group to look at the way CERN runs and into the consequences of applying a range of alternative measures. This follows the concern in the UK about the funding of CERN and its future involvement.

The members of the review group are drawn from a number of the participating CERN member states. Professor Brian Fender, Vice Principal of Keele University and Chairman of SERC's Science Board, is a member of the group.

RGO to move to Cambridge

At its meeting in June, the Council of SERC carefully reviewed whether the Royal Greenwich Observatory (RGO) should remain at its present site and decided that it should be moved to Cambridge. It did so on the basis of submissions from Cambridge, Edinburgh and Manchester and further submissions that it had invited, and received, from the Royal Society, the Royal Astronomical Society, the Staff, Trades Unions and the Director of the RGO and also the views contained in the 165 letters which had been received between its March and June meetings. The Council also had before it the Official Report of the House of Lords debate on 11 June.

After the Council meeting, Professor Mitchell, Chairman of SERC said: "The Council's decision to retain the RGO as a single unit demonstrates the great faith and confidence that it has regarding its work. The construction and operation of the La Palma telescopes is a major achievement and the Council wishes to take this opportunity to congratulate all of the staff for their tremendous efforts in making it such a success. It hopes that the staff of the RGO will come to recognise the stability and the exciting opportunities afforded by its new location and is confident of their cooperation with the Council during the difficult period of the move. The RGO at Cambridge promises to continue the tradition of being amongst the very best Observatories in the world and, with the Royal Observatory, Edinburgh, and the excellent telescopes on La Palma and Hawaii, gives the UK astronomical community a set of facilities for research which is second to none. The maintenance of the UK position amongst the world-leading astronomical nations remains a high priority in the Council's portfolio. For the longer-term we are encouraging astronomers to say what facilities they need, bearing in mind that the scale of many of these will mean collaboration on an international basis."

The Council's decision has now been submitted to the Secretary of State for Education and Science for approval.

In making its decision to move the RGO to Cambridge, Council is planning for the 1990s when the role of the RGO will have changed dramatically from that in 1948 when it moved to Herstmonceux. That move was to take advantage of the clearer skies of Sussex; now that the telescopes have been moved to sites with even better atmospheric conditions, this reason no longer applies. Council's policy, as contained in its Corporate Plan, is to operate its establishments in support of university and polytechnic science and engineering, rather than as independent research institutes. The Council decided that, in astronomy, this support is best provided by closer association of the observatories with other astronomers, scientists and engineers.

It is the Council's intention to move all of the RGO's associated activities to the Cambridge site, thus maintaining its integrity and identity in its new environment, with the exception of the Equatorial Group of Telescopes and the Exhibition Centre. Council has initiated discussions with the National Maritime Museum regarding the operation of these latter items to provide the Council with facilities for instrument testing and to preserve the public interest and educational aspects in Sussex.

The move is expected to be completed by 1990; it will be phased so that minimum disruption is caused to each element of the RGO programme.

Reorganisation for astronomy

As a consequence of its participation in the new British National Space Centre (BNSC: see *SERC Bulletin* Vol 3 No 5, Summer 1986), SERC has reorganised its support for astronomy, solar system science and Earth observation. The Council's Astronomy, Space and Radio Board and its three main committees (Astronomy I, Astronomy II, Solar System) have been replaced by new bodies within SERC and the BNSC.

SERC's new Astronomy and Planetary Science Board will continue to advise Council on scientific policy in astronomy and solar system science, supported by a technique-based subcommittee which will be responsible for approving grants associated mainly with research using ground-based facilities. Professor A H Cook FRS continues as Chairman of the new Board, and the Head of the operating division reporting to the new Board remains Dr Barry Martin.

In the BNSC, which is reponsible for UK space policy, a Space Science Programme Board has been established to advise BNSC on its programme of space-based astronomy and solar system science; Professor Peter Willmore will chair this Board. An Earth Observation Programme Board is also being set up to advise on those activities in atmospheric sciences and remote sensing previously supported by SERC.

Because it expects to liaise with the BNSC, not only in astronomy and Earth observation but also in space technology and microgravity, SERC has formed a Space Planning Committee to advise it on all space matters and in particular to comment on the national space plan which is being developed by the BNSC. Professor R Wilson FRS will chair this committee.

The BNSC is split into two groups under the overall control of Roy Gibson, the Director General: Jack Leeming directs the Policy and Programmes Group and Jeffrey Fellows the Projects and Technology Group.

Two senior posts have been filled by staff on secondment from SERC: Dr John Harries of the Rutherford Appleton Laboratory (RAL) and Professor V E M Bowell, formerly Head of the Nuclear Physics Division at SERC Central Office, Swindon.

Dr Harries will act as deputy to Mr Fellows, directing the space programme at RAL (which is now one of the BNSC's technical centres) where he will still be based; he will also continue to direct SERC's astronomy and geophysics programme at the laboratory.

Professor Bowell, as Head of the Science and Microgravity Directorate, reports to Mr Leeming. She is based at BNSC, Millbank Tower, Millbank, London SW1P 4QU; telephone 01-211 6189. Her place as Head of Nuclear Physics Division has been taken by Dr David V Thomas.

Major new grants

approved by Council, March-July 1986

ASTRONOMY, SPACE AND RADIO

Professor J L Culhane (University College London): a grant of £781,600 plus computing facilities over one year, for geophysical and astronomical research at the Mullard Space Science Laboratory.

Sir Francis Graham Smith (Manchester University): a grant of £591,500 over one year, for radio astronomy research at Jodrell Bank.

Professor A P Willmore and Dr C V Goodall (Birmingham University): an additional £133,000 over two years, making a revised total of £417,600, for work on the ROSAT Wide Field Camera.

Professor K A Pounds (Leicester University): a grant of £542,000 over one year, for X-ray astronomy and astrophysics.

Professor A Hewish (Cambridge University): a grant of £467,100 over one year, for support of the Mullard Radio Astronomy Observatory.*

ENGINEERING

Dr J M Robertson et al (Edinburgh University): a grant of £1,751,600 (plus notional costs of £69,000) over four years, for development and support of the Edinburgh Microfabrication Facility.

Professor H A Kemhadjian et al (Southampton University): a grant of £1,351,000 (plus notional costs of £156,850) over four years, for the Silicon Central Microfabrication Facility.

Professor K E Singer, Dr A R Peaker, Dr W S Truscott and Dr B Hamilton (University of Manchester Institute of Science and Technology): a grant of £824,300 (plus notional costs of £28,500) over three years, for low dimensional devices.

Professor E G S Paige, Dr L L Solymar and Dr T Wilson (Oxford University): a grant of £515,700 (plus notional costs of £72,400) over four years, for device aspects of analogue processing.

SCIENCE

Professor J M Thomas (Royal Institution): a grant of £807,000 over four years, for studies in heterogeneous catalysis.

Dr H Ahmed, Dr M Pepper and Dr R S Elliott (Cambridge University, with GEC plc and British Telecom): an additional £300,000 for equipment, making a revised total cooperative grant of £1,304,000 over four years, for three dimensional nonometer micro-electronics.

Dr R J Nicholas and P Walker (Oxford University): an additional £62,000 for equipment, making a revised total of £583,000 over four years, for MOCVD growth of III-V narrow and wide gap semiconductor heterojunctions.

Professor L J Challis and 12 others (Nottingham University): an additional £390,000 for equipment, making a revised total of £1,394,000 over four years, for investigation of low dimensional MBE structures grown by NUMBERS.

Professor E H C Parker (Warwick University): a grant of £812,700 over four years, for low dimensional phenomena in silicon.

Professor E T Hall and Dr R M Hedges (Oxford University): a grant of £804,200 over four years, for the development of the Oxford Radiocarbon Accelerator Unit.

NUCLEAR PHYSICS

Rolling programme grants to particle physics experimental groups at:

Birmingham University	£720,000
Cambridge University	£519,000
Glasgow University	£723,000
Imperial College of Science and Technology	£1,070,000
Liverpool University	£638,000
Manchester University	£632,000
Oxford University	£968,000
Queen Mary College, London	£455,000
University College London	£748,000

each grant over a period of three years.

RESEARCH GRANTS, POSTGRADUATE STUDENTSHIPS AND FELLOWSHIPS

Exploitation of Research Council-funded inventions

In the *SERC Bulletin* for Autumn 1985 (Vol 3 No 3), the changes in arrangements for exploitation of research council-funded inventions were summarised. Since then, responses from universities and colleges have been received and on 23 July 1986 the first 33 authorisations to exploit inventions arising from work funded by research councils were issued. These are valid for three years in the first instance and institutions are asked to report annually on the exploitation that has been pursued. Other universities and colleges are still discussing their proposals and four have decided to stay with the British Technology Group at this stage.

Invitations to submit proposed arrangements have also been issued to polytechnics in Inner London, Scottish central institutions and to local education authorities in England and Wales in respect of other polytechnics and colleges in receipt of research council funding. SERC's Finance Officer has written to the institutions thus affected offering interim research grant conditions, on a similar basis to those offered to universities in 1985.

With the issue of authorisations, revised conditions governing exploitation will apply to research grants, postgraduate studentships and fellowships to authorised institutions and these are being published in the appropriate research grants, studentship and fellowship booklets.

Any enquiries concerning the new arrangements should be addressed to Mr R G Tidmarsh, SERC Central Office, Swindon, ext 2179.

Congratulations to...

Professor J F Nye FRS and **Dr J V Hajnal** of the H H Wills Physics Laboratory, Bristol University, as joint winners of the Metrology Award of the National Physical Laboratory, for new concepts about the structure of electromagnetic wave-fields and their verification by measurement using a modulated scatterer technique.

Professor F J Bayley and **Dr J M Owen** of the Sussex Thermo-Fluid Mechanics Research Centre at Sussex University, as winners of the first prize in the Academic Enterprise Competition sponsored by the British Technology Group, for the transfer of technology from the Centre into industry, and in particular to Rolls-Royce and GEC Ruston Gas Turbines as part of their Cooperative Research Grant activities.

£5 million molecular sensors programme

Over the next five years SERC is expecting to spend about £5 million in universities supporting research and development in molecular sensors. This activity is being coordinated by the Molecular Sensors Steering Group which covers the sensors programmes of SERC's Biotechnology Directorate, Medical Engineering Subcommittee and Chemistry Committee. The coordinator who will be responsible for planning and promoting the programme is Dr Arthur Mason.

Molecular sensors are devices which combine electronics technology with materials developments in chemistry and biology to detect and measure the concentration of specific chemical or biochemical species rapidly. Coupled with advances in signal processing, they could provide compact, low-cost instruments and real-time control systems for a wide range of applications. Because molecular sensors are easy to operate, there is a greater number of areas where they can be used by unskilled operators. These areas include human and veterinary medicine, biotechnology, chemicals, food and drugs processing, agriculture, defence, and environmental monitoring.

The development of such sensors should enable major advances to be made in the research laboratory, industry and medicine: for example, nutrient uptake in plant physiology; *in vivo* measurement of neurometabolism, composition of flue gases in combustion; *in vivo* measurement of glucose for treatment of diabetes; better control of industrial processes; and development of cheap sensors for clinical medicine, where their diagnostic use could be extended to clinics, surgeries and homes.

An important aspect of the programme will be collaboration with industry and with the Department of Trade and Industry and the Department of Health and Social Security. If successful, there are immense export possibilities for the UK and many companies will be anxious to take advantage of the potential opportunities.

Sensors based on both synthetic and natural molecular recognition methods are to be researched in the programme. Synthetic methods can be used to:

□ extend the selectivity and reproducibility of adsorption on semiconductor surfaces;

□ develop novel chromophoric methods;

Dr Arthur Mason

□ develop novel ionophores;

□ devise reversible ligand-binding systems for continuous monitoring; and

□ investigate and develop ordered multimolecular and macromolecular systems such as polymeric membranes and multilayers, and liquid crystalline phases.

Sensors using natural or synthetic methods to measure natural substances (biosensors) will be used in the following areas: enzyme studies, antibody-antigen interactions, antibody engineering, biological membrane studies, and DNA-DNA interactions. In general the natural recognition systems are more selective and the synthetic systems more stable. To combine both advantages, synthetic systems can be foreseen which mimic those found in nature.

Potential applications for molecular sensors are many. Some examples are:

Medicine 'Through the skin' blood-gas measurement; use in catheters; feedback control for drug delivery and anaesthesia; detection of genetic and immune system disorders; infectious disease; ovulation; and determination of ions and molecules, such as potassium, sodium, calcium, urea and glucose.

Industry Gas and environmental monitoring; process control chromatography; the analytical determination of metals and non-metals in liquids; geochemical probes; on-line liquid sampling; building safety; quality control; food production freshness and safety; robotics; detection and measurement of ions and other entities in fermenter or downstream processing.

The molecular sensors programme will help reduce the performance limitations of current sensor systems and develop new systems and approaches. Thus research in several areas of science will be necessary: analytical chemistry, organic chemistry, physical organic chemistry, polymer chemistry, protein engineering and biochemistry, molecular imprinting, immobilisation methods and membrane technology. Improving encapsulation techniques will require the identification and adaptation of new device and polymeric materials technology.

There is great demand for a method of making accurate and quick quantitative chemical measurements by people who want to characterise precisely the system with which they are working: for example, living organisms, fermentation broths or a potentially dangerous (contaminated) closed space. The new sensors should be selective, sensitive and accurate and their behaviour well understood with a sound quantitative theoretical model developed to describe their response to analyte and interferent alike.

To achieve these objectives research will need to be done in areas of electrochemistry and optical techniques including:

□ amperometry with novel electrodes involving conducting polymers, immobilised enzymes and conducting organic salts and the direct conversion of the rates of enzyme reactions into electrical current;

□ optical wave guides, by using for example, the evanescent field or surface plasmon resonance to quantify reactions on the wave guide surface — new developments in potentiometric sensors concerned with the development of integrated devices such as integrated silicon field effect transistors, chemical field effect transistors and hybrid devices;

□ studies of reference electrodes;

□ understanding the fundamental operation of these devices and also of semiconducting gas sensors, so as to eliminate reference electrodes, or invent new types of gas sensors with improved specificity.

Dr Mason can be contacted at
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WARRINGTON WA6 6EN.

Working together offshore

Project MASS is the vehicle for Strathclyde University's marine technology research involvement and industrial collaboration. In response to SERC's 1975 initiatives in marine technology, Strathclyde academics, from nine departments, have participated in multi-disciplinary research programmes, enhanced the postgraduate course and made positive contributions to practice.

Right from the outset, the aim of the Project MASS programme was that research had to be directed to tackling real problems. Once these have been identified the effort must be devoted to matching the academic quest for knowledge with the need to produce results on schedule and, if necessary, in stages. Another integral part of the total marine technology activities is the provision of the right kind of postgraduates for industry.

It is therefore not surprising that the first round of research awards from SERC was devoted to projects in the areas of Maintenance Activities Subsea Surface, hence the acronym, MASS. The motivation, for what appears to be an unglamorous and almost unacademic topic, stems from the fact that the offshore structures, installed in the North Sea in the early 1970s, were designed with little or no attention paid to maintenance. Yet they are planned to have working lives of 20 to 30 years in a hostile environment. Clearly, there was no shortage of opportunities for academic attention and energy.

The specific aim was to improve overall efficiency of subsea inspection and maintenance of offshore structures. The tasks were demanding, the technological hurdles high and practical experience almost non-existent. Research had therefore to be approached from first principles. These led to useful research in areas such as:

- Effective and reliable non-destructive testing (NDT) methods for inspection of structural defects;
- Causes and effects of marine growth on structures;
- Improving the effectiveness of surface support to subsea work by reducing stoppages due to bad weather.

A typical example of the research was a project devoted to increasing the capability for launch and retrieval of diving bells through the air-sea interface, from a mother vessel operating in hostile seaways to subsea locations. The popular method is to perform the operations via a moonpool (a vertical centre well in the ship) and the choice of its principal dimensions has traditionally been determined solely by the size of the diving bell. This approach has many good features such as providing protection to the equipment from full impact of wave forces. But there is one major drawback; because of resonance effects, the magnitude of water oscillation inside the moonpool can build up to four times the height of waves outside the ship. Operations then have to be suspended for safety reasons.

The prime objective became to minimise the level of water oscillations scientifically and this was a complex problem involving seven key parameters. To derive usable results, the researchers had to correlate theoretical advances, model experiments and full-scale measurements. Sample results of what can be achieved by proper design are shown in figure 1. The research expertise which developed led, for example, to invitations to design efficient moonpools for Houlder Offshore's third-generation diving support vessel *Orelia* and for British Petroleum's novel *Swops* ship to be employed as a floating production system. Offshore measurements also became a regular event for our researchers and postgraduates.

While research was progressing satisfactorily, the role of postgraduate education was not forgotten. Strathclyde's one year MSc in Marine Technology, recognised by SERC for the award of advanced course studentships since 1976, has adopted its own brand of educational philosophy in the training of graduates. Success requires the graduates to possess a proper balance of the three inter-related qualities of *competence, confidence* and *communication skills*. The degree programme meets these goals by teamwork and individual projects.

The first six months are devoted to teamwork where the students are grouped into 'consultancy teams' to examine technological and economic aspects of a group project such as the development of a small oil field in the

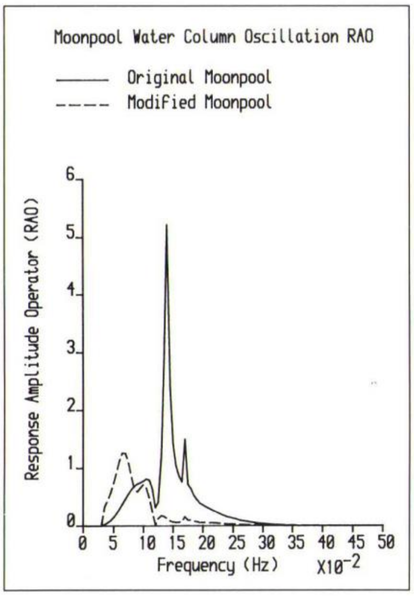


Figure 1: Comparison between water column oscillation responses in original and modified moonpool designs.

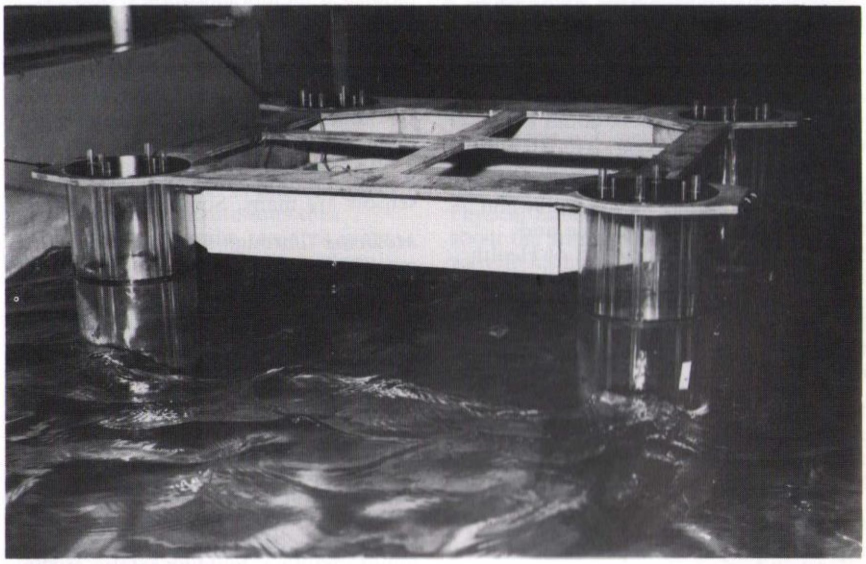


Figure 2: Stability experiments of a semi-submersible model in waves.

North Sea. Taught classes are supplemented by seminars involving industrial personnel, who provide support for this group study. The completed written reports are formally presented to a panel of experts from industry who ask searching questions on the presentations. During the second period each student tackles an individual project which is selected from problems encountered in practice and this leads to the submission of a thesis. In this way, a ready 'test bed' is available to try out fresh ideas and some have become the seed corn of new projects in the Project MASS programme.

Over the years, with the help of our former postgraduate students in industry, the Project MASS programme has broadened its research base. The programme has also steadily increased its grants from non-SERC sources and is now, in the period 1985-87, around 40% of the total budget. Working closely with the Marine Technology Directorate, our approach has now been applied to other research areas and Project MASS now provides coordination for two 'managed' programmes. In addition, there is a series of special projects.

The development of improved stability criteria for the semi-submersible, which can more rationally relate to its performance, forms the basis of the first managed programme. Research considers both fundamental questions such as motion response of a listed semi-submersible in waves and how the research findings can best be adapted for use in generating a series of stability criteria which offer various degrees of sophistication. Figure 2 shows a model experiment in progress. The SERC grant is enhanced by additional awards from the Department of Energy and six companies.

The second managed programme, complemented by projects led by Heriot-Watt University, is aimed at increasing the effectiveness of subsea work and associated surface support. Typical of the six tasks involved are research into acoustic methods for cleaning marine fouling on subsea structures so that inspection of defects can proceed; and handling a subsea unit from a crane on the side of a ship during its passage to subsea work locations.

One of the other projects is a novel method of testing and determining how the presence of marine growth on members of offshore structures can increase the magnitude of loading; this has received considerable interest from industry for whom marine fouling is a problem. Figure 3 illustrates the changes in the drag coefficients between a clean and a fouled cylindrical structure. Progress depends on having samples for analysing and this task of gathering data is achieved by placing cylindrical specimens in fast-growing marine fouling areas which are located in the Clyde Estuary. The researchers are confident that information from their studies will be used to develop more cost-effective offshore structures.

What next for Project MASS? Although the future is unknown, there is a solid foundation on which to build. And there is no shortage of ideas. Suggestions range from advanced robots for subsea work, safety and cost-effectiveness of floating production systems for use in the small oil fields, and reliability of equipment and systems in deep-water operations. There is a great deal more work to be done. The major challenge for the Project MASS team will continue to be to pinpoint precisely the academic contributions they can make which will be most relevant to the nation's needs. Once the goals have been established, they have the confidence to see the projects through.

Professor Chengi Kuo
Coordinator of the marine technology research programme at Strathclyde University

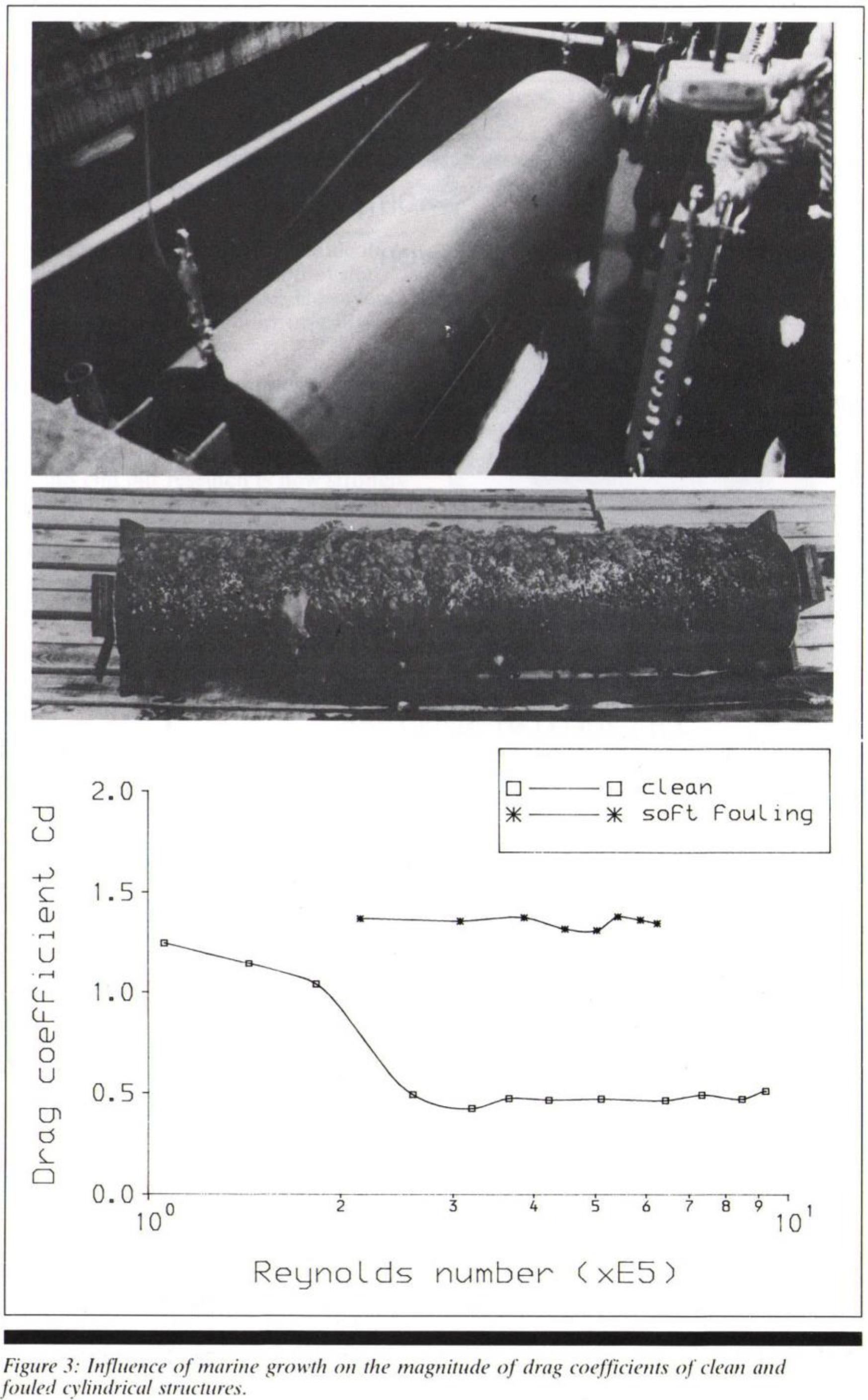


Figure 3: Influence of marine growth on the magnitude of drag coefficients of clean and fouled cylindrical structures.

Biotransformations for industry

The large-scale synthesis of organic molecules by the chemical industry has been achieved traditionally using chemical catalysts often in multistep reactions with low specificity. In some cases it has not even been feasible to contemplate a particular synthesis because the yield of product may be far too low to make an economic process. This is particularly true for some of the speciality organics required by the agrochemical and pharmaceutical industries, who are now requiring a variety of functionalised organic compounds often with chiral centres and showing a high degree of enantiomeric purity as building blocks for the synthesis of biologically active molecules. As a result these, and other industries in the organics sector, are showing an increasing interest in the use of biological systems to synthesise specialised organic molecules.

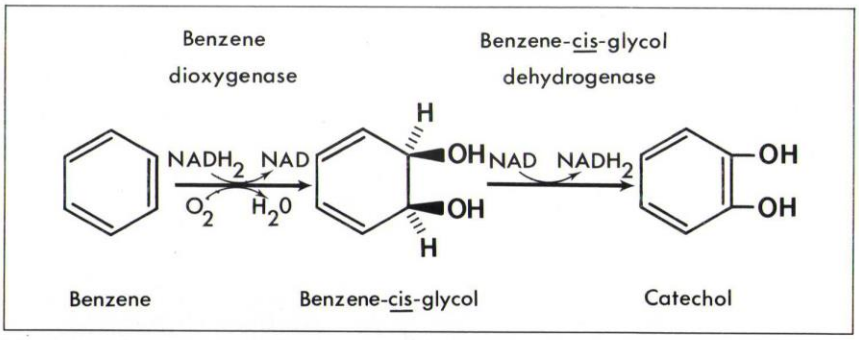


Figure 1: Pathway of benzene oxidation in Pseudomonas putida. *The catechol can be further metabolised to central metabolites.*

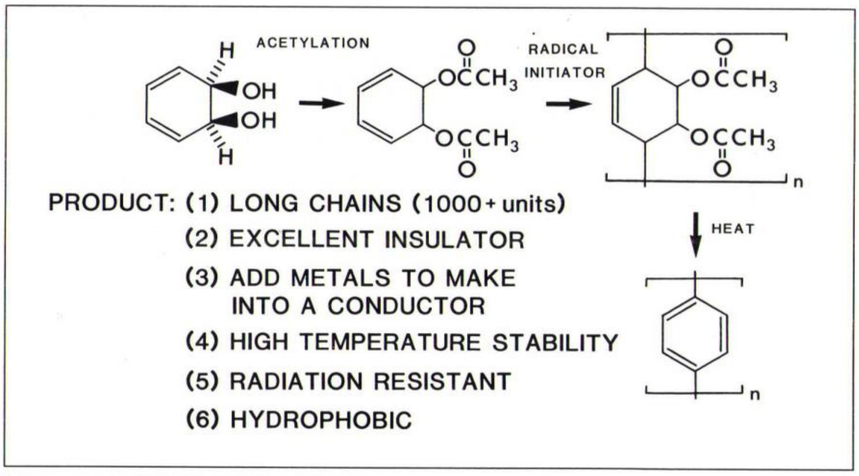


*Figure 2: Synthesis and properties of polyphenylene from benzene-*cis*-glycol.*

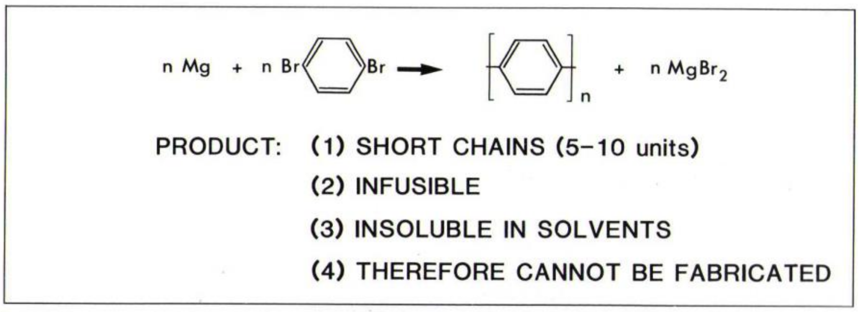


Figure 3: Chemical synthesis and properties of polyphenylene from dibromobenzene.

These biological systems can be either whole cells (particularly, though not exclusively, microbial) or specific enzymes extracted from them. In either case each system can be regarded as a biocatalyst, the choice depending very much upon, among other things, the nature of the substrate and product and stability of the biocatalyst to be used.

Of particular interest is the direct synthesis of alcohols, diols and epoxides from hydrocarbons which has proved particularly difficult for the chemical industry and yet such syntheses can be readily catalysed by a class of enzymes know as oxygenases. These are enzymes that specifically incorporate either one or both atoms from dioxygen O_2 into both saturated and unsaturated hydrocarbon substrates and can be found in various forms in all biological systems. One such enzyme is benzene dioxygenase (BDO) found in the soil bacterium *Pseudomonas putida.* BDO catalyses the O_2- and reduced pyridine nucleotide (NAD(P)H)-dependent formation of +*cis*-1(S),2(R) dihydroxy cyclohexa-3,5-diene (abbreviated to benzene-*cis*-glycol or BCG) from benzene which is then further transformed by the organism to central metabolites by other enzymes (figure 1).

It has recently been demonstrated by ICI scientists that BCG can be used in the chemical synthesis of polyphenylenes. These are aromatic polymers showing a number of novel properties and have interesting applications in the electronics industry (figure 2).

Although polyphenylene can be synthesised directly from dibromobenzene, the resultant polymers are too short in chain-length to give them the desired properties (figure 3). However, synthesis of polyphenylene from BCG is not without problems, since the chemical synthesis of BCG requires a three-stage process with a low overall yield. A biological route, based on benzene dioxygenase, would therefore have a significant advantage since yields approaching 100% are theoretically possible.

To make BCG from benzene using the biological system, BDO enzyme as extracted from the cells could be used. Unfortunately, the enzyme activity *in vitro* is low, unstable and prohibitively costly in its requirements for the cofactor NADH. An alternative strategy that has been used in the Biotechnology Directorate-funded studies at Warwick is to employ a mutant organism which lacks BCG dehydrogenase, the enzyme responsible for the conversion of BCG to catechol, so that the mutant cannot grow on benzene. Consequently the organism, when grown on glucose in the presence of benzene, will accumulate high concentrations of BCG in the growth medium.

The biological route therefore holds significant promise but it is not without its problems either. One of these is that of process longevity. Although BCG can be produced at concentrations of more than 20 g/litre in the fermentation broth, production has not so far been sustained for more than a few hours. We have sought to identify the reasons for this instability and to make improvements to the process. Because of the carcinogenic nature of benzene we have chosen to use toluene as substrate and make toluene-*cis*-glycol (TCG). There appears to be little difference between the two substrates to the bacterium.

To produce the TCG in fermenters it is first necessary to grow the organism on glucose since the mutant strain will not grow with toluene due to its impaired glycol dehydrogenase. At a sufficient cell density toluene is added to the system to induce synthesis of the BDO enzyme which then converts toluene to TCG (figure 4). To maintain production of the TCG it is necessary to keep the enzyme supplied with NADH; this the cell makes through metabolism of glucose, so glucose must be continously fed to the fermenter (a fed-batch culture). Here the first problem is encountered: too high a level of glucose inhibits TCG formation through catabolite repression, too low a level slows down TCG formation due to a low NADH supply rate. Careful control of glucose in the fermenter vessel is therefore essential.

The high concentration of product desired in the fermentation also leads to problems. At concentrations greater than 20 g/litre, TCG exerts a strong inhibitory effect upon the BDO enzyme causing it to lose activity irreversibly. Furthermore, and possibly as a consequence of the high TCG levels within and outside the cell, there is a marked decrease in overall cell viability. Finally there is a net loss of TCG from the system due to selection of revertant organisms within the population that have now regained the ability to metabolise the TCG.

It is anticipated that other hydrocarbon-based biotransformations will suffer from process instability due to product toxicity. Since the accumulation of such metabolites is unnatural it is unlikely that the organism will possess efficient mechanisms for their elimination from the cell. TCG is a polar molecule and therefore will not freely diffuse out of the cell. Its toxicity may stem from non-specific interference with metabolism due to the accumulation of high internal concentrations. In the case of transformations where the product is less

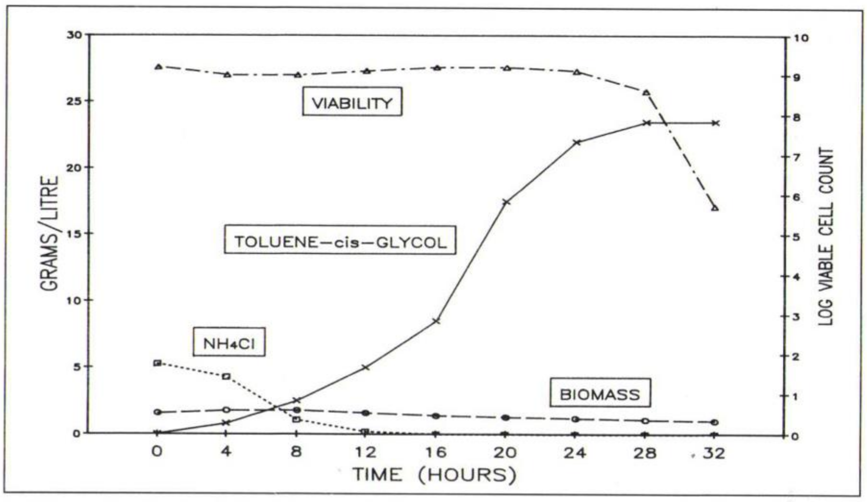


*Figure 4: Production of toluene-*cis*-glycol in glucose-fed batch culture by* Pseudomonas putida.

polar (for example, monohydric alcohols and aldehydes), free diffusion of the product would be expected. However many such products are intrinsically toxic to microbial cells.

The development of biotransformations using mutant organisms as catalysts will depend on devising strategies aimed at overcoming the problems outlined here. To this end our research is now strongly focused upon a combination of strain development, manipulation of the growth environment and, most importantly, methods for the continuous removal of the product.

Professor H Dalton

Professor H Dalton
Department of Biological Sciences
Warwick University

PED goes private

On 1 October 1986, the Polymer Engineering Directorate completed its transition into the private sector. It is now to be known as the Polymer Engineering Group (PEG). The new group is headed by Dr Ken Sleep, formerly with ICI plc, with Dr John Baldwin of Norsk Hydro as his deputy. Mr Peter Rice completed his duties as Director of PED on 30 September.

The Group will undertake much of the work for SERC previously carried out by PED in stimulating and monitoring Government-funded R & D at universities and polytechnics. SERC's Director, Engineering, Tony Egginton said: "The new industry-based group will undertake many of PED's previous tasks in support of SERC's continuing substantial programme of research in this field. The group's establishment represents a further step in the development of an effective R & D coordination body of the industrial and academic communities."

The key aims for the new group will be:

- ☐ To participate in the development of overall technical strategy and targets for the UK polymer industry, and to assist in defining the R & D programmes required.
- ☐ To stimulate technical work to meet industry's specific needs within the R & D community for polymers, which includes academic institutions, research associations, Government establishments, and industrial research centres.

PEG has the full commitment of the British Plastics Federation and the British Rubber Manufacturers Association. It will be based at the BPF's offices at 5 Belgrave Square, London SW1X 8PH (telephone 01-235 7286).

Research initiatives in electrical engineering

Over the last year, the Electrical Engineering Subcommittee has been developing two research initiatives — in integrated drive systems and electrical power systems. These are part of an overall strategy whereby a coordinated approach to research is being developed.

Integrated drive systems

This area has been selected by the Machines and Power Committee as a priority for formulating a cohesive programme of research. Exciting and important new developments both for engineering science and commercial exploitation are opened up by the possibilities arising from the informed integration of modern power electronics, electromechanical devices and control electronics, including software. Recent advances in new semiconductor devices and permanent magnet materials are now ripe for exploitation in the new markets which are developing in, for instance, information handling devices, from the increasing emphasis on energy efficiency, and from demand for more sophisticated controlled drives in areas such as avionics, domestic appliances, machine tools and automatic and flexible manufacturing systems. These areas cover from tens of watts up to megawatts, and provide an opportunity for academic research teams to contribute towards an important industrial need.

Fruitful topics for research include:

☐ permanent magnet systems
☐ switched reluctance systems
☐ stepping motor systems
☐ improved switching and control circuit design exploiting progress in solid state devices
☐ development of new switching devices especially to meet drive requirements
☐ limited motion devices for specific applications
☐ exploration of intelligence in drive systems
☐ fundamental energy converting capability of different types of electromechanical structure

The initial stage of the programme was founded on permanent magnet systems and discussions have been held between academic groups and manufacturers with a view to formulating a cohesive set of projects. Strong interest has been shown by the electrical machines groups, but SERC would now like to encourage more participation from power electronics groups.

The programme is expected to include a range of projects from those of direct industrial interest, in the form of Cooperative Research Grants, through the more general type which might interest a group of companies, to those of a more fundamental nature. Collaboration between academic groups will be particularly welcomed, especially if these cross the boundaries between machines, power electronics and control. Financial provision from SERC is expected to be about half a million pounds a year.

The programme has the strong support of the Department of Trade and Industry and the National Economic Development Office, both of which are encouraging manufacturers to collaborate in research and development, both with other companies and with academic groups.

Profesor P J Lawrenson, Leeds University, has been appointed programme leader, with responsibility for helping to formulate a cohesive set of projects in collaboration with industry.

For further information contact:
C P Whitlock, Secretary to Electrical Engineering Subcommittee, SERC Central Office, Swindon, ext 2350.

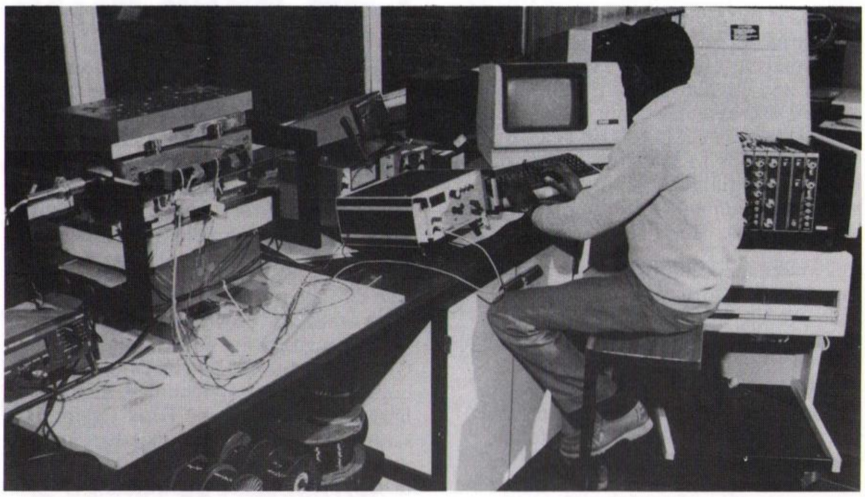
Electrical power systems

SERC has over many years supported research at a number of institutions on electrical power systems and has recently decided to develop a more cohesive programme; the coordinator is Professor M J H Sterling, Durham University, Science Laboratories, South Road, Durham DH1 3LE; telephone Durham (0385) 64971, ext 528.

In this context the area of electrical power systems covers the generation and distribution of electricity to consumers, including control and switching.

The actual generator is usually regarded as a 'black box', although in some studies the source of primary energy is considered. Similarly individual consumers are lumped together as loads on the system of broadly defined size which vary with time.

Cross-section of the laminations of a 3 kVA switched reluctance motor, showing the 24 teeth on the outer stator and the 22 teeth on the inner rotor (radial airgrip enlarged for clarity). (Drawing: Newcastle upon Tyne University).



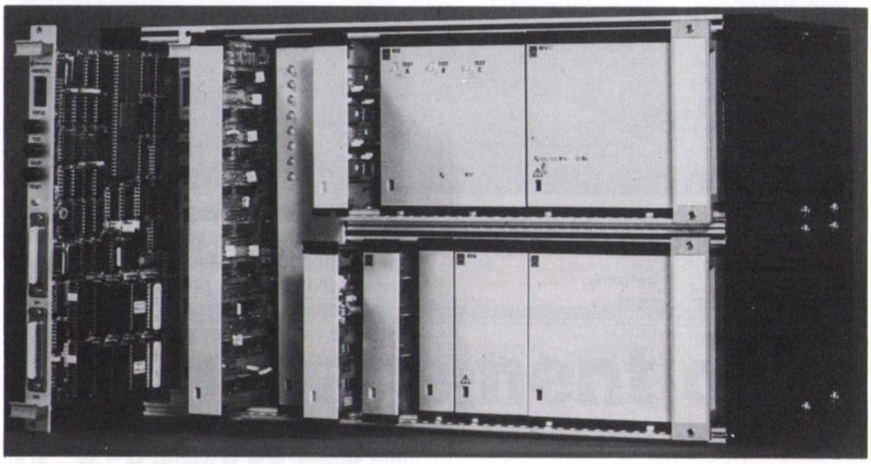
Dr Adam Musoke, Senior Research Associate with the Newcastle team, working with a linear stepping motor rig, designed for fundamental investigation of the important effects of magnetic saturation on force production between iron teeth in stepping and switched reluctance motors.

Four areas of interest have been recognised, covering timescales ranging from milliseconds to years. There is a team leader for each area (detailed below). The sizes of system studied also vary from a few kilowatts for a small isolated installation to thousands of megawatts in a national network.

The general objective is to encourage a coordinated programme of academic research whose results will be of assistance to the UK electricity supply industry, and to UK manufacturers of equipment and to consultants whose interests often lie mainly overseas. Most of the current research is carried out in collaboration with industry and about 30% of the projects are supported by Cooperative Research Grants.

The Electrical Engineering Subcommittee has earmarked a budget of £300,000 a year for research grants in this area. The 14 current and recently awarded grants total £880,000.

Left to right: Professor Allan Johns of City University, with Susan Rose and Edward Walker, both of GEC Measurements Ltd, in front of the first prototype of the new directional comparison protection scheme installed at the Cellarhead Substation. At the top of the rack is the relay, with digital and analog recording equipment below.



Pre-production prototype of the new directional comparison protection scheme, showing the microcomputer measuring modules, decision logic, and current and voltage interfaces. The project was developed at Bath University in collaboration with GEC Measurements Ltd.

Protection and measurement

Protecting high-voltage systems by the rapid detection of faults involves working in timescales of milliseconds using microprocessors to monitor the state of, for example, long-distance transmission lines. Steps are being taken to promote the best and most efficient use of academic research facilities and to this end programmable protection test facilities are being made available in the protection and measurement research laboratories at the City University. It is also intended to establish a multi-user computer-aided design facility to give remote user access to system fault databases via the Joint Academic Network (JANET). Enquiries about this area of research should be addressed to Professor A T Johns at the City University, Northampton Square, London EC1V 0HB; telephone 01-253 4399, ext 3811.

Real time monitoring and control

Monitoring and controlling power systems involves timescales ranging from a second to a day. The objective is the production of centralised techniques for control to achieve the most economic use of power system networks. Computer simulation of networks is used to study the effects of various algorithms and control strategies. In order to implement the control strategies it is necessary to monitor the state of the system through real time measurements of currents, position of switches etc. Access to a VAX 8600 computer, recently installed at Durham University, will be available to assist research in this area by other groups. Any enquiries about this area of research should be addressed to Professor M J H Sterling at Durham University (address on page 10).

Operational planning

Here the timescale is hours to months and the objective is the planning of operating and tariff strategies ahead of real-time control of a power system. Typical projects study the interaction of forecasting loads, planning maintenance schedules, and the logistics of fuel, transport and manpower on a system. System simulation is used for those studies which can also include emergency operating strategies and the effects of variable prices and tariffs. The degree of complexity of the resulting computing packages is tailored to the needs of the user with emphasis on ease of use and clarity, especially for overseas applications. Any enquiries about this area of research should be addressed to Dr B J Cory, Imperial College of Science and Technology, Exhibition Road, London SW7 2BT; telephone 01-589 5111, ext 5125.

System planning

Electrical power system planning is a multidisciplinary exercise involving timescale of years. It is intended to concentrate on three areas for academic research: methodology, UK planning issues, and information exchange. Within these areas, subjects identified for study include systems, standards and economics; energy resources, sources and uses; modelling principles; demand forecasting; fuels and generation plant mixes; network structure and transmission and distribution economics. Rural electrification and the application of electricity economics and load management to developing countries are other topics of interest. Any enquiries about this area of research should be addressed to Professor M A Laughton, Queen Mary College, Mile End Road, London E1 4NS; telephone, 01-980 4811, ext 4331.

Image converter camera for high speed photography

SERC has recently purchased an image converter camera to facilitate research on fast transient phenomena. Surrey University's Department of Chemical and Process Engineering, the first users, have used it to study impact attrition of particulate solids. The facility has already proved useful in elucidating qualitatively the mechanisms involved in impact attrition, and in focusing attention on where exactly the problems lie. Here we summarise Surrey's short experience with the facility.

High speed photography is an essential tool in the study of transient processes with time-scales measured in microseconds - for example impact, brittle fracture and shock waves. It effectively expands this time-scale by recording the state of the event at a given instant or series of instances at very short exposure times. SERC recently purchased an Imacon 790 camera capable of reaching framing speeds up to 20 million frames per second and also equipped with streak facility. This should be much welcomed by the academic research community because high speed cameras are generally too expensive to be purchased for only one project.

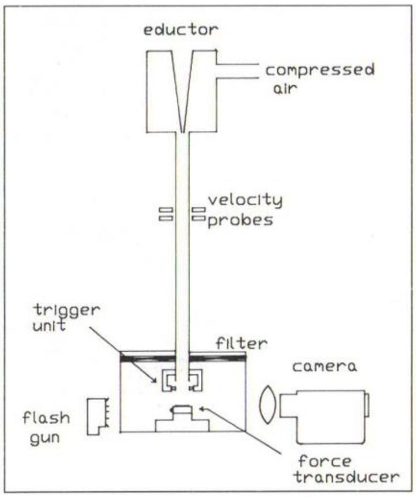


Figure 1: Schematic diagram of the experimental rig.

The Imacon 790 is an image converter camera. The optical image falls on a sensitive photocathode which releases electrons. Further processing is then carried out 'electronically', and hence the potential for very high speeds. A series of deflector and shutter plates moves the electron beam to different parts of a phosphor screen, where the electron beam is converted back to a light beam. As a result of the deflection of the electron beam, a set of frames is produced which is recorded on a stationary film behind the screen. The number of frames can be preselected between 8 and 20, depending on the geometry of the image. The exposure time of each frame and interframe delays are controlled by a plug-in module. For each framing speed a module, tuned with the image-tube, must be inserted into the camera. The present facility has modules for framing speeds of 1×10^4, 1×10^5, 2×10^5, 5×10^5, 1×10^6, 2×10^6 fps and streak capabilities for 10-100 ns/mm and 100-1000 ns/mm.

There are, of course, other types of high speed camera such as rotating prism and rotating mirror cameras. However, as the first choice for a high speed camera with a wide range of applications, the Imacon 790 has several advantages: it is portable and can be assembled quickly; synchronisation and triggering are easy because the camera is fully electronic; it operates at lower light levels than other cameras and in fact standard electronic flash guns are adequate in most cases; the results are obtained fairly instantly if Polaroid film is used.

Since the purchase of the camera in January 1986, we have used it to observe the process of impact attrition of sodium chloride particles. This is a cooperative research project funded by SERC's Specially Promoted Programme in Particulate Technology, and the New Science Group and Mond Division of ICI plc. The aim of the project is to elucidate the fundamental mechanisms by which particulate solids break down by impact. In a simple set-up in figure 1, solution-grown NaCl crystals (about 1 mm cubes) were accelerated in a concentric eductor and impacted on to an instrumented target plate. The particle velocity was measured by a pair of photoelectric detectors. The camera and flash guns were triggered by another photoelectric detector placed near the target plate.

Figures 2 and 3 show the impact of a particle at 30 m s^{-1}, recorded by the Imacon camera at 5×10^4 fps. The exposure time of each frame is 4 μs, and interframe delay is 20 μs, thus giving a total recording time of 160 μs. The sequence of the frames is: first frame on top right of the plate, next below and subsequent frames moving to the left. The results are illuminating. A 'face-first' impact (figure 2) breaks the crystals into large fragments, the cracks are formed normal to the impacting surface and parallel to the planes in the ‹100› zone. In a corner impact (figure 3) where the impact axis is in line with the cube

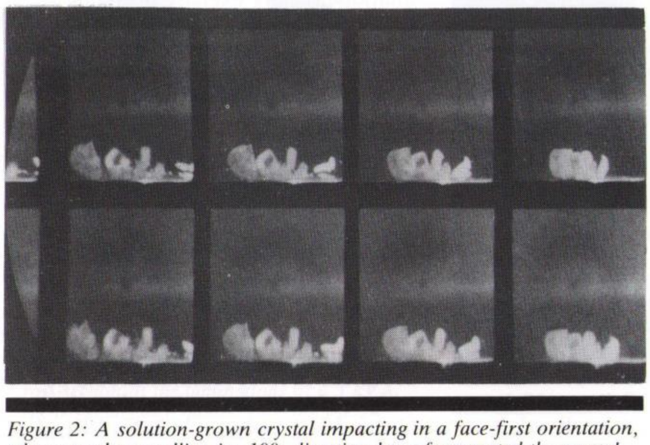


Figure 2: A solution-grown crystal impacting in a face-first orientation, where cracks travelling in ‹100› direction have fragmented the crystal.

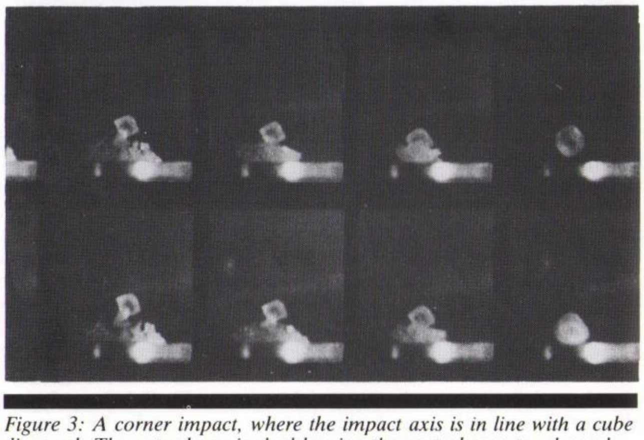


Figure 3: A corner impact, where the impact axis is in line with a cube diagonal. The outer layer is shed leaving the central core to rebound with little damage.

diagonal, the particle sheds its outer layer permitting the central core to rebound with little damage; most of the kinetic energy appears to be taken up by this outer structure. It should be noted that the solution-grown NaCl crystals used in this work have a central core which can be regarded as a 'single' crystal, surrounded by a 'polycrystalline-like' structure about 300 μm thick. The outer layer contains many crevasses and voids and its external surface has a stepped profile (see figure 4). This type of morphology is believed to have been produced in the industrial crystallisation process. On impact, the outer layer forms the main bulk of the debris. It appears that the porous structure of this region does not allow stresses to be transmitted effectively to the central core; fragmentation of the surface layers inhibits propagation of strain, and therefore propagation of cracks into the central core.

In summary, the short use of Imacon 790 has made it possible to observe that, in impact attrition of solution-grown NaCl crystals, the macroscopic growth features play a dominant role in determining the characteristics of the attrition debris of solution-grown NaCl crystals. The camera will also be used to measure the dynamic yield stress and the influence of strain rate directly.

Finally a note for potential users who may have to design or modify their experimental rig to fit the camera. Careful advanced planning for details of fitting the camera, lighting and triggering is needed before the camera is actually borrowed in order to avoid excessive down-time. The camera is in the custody of the Process Engineering Secretariat (SERC Central Office, Swindon, ext 2492), to whom any enquiries concerning the loan of the camera should be addressed.

Dr M Ghadiri and Dr K R Yuregir
Department of Chemical and Process Engineering
Surrey University

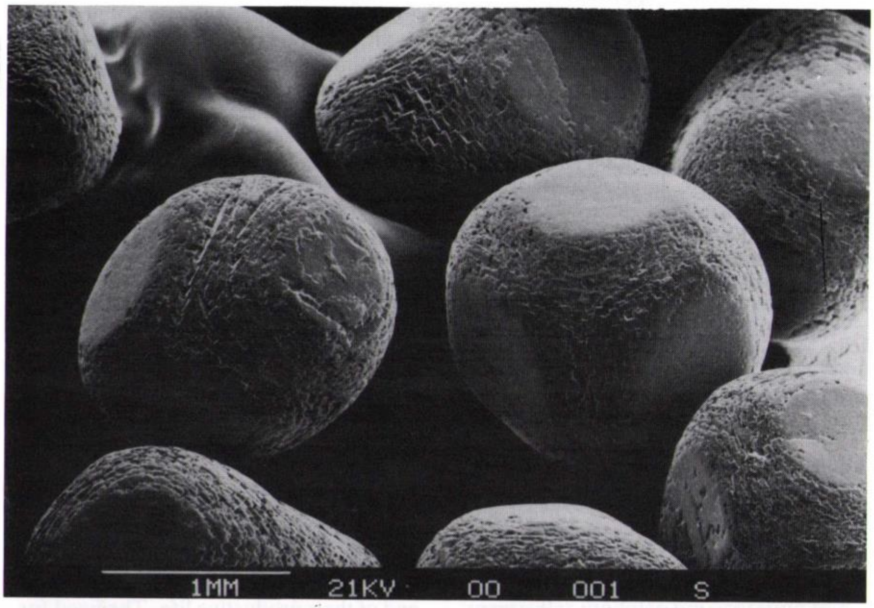


Figure 4: A scanning electron micrograph showing the surface morphology of the solution-grown sodium chloride crystals.

The successful management of technological change

Many problems within industry and the public service demand an understanding of both technical and socioeconomic aspects and their interrelationship. To promote this understanding, the Joint Economic and Social Research Council-SERC Committee was established in 1968 to provide support for postgraduate training in inter-disciplinary areas involving science or engineering and social or economic science.

The Joint Committee is now launching a research initiative on the successful management of technological change. As a nation we need to be more effective in the way in which we manage the exploitation of technology and its introduction to product and processes in industry and commerce. Technology of itself does not produce the results; this comes from its applications and successful applications derive from the marriage of technology with a range of other activities, particularly those concerned with human behaviour, organisational and management issues, marketing, legal, economic and financial considerations. The consequent need for a multidisciplinary approach provides a focus for research to be sponsored by the Joint Committee.

Complementary programmes are being developed by the ESRC initiative on 'new technology' and their Programmes on Information and Communication Technologies, as well as projects funded by the ACME Directorate of SERC.

The Joint Committee proposes to spend a substantial proportion of its research budget in this area, and among the topic areas that are thought to be potential fields for research are:

- ☐ The role and career patterns of qualified scientists and engineers in business;
- ☐ The implementation of technological change;
- ☐ Technology in the service sector;
- ☐ Environmental and societal constraints on technological change;
- ☐ Production management.

The overall intention is to stimulate good quality research projects which are genuinely multidisciplinary. The Committee, when considering research applications, will encourage those researchers who wish to make their results available to industry and commerce by publishing their findings outside the narrow field of specialist channels and conferences.

The Joint Committee foresees the first phase of this initiative lasting about four or five years before being reviewed. In that time it would hope to fund between five and eight programmes in any one year.

Further details about the new initiative can be obtained from Miss A M Wilson, Joint Committee Secretariat, SERC Central Office, Swindon, ext 2427.

Electrostatic coalescence

Electric fields can be used to promote coalescence between droplets of a conducting liquid that are insoluble and finely dispersed in a second insulating liquid. The method is applicable specifically to emulsions or dispersions of the 'water in oil' type. The electric force field causes water droplets to coalesce so that small droplets quickly grow to a size where they can gravitate speedily from the oil. By using this method to achieve rapid liquid-phase separation substantial savings can be made in equipment size and liquid inventory in circumstances where it is necessary to resolve emulsions and dispersions that would otherwise take a long time to separate out.

Liquid-phase separation by electrostatic fields has been the subject of research at Bradford University for the past eight years. the work has been supported through collaborative ventures with industry and by substantial grants from the Process Engineering Committee. An important innovation arising from the investigations at Bradford is the use of pulsed dc with the high voltage applied by an electrode coated with a layer of insulating material. This combination permits the efficient treatment of emulsions and dispersions containing high water fractions. The effect of any short-circuit through the mass of conducting droplets is localised by the insulating coating on the high-voltage electrode; the field elsewhere between the electrodes remains effective and undiminished by the local short-circuit. It has been found that coalescence performance may be improved by the correct choice of pulsation frequency.

It is hoped that the new technology will be applied in the production of crude oil where the co-produced saline water must be removed from the crude oil at the well-head. In this instance there is a strong incentive to improve existing methods of electrical treatment to cope with the high water cut emulsions that occur particularly as oil fields near the end of their productive life. The need for more efficient separators is especially apparent in offshore locations where space and weight are at a premium.

In the future it is likely that the large-scale use of electrical methods of liquid phase separation will not be restricted to the petroleum industry. There are now new processes outside the oil industry where electrostatic coalescence has been shown to offer important advantages. Foremost among these processes are those employing solvent extraction or liquid membrane technologies for the recovery of organic or metallic species. Hydrometallurgical routes for metals such as copper are of particular interest since they necessitate the separation of large quantities of aqueous-in-organic dispersions. The merit of pulsed dc for accelerating the removal of aqueous droplets from a copper-selective organic reagent (LIX64N) has been clearly shown at Bradford. Other applications, notably the downstream processing of fermentation broths, should eventually be candidates for electrostatic phase separation despite the influence of solids, cell debris and stabilising chemicals.

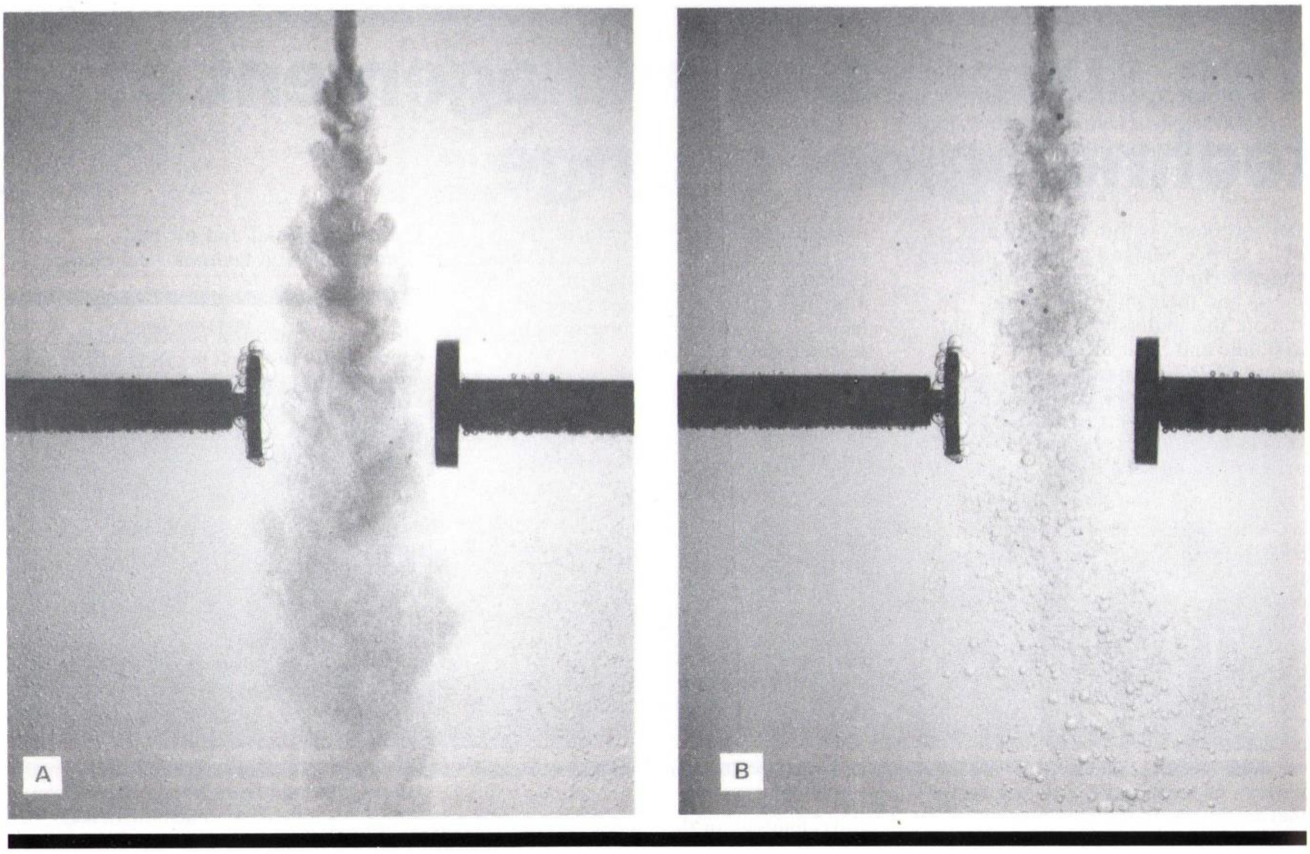
For further information on this project contact:

Dr P J Bailes
Schools of Chemical Engineering
Bradford University
BRADFORD BD7 1DP

A dispersion of water droplets in LIX64N diluted with kerosene passing between parallel electrodes 3.3 cm apart (aqueous:organic phase ratio = 1:3)

A: No electric field applied to the jet of dispersion.

B: 4 kV pulsed at 10 Hz applied to the PTFE coated right-hand electrode of the pair with the bare metal left-hand electrode earthed. Note the speed at which coalescence is occurring.



Design of high speed machinery

The Engineering Board of the Science and Engineering Research Council is supporting, through its Machines and Power Committee, a Specially Promoted Programme (SPP) aimed at improving the designs and performances of high speed machinery in the UK by encouraging multi-disciplinary academic research in collaboration with industrial companies.

The programme, which began in March 1985, is scheduled to run for five years and so far 17 investigations from the textile, packaging and sheetmetal working industries are being supported. The investigations, 13 of which involve direct collaboration between academic and industrial establishments, relates to improving the performances of machines only or of machines and processes jointly.

The SPP is pursuing the following strategy:

1. A comprehensive suite of 'front-line' investigations is being established. Each investigation involves, or will involve, collaborative multi-disciplinary activities between academic and industrial establishments and appropriate data are, or will be, exchanged regularly between different investigations through meetings, high speed video and regular inter-establishment visits.

2. Common problems from the front-line investigations are being identified and academic research workers will be encouraged to investigate these problems in depth so that useful information can be fed back to the front-line investigations requiring it and passed to industry generally. For example, problems common to a number of investigations will probably occur in the areas of *control and measurement* and *actuators, drives and mechanisms.*

3. A national centre for the design of high speed machinery may be set up; it would perform these duties:

□ Collect information of potential general use from front-line and supporting investigations, interpret and generalise the results, and compile software packages, databases, data sheets and technical literature as appropriate;

□ Distribute generalised information to industry;

□ Provide supporting services on information up-dates and give advice on practical applications;

□ Provide information generally on all matters affecting the designs and performances of high speed machinery.

Front-line investigations

The following three investigations typify the approach which is being adopted with the SPP and are representative of the investigations currently under way.

High speed actuators

Bentley Engineering Ltd uses electronic controls and electromechanical actuators on its circular knitting machines (for sock, other garment and fabric manufacture) to attain the flexibilities of operation and choices of pattern normally associated with flat-bed knitting machines while retaining a 200% production advantage. Despite this progress, electronically controlled machines are much slower than totally mechanical machines and are not feasible for fine yarns. A collaborative investigation with Bristol University is therefore aiming to develop low cost, ultra-high speed actuators. The multi-disciplinary, inter-departmental programme, involving mechanical, electrical and textile technologies, will ensure that the actuators developed, the knitting machines and the process will be compatible.

The investigation should result in the availability of controlled actuators capable of operating at rates of more than 80 times a second; such actuators and the associated technology should find many other applications in industry and other companies are being invited to join the programme.

Carton erection

Erecting rectangular cardboard cartons under production conditions is unreliable and Liverpool Polytechnic is carrying out an investigation on behalf of Unilever Research to improve reliability with a speed range of 100 to 500 cartons a minute.

A specification of the ideal motion required will be produced. Mechanisms will then be designed, using computer-based dimensional synthesis to relate as closely as possible to the ideal motion, and tested. Possible mechanisms could range from those having rigid, coordinated linkages (which give high operating speeds but are difficult to adapt to different carton and batch sizes) to those having independently driven and controlled linkages (which give slower speeds but allow far greater operating flexibility). Early results indicate that a hybrid mechanism, of fixed linkages with some degree of computer control, may be most suitable.

The mechanisms developed, together with the associated techniques of selection and design, should have a wide range of application.

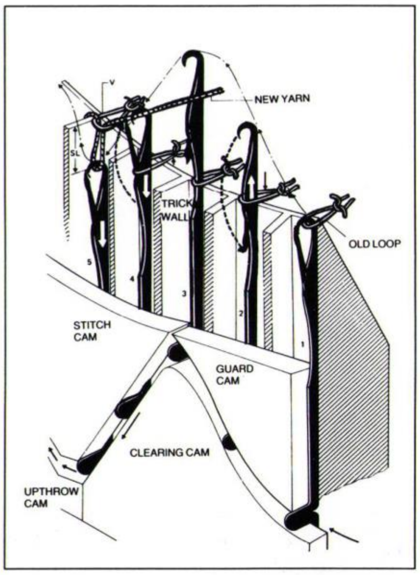
Sheet metal feed

Many high volume manufacturing systems require rapid transfer of materials between stations and highly accurate, synchronised motion control for registration. Indexing flexibility to achieve quick changeovers between products and avoid wasting materials is also frequently required.

The high speed pressing of metal sheet using multiple impressing tooling, such as that required by Metal Closures Ltd to produce metal caps for bottles, is one such system and a collaborative investigation is underway with Birmingham University to introduce electrical servo motors for the accurate control of press cycles.

In-process adaptive control strategies are being studied, with associated measuring systems for transferring sheets between magazines, press infeed systems and outfeed arrangements, together with microprocessor-based controller modules for operating in high speed, interactive modes. A systems engineering approach will ensure that developments can be retrofitted smoothly into practical production environments.

For further information on the SPP, please contact the Coordinator, Dr G Sweeney, 8 Hall Hill, Bollington, MACCLESFIELD, SK10 5ED; telephone Macclesfield (0625) 72623.



Mechanism for circular knitting machines.

Clustering in nuclei

Nuclei are made up of neutrons and protons, or so conventional wisdom goes. However, recent experiments reveal that an alternate and perhaps simpler picture may be valid in which we can view the nucleus as comprising clusters of nucleons. At the Nuclear Structure Facility new experimental techniques are being developed to enable this clustering to be explored.

Over the past 25 years a large effort has been expended in the study of nuclear reactions as a means of investigating the structure of the nucleus. In a nuclear reaction a beam of high energy projectile nuclei, provided from an accelerator such as the Nuclear Structure Facility (NSF) at Daresbury Laboratory, is used to bombard a thin target foil. Some of the projectile nuclei pass close enough to the nucleus of an atom in the foil for a collision to take place. By detecting the scattered nuclei, we can indirectly infer much about the properties of the nuclei themselves — for example their masses, charge, shape, as well as quantum mechanical properties such as the energy and spin (angular momentum) of their excited states.

Until recently only binary reaction processes have been studied in detail (a binary process is characterised by having only two nuclei emerging after the collision, see figure 1a). The experimental study of such reactions is much simplified by the constraints of energy and momentum conservation, as it is only necessary to measure the energy and angle of one of the two emerging nuclei for the reaction energetics to be completely specified. In a reaction with three emerging nuclei (see figure 1b) it is necessary to record simultaneously the energy and scattering angle of two of the nuclei, a much more time-consuming process since the efficiency is greatly reduced. As a consequence there have to date been few attempts to study such reaction processes. Now, several experimental developments can be turned to advantage to make these experiments feasible and, although the ternary processes turn out to be intrinsically much less frequent than binary events, their study is proving most fruitful in revealing new insights into the structure of the nucleus. A few of the results from recent experiments on the NSF are outlined here.

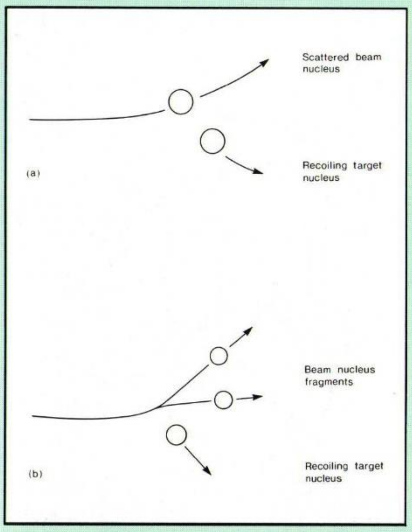


Figure 1: Schematic illustration of two different reaction processes: (a) a binary reaction and (b) a ternary reaction (projectile break-up).

Alpha clustering

The existence of alpha particles inside the nucleus has been investigated for some time — one example of evidence for this is the alpha decay process. An alpha particle consists of 2 protons and 2 neutrons and is therefore an isotope of helium. In nuclear physics we denote this by $^{4}_{2}He$ using the standard chemical symbols with a subscript denoting the number of protons and a superscript denoting the total number of neutrons and protons. In alpha cluster models a nucleus such as $^{16}_{8}O$ (8 protons and 8 neutrons) is described as a $^{12}_{6}C$ core (6 protons and 6 neutrons) around which an alpha particle orbits. In the cluster model, the excited states of $^{16}_{8}O$ entail the alpha orbiting with increased energy and angular momentum. The experimental study of such states has been difficult to date, but the three-body technique turns out to be ideally suited to these investigations. The reason is that the excited states in $^{16}_{8}O$ corresponding to these alpha cluster configurations have a high probability of breaking up into a $^{12}_{6}C$ nucleus and an alpha particle. By exciting these states in $^{16}_{8}O$ in a nuclear collision we can then record the $^{12}_{6}C$ and alpha emerging from the break-up and, if the energies and momenta are accurately enough determined, work back to evaluate the excitation energy and spin of the alpha cluster states.

Figure 2 shows an experimental energy spectrum for $^{16}_{8}O$ determined using the break-up technique. There are thousands of states in $^{16}_{8}O$ in the energy interval covered, but the technique picks out those states which have the special property of a well developed alpha cluster character. These appear as the peaks discernible in the spectrum. The peak at 29 MeV turns out to be of particular interest as a more detailed analysis shows it is actually two unresolved states with spins of 8ħ and 9ħ (ħ is Planck's constant - the quantum unit of angular momentum). This spin 8 state had not been located previously and its absence in the $^{16}_{8}O$ spectrum had been a considerable puzzle to theoreticians for many years. New calculations which treat $^{16}_{8}O$ as consisting of four alpha particles may eventually resolve the theoretical puzzle. In this model the excited $^{16}_{8}O$ splits into a single alpha separated from a group of three alphas, with the configuration of the three alpha cluster appearing to correspond to that of $^{12}_{6}C$.

Nuclear molecules

Recent experiments on the NSF have revealed the existence of even larger clusters — what might be called nuclear molecules. When a beam of high energy $^{24}_{12}Mg$ nuclei is directed at a target, detectors placed around the target reveal many coincidences of pairs of $^{12}_{6}C$ nuclei emerging from the reactions in the target. Figure 3 shows the summed energy of the two emerging $^{12}_{6}C$ nuclei. The large peak at the right of the figure corresponds to events where the incident $^{24}_{12}Mg$ nuclei has split symmetrically to form two $^{12}_{6}C$ nuclei. This rather dramatic splitting reveals that an excited ^{24}Mg nucleus can look like a configuration involving two $^{12}_{6}C$ nuclei — hence the term nuclear molecule. Indeed, theoretical work is now revealing that such a cluster model of

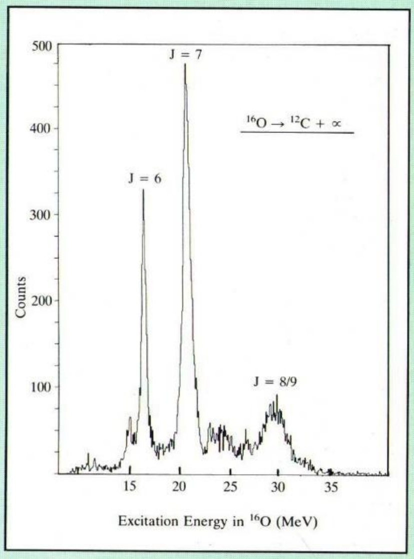


Figure 2: A spectrum of the alpha-cluster states in $^{16}_{8}O$ observed from break-up of $^{16}_{8}O$ into $^{12}_{6}C+\alpha$. The spins of the states are identified from a measurement of the angular correlation of the break-up fragments.

^{24}Mg formed from two $^{12}_{6}$C nuclei orbiting their common centre of mass has considerable success at describing the known excited states in ^{24}Mg. Evidence has also been obtained that $^{28}_{14}$Si may look like orbiting $^{16}_{8}$O and $^{12}_{6}$C nuclei, and further experiments are in preparation to determine the full extent of this large-scale clustering effect in nuclei.

Towards 4-body experiments

Important information on nuclear states can also be obtained from processes which produce four outgoing particles. If $^{24}_{12}$Mg is produced by bombarding $^{12}_{6}$C with $^{16}_{8}$O, the sequence of decays from an excited state in $^{24}_{12}$Mg can be as follows:

$$^{12}_{6}C + ^{16}_{8}O \rightarrow ^{24}_{12}Mg^* + \propto$$

$$\rightarrow ^{20}_{10}Ne^* + \propto$$

$$\rightarrow ^{16}_{8}O + \propto$$

(the * symbol denotes an excited nucleus).

It appears that a careful analysis of the angular correlation of the outgoing particles (how the yield varies with the angle between the particles) can enable the angular momentum of both the ^{24}Mg and ^{20}Ne excited alpha-cluster states to be determined. This is a useful new spectroscopic tool, but it clearly is considerably reduced in efficiency since it requires three particles to be detected simultaneously and can only be performed if a large number of detectors is utilised.

A new charged particle detector array

The measurements discussed here pose stringent experimental demands. The detection systems used must be capable of identifying uniquely specific nuclei in the presence of a huge flux of more readily produced reaction products. They must be able to register coincident events of nuclei of interest, and accurately record their energies and scattering angles (both in and out of plane).

Experiments performed so far at the NSF have made use of existing scattering chambers and detectors (see figure 4). However, these can only operate in a relatively inefficient way and, as interest in these studies has grown, plans have evolved for a purpose-built array of detectors specifically designed for high efficiency multi-particle studies. The proposal currently being developed comprises an array of some 40 detectors in a purpose-built scattering chamber along with the associated electronic and data acquisition facilities. These detectors would cover a full 2π of scattering angle, and such a facility would provide an order of magnitude increase in our data-taking ability, enabling much weaker processes to be isolated.

The combination of this novel new array and the resources provided by the NSF at Daresbury will provide a unique facility and will enable UK groups to maintain their world lead in this area. We await with considerable interest the new understanding on the structure of nuclei which this will provide.

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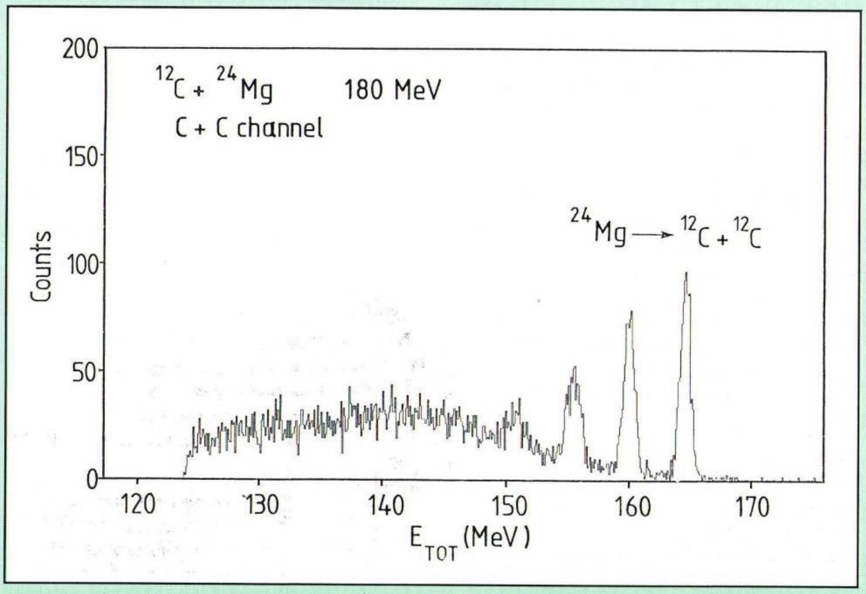
Figure 3: Spectrum of the summed energy for pairs of $^{12}_{6}$C nuclei produced in the scattering of high energy $^{24}_{12}$Mg nuclei. The highest peak corresponds energetically to the symmetric break-up process $^{24}_{12}$Mg→$^{12}_{6}$C→$^{12}_{6}$C.



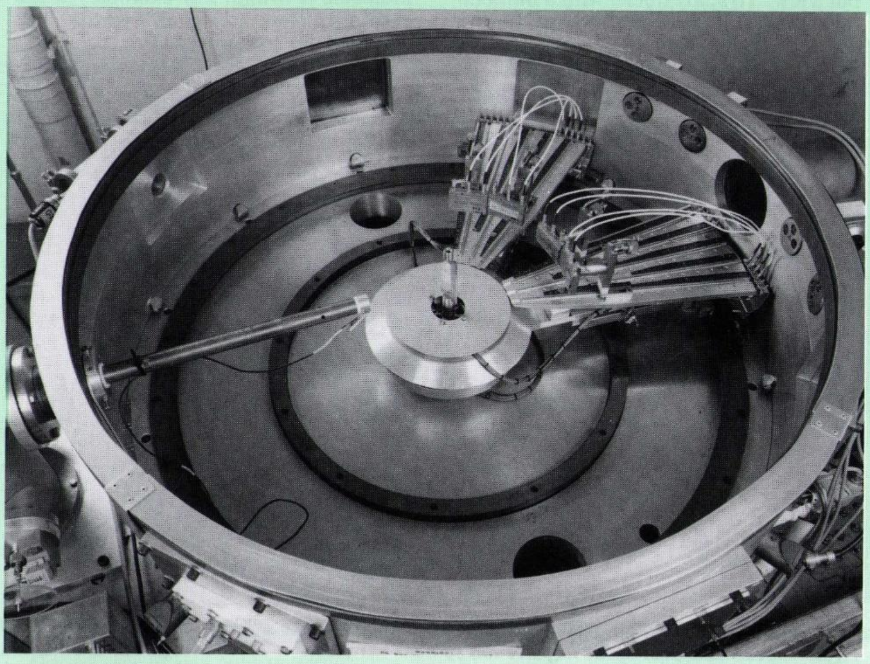


Figure 4: Detectors set up for one of the early coincidence experiments on the NSF. The next generation of experiments will be carried out in a purpose-built chamber housing an array of up to 40 detectors.

50th beam from the NSF

The Nuclear Structure Facility at Daresbury Laboratory has just accelerated its fiftieth different beam species, emphasising its versatility in the field of nuclear physics.

Extending our knowledge and understanding of the properties of the atomic nucleus relies primarily on the provision of energetic beams of particles from accelerators like the NSF as nuclear probes. They are made to interact with target nuclei and the interaction studied by suitable techniques devised to detect the radiation emitted in the process. In the early days of nuclear structure physics, beams of the lightest nuclei — protons and alpha particles — were used because only modest energies and hence small accelerators were required for a nuclear interaction to take place. Indeed, in the earliest experiments of all, carried out by Rutherford, the α-particle 'beam' was produced by the decay of a radioactive isotope. As nuclear physics progressed, the need grew for accelerators to provide beams of heavier and heavier nuclei with as broad a mass range as possible. The impetus for this demand stemmed from a variety of reasons dictated by the ever-widening range of experiments being performed.

For example, if the physics of a rapidly rotating nucleus is to be studied, then the appropriate amount of angular momentum must be injected into the system. This is achieved by using energetic beams of heavy nuclei, such as sulphur, calcium or selenium to name but a few. To study nuclei with a number of neutrons and protons far from that required for stability first requires the creation of these exotic nuclei. This can be achieved by fusing heavy projectiles with heavy target nuclei. These needs led to the birth of the NSF.

An electrostatic tandem accelerator is ideally suited for producing a wide variety of particle beams with precisely defined energies. This versatility relies in no small way on the properties of the primary beam generator itself — the 'ion source'. In the case of a tandem Van de Graaff, a source is required which produces negative ions for injection into the accelerator. After initial acceleration to the positive high voltage terminal, between 8 and 12 electrons are stripped off and the resultant positively charged ions are further accelerated from the terminal to ground potential where they emerge as an energetic beam.

Negative ions are produced in the source by the sputtering process. Sputtering is achieved by bombarding a small pellet with a very low-energy, well focused beam of singly charged positive caesium ions, as shown in figure 1. The caesium beam not only coats the surface of the pellet with neutral caesium but also sputters atoms from the pellet which then pass through the surface layer of caesium, an element which readily donates electrons. In so doing, a negative ion is formed which is electrostatically extracted from the source. The required ion is obtained by simply making the pellet out of the appropriate material. For example, a carbon beam is obtained from a graphite pellet, a sulphur beam from a lead sulphide pellet, and so on. If the negative ion of the element does not exist because the ion is unstable and hence cannot be formed, then a suitable molecule is found. For example, in the case of calcium a calcium hydride negative ion is extracted by simultaneously sputtering the surface of a calcium pellet with caesium and directing a low pressure jet of ammonia gas on to the surface. The molecule is accelerated to the terminal of the tandem where it is dissociated in the electron-stripping process and the positive calcium ion alone further accelerated out of the terminal. In this way, beams of almost any element may be produced.

The pellets used can be very small, typically 2 mm cubed, and so very little material is required. This further increases the versatility of the source by making possible the provision of beams of low natural abundance isotopes. Most elements have several stable isotopes whose natural abundances vary considerably. For example, natural sulphur consists of 95% ^{32}S, 0.75% ^{33}S, 4% ^{34}S and 0.02% ^{36}S. A nuclear physicist may require beams of any one of these isotopes depending on the particular experiment he is carrying out. Provision of a ^{36}S beam would then necessitate the pellet material being enriched in that isotope. Isotopically enriched material can be very costly, making it prohibitively expensive if large quantities are required. The NSF ion source can require as little as 10 mg of material thus making the provision of such beams viable.

The number of beam species accelerated by the NSF since it began operation in 1983 has now increased beyond 50. These are displayed in figure 2 and vary in mass from protons to gold including the radioactive beam species tritium and carbon-14. This broad range is entirely due to the combination of the versatilities of the ion source and the NSF tandem. To a large extent the experimental programme owes its success to this capability.

Dr H G Price
Daresbury Laboratory

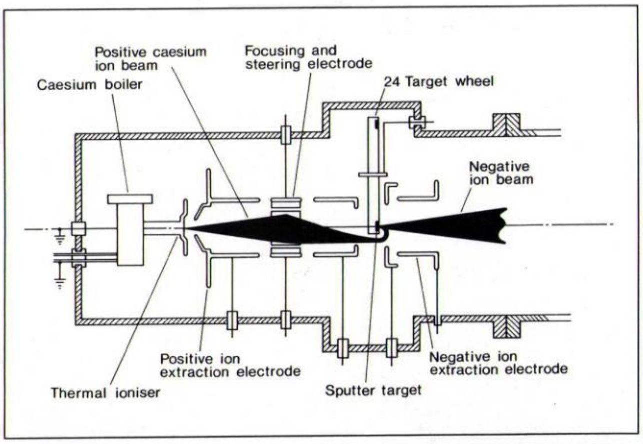


Figure 1: Schematic plan of the negative ion source.

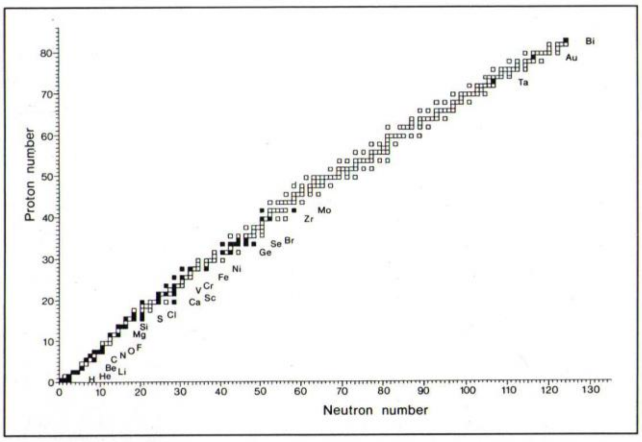


Figure 2: The stable isotopes. Beams accelerated are indicated as solid squares.

High pressure as a research tool

SERC supports experimenters using high pressure techniques from a wide range of disciplines, such as chemistry, physics, biology and material science. In a series of articles (Volume 3 No 2: June 1985, No 3: Autumn 1985 and No 5: Summer 1986). *SERC Bulletin* has featured some of the channels through which that support is given, including the Daresbury and Rutherford Appleton Laboratories and direct grants to the scientific community. In this final article, we describe the work of the High Pressure Facility provided at the Standard Telecommunication Laboratory (STL).

Pressure, like temperature, is a major thermodynamic variable, but that hackneyed statement gives little feeling for the magnitudes involved. For relatively incompressible solids such as oxides, a pressure of 5 GPa changes free energy as much as 1,000°C (but with opposite sign) — and one can generate steady pressures of more than 100 GPa. Very high pressures, then, *should* have major effects — indeed, under them, familiar phase diagrams distort dramatically and band structures flex as if made of elastic (not too surprising since such pressures can significantly alter interatomic distances).

Pressure is force per unit area, and high pressure apparatus is based on applying large forces to small areas, for example 1 GPa corresponds to a large man's mass applied to an area of about one mm^2. The limit is set by the strength of available materials, which can be deduced from the indentation hardness. Diamond, with the highest value (7,000 kg/mm^2 or more) is used to obtain the highest possible pressures (the present 'record' being about 500 GPa) but for constructing large apparatus, cemented tungsten carbide (hardness about 2,000 kg/mm^2) is generally used.

High pressure phenomena do not necessarily require special apparatus but can be very much part of the everyday world. Thus friction and wear can involve dynamic pressures in the GPa range, as can shock waves (whether from impact between hard objects, or from cavitation or explosion). Investigation of physical and mechanical properties under controlled static pressures could throw important light on these effects. In a rather different context, marble and other metamorphic rocks have been formed (and deformed) under high pressure — its application inhibits cracking, so that solids brittle at 1 atmosphere can be made to deform under pressure, which incidentally is not without implications in metallurgy and ceramics. It is therefore surprising how little direct assessment of pressure effects has been carried out by geologists and mineralogists, metallurgists and ceramicists — and most of that work has been done abroad.

Perhaps the most active area for very high pressure research is solid state physics, where pressure has proved an invaluable tool for investigating the detailed nature of band structures and a wide range of other topics ranging from phonon spectra to crystal field interactions. It is to exploit these possibilities that a special collaboration has been set up between the SERC High Pressure Facility located at STL, Harlow, Essex, and six university groups (at Cambridge, Imperial College of Science and Technology, Nottingham, Oxford, St Andrews and Surrey) to investigate the effects of pressure on Low Dimensional Structures (see also page 24).

Another area of interest is the synthesis of new solids. The first new material prepared by the action of pressure was the black form of phosphorus, first made some 75 years ago by Bridgman. This appears to be the thermodynamically stable form at 1 atmosphere, which suggests that there could be other solids whose familiar form may yet prove metastable and transformable by pressure into the truly stable form. Although many materials have been shown to transform into other structures at sufficiently high pressures (for example, by the techniques described by Dr Hatton and Dr Adams in previous articles in this series), rather few such high pressure forms can be retained under 1 atmosphere conditions, diamond and cubic boron nitride being the best known.

A further field of great promise is reaction chemistry. The enforced closer approach of molecules under pressure can greatly alter reaction kinetics and might well enable entirely new reactions to be achieved, which could interest organic chemists in search of new routes for synthesis.

It can be remarkably easy to do experiments at high pressures: the SERC High Pressure Facility provides a variety of equipment and techniques to enable researchers to do so with minimum effort and at little or no cost. Equipments range in capacity from some 75 ml at 1.5 GPa near room temperature to a few mm^3 at 10 GPa and 1500°C. Groups from some 15 universities and polytechnics have used the Facility to carry out research in a wide variety of fields in physics, chemistry and metallurgy. The Facility is open to general use via the SERC Physics Committee but, before making an application, physicists, chemists, metallurgists, ceramicists, mineralogists, or anyone else interested in using the Facility should contact the author in order to discuss how the proposed experiments might best be done.

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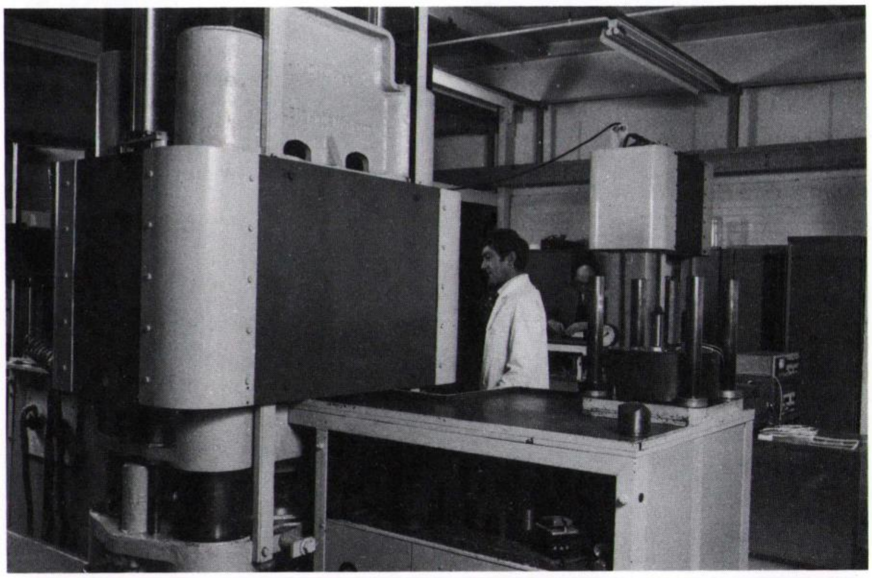


General view of high pressure facility

Synchrotron radiation at Daresbury Laboratory

At any one time there may be up to 20 different experiments running simultaneously on the Synchrotron Radiation Source (SRS) at Daresbury Laboratory, on such disparate topics as the ionisation of helium atoms, the surface structure of magnetic alloys, how a frog's leg muscle stretches, or how dislocations move in ice. What draws together this mixed band of scientists — physicists, chemists, biologists, metallurgists — is the special light called synchrotron radiation.

Synchrotron radiation provides light (photons) of all wavelengths from the infrared, through visible and ultraviolet to X-rays. The SRS at Daresbury is dedicated to providing this light for use in experiments using a wide variety of techniques, including absorption and photoemission spectroscopies, scattering and diffraction. This article attempts to give the flavour of 'life at Daresbury' by describing just four of the latest experiments conducted at the SRS.

Right from the earliest days of using synchrotron radiation for experimental science, one of the largest areas of application has been the study of surfaces, and with the recent SERC initiatives in Low Dimensional Structures (see page 24) and in Interfaces and Catalysis, the surface-sensitive synchrotron radiation-based techniques seem sure to assume even greater importance. EXAFS (Extended X-ray Absorption Fine Structure) is one of the best methods for determining the structure of disordered systems, since it gives the local atomic distribution around a particular type of atom directly. Surface EXAFS has recently been applied by a team of scientists from Daresbury, Thorn-EMI-Varian and Manchester University to study the surface structure of thermionic dispenser cathodes. Almost every home contains one type of cathode device (the television tube), and they are also used in radar installations and high-power radio applications. Cathodes have evolved to their present efficient state largely by empirical development, and we are still rather hazy about the details of how they work. The key to their operation is the surface coating (only one atomic layer thick) which lowers the work function and allows electrons to be emitted more easily. This coating contains barium and oxygen, but how the atoms were arranged on the tungsten surface of the cathode was not known, and its polycrystallinity had precluded definitive study by other techniques.

Surface EXAFS measurements were conducted on real cathodes (not idealised models), and the results show conclusively that the barium atoms sit on top of the oxygen, which likes to lie in the atomic hollows of the tungsten substrate. Such a Ba/O/W 'sandwich' is consistent with what might be expected: electron transfer from Ba to O atoms leaving them partially ionised, will lower the work function. Because the cathode surfaces are polycrystalline, there are many possible detailed geometric arrangements, and alloying the tungsten with other similar metals can give better cathodes. Figure 1 shows suggested models for the Ba/O/substrate complex for representative crystal faces of two of the different types of commercial cathode studied. The type shown in figure 1 (a), with Ba bridging two oxygen atoms, is a more efficient electron emitter than that shown in figure 1 (b), where the barium cannot remain as highly ionised. The findings of this work imply that the detailed crystallography of the tungsten matrix is important in giving a structure where the O/Ba complex can orient itself to give the lowest work function. With the understanding derived from this study, it is hoped that even more efficient cathodes could be devised.

X-ray measurements have recently started at Daresbury using glancing-angle geometries. When the incoming photon beam is incident on the sample at a sufficiently small angle (typically less than 0.5°) the X-rays are totally reflected from the near-surface layer, and information may be obtained on the topmost atomic layers (less than 5 nm deep) of the sample. This idea is neatly illustrated in figure 2, showing results of a glancing-angle EXAFS experiment on uranium dissolved in borosilicate glass performed by Daresbury, ICI plc and the Universities of Strathclyde and Modena (Italy). The three curves show how the local environment of uranium near to the glass surface changes as a result of corrosion by water. Peak B in

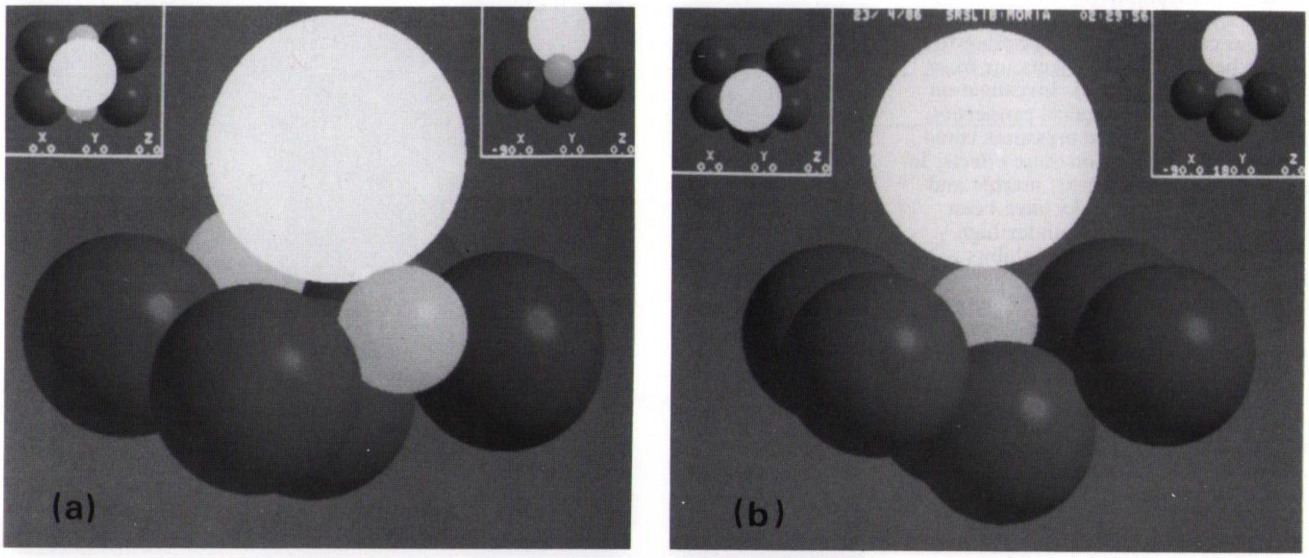


Figure 1: Model derived from surface EXAFS results for the Ba/O/W complex on the surface of two types of commercial thermionic dispenser cathode: (a) W/Os alloy-coated cathode; (b) pure W matrix cathode. Ba atoms are shown white, O atoms grey and W/Os atoms black.

the radial distribution is due to contacts between uranium atoms, and it is seen that this grows in intensity as the corrosion advances. This indicates that the uranium atoms in the near-surface layers are tending to form clusters. The concentration of uranium in this sample was about 0.5 atomic %, which is the level proposed for nuclear waste disposal, and clearly this technique has promise in studying this, and other, corrosion problems. Because the X-rays can quite readily penetrate a layer of liquid, or a gas, above the surface being studied, these measurements could easily be conducted *while a reaction is taking place.*

On an adjacent beamline to the 'high tech' examples given above, scientists from Keele University and Daresbury have been studying earthworms, and in particular seeing the distribution of heavy metals in worms found near a Welsh lead-mine. Their technique has been the relatively simple one of contact microscopy: thin sections of the sample are placed on a photo-sensitive resist material, then exposed for a few seconds to a broad band of radiation (about 2 to 4 nm) from the SRS. The resist, when developed, shows contrast due to differential absorption in different parts of the sectioned worms. Figure 3 displays some of the results, clearly showing stronger absorption (white areas in this figure) due to lead concentrated on the periphery of the chloragosomes and in debris vesicles. The use of monochromatic radiation should allow images to be taken at either side of an elemental absorption edge, and the distribution of quite complicated, multi-component systems could be studied.

Further biologically-related work on the SRS has used X-ray diffraction at the SRS to examine complex molecules in solution or as fibres. Such studies, by another group at Keele University, have revealed new information about the function of DNA, the molecule which carries the genetic code in living things. The well known double helix structure of DNA can be coiled more or less tightly, depending on its chemical surroundings, and the helix can have either left- or right-handed twist. Figure 4 shows a series of diffraction 'snapshots', taken 30 seconds apart, of the change from the semi-crystalline D-DNA, with a helical pitch of 2.4 nm, to the non-crystalline B-DNA, with a pitch of 3.4 nm, and the same direction of twist. Interpretation of such structural details can provide essential clues to how DNA work. A new beam line specifically for time-resolved X-ray studies of biological systems, partly funded by the Medical Research Council, is about to come into use at Daresbury.

This brief selection is intended to give some idea of the wide variety of science being carried out at the SRS. This is not easy to do in just two pages — readers who are really interested, or might like to use synchrotron radiation for their own researches, should visit the laboratory to see for themselves!

Dr D Norman
Daresbury Laboratory

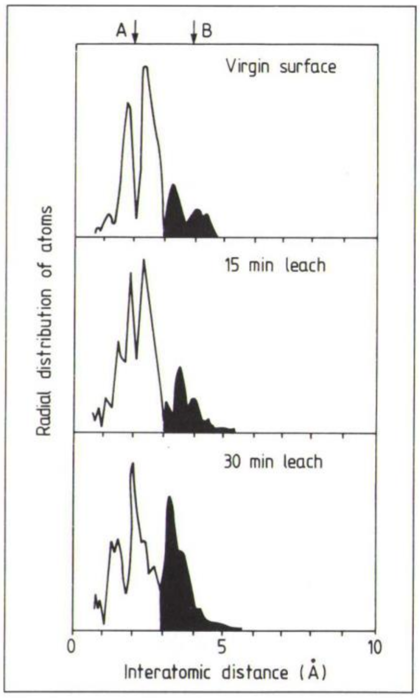


Figure 2: Glancing-angle EXAFS results for the leaching of uranium in borosilicate glass.

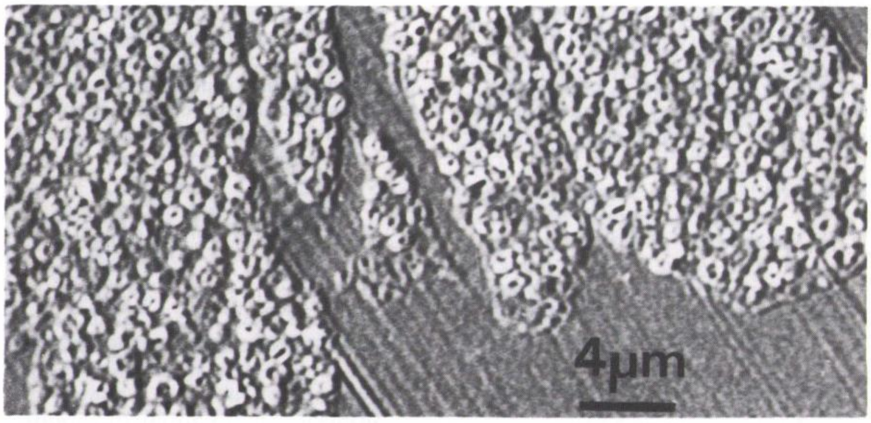


Figure 3: X-ray contact image of lead-contaminated cells from an earthworm. The whiter areas correspond to concentrations of lead. The magnification bar is 4 µm.

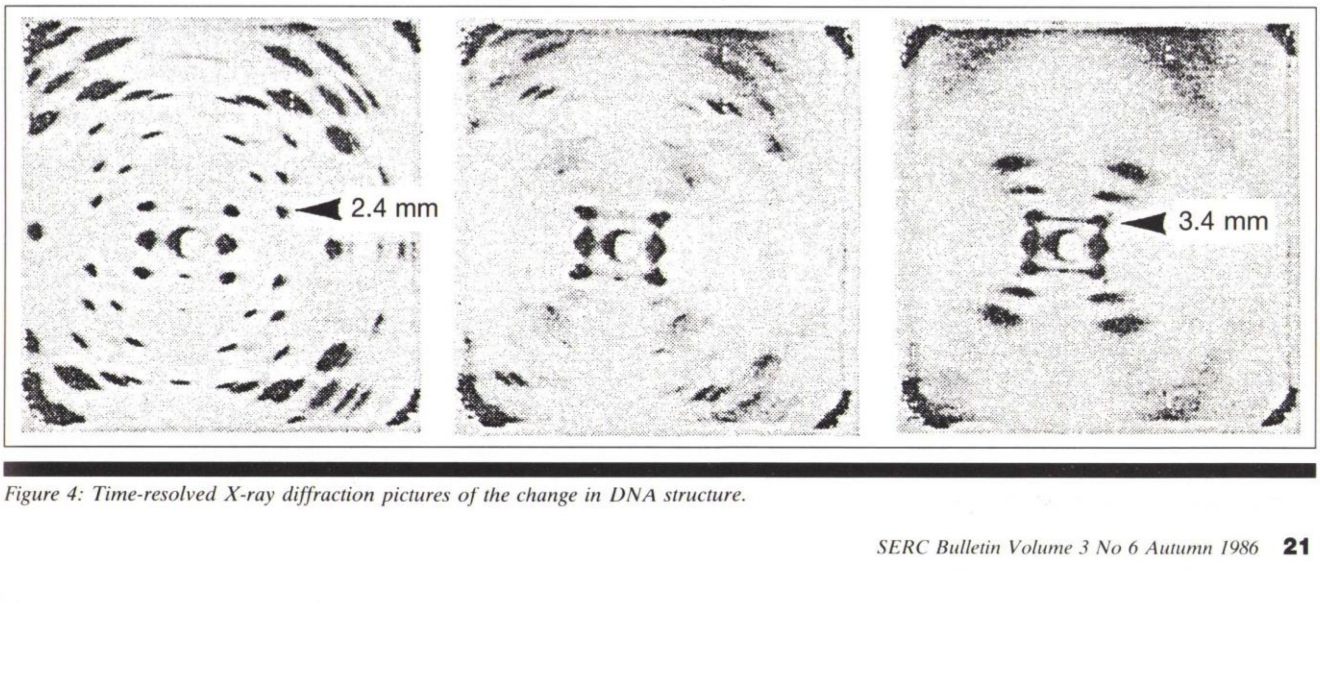


Figure 4: Time-resolved X-ray diffraction pictures of the change in DNA structure.

Developments in polymer science

Polymer chemistry is a broad discipline which encompasses the whole of chemistry and several other fields as well, such as engineering, biology, and medicine. The challenge of polymer chemistry is the application of fundamental chemical and physical ideas and techniques to large and complex molecules.

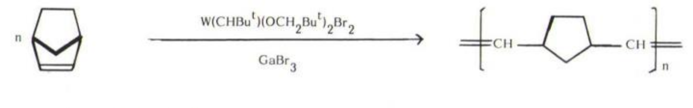
Sixty to seventy years ago there was still considerable debate about whether macromolecules could exist. The work of Staudinger, which did much to convince a sceptical chemical community that they could, earned him a Nobel Prize. Polymer science has come a long way since then but its progress has been hampered by its tendency to be considered sometimes as a subsection of physical chemistry, sometimes as a quite separate section of chemistry, and sometimes simply as a branch of technology. Once it was accepted that macromolecules could exist subsequent work was concerned with the development and understanding of the process of polymerisation and the physical and material properties of macromolecules. A major objective was the synthesis of cheap inert materials. This led to the commercial production of addition polymers such as poly(vinylchloride), poly(methyl methacrylate), poly(tetra-fluoroethylene), and synthetic rubbers and of condensation polymers such as Terylene and the nylons. Further breakthroughs came with the discovery of Ziegler-Natta catalysts, which allow the synthesis of stereoregular polymers, and anionic polymerisations, which allow the synthesis of block copolymers.

At this stage there was a surprising tendency to regard the subject as a mature science, but when one considers what Nature achieves with macromolecules it is clear that the subject is in its infancy and much remains to be done. For example, Nature produces materials with exceptional physical properties by using macromolecules which can become highly orientated. Can we do the same? The code of life is stored and read from macromolecules. Can we synthesise data storage systems or develop recognition systems using similar principals? The catalytic efficiency and selectivity of enzymes depends heavily on their macromolecular nature. Can we prepare synthetic macromolecules with useful catalytic activity and selectivity for general use in synthesis?

In recent years good progress has been made towards some of these goals as the following areas of active interest indicate. The cornerstone for many advances is synthesis. Metathesis polymerisation (see figure 1a) has provided new types of polymers; group transfer polymerisation (see figure 1b), which is based on organosilicon chemistry, has provided a valuable new synthetic route to block copolymers; and the idea of using precursor polymers (polymers which are soluble and easily fabricated and which can subsequently be transformed *in situ* to the desired polymer: see figure 2) has provided excellent synthetic routes to polyacetylene and to poly(p-phenylene). Polymers with liquid crystal groups in the main chain have excellent mechanical properties. Such properties can also be obtained using polymer blends and interpenetrating polymer networks. Many drug delivery systems use macromolecules and it is hoped that eventually each of these may provide, in effect, a recognition system to ensure delivery of the drug to the required location. The introduction of solid phase peptide synthesis by Merrifield and the related oligonucleotide synthesis have given substantial impetus to the study of reactive polymers for use in organic synthesis or chromatography. Polymer films which either crosslink or degrade on irradiation have led to several lithographic processes, such as resists for use in silicon chip technology. Side chain liquid crystal polymers have applications in optoelectronics.

Figure 1: Some recent new polymerisation methods

(a) Metathesis



(b) Group transfer polymerisation

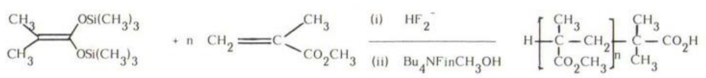
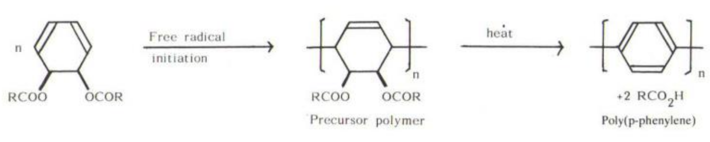
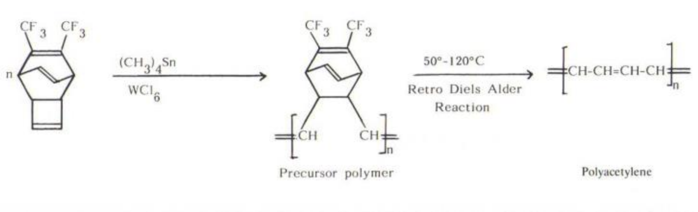


Figure 2: Some recent precursor polymers

(a)



(b)



The interest in the synthesis of polymers, and particularly speciality polymers, is world-wide. Unfortunately in Britain this coincides with an acute shortage of trained polymer chemists. Although polymer-related industries employ a high proportion of university chemistry graduates, a recent survey shows that only about half of university chemistry students are taught polymer chemistry to any significant extent.

The shortage of trained polymer chemists is a considerable concern to many companies and it recently prompted ICI (New Science Group) to raise the problem with SERC. After much discussion, the Chemistry Department at Lancaster University was selected as a place where polymer science activities could be strengthened. Several postdoctoral assistantships and studentships were awarded for research in collaboration with ICI. Courtaulds are also helping to ameliorate the problem by providing support for temporary lectureships in polymer science. This is an encouraging boost for British polymer science but much remains to be done if trained polymer chemists are to be available in sufficient numbers to meet industries' needs and if British polymer science is to retain its high international reputation.

Professor Philip Hodge
Chemistry Department
Lancaster University

Time travel in fruit flies

The fruit fly *(Drosophila melanogaster)* is easy to culture, has a reasonably simple genetic system, shows interesting behaviour and is thus a favourite organism for studying how genes control the nervous system. The courtship of male *Drosophila* is particularly revealing.

When a male fruit fly makes amorous advances to a female, he orients to her, follows her as she runs modestly away, extends his wing and vibrates it (this produces a 'lovesong' - see figure 1), and then attempts to copulate. The 'lovesong' contains a series of pulses, which have gaps or interpulse intervals (IPIs: figure 2), which cycle regularly from 30 milliseconds (ms) to 40 ms every 55-60 seconds (figure 3). This 'lovesong' stimulates the female to mate.

Geneticists have been fascinated by this apparently innate behavioural sequence, and over the years have searched for gene mutations which show abnormal sexual behaviour. For example the *cacophony* mutant sings a very LOUD 'lovesong', *stuck* mutants become just that, and cannot dismount from the female after copulation (often dying in the attempt), *fruitless* mutants court other males instead of females (we call it 'fruity') and *coitus interruptus* mutants — I'll let you guess what's wrong here. The rationale for making mutations is that by studying what can go wrong with a gene, you find out what is required from that gene for normal behaviour. Sophisticated genetic techniques are also available which allow us to find out which part of the fly's anatomy is affected by the mutation. Thus mutant genes can be used as a 'scalpel' to dissect behaviour.

Coming back to the 'lovesong', you will remember that it shows a regular cycling in its pulse intervals. Working with Jeff Hall at Brandeis University in the USA, we found three mutations which changed this one-minute 'lovesong' rhythm. One mutation called *per*^{s} shortened it to 40 seconds, another *per*^{1}, lengthened it to 80 seconds, and the third *per*^{o} obliterated it. These *per* or *period* mutant genes were isolated in 1971 by Ronald Konopka at the California Institute of Technology, when he was studying the fly's 24-hour circadian clock. A fly will show locomotor activity rhythms which look like sleep-wakefulness transitions. Like scientists, in the morning a fly is very active; it snoozes at lunchtime, and perks up again in the evening before settling down for the night. This activity rhythm cycles every 24 hours, even in darkness, and so is controlled by some kind of internal clock. Konopka found three mutations, *per*^{s} which had a short 19 hour rhythm, *per*^{1} which had a long 28 hour rhythm and *per*^{o} which was arrhythmic. Remarkably all three mutations affected the same gene, which Konopka called the *period* gene, hence, the *per* mutants. It was these mutations which had, in the same way, so drastically affected our one-minute 'lovesong' rhythm, suggesting that the song and circadian oscillations, which have widely different cycle times, actually share a common 'clock' mechanism.

Next we used temperature-sensitive mutations with which we could temporarily 'shut down' the nervous system by simply warming up the fly. Courting mutant males were given a brief paralysing 'sauna' before being returned to the female, whereupon they resumed their lovesong. When we looked at the song before and after this treatment, we observed that the mutant's song clock had apparently stopped during the time that the heat pulse had blocked his nervous system. We concluded that the nervous system must hold the key to the song clock.

Konopka, Hall and the author are currently making flies in which part of the nervous system expresses the normal clock gene, and part expresses the short clock mutant, *per*^{s}. These *mosaic* flies have mutant nerves marked histochemically to distinguish them from normal nerves. By correlating the internal distribution of normal and mutant nervous tissue with the circadian and song cycles shown by each mosaic, we have preliminarily found that the brain controls the 24-hour clock, but the thorax controls the song clock. Thus a mosaic fly may have a normal 24-hour locomotor activity rhythm but a short 40 second song rhythm, if his brain and thorax express the normal and mutant clock gene respectively. Thus the clock gene works independently in different tissues to produce the two rhythms.

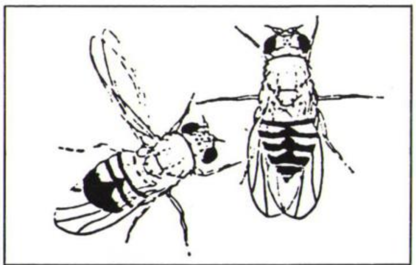


Figure 1: the male fruit fly extends a wing and vibrates it to produce a 'lovesong'. (Drawing by Barrie Burnet, Sheffield University)

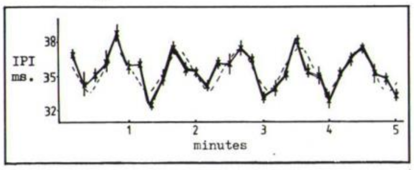


Figure 2: the fruit fly's 'lovesong' consists of pulses separated by an interpulse interval (IPI).

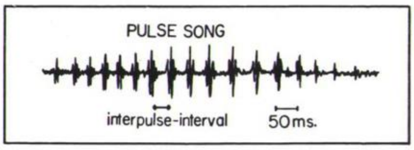


Figure 3: The IPIs fluctuate rhythmically within a period of approximately one minute. Each point represents the average IPI in each 10 second fraction of time.

More recently, we have been working in a molecular study of the clock gene. Genes consist of long sequences of DNA (deoxyribose nucleic acid) which usually code for proteins, the building blocks of organisms. Some colleagues in West Germany had cut out stretches of DNA from a region of chromosome near the clock gene and we believed that some of these DNA fragments might contain it. The Brandeis group injected small sub-fragments of this DNA into mutant arrhythmic *per*^{o} embryos. This technique permits 'foreign' DNA (ie the DNA injected) to be incorporated into the embryo's genetic material and be transmitted through subsequent generations. If the foreign DNA contained the clock gene, then the progeny of these embryos might show rhythmic behaviour. We observed that some of these DNA fragments did indeed restore rhythmicity to the progeny of the injected arrhythmic mutants in both locomotor activity and 'lovesong' rhythms. Consequently, the clock gene has been isolated at the molecular level and work is in progress attempting to identify the protein product. Interestingly, a group at Rockefeller University have observed that mice have DNA sequences very similar to *Drosophila's* clock gene, suggesting that perhaps the molecular basis of biological rhythmicity is similar even between species that are so far removed from each other on the evolutionary scale.

Biological rhythm research is beginning to apply itself in industry (eg shift work), drug research and medicine. It is comforting to the pure scientist to know that the lowly fruit fly is providing the key to understanding how biological clocks work.

Dr C P Kyriacou
Department of Genetics
Leicester University

Low dimensional structures

Grants were first formally labelled *low dimensional structures* (LDS) within SERC in April 1984 and a specific budget was approved by Science Board in October 1985 (*SERC Bulletin* Vol 3 No 4). The development of the programme since those initial steps has been explosive: from a very low level of expenditure on LDS research before 1984, the programme has committed £9 million in two years. Applications to the programme have been of extremely high quality and are still rising in volume. The topic itself continues to expand and the level of scientific interest has increased dramatically worldwide. All these facts point to a continuing, dynamic programme of research into LDS.

Wider scientific interest has tended to concentrate on low temperature electronic studies of heterostructures and inversion layers, particularly since the award of the Nobel Prize for Physics in 1985 to K von Klitzing for his work on the quantum Hall effect (QHE). The essential contribution of M Pepper (Cambridge) to that work should not be overlooked. At higher magnetic fields the fractional QHE appears, suggesting that in the ground state the interacting electrons cluster together with some kind of local order, reminiscent of an incompressible fluid. A detailed theoretical explanation has not yet been established and even more complex behaviour has recently been found by R Clarke and R Nicholas (Oxford) using ultra-high mobility samples provided by T Foxon of Philips, Redhill.

Within the LDS community there are other equally important and challenging interests. For example, in complex layered structures it is possible to arrange for electrons to tunnel through a repulsing potential, thus realising in practice a one-dimensional problem studied by generations of undergraduates in their first course on quantum mechanics. But, if the electron tunnels into a potential well, it will do so more or less efficiently depending on whether or not there is a quantum state in the well with exactly the right energy to receive it. This allows the construction of a kind of electron spectrometer within the structure, for studies both of the properties of the structure itself and of the interactions of electrons with each other or with lattice vibrations or defects. L Eaves and G Toombs (Nottingham) have recently explained some puzzling effects observed in such structures by showing the importance of changes in internal electric fields due to the accumulation of electrons in certain regions of the structure.

Optical studies of layered structures are also of growing interest. There is a continuing refinement of optical techniques for characterising layered structures, ranging from the study of quantum wells using photoluminescence to the observation of very rapid electron transition processes using pico-second laser equipment. There is also a wide field of study of the interaction between light and the complex system of interacting electrons in the semiconductor. Light emission, light absorption, the interaction of light with excitations of the electron system and the change of refractive index with illumination are all of current interest. The change of refractive index of a material with illumination is a non-linear effect which can be exploited to make optical devices.

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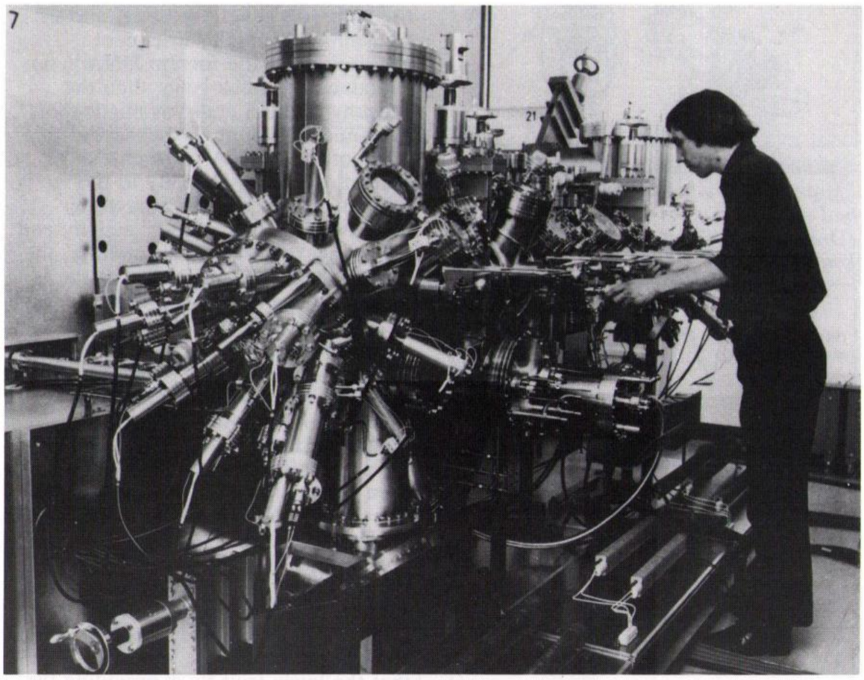


The molecular beam epitaxy facility at the Cavendish Laboratory, Cambridge. The twin growth chamber machine has been specially designed and constructed by Vacuum Generators, and includes provision for later incorporation of in situ *electron and ion beam lithography. The machine is being operated by Dr David Peacock, on secondment to the Cavendish from GEC plc. GEC and British Telecom are cofunding the research with SERC on a cooperative research grant.*

The pace of the LDS programme is now accelerating as the growth centres start operation: the availability of suitable samples has so far been a serious restriction on many experimental programmes. The CVT Metal Organic Chemical Vapour Deposition (MOCVD) equipment at Oxford has been producing test layers since spring 1986. The Varian Gen II Molecular Beam Epitaxy (MBE) equipment at Nottingham has been fully commissioned and is already growing good quality GaAs layers. GaA1As layers will be grown after a little more operating experience is gained. The Vacuum Generators V80H MBE equipment installed at Cambridge has completed commissioning and has begun initial layer growth. In all three cases the universities have provided excellent facilities for the growth centres; industrial laboratories and the Royal Signals and Radar Establishment have been extremely helpful in training staff and assisting with initial operations; and the equipment has performed well. This is most encouraging, and the high level of collaboration and enthusiasm promises great success.

Equipment for the growth centres at Imperial College of Science and Technology (narrow band gap materials) and Hull (II-VI compounds) is nearing completion and should be installed as soon as the laboratories are ready. A sixth growth centre at Warwick (Si, SiGe alloys) is awaiting approval by the Department of Education and Science.

A facility of a different kind has been established in collaboration with STL. Under the direction of A Adams (Surrey), several university groups are undertaking research using high pressure as a means to study LDS properties (see *SERC Bulletin* Vol 3 No 5, Summer 1986). The application of hydrostatic pressure lifts degeneracies among electronic states and alters the relative positions of the energy gaps of different semiconductors. These changes can be exploited in a range of elegant experiments to give great insight into semiconductor properties.

A good perspective on the range and future prospects of LDS research is provided by the overall list of research grants. The investigators come from 25 different institutions (ie more than half of the UK universities) and from departments of physics, applied physics, electronic engineering, chemistry and materials. The coverage of the scientific field is fairly good, though in places lacking in depth, but attention will have to be given in the coming year to a small number of noticeable gaps. A proportion of the grants awarded has been for supporting theoretical and characterisation studies.

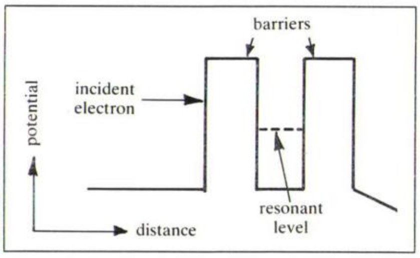
Industrial involvement

A particularly pleasing feature of the LDS programme has been the degree of industrial involvement. In addition to the help with training already mentioned, direct cash support, provision of samples and other facilities, sponsorship of Cooperative Awards in Science and Engineering and shared research have all been of crucial importance. The small number of electronic companies with obvious interests is gradually being supplemented by others with somewhat less direct commercial relevance. It is worth remembering that this valuable and effective university/industry collaboration has resulted from the clear perception by SERC and industry of the need for a fully integrated research programme; and that most of the university funding has been provided by the Science Board.

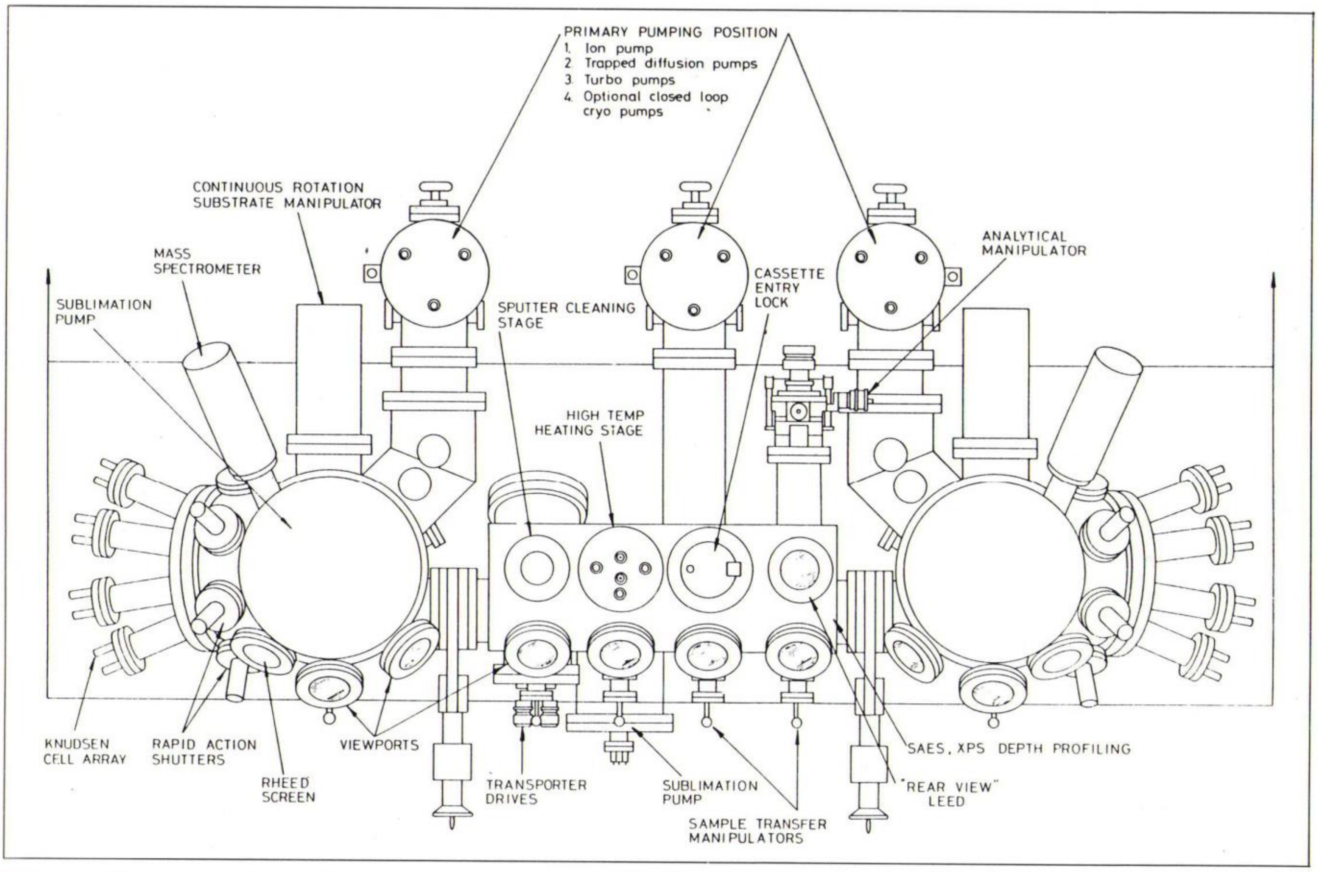
There is a swing in the applications to the LDS programme towards research related to the utilisation of LDS in devices. This is being matched by increased activity within the device community and the Solid State Devices Subcommittee has established a Low Dimensional Devices (LDD) programme to support such work. A major aim in the coming months must be to ensure that the LDS and LDD programmes are as closely integrated in their management as they already are at the research level, and this is already being done within SERC.

This review has described a vigorous LDS programme with a large active community. One final point deserves mention, and that is the way in which individuals and departments used to doing research in splendid isolation have responded to the need to collaborate in large groups and across departmental and subject boundaries. There were those who thought that the investment of large sums of scarce money was a risk that would fail because of this necessary little-science-to-big-science transition. Happily the results to date suggest that this transition is being achieved and that the investment will be well rewarded.

Professor J L Beeby
Coordinator of the Low Dimensional Structures Programme



The resonant tunnelling effect. The diagram shows the potential felt by a conduction electron in an elementary structure. There are two (repulsing) barriers between which can be formed an approximate quantum-bound state or resonant level. The incident electron must tunnel through both potential barriers to reach the right-hand side; it is more likely to do this if its energy is close to that of the resonant level.



Plan view of a twin-chambered molecular beam epitaxy machine (Diagram: VG Semicon Ltd).

Fellowships for women returners

The report on *Career breaks for women chartered and technician engineers*, recently published by the Engineering Council, emphasises that competition to recruit the most able young people is increasing and the available supply is decreasing. It draws attention to the unused skills of qualified women who have taken career breaks.

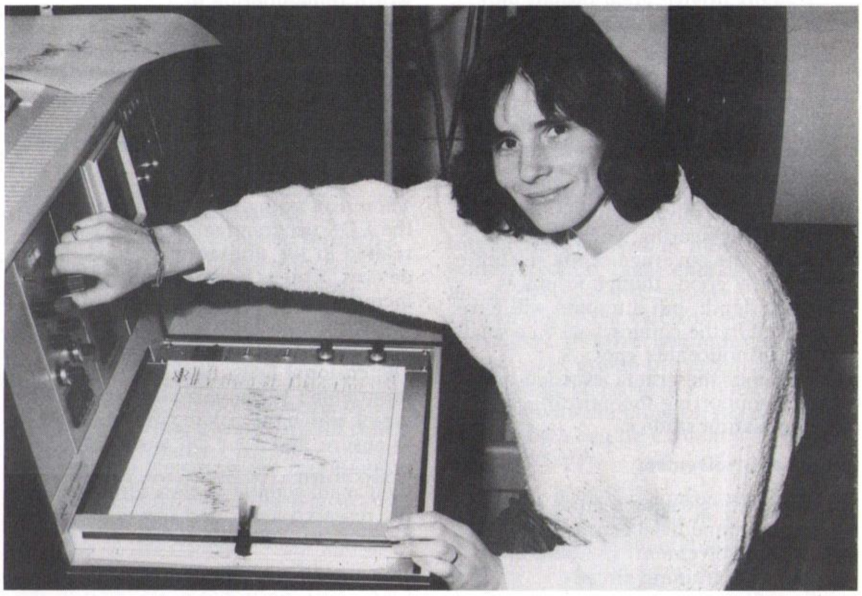
The career break has a massive effect on the careers of women in universities and polytechnics. In 1979, the percentages of women in universities in all disciplines were 15% of lecturers, 4.8% of readers and senior lecturers and 2.7% of professors. In 1983, only 8% of the New Blood and IT lectureships went to women; in 1984 the proportion rose to 13%.

At present, universities have a rather rigid view of the age range at which it is appropriate to appoint or promote. This is very adverse to those women who take time out to raise children as they then have a gap in their cvs and in their publication lists.

The objective of the fellowship scheme for women returners to research in science and engineering is to provide the opportunity for well qualified women to regain the expertise and self-confidence necessary to conduct advanced research so that they may compete on equal terms for permanent academic posts. This is achieved by offering *flexible, part-time* fellowships in universities. Each fellow obtains retraining in research and is undertaking a high level research project under the guidance of a university supervisor.

Mrs Jean Tunnicliffe-Wilson is working in the Department of Engineering of Lancaster University on the use of computers in manufacturing systems, in particular the integration of available and developing technologies with emphasis on the man-machine interface. Close contacts are being established both with a company manufacturing flexible robot systems and with a company seeking to improve its manufacturing system by greater use of computer technology.

Dr Alison Graham, who trained as a theoretical particle physicist, is now working in the Department of Chemistry at Leicester University on muon spin rotation. This involves the interaction of positive muons and following the possible reactions that occur by observing emitted positrons. At present, the group is working at the Swiss National Nuclear Physics Laboratory (SIN) but hopes in the near future to use the new source under construction at Rutherford Appleton Laboratory.



Particle physicist Dr Alison Graham returned to academic work on a fellowship to Leicester University.

Dr Hilary Perry is working in the Department of Biochemistry at University College, Cardiff. She started her career as a botanist but is now converting to biotechnology. Wholemeal flours deteriorate rapidly on storage and degradation of such flours causes significant commercial loss. This degradation process is started by a lipase that is localised in the bran component. The project involves a biochemical study of this wheat bran lipase including the delineation of factors controlling its activity and the search for a single assay for the enzyme which could be used for routine monitoring of wholemeals in order to predict potential shelf life.

Mrs Elizabeth Hogger, a graduate in physics and maths, is working in the Computing Unit of Surrey University. She is investigating the use of intelligent knowledge-based systems for the computer-aided teaching of formal languages, including logic languages such as PROLOG as well as procedural programming languages. A distinctive feature of this research is the utilisation of modern work in applied linguistics. The aim of the project is to integrate different areas of knowledge: IKBS and CALL, applied linguistics and (formal) language learning, and from a practical point of view to assist in solving the current problem of skill-shortage and lack of training facilities in innovative fields such as logic programming and IKBS.

So far, nine fellows have been appointed with funds provided by the Leverhulme Trust, the Institute of Physics, GEC, British Gas, British Telecom, ICI and BICC. Funds are in hand for a further eight fellowships, provided by BP, Cable and Wireless, Shell and the Nuffield Foundation, and vigorous efforts are being made to raise more.

More than *one hundred* applications had been received by May of this year and over half of the applicants have PhDs and publication lists. The remaining candidates are all graduates in science and engineering, many with experience in industry or research, and would make excellent research assistants. SERC has explicitly announced that fellowships and assistantships on its grants can be held on a part-time basis (*SERC Bulletin* Vol 3 No 3, Autumn 1985). In view of the generous interest shown in the fellowship scheme by university staff, it is greatly to be hoped that they will use their own initiative to provide other part-time opportunities for well qualified women.

It seems possible that similar schemes will be developed in the USA and West Germany. In both cases, it is anticipated that federal funds will be available. In this country, all the funds have come from charitable bodies and industry.

For further information about the fellowship scheme, contact:

Professor Daphne Jackson
Department of Physics, Surrey University, Guildford, Surrey, GU2 5XH. Telephone Guildford (0483) 571281.

Fellowships 1986

The table shows the allocation, number of applications and distribution of awards in 1986 between the various Fellowships Schemes and the Special Replacement Scheme.

Type	Allocation	Applications	Awards
Senior	2	19	2
Advanced	12	68	12
Postdoctoral	49	215	49*
RS/SERC Industrial	10	6	5
Special Replacement	†	6	0

* In addition nine awards tenable in Europe were taken over from the Royal Society. A further two awards in the Natural Environment Research Council's field were supported under the NATO programme.

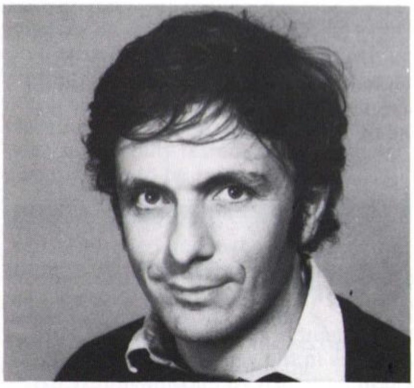
† A specific allocation was not made for Special Replacement awards in 1986

Fellowships to commemorate the Australian Bicentennial

To commemorate the Bicentennial of Australia in 1988 the Council has decided to allocate two postdoctoral fellowships, for take up at the beginning of the academic year 1987/88, for tenure in Australia. The awards will be governed by the usual conditions for postdoctoral fellowships and applications are invited for the closing date on 31 December 1986.

Senior fellowships

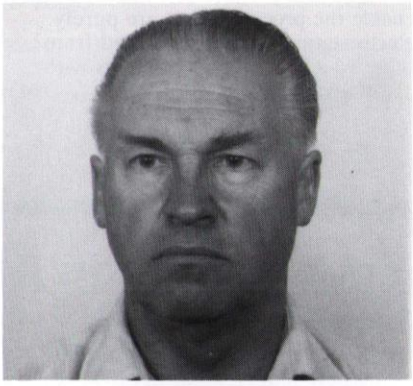
Demand was high this year with 19 applications received for awards under the scheme. Two awards were made, to Dr J Bryce McLeod of the Mathematical Institute, Oxford University, and to Professor M B Green of the Department of Physics, Queen Mary College, London.



Professor M B Green

Professor M B Green was born in 1946. He was educated at Cambridge. Immediately before his appointment as lecturer in the department of physics at Queen Mary College, he held an SERC Advanced Fellowship in the department of theoretical physics at Oxford. He was promoted to professor in 1985. He is established as a leading international authority on 'superstring' theories of elementary particles, which hold out promise of solving one of the central problems of contemporary physics by providing the basis for a consistent quantum theory of gravity and a unique derivation of a unified theory of all the forces and particles. His work has already had a profound influence on the activities of leading international workers in this field.

Dr J B McLeod was born in 1929 and educated at the Universities of Aberdeen and Oxford. After holding appointments at Oxford and Edinburgh he was appointed in 1960 to his present post of Fellow and Tutor in Mathematics at Wadham College, Oxford. He has established an international reputation in the study of non-linear differential equations, which as well as posing challenging problems in pure analysis find applications in many branches of physical applied mathematics and applied biology. As a teacher he has played an important role in recruiting distinguished UK workers to this field. He will now devote himself to strengthening work in the UK on non-linear differential equations in the analytical direction.



Dr J B McLeod

Advanced fellowships :

The regulations of the Advanced Fellowships Scheme have been altered to enable fellows to interrupt their appointment to spend some time, while not supported by SERC, working on a related activity. Provided that SERC approves, fellows are now allowed to break their service not more than twice for periods totalling not more than two years without any reduction in the overall period of the award. Other conditions are that a break should not cause the fellow to be more than 45 in the final year of the award, and that such breaks should not be taken during the final year.

Industrial fellowships

For 1986, Royal Society/SERC Industrial Fellowships have been awarded to:

Professor D Bloor (Queen Mary College, London) to GEC Research (Marconi Research Centre);
Dr C M Jefferson (Bristol University) to International Research and Development plc;
K A Cliffe (UKAEA) to Oxford University (wholly supported by the Royal Society);
D R Coleman (Portsmouth Polytechnic) to IBM (UK) Ltd; and
Dr A W Palmer (City University) to SIRA Ltd.

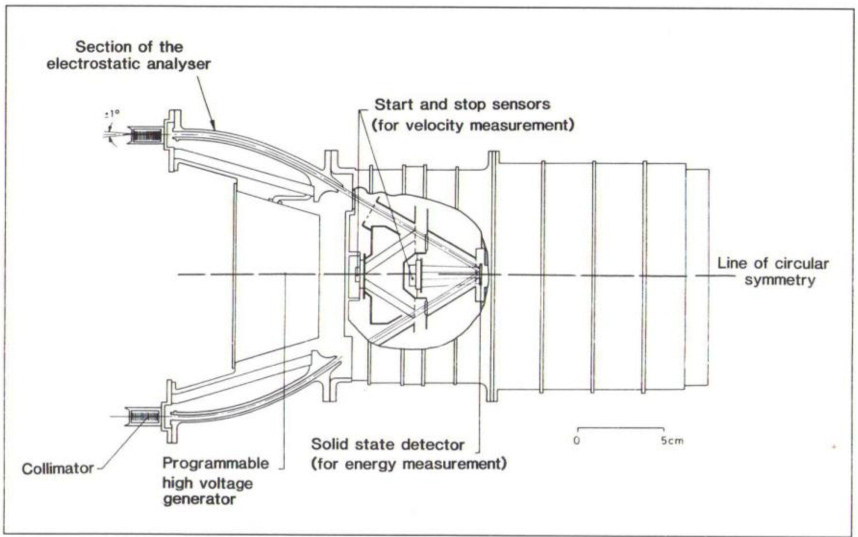
Discontinuation of the Special Replacement Scheme

The Special Replacement Scheme was set up to provide some relief to the shortage of young researchers joining academic departments — a role last played on a broader basis by the New Blood scheme operated by the University Grants Committee. Last year the Council agreed that awards would be made only where the quality of the proposal was exceptionally high and the need exceptionally pressing, and none of the applications received were sufficiently strong to merit an award. The Council decided that the standing of the scheme was unsatisfactory and agreed that it should be discontinued.

Aurora Borealis studies by MICS

Sweden's Viking satellite — launched by the European launcher 'Ariane' on 22 February — carries a completely new instrument, a Magnetospheric Ion Composition Spectrometer (MICS). This was developed by an international consortium led by the Max-Planck-Institute for Aeronomy, Lindau, West Germany, and including Rutherford Appleton Laboratory and Sussex University. The instrument was switched on and began successfully detecting ions on 4 March, since when it has been in continuous operation.

Viking, the first satellite to be designed and constructed in Sweden, is carrying out scientific research in the regions of space above the Aurora Borealis, the spectacular light display seen in the extreme northern hemisphere. In addition to investigation of the aurora, a number of basic and universal problems of plasma physics are being studied in these regions, which contain the most accessible of all cosmic plasmas.



The Magnetospheric Ion Composition Spectrometer

The Ion Spectrometer is identifying the ions that are in space near the Earth and determining the degree of ionisation of individual ions. This information will enable the processes that are purely electrostatic to be distinguished from those which involve interactions with plasma waves.

RAL was responsible for the collimator, electrostatic-analyser and programmable high voltage generator of the instrument (see diagram). The electrostatic-analyser design makes sure that the instrument is compact but still 20 times more sensitive than ion composition instruments that have been included in previous missions.

The design was based upon techniques devised and proved during the UK programme of auroral-zone studies using rockets. The extra sensitivity is necessary for significant numbers of the major ion species to be detected over a broad range of energy (10-300 keV), and also for the detection of the rarer ion species that may be present.

The Ion Spectrometer is expected to continue making measurements until the first period of operation finishes at the end of 1986.

New head for Anglo-Australian Observatory

Dr Russell Cannon, currently Deputy Director of the Royal Observatory, Edinburgh, and Head of the ROE's UK Schmidt Telescope Unit, has been appointed as the next Director of the Anglo-Australian Observatory (AAO). There he will be responsible for the operation of the 3.9 m Anglo-Australian Telescope (AAT) on Siding Spring Mountain, and for the running of the associated Laboratory in Sydney. The AAO is funded equally by the UK and Australia and is administered by the independent bi-national Anglo-Australian Telescope Board; the UK half of the funding is channelled through the SERC's Astronomy Space and Radio Board.

Dr Cannon takes over the Directorship of the AAO at a particularly important time, when SERC is re-assessing its overall strategy for ground-based astronomy both in the UK and overseas. He feels that it is crucial for the UK to maintain powerful astronomical facilities in Australia, since some of the most exciting and challenging observational questions involve southern objects. The Magellanic Clouds, which are our nearest neighbours in intergalatic space and the only external galaxies near enough for detailed study of many of their constituent stars, can be seen only from southern hemisphere observatories, while the intriguing central regions of our own Milky Way galaxy pass overhead in Australia. There are also now many observational programmes requiring all-sky coverage, notably those concerning the large-scale structure of the Universe as shown in the distribution of quasars and clusters of galaxies, and the identification and study of new objects discovered by satellites surveying the whole sky, such as IRAS at infrared wavelengths and ROSAT in X-rays.

At the same time, the AAO is a bi-national observatory and it is equally important for it to satisfy the needs and interest of Australian astronomers. Dr Cannon hopes to expand the direct involvement of astronomers from both countries in the working of the AAT, and in particular to encourage research students to consider spending substantial amounts of time working with AAO staff astronomers, along the lines of the very successful current collaborations at ROE. Also important is the development of new instrumentation.

The AAT has long held a leading place among the world's largest telescopes because of its excellent instrumentation. To maintain this position it is essential to keep developing new instruments and pushing techniques to new limits. Among the most exciting instruments already in the pipeline are the fast very high-dispersion echelle spectrograph being built by a team from University College London; the large-format very sensitive CCDs (charge-coupled devices) now on the market; and array detectors for direct imaging at infrared wavelengths (a prototype of which is currently being tested at ROE).

The James Clerk Maxwell Telescope

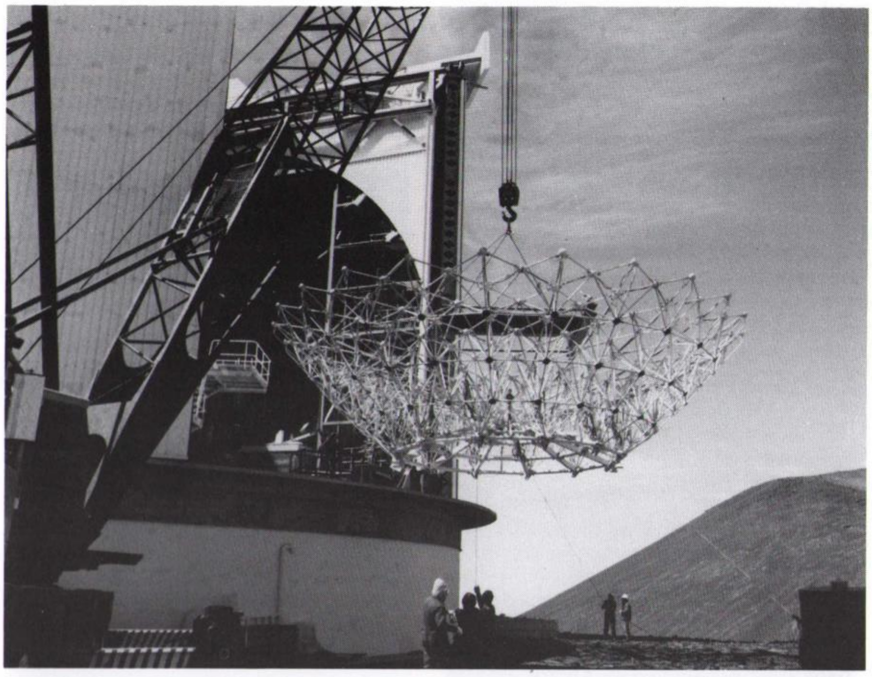
In April 1986 it was announced that the UK/Netherlands Millimetre-wave Telescope was to be named the James Clerk Maxwell Telescope in honour of the nineteenth century physicist, famous for his discovery of the laws of electromagnetism (see *SERC Bulletin* Vol 3 No 5, Summer 1986). The announcement coincided with the final stage in the assembly of the telescope — the installation of the secondary mirror by staff from the University of Utrecht.

The telescope structures arrived at the Mauna Kea Observatory in Hawaii in July 1985 and were assembled in the enclosure by the middle of September. From September until the end of the year the backing structure was prepared to receive the surface panels. Each of the 828 panel adjusters was installed, accurately aligned, connected to the cable harness and its operation checked. In January 1986 the 276 panels were fitted for the first time and, with the tetrapod installed, the telescope looked almost complete, though there was still much to be done. In Feburary the protective membrane was pulled into positon and tensioned to produce the correct shape. At the same time the elevation and azimuth drive systems were successfully tested, showing their performance to be to specification.

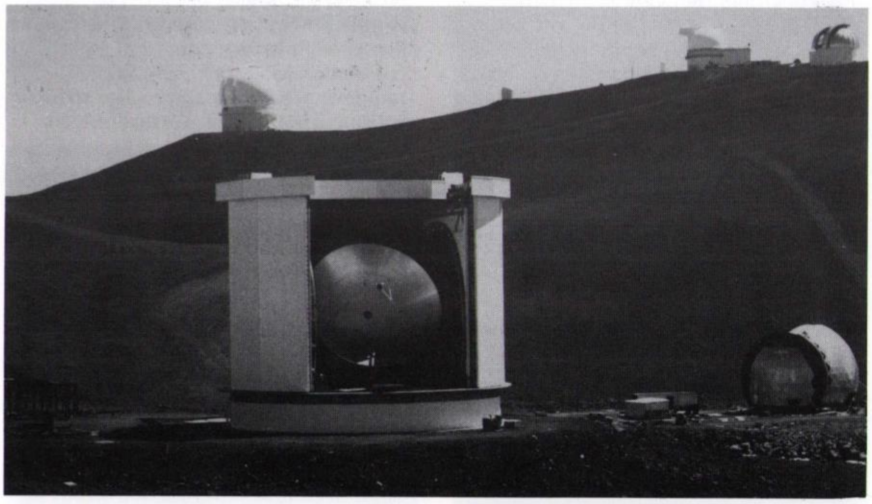
In April, the enclosure and telescope were co-rotated under the control of the facility's main computer with a small optical sighting telescope with TV camera pointing at the moon.
During the same month the secondary mirror system arrived from the Netherlands. By the middle of May this had been installed on the telescope, aligned and shown to move as required by the specification. Although there were still a number of systems to be completed the installation of the secondary mirror system marked the completion of the installation of the last major sub-system forming the telescope. The first commissioning receiver left Cambridge University at the end of May and was installed at the Cassegrain focus of the dish during August.

Although some tests have already been carried out, the rest of 1986 and the early part of 1987 will be fully occupied in testing and commissioning the telescope ready for its scheduled operation. This is still expected to start in April 1987, when it will be handed over to the Royal Observatory, Edinburgh.

Dr R W Newport
Rutherford Appleton Laboratory



The backing structure during installation (September 1985).



The completed surface photographed in March 1986.

Award for excellence

The rotating building for the James Clerk Maxwell Telescope has won the 1986 Honor Award for Engineering Excellence by the Consulting Engineers Council of Hawaii.

The first installation of the membrane (February 1986).

Semiconductor devices simulation

As part of the European Community (EC) ESPRIT initiative in Information Technology, the EC is funding 50% of the costs of a £7 million collaborative programme to develop better methods for modelling the behaviour of semiconductor devices. As a result of this programme, industrial companies in the EC will gain an essential advantage in the competitive world market of device design and manufacture.

SERC is the prime contractor in the project, acting through its Rutherford Appleton Laboratory (RAL) for a consortium of universities and companies. There are nine other partners — GEC plc at its Hirst Research Centre at Wembley; Nederlandse Philips Bedrijven BV at Eindhoven; University College, Swansea; Trinity College, Dublin; the University of Bologna; SGS-Microelettronica SpA at Agrate, Italy; the Inter-university Microelectronics Centre (IMEC) at Leuven, Belgium; Analog Devices BV at Limerick; and the National Microelectronics Research Centre at Cork. This is another example of the increasing trend in information technology towards collaborative projects between academic and industrial sectors.

The main aim of the programme is to develop robust and efficient algorithms to simulate the steady-state and time-dependent behaviour of three-dimensional semiconductor devices. These algorithms will be incorporated into a research computer program which will be developed as part of the project. The accuracy of the numerical techniques and the physical models used in the software will be confirmed by comparing the solutions with predicted results for selected test problems and with measurements on real devices.

The results of the numerical modelling will be used to produce a suitable mathematical description of the device which represents its behaviour when different input voltages are applied. This description can then be used as data in a simulation program to predict the performance of circuits containing large numbers of these devices.

Computational modelling is the only predictive tool which can practically be used for device design. The simulation will be based on the classical forms of Poisson's equation and current continuity equations including temperature dependence. The models will incorporate the physical effects relevant at sub-micron device sizes, for which it is necessary to take account of three-dimensional effects.

The emphasis throughout is on flexibility and the generation of general purpose algorithms applicable to a wide class of problems including both metal-oxide-silicon and bipolar transistors, producing results on a powerful computer in a reasonable time.

The project presents some formidable numerical problems at the forefront of research. However each partner has an established reputation and brings a wealth of complementary expertise to bear upon these tasks. The project builds upon the experience gained by five of the partners in an earlier three-year project funded by the EC in Microelectronic Technology.

This new programme started in April 1986 and will run initially for two years with the likelihood of a further two years to follow.

Further details of this project can be obtained from: C W Trowbridge, Rutherford Appleton Laboratory, telephone Abingdon (0235) 21900 ext 5221.

Alvey conference 1986

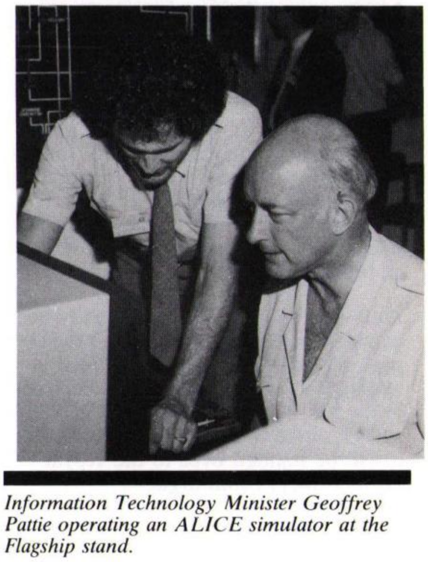
More than 400 delegates descended on the Falmer campus of Sussex University for the second Alvey Conference held from 1-4 July. The first was held in Edinburgh last year.

With some 187 projects now under way in the Alvey programme, the conference is a useful way of bringing together those taking part to mull over successes and problems.

The opening day included plenary speeches from the Minister of State for Industry and Information Technology, Mr Geoffrey Pattie; Alvey Director, Mr Brian Oakley and SERC's Director, Engineering, Mr Tony Egginton. The guest speaker at the conference dinner in the evening was the Parliamentary Under Secretary of State for Education and Science, Mr George Walden.

Geoffrey Pattie stressed the collaborative nature of Alvey. "Whether in domestic or in European programmes, collaboration between firms, or between firms and higher educational institutions, or between countries is increasingly going to be the name of the competitive game," he said. The previous day, Mr Pattie had chaired a ministerial meeting on the major European Eureka initiative which involves major industrial collaboration across European frontiers. He also announced that ICL had delivered, on schedule, the experimental transputer-based ALICE parallel processor which is to be a major part of the biggest Alvey project, 'Flagship', featured among the displays.

Brian Oakley summarised the main features of the Alvey programme. Nearly all the funds had been committed and some 187 projects were now set up. When the funds were fully committed there would be around 200 projects. In the present projects, Mr Oakley said, there were 53 universities or university colleges taking part as well as 11 polytechnics; every university in the country was involved. There were academic partners in 85 % of the industrial projects and also 15 research establishments and non-profit making distributing bodies involved with Alvey.



Information Technology Minister Geoffrey Pattie operating an ALICE simulator at the Flagship stand.

Physicists of the future

SERC administers the Holmes-Hines Memorial Fund. This is a bequest from the late Miss Frances Hines; it states that the fund should provide annual prizes, scholarships, exhibitions or research grants and a number of other payments selected by Council.
It can also be used to help individuals achieve their scientific aspirations and to sponsor activities related to science for which public funds are not available.

Recently the fund has provided backing for two ventures: a Women and Physics course at Glasgow University and the XVII International Physics Olympiad.

Three of the delegates on Glasgow University's ***Women and Physics*** *course take advantage of the university's laboratory facilities. As some 350 sixth-form girls wanted to attend the course, the organisers ran, in addition to the two-day residential course, two one-day condensed courses taking 130 girls each day.*

Some 100 competitors in the ***XVII International Physics Olympiad*** *on one of their rest days toured SERC's Rutherford Appleton Laboratory. RAL played host to pre-university students from the Netherlands, Hungary, Iceland, Finland, Cuba, Rumania, the USA and the USSR, seen here in the ISIS experimental hall. The Olympiad is a week-long competition consisting of theoretical and practical physics examinations.*

Some new publications from SERC

Astronomy reports
The annual reports for the Astronomy I Committee (1984-85), Astronomy II Committee (1983-85) and Solar System Committee (1984-85) are now available from SERC Central Office, Swindon, the first two from Mrs S Williams, ext 2157, and the last from Mrs F Webb, ext 2239.

Physics Committee
Two reports, *Physics Committee research themes* and *Report for the period 1981-1985*, are available from Ms J Niven in the Physics Secretariat, SERC Central Office, Swindon, ext 2215.

Biotechnology review
The findings and recommendations of a panel under the chairmanship of Dr C H Reece of ICI, set up to assess the achievements of SERC's biotechnology programme, have been published in the *Report of the Biotechnology Review Panel*. Copies are available from the Biotechnology Directorate, SERC Central Office, Swindon, ext 2310.

Support for engineering
The results of a two-year study of SERC's support of engineering research and postgraduate training over the last ten years are published in the *Report on a study of support for engineering*, available from Mr A Brittain, SERC Central Office, Swindon, ext 2174.

Chemical engineering
A report on the *Future supply of academic manpower in engineering: a case study in chemical engineering* has been prepared by a working party chaired by Professor Roland Clift. Copies are available from the Process Engineering Secretariat, SERC Central Office, Swindon, ext 2400.

Engineering annual reports
The Materials and Environment Committees' *Annual reports 1984-85* are available from SERC Central Office, Swindon: Materials from Ms D James, ext 2330, and Environment from Miss T Instone, ext 2123.

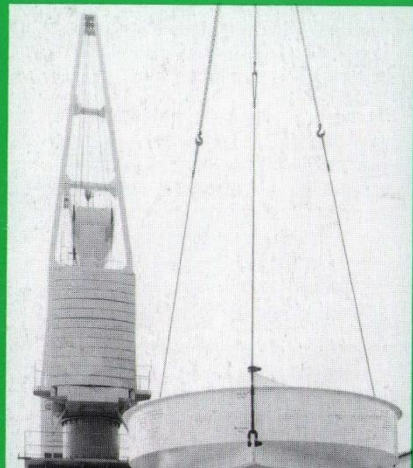
High speed machinery
Copies of the *Specially Promoted Programme on the Design of High Speed Machinery: Report 1* are available from Mrs K Newton, Machines and Power Committee, SERC Central Office, ext 2116.

Civil engineering
Copies of the second issue of the *Civil engineering newsletter* are available from the Environment Committee Secretariat, SERC Central Office, Swindon, ext 2123.

Herschel Telescope arrives on La Palma

The William Herschel Telescope has arrived safely on the island of La Palma in the Canaries. Shipped out in early April, the telescope is now in the final stages of construction by engineers from the Royal Greenwich Observatory. It is scheduled to begin operations in the Spring of 1987.

The aluminising tank rolls out from its storage place to begin its ten-mile journey to Blyth docks. This travelled as deck cargo (it was too tall to fit in the hold) and fortunately the weather was calm for the ten-day trip to La Palma.



Steady as she goes. The 4.2 metre mirror is craned aboard the Dutch-owned MV Ston. *The mirror had been stored at NEI Grubb Parsons and the ten miles to the dock took just one hour to complete, under police escort.*

Up the road to the 8000 ft-high observatory goes the telescope's base plate. The telescope was hauled to the observatory at the rate of two loads every other day for two weeks. Because of the sizes of the various loads, it had been necessary to check the road widths and bend radii with dummy loads. There were no problems.