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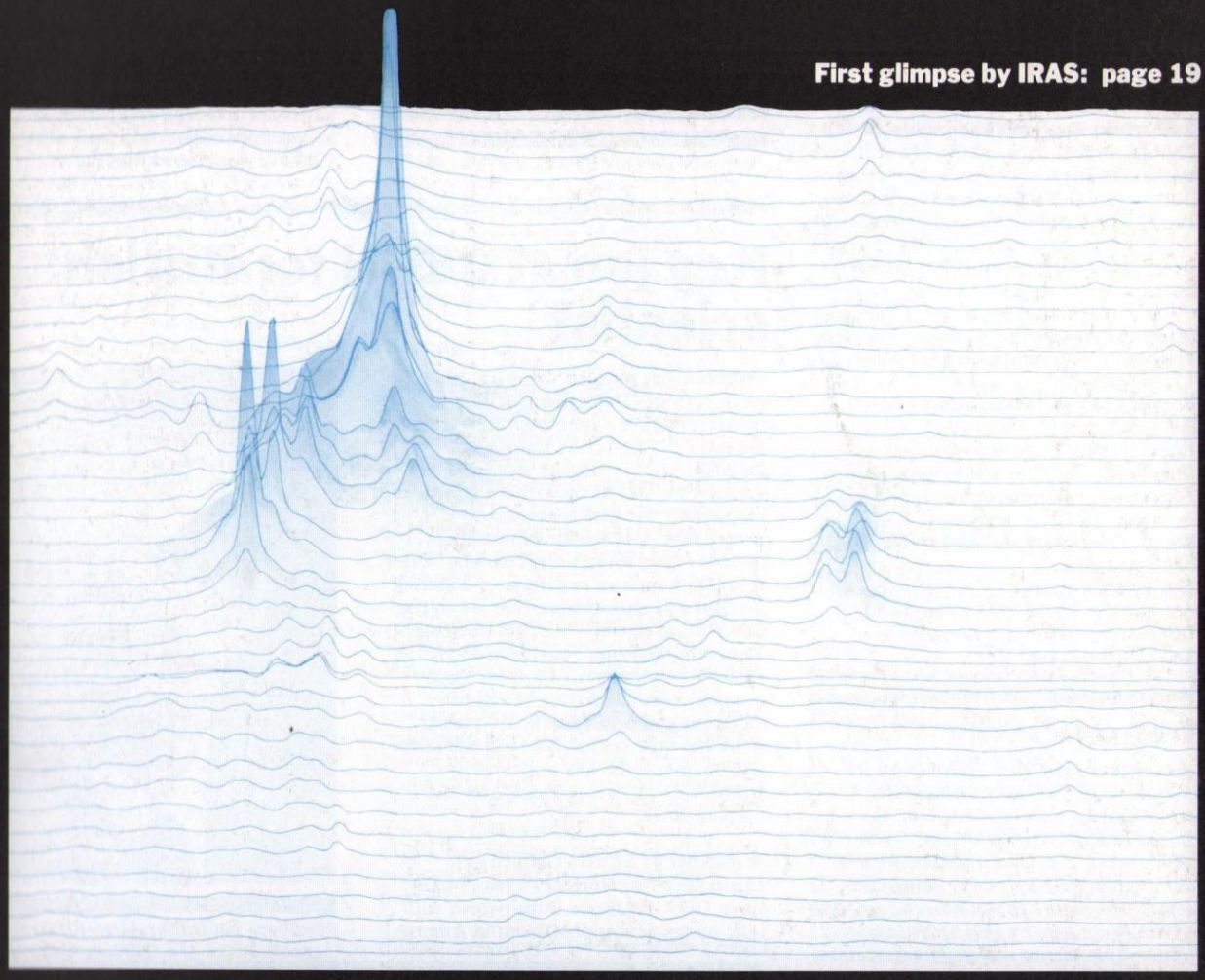

First glimpse by IRAS: page 19

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Establishments of the Science and Engineering Research Council

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Front cover picture

A mosaic map of part of the Large Magellanic Cloud, taken by the IRAS telescope at a wavelength of 100 microns (see page 19). At 155,000 light years away, this is the nearest galaxy outside our own Milky Way galaxy. Each line across the picture shows how the strength of the signal seen by one of IRAS's fifteen 100-micron wavelength detectors changes with time as the telescope tracks across the sky. Very intense and complex emission is seen from the vicinity of the 30 Doradus ('Tarantula') nebula to the left of centre. A new cluster of massive stars (each 10-100 times heavier than the sun) has probably been recently born here, although some astronomers have suggested that this nebula contains a monster star, thousands of times more massive than the sun. These pictures will help astronomers to understand the processes by which new stars condense out of clouds of gas dust both in the Large Magellanic Cloud and in our Galaxy.

New chairman for ABRC

Professor Sir David Phillips FRS

Professor Sir David Phillips FRS, Professor of Molecular Biophysics in the University of Oxford, has succeeded Sir Alec Merrison as Chairman of the Advisory Board for the Research Councils (ABRC). The appointment was made by Sir Keith Joseph, Secretary of State for Education and Science and is for four years from January 1983. Sir David, who is 59, is a Fellow of Corpus Christi College, Oxford. He was Biological Secretary and Vice-President of the Royal Society from 1976 until April 1983 and a member of the Medical Research Council from 1974 to 1978. SERC has supported some of his work on protein crystallography, particularly on the computing side, and he has done pioneering work with the CRAY computer at Daresbury.

Key job at CERN for British scientist

Professor Ian Butterworth FRS, head of the Physics Department at Imperial College, has been appointed Research Director at CERN, the European Organisation for Nuclear Research, in Geneva. He will be one of two Directors responsible for CERN's research programme, and the areas he will cover include experiments using colliding beams. It was just such an experiment, colliding protons and antiprotons, that led to the observation of the W particle (see page 4). The colliding-beam design is also used in CERN's new project LEP, which will contain counter-rotating beams of electrons and positrons, and on which work has now started. The job therefore will be one of the key positions in world-wide physics research over the coming years.

A member of SERC's Council and Chairman of its Nuclear Physics Board since 1979, Professor Butterworth will take up his new appointment in August.

Professor Ian Butterworth FRS

The Science and Engineering Research Council is one of five 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. The *SERC Bulletin* summarises topics concerned with the policy, programmes and reports of SERC.

All publications described are available from the appropriate department of the Council, free, except where otherwise stated. SERC's 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.

Enquiries and comments are welcome and should be addressed to the editor, Miss J Russell, at the Science and Engineering Research Council, Polaris House, North Star Avenue, Swindon SN2 1ET. Tel Swindon (0793) 26222.

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Council commentary

Estimates, 1983/84
Council has submitted its estimates for 1983/84 at a level of £254.5 million, as recommended by the Advisory Board for the Research Councils. Within this sum £206.93 million was directed to the Council's domestic programme and £47.57 million to international subscriptions. The latter figure is based on 22 November 1982 exchange rates, as instructed by the Treasury, but since that date sterling has fallen considerably. In consequence, Council faced the possibility in April this year of having to find a further £5.3 million from its domestic programme to meet the extra cost of international subscriptions unless it was given some dispensation by the Secretary of State. At time of going to press, officials of SERC, the Department of Education and Science and the Treasury were still discussing possible alternative ways of dealing with the exchange rate variations affecting these subscriptions.

The weakness of sterling has also caused difficulties in containing Council's overseas expenditure in the current financial year, 1982/83. However, measures have been taken to limit the Council's other expenditure and it is expected that the final outturn will not exceed the permitted total.

'New Blood' Lectureships
The Council warmly welcomed the announcement by the Secretary of State for Education and Science, in the House of Commons on 16 December 1982, of the provision of funds for 300 extra university appointments in 1983/84. Of these so-called 'New Blood' posts, 212 have been made for appointments in the natural sciences, including engineering, and 70 are earmarked for information technology. The appointments will be made by the universities on the ordinary terms applying to university lectureships using funds provided by the University Grants Committee (UGC). The distribution of posts to individual was determined jointly by the UGC and the research councils. Similar numbers of research councils. Similar numbers of extra new appointments are expected in 1984/85 and 1985/86.

Excluding information technology, 133 of the posts to be established from the academic year 1983/84 lie in SERC's field of interest, divided as follows between its major disciplines:

Engineering	47
Physics	27
Chemistry	27
Biological sciences	12
Mathematics	19
Area of the Joint SERC/SSRC Committee	1

Growth in information technology
SERC has received an extra £8.55 million in 1983/84 to support significantly enhanced activities in information technology. Approximately £5 million will be devoted to increasing *research grant* expenditure, allied to which there will be an expansion in *postgraduate training* opportunities amounting to an additional 120 research studentships, 100 additional advanced course studentships, nine more advanced fellowships and 36 more postdoctoral fellowships.

The major part of the £3.55 million allocated to postgraduate training (£2.63 million) has been provided to enable SERC to administer a *'conversion course'* programme on behalf of the Department of Education and Science. The programme covers courses and 900 studentships in universities and polytechnics designed to increase the number of graduates trained in aspects of information technology.

The 70 new posts directed to information technology within the Secretary of State's 'New Blood' proposals will provide the necessary additional research and teaching effort in universities, 40 of these posts being associated with the conversion course programme. Similar increases in polytechnic staff are envisaged. SERC's allocations for 1984/85 and subsequent years are also expected to contain additional provision for information technology. For further details, see page 11.

Special directorates for Engineering Board
In January Council received a paper from the Engineering Board reporting on the operation of its special directorates and seeking approval to establish three new ones. The council endorsed the Board's views that directorates were an essential and continuing feature of SERC's support for engineering, though individual directorates would not necessarily remain the Council's responsibility throughout their lives. It was felt that, after a period of operation within SERC, established directorates should become more closely related to the industry they served. New Directorates for Information Technology and for a programme in the Application of Computers to Manufacturing Engineering (ACME) were proposed (see page 11). Council reserved a decision on the establishment of a Civil Engineering Directorate, while reaffirming its commitment to an initiative in this area at some level along the lines of Sir Alan Muir Wood's Task Force Report.

Postgraduate awards
The advent of 'New Blood' appointments and the Royal Society's 1983 University Fellowships Scheme led Council to re-examine the number of awards it proposed to make under its own Advanced Fellowship and Special Replacement Schemes. It concluded that, notwithstanding these related developments, it would be premature to reduce the number of Advanced Fellowships available but the practice of accepting only candidates of the highest calibre should be maintained, even if fewer awards were taken up in consequence. Financial provision has been made, therefore, to accommodate 18 Advanced Fellowship awards annually, together with a further seven awards for the Special Replacement Scheme.

La Palma Telescopes
Good progress continues to be made with the telescope installations on La Palma. The modified and refurbished 2.5m Isaac Newton Telescope and the new 1.0m telescope will both be on the island by mid-1983, and should be available to astronomers early in 1984. The capital construction costs of the two phases of the project are £9.889 million (for the 1m and 2.5m telescopes) and £13.563 million (the 4.2m telescope), both expressed at 1 October 1982 prices.

Congratulations to...

Dr R J Cashmore (Oxford University: an SERC Senior Research Fellow), who has been awarded the Charles Vernon Boys Prize, for his work in experimental high energy physics;

Dr A F Gibson (Rutherford Appleton Laboratory) who has been awarded the Glazebrook Medal and Prize, for his work on the Laser Facility at RAL;

Dr J D Lawson (Rutherford Appleton Laboratory), who has been elected a Fellow of the Royal Society, for his work in applied electromagnetism;

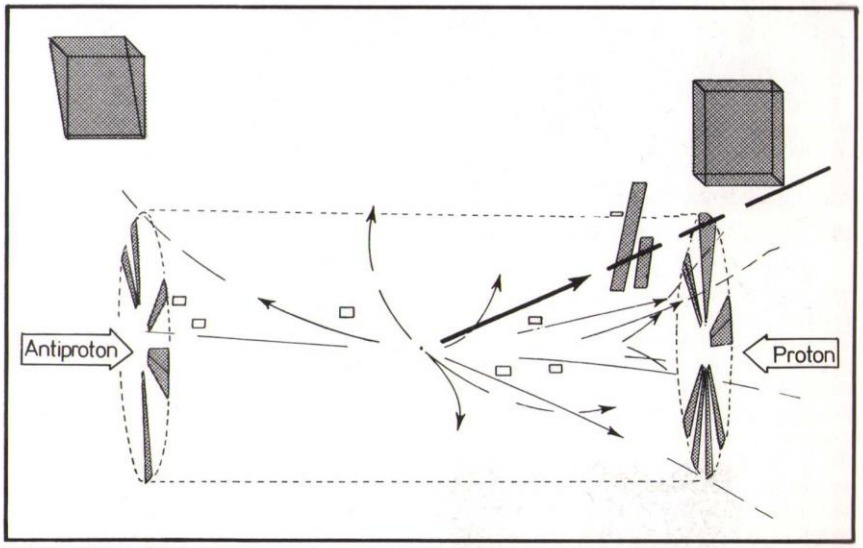
Mr O Roith (Chief Engineer and Scientist at the Department of Industry and a member of Council), who has been elected to the Fellowship of Engineering for his work in North Sea Oil engineering and management;

Mr C P Sandbank (BBC Research Department and a member of the Engineering Board's Departmental Users' Committee), who has been elected to the Fellowship of Engineering for his work on semi-conductors and optical fibre communication systems.

The discovery of the W

The observation of the W intermediate vector boson, the particle that carries the weak nuclear force responsible for radioactive decay and the energy cycle in the sun, is the most outstanding achievement of the CERN laboratory in Geneva and one of the most important advances in physics of this century. It is the successful conclusion of a five year effort that has involved converting the Super Proton Synchrotron into a proton-antiproton collider, an imaginative and challenging project at the forefront of accelerator technology, suggested by Carlo Rubbia of CERN.

Precise properties of the W were predicted by the 1979 Nobel Prize winners Glashow, Salam and Weinberg. It is an unstable particle with a mass 80 times that of the hydrogen atom and two highly sophisticated experiments were designed to detect its decay products. Five events consistent with the decay of a W into a high-energy electron accompanied by an unseen neutrino have been recorded in one of the experiments (UA1), which has large UK participation from the University of Birmingham, Queen Mary College and the Rutherford Appleton Laboratory. The other experiment (UA2) has detected four events. A second particle, the Z, is expected but more running time is needed as its production rate is ten times lower. Parts of the apparatus crucial to the search, one of the large energy-measuring calorimeters and the electronic triggering system that selects events, were built in the UK.

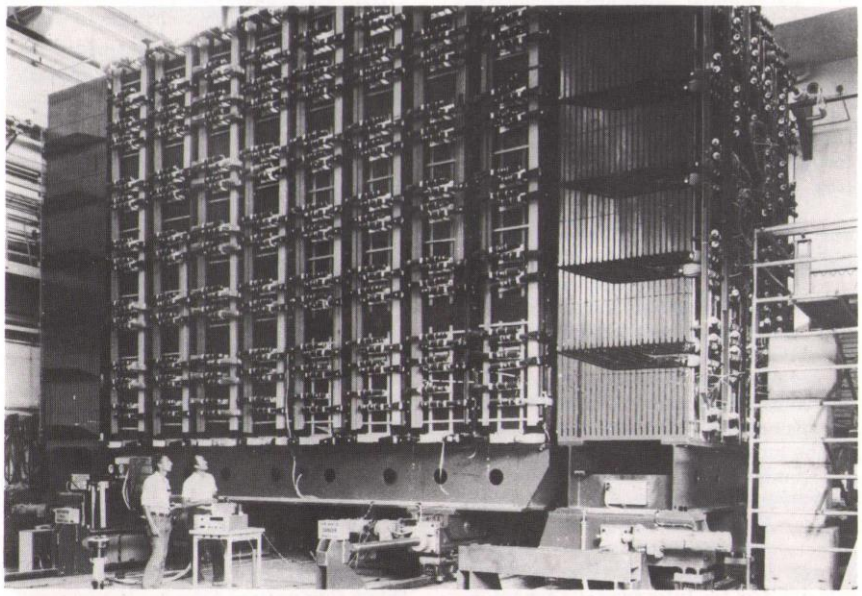


One of the five events. The heavy line shows the electron track in the cylindrical image chamber. The shaded patterns indicate deposition of energy in the calorimeter.

Why is it important?

The significance of the result is that it confirms the theory that unifies the weak and electromagnetic forces. The only previous example of such a unification is the electromagnetic force itself which unites electricity and magnetism. This was the work of James Clerk Maxwell in 1860 following the experiments of Michael Faraday. The discovery of electromagnetic waves (radiowaves) by Hertz in 1880 was the corresponding confirmation of the correctness of this theory. Physicists believe that the 'electroweak' force will eventually be combined with the other two known forces of nature – gravity and the strong nuclear force – in a Unified Field Theory, realising a dream of Einstein. The W discovery suggests that the scientists are on the right track. Tests of a Grand Unified Theory, uniting the strong, weak and electromagnetic forces, are already under way, with decisive results expected in the next few years.

The theory underlying the discovery is also the basis on which the next CERN accelerator, LEP, has been designed.



Side view of the assembled hadron calorimeter. The slots in the iron, the photomultiplier tubes and the light guides are visible.

How was it done?

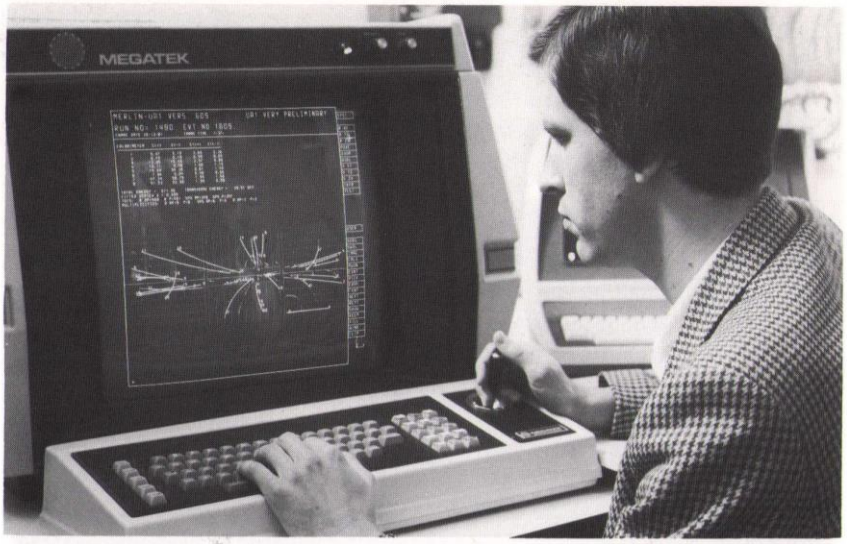
UA1 is the biggest experiment ever carried out at CERN. The main part of the UA1 apparatus consists of several concentric components. Surrounding the vacuum chamber of the collider is a large cylindrical tracking chamber, 6 metres long and 2.2 metres in diameter filled with gas. Charged particles emerging from the collision leave ionised trails which give an electronic picture of each event. By placing the chamber inside a large dipole electromagnet, the particle trajectories are curved with radii proportional to their momenta. The tracking chamber and magnet were designed by the CERN group. Around the chamber are calorimeters designed and constructed by groups from Annecy, Saclay and Vienna for measuring the energy flow of electrons and photons. These calorimeters sit inside a very large hadron calorimeter which was the responsibility of the three UK groups.

What did the UK do?
The Hadron calorimeter is incorporated into the 1500 tonne iron yoke of the electromagnet and consists of 7000 sheets of plastic scintillator, each typically 0.9 metre square and 1 cm thick, sandwiched inside the iron, each one having two light-guides to be read out by an array of 1500 photo-multipliers. Every sheet had to have its energy response measured, and a laser system with 7000 optical fibres was used to monitor these responses and correct for any drifts. The construction of the hadron calorimeter was a major technological undertaking and was shared between the participating UK teams and two industrial contractors (the specialist plastics firms of Carville Ltd and William Cox Ltd) with engineering design and coordination provided by RAL. At QMC, quality control and testing of scintillator sheets were carried out as batches were delivered, and Birmingham made uniformity measurements on samples of the finished items. At CERN, UK physicists have also contributed to other aspects of the hardware effort including the central tracking chamber and the muon chambers.

Hadrons (particles which respond to the strong nuclear force) interact in the iron and produce showers of particles which traverse sheets of scintillator. The total light output is a measure of the hadron energy. The calorimeter, being segmented into many pieces, can determine the directions of flow as well as the energies of all particles.

The electronic triggering system, a major undertaking, involved the RAL Electronics Group, working closely with university and laboratory physicists who had to move to CERN to commission the equipment. In order to record the most interesting events, from the very large number of collisions, the UK groups also designed and constructed a trigger processor, a sophisticated purpose-built electronic device incorporating both analogue and digital techniques, which makes a decision on the basis of energy flow patterns from all calorimeters. The electronic processor is capable of quickly measuring the energy in an event and deciding whether to record it or not. This decision had to be made between beam crossings (ie in about 4 micro seconds) to avoid losing events. The Electronics Group at RAL produced this special processor and this is a vital part of the apparatus, since it enables the experiment to select the few interesting events from the thousands that are produced every second (the five W events observed by UA1 were the end-product of 100 million proton-antiproton collisions).

To obtain the required performance from the processor was as much an exercise in engineering as it was in electronic design.



Mike Edwards, SERC Research Student at Birmingham University, examining a UA1 event on the Birmingham Megatek.

UA1 is the biggest experiment ever carried out at CERN. The paper which reports the result was signed by 135 people, including some of the engineers who have played a crucial part. Of these, 25 are currently members of the British groups:

Birmingham University
Professor J D Dowell, Dr J Garvey, Dr R Homer, Dr I Kenyon, Dr T McMahon, Dr P Watkins, Dr J Wilson, Dr M Corden (SERC-supported), Mr M Edwards (SERC Research Student).
Queen Mary College
Professor P I P Kalmus, Dr E Eisenhandler, Dr W Gibson, Dr A Honma. Dr R Keeler. Dr G Thompson, Mr T Bowcock and Mr G Salvi (both SERC Research Students).
Rutherford Appleton Laboratory
Mr G Arnison (based at CERN), Dr A Astbury, Dr G Grayer, Dr W Haynes, Dr A Nandi, Dr J H C Roberts, Dr W Scott, Dr T Shah.

There were approximately 15,000 integrated circuits in the processor system, and a further 10,000 in the fast analogue-to-digital convertors. The whole system was designed to be loaded, operated and tested entirely under computer control. Construction was by wire-wrapping very large cards, each containing up to 350 integrated circuits.

What our European collaborators did
Outside the hadron calorimeter are planes of chambers which register muons – particles which do not feel the strong force and hence penetrate through the iron. These chambers were designed by an Aachen group. Two other calorimeters and chambers were constructed by Collège de France and Rome groups, and the final one, from a California (Riverside) group, has given a measurement of small angle elastic scattering between protons and antiprotons.

All groups, including also one from Helsinki, contributed to the online and offline computing used in this project, to the assembly, testing and running of the complete experiment, and to the analysis of the physics. Evidence for the W particle is by no means the first piece of physics to emerge from UA1, and indeed a dozen papers have already been published.

SERC's part in the UK programme
The UK part of the collaboration is an example of the importance of RAL in the support of particle physics experiments. Physicists from the three institutions joined forces to design and test prototypes and monitor the construction, most of which was done by industrial firms in close contact with Laboratory staff. Everything had to be built to exacting timescales.

A huge amount of *analysis work* is associated with the experiment. SERC has provided the Birmingham group with an IBM 4341 computer for this and other work and a Megatek graphics system similar to one at CERN used to examine the details of events. All potential W-candidates were carefully scanned at CERN and extensive use of graphics has proved essential in many aspects of the work. Analysis of data has been carried out using the Birmingham installation and the RAL IBM 3081, used both from QMC and locally. A Megatek system is now working at RAL.

Physicists from the UK groups have contributed strongly to the software development and their expertise, combined with the excellent local computing facilities, has allowed the UK to play a major role in the data analysis.

NSF experiments on high-spin nuclei get under way

Nuclear research in the UK received a major boost in the latter part of 1982 with the completion of the Nuclear Structure Facility (NSF) at Daresbury Laboratory (DL) in Cheshire. Teams of researchers began carrying out their first experiments in the autumn and, since the New Year, a start has been made on a full programme of planned research. So far these studies have sought to explore the structure and dynamical behaviour of nuclei which are subjected to a high rotational stress. Nuclei being investigated are not those which occur in nature, for which considerable information already exists, but are unstable ones which lie on the neutron deficient side of the valley of nuclear stability.

Built by DL scientists and engineers to a unique design, the NSF will be used for basic research into the behaviour and properties of the atomic nucleus. The facility houses a large electrostatic tandem accelerator capable of accelerating a wide range of nuclear species to high energies, with excellent energy resolution and easy energy variability. Initial studies have been carried out using beams of sulphur, calcium and titanium ions. In a collision with a target nucleus, a massive projectile such as one of these imparts a great deal of angular momentum as well as energy and gives rise to a rapidly rotating residual nuclear system.

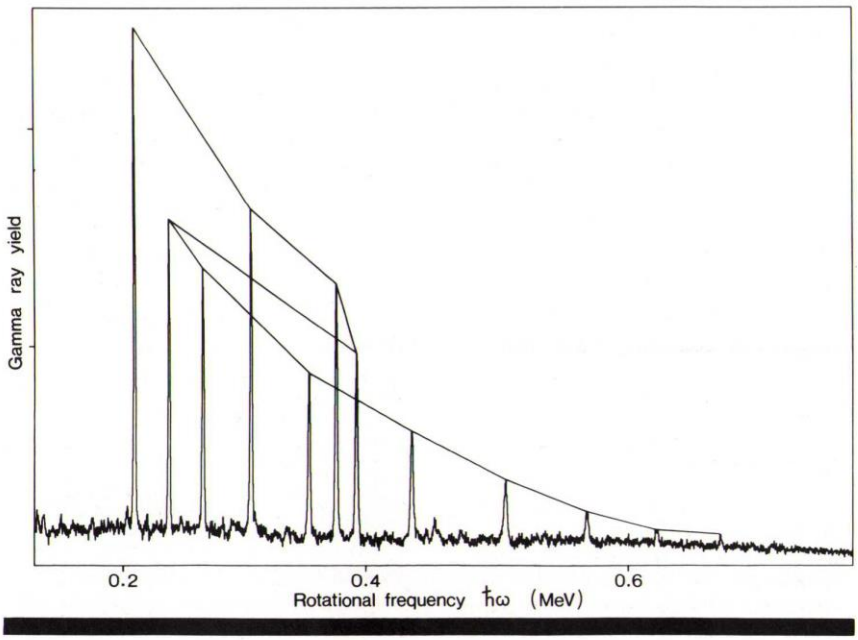
Scientists from Liverpool and Manchester Universities, Daresbury Laboratory and the Niels Bohr Institute, Copenhagen, have formed groups whose aim is to study the rotational behaviour of nuclei in different regions of the Periodic Table. These include both light and heavy rare-earth nuclei which are known to be deformed in their ground states. Studies also are being pursued to discover the properties of nuclei in a newly-discovered region of highly-deformed but unstable nuclei. These are particularly interesting because they are lighter than other, better known, deformed nuclei and offer the possibility of observing nuclei rotating at speeds considerably in excess of those that have been achieved so far.

The study of rotating nuclei is an interesting one. Nuclei exist as dense, compact units of nuclear matter. They are disrupted by subjecting them to a nuclear collision. In this, the struck nucleus will respond to the transient impulse delivered to it by the bombarding particle. However, if a heavy-ion is used as the projectile, and this collides with and sticks to the target nucleus, the resulting composite may, after a short time, boil off a few particles and then remain for a long time (on a nuclear time scale) spinning with whatever angular momentum was brought in during the collision. In this condition, the nucleus is subjected to a steady stress arising from the centrifugal and Coriolis forces. This gives rise to effects which are analogous to those produced by the application of a magnetic field to a superconductor.

In a nucleus which is at rest or spinning slowly, the individual nucleons are paired with their intrinsic angular momenta opposed and do not contribute to the angular momentum of the nucleus as a whole. This is similar to the pairing of electrons in a metallic superconductor. At higher speeds, the Coriolis force tends to break down the nuclear pairing correlations, and align the individual nucleon angular momenta with that of the rotating nucleus. Certain pairs may be broken at a particular rotational frequency leading to an anomaly in the sequence of nuclear levels. A consequence of the pair breaking is that the strong short-range pairing interaction in nuclei weakens at very high angular momentum leading to a phase of nuclear matter analogous to the normal (non-superconducting) state of a conductor.

The apparatus needed to carry out these investigations is sophisticated and the principal effort so far has centred around a unique piece of experimental equipment called TESSA (Total Energy Suppression Shield Array). It consists of several liquid-nitrogen-cooled, germanium detectors, each with its own sodium iodide crystal to suppress Compton-scattered photons, and a set of bismuth germanate (BGO) scintillation detectors which form a shell surrounding the nuclear collision region. A rotating nucleus de-excites by emitting a series of gamma-rays. The germanium detectors record individual gamma-rays with high energy resolution; the BGO array acts as a calorimeter measuring the total emitted gamma energy and registers the number of gamma-rays emitted in the de-excitation of the spinning nucleus.

In October 1982, TESSA I, an early version of the apparatus, was used by a group from Liverpool University to study the cerium nucleus, ^{130}Ce, following the bombardment of isotopic molybdenum targets by high-energy beams of sulphur ions from the NSF.



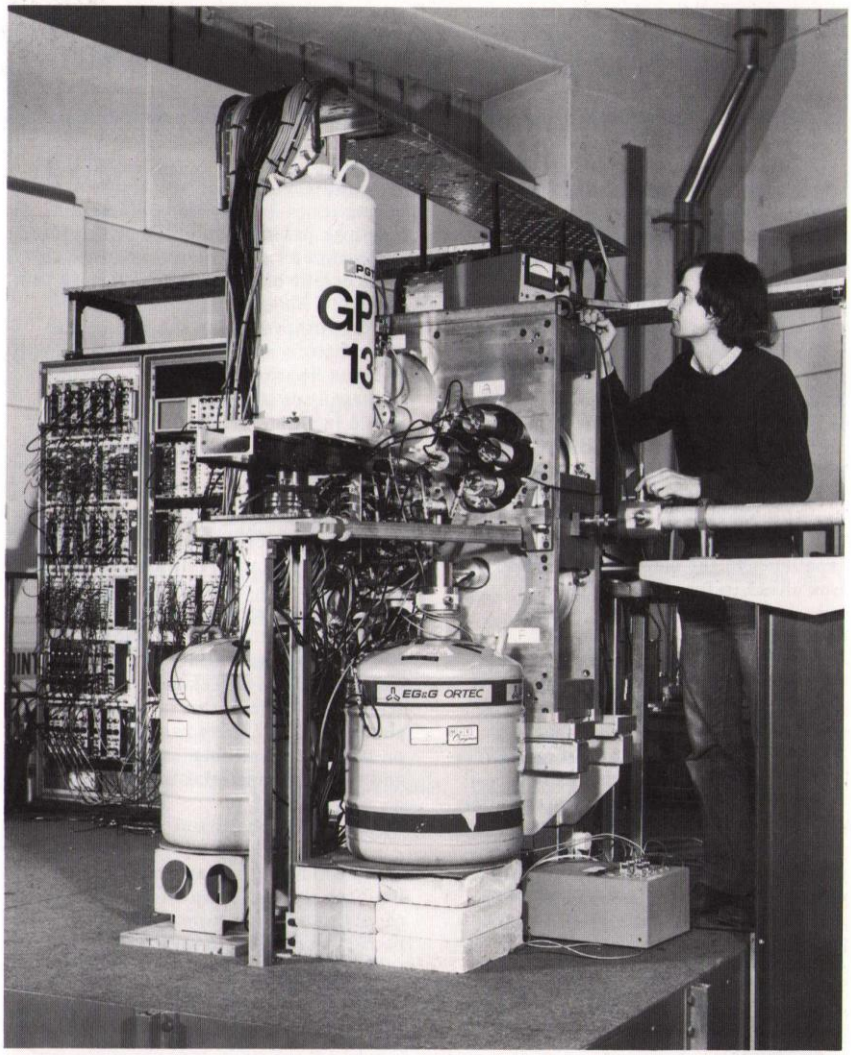
Spectrum of gamma-rays for the nucleus ^{130}Ce. Each peak corresponds to the nuclei jumping from one well defined energy state to another. The line connecting the tops of the energy peaks indicates the order in which the gamma-rays are emitted in the cascade, and reveals the pronounced anomaly or 'backbend' in the sequence of de-excitation energies for this rotating nucleus.

The trace shows a spectrum of gamma-rays observed in this experiment. Each peak corresponds to a de-excitation of the nucleus from one discrete state to another. A trained observer can see transitions which show that this nucleus must have been spinning very fast indeed. In a more detailed analysis, discrete nuclear states have been identified at a rotational frequency which is the highest ever seen in these rotating systems. A rotational anomaly, called a 'backbend' because of the way the transition energies fold back on each other, is observed, indicating the alignment of particular pairs of nucleons. Other methods of analysis reveal evidence of rotational structure at even higher rotational frequencies beyond the region where discrete states can be resolved. Results obtained so far have been reported at an international conference at Oak Ridge, USA, and have been submitted for publication.

Much of our current understanding of nuclear structure has been gleaned from studies of stable or nearly-stable nuclei. It is of particular interest to try to determine the properties of nuclei which have a large neutron or proton excess. These lie far from the valley of nuclear stability and are therefore difficult both to produce and to detect. A heavy ion tandem accelerator with its versatility in species of accelerated beam can form such nuclei via, for example, the fusion reaction. Identification of particular residual nuclei far from stability is accomplished by observing how many neutrons, protons and alpha particles are emitted in coincidence with the shower of gamma-rays.

Such experiments have been carried out by UK physicists at the NSF following work they had begun at Brookhaven National Laboratory, USA. These experiments have shown the existence of a region of nuclei with highly deformed shapes. The very existence of such a region together with the determination of the nature and extent of the deformation is leading to a deeper understanding of the interplay between the microscopic nucleon orbits and macroscopic 'liquid drop' behaviour of the nucleus. What happens to these nuclei when they are subjected to the stress of rapid rotation is one of the exciting prospects for research using the NSF.

Early in 1983 an experiment was carried out by an Anglo-Danish collaboration to study the high spin properties of a hafnium isotope ^{168}Hf. The NSF tandem was operated at 18 MV, which currently is the highest voltage available for research in the world. The hafnium nuclei were produced by a nuclear reaction in which a beam of 216 MeV titanium ions bombarded a tin target. The gamma cascades from de-excitation were recorded using an upgraded version of the



The experimental equipment TESSA II showing the liquid-nitrogen cooled detectors and associated equipment surrounding the target location used in the studies of rapidly rotating nuclei.

detection array (TESSA II), which now consists of six Compton-suppressed germanium detectors, surrounding an internal 50 element BGO calorimeter ball. The accompanying picture illustrates this latest version of the array.

A preliminary analysis of these hafnium data has already provided new information on the rotational frequencies at which pair breaking occurs and on the nature of the nuclear configurations involved. In addition, there is evidence that the results will provide important insight into the manner in which the pairing interaction in nuclei disappears at high angular momenta.

In the few weeks the tandem was available to them up to February, experimenters had to spend considerable time learning how to use the facility and commission their equipment. Yet, in that time, new observations in hitherto unexplored regions were already beginning to emerge from the preliminary analyses. The combination of the high quality, isotopic beams delivered by the NSF and the unique detection equipment used to record the nuclear events is unmatched anywhere in the world. UK scientists and their collaborators are poised to make major advances in the study of high-spin phenomena in nuclei.

All this is only part of the initial programme of research on the NSF to investigate the varied aspects of nuclear structure and nuclear reaction mechanisms. The NSF is a world-class facility and will remain so for many years to come; all scientists working with it look forward eagerly to the new discoveries which will be made.

Dr John Lilley
Senior Nuclear Experimentalist, Daresbury Laboratory

Materials research at the SRS

Research into the characterisation, dynamic behaviour and applications of materials has formed a substantial proportion of the work so far carried out at the SERC Synchrotron Radiation Source (SRS) at Daresbury Laboratory. A recent survey of European scientists, in the preparation of the case for a very powerful European source, also showed that about 25% of its utilisation would be for materials studies. This represents a very significant growth, since powerful storage rings were originally conceived as facilities for pure scientific research. The SRS has now been running for nearly two years and it is interesting to review experience in the materials field and look ahead to future applications.

Electron storage ring sources of synchrotron radiation, when run at high enough energy and current, emit a continuous spectrum of radiation from hard x-ray to far infrared that is much more intense than any competing sources in the whole range except for some narrow-band lasers. Most of the materials applications so far have been in the x-ray region below about 2 Å, though softer x-rays will become more important as new instrumentation becomes available for surface studies and high-resolution lithography.

Synchrotron radiation also shows unique properties of high natural collimation, very high polarisation in the orbit plane, and a pulsed time structure that can to some extent be controlled between a few and a few hundred megaherz (MHz).[1] Synchrotron radiation sources are still at a relatively early stage of development, and flux improvements of several orders of magnitude plus several features that would facilitate more advanced experiments can be expected in the next decade.

The table summarises the main techniques so far used, or envisaged, for the study of materials by synchrotron radiation. An introduction to most of these with examples of their applications and comparison with other techniques will be found in the proceedings of a recent Daresbury Study Weekend.[2] Rather than attempting to say a little about each field, this account concentrates on two topics: mechanical properties, and electronic materials and devices.

Mechanical properties of materials

The plasticity of metals and other crystals has been studied by an enormous variety of methods. X-ray topography is particularly suited to the study of individual dislocation behaviour and the microstructure during yielding, when the overall dislocation density is too low for electron microscopy. Information from the latter is much more useful in the post-yield region. Specimens that are representative of bulk material, rather than thin foils, can be used in the x-ray case. With video image converters and image processors, much real-time information can be obtained at about 50 Hz rates. This has been used at the SRS and at other storage rings to study yielding in iron alloys, silicon and organic crystals over a wide range of temperatures. In crystals in which the slip bands are not too dense, dislocation velocities under stress can be measured, and this probably provides the *only* reliable quantitative data on dislocation dynamics. In others (for example, the iron alloys), slip band growth and propagation can be studied and this has led to information on bulk crystals relating to the influence of surface orientation on slip initiation.

X-ray topography has also been applied to the fracture of nearly-brittle crystals (molybdenum, niobium and their alloys). A topograph of the fracture surface (figure 1) shows the near-surface dislocations and the locked-in elastic strains caused by the passage of the fast crack. Successive etching and measurement of the elastic strains (from the image distortion) result in a quantitative measure of the depth of damage left by the crack. These are 'model' materials, but the importance of the result is that it permits a choice to be made between alternative fracture models for the crack propagation and hence the correlaton of fracture mechanics with direct observation.

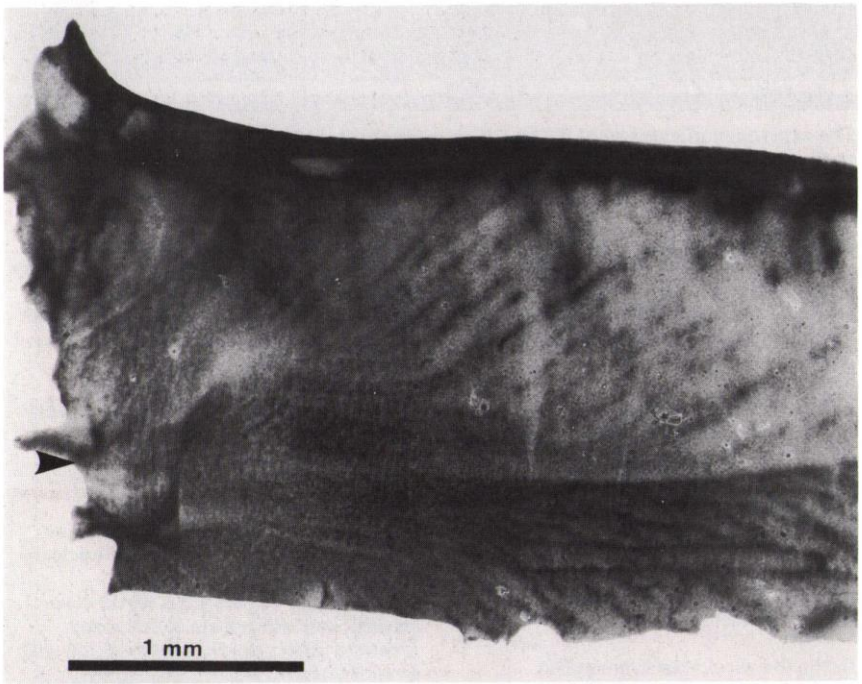


Figure 1: White radiation reflection topograph of (100) fractured surface in crystal. The arrow (left) shows the site of crack initiation. Courtesy A B Hurelo, J C Billello, S T Davies and D K Bowen (New York and Warwick Universities).

Electronic materials and devices

These have been a major topic of study at the SRS, especially on the x-ray topography facility. An important reason is that the large area, low divergence and high strain sensitivity of the synchrotron radiation beam in the x-ray region is perfectly matched to the assessment requirement for large silicon wafers of extremely high perfection and homogeneity for VLSI circuit production and, for smaller samples, to the detailed defect and strain characterisation required for highly advanced III-V and II-VI compound semiconductors.

This characterisation work, much of it in close collaboration with industry, has been performed on silicon, indium phosphide, gallium arsenide, cadmium telluride and complex quaternary

multi-epilayer structures. It relies upon novel x-ray optical techniques that are only possible with synchrotron radiation sources. III-V compounds have also formed the subject of one of the first surface physics studies at the SRS, on the nature of the metal-semiconductor interface by Professor R H Williams's group at the New University of Ulster, Coleraine. Understanding of this interface is essential for the control of device characteristics. This is the beginning of a major programme intended to lead to a detailed understanding of the physics of molecular beam epitaxial (MBE) epilayers and conductive coatings at all stages of the fabrication process. Since III-V and related devices are essential components of the optical communication systems involved, for example, in the 'cabling of Britain' these two lines of attack are of the greatest relevance to modern industry.

Piezoelectric materials, in wide use as transducers, oscillators, delay lines and filters, are also proving a most fruitful field of study: quartz, lithium niobate, KDP and its homologues are all being studied at the SRS. In a very exciting development, the high-frequency time structure of the SRS has been exploited to image, stroboscopically, travelling waves in a SAW filter (figure 2). This makes it possible to study the detailed propagation and dispersion of these waves for the first time and to correlate them with the crystal defect microstructure. The applications to acoustic device design and quality control are obvious and the experiment opens up many new possibilities in the study of high frequency crystalline devices.

Materials research is a very active field at the SRS, and one which will continue to grow as new facilities come into operation. The new methods of studying materials, and new applications developed during the first phase of operation, show great promise for the future.

Keith Bowen
Dr Bowen has a joint appointment at Daresbury Laboratory and Warwick University, where he is Senior Lecturer in the Department of Engineering.

Synchrotron radiation techniques for materials research

Method	Description	Applications
NON-IMAGING		
Powder diffraction	Rapid crystal structure analysis by energy – or wavelength – dispersive diffraction on small particles or grains.	Conventional structural analysis. Dynamic study of phase transformations and structural changes on deformation or heat treatment. Phase diagram determination.
EXAFS	Extended x-ray absorption edge fine structure.	Structural analysis through radial distribution function: best for nearest neighbours. Bonding in glasses, amorphous metals, oxides, unknown phases.
Interferometry	X-ray interferometry.	High precision scattering factor measurements. Possible applications in phase contrast x-ray microscopy.
Trace element analysis	Chemical analysis with $\geqslant 10^{-8}$g/g sensitivity, using x-ray fluorescence.	Trace element analysis for $Z \geqslant 9$ in wide range of materials. $Z < 9$ could be developed.
Small-angle scattering	Scattering within $\sim 2°$ of incident monochromatic beam.	Determination of particle-size distribution, and long-period structures.
Thin film scattering	Large-angle scattering with incident monochromatic beam confined to surface layers.	Surface structures: structure of thin films (oxides, epilayers, corrosion products) especially in early stages.
IMAGING		
White radiation topography	Transmission or reflection topography using white spectrum (Laue spot topography).	Crystal assessment, with greater range than Lang topography (poor crystals can be studied). Dynamic studies on crystal growth, phase transitions, magnetic and electric domains, recrystallisation, mechanical yielding.
Double crystal topography	Topography with monochromatised incident beam. Stroboscopy possible for cyclic phenomena.	Precision lattice parameter ($1:10^8$) measurement on near-perfect crystals. Rapid perfection assessment. Imaging of epilayer defects. Possible analysis of corrosion/oxidation products.
Microradiography	Element distribution on $\sim 0.1\,\mu$ m scale.	General microstructural study. Segregation in alloys: dynamic study of segregation on 1-5 μ m scale, $\sim$ seconds time resolution.
Microanalysis	Fluorescent or absorption analysis down to $\sim 1\,\mu$ m.	Correlation of quantitative analysis with microstructure. Segregation; general metallography.

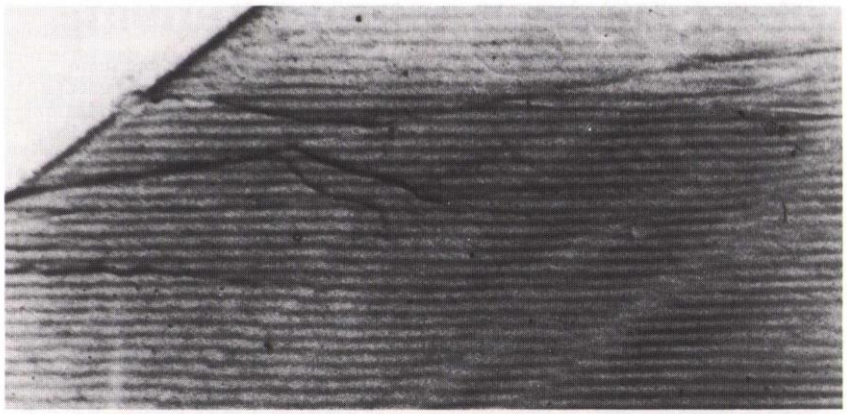


Figure 2: Stroboscopic (37.46 MHz) topograph of travelling Rayleigh acoustic waves on $LiNbO_3$ television 1F filter SAW device. Courtesy R W Whatmore, P A Goddard, B K Tanner and G F Clark (Plessey Ltd and Durham University).

References

[1] K R Lea and I H Munro, *The Synchrotron Radiation Source at Daresbury Laboratory* (Daresbury Laboratory, 1980).

[2] D K Bowen (ed), *The application of synchrotron radiation to problems in materials science.* Proc Daresbury Study Weekend, 13-14 November 1982. Daresbury Laboratory Report to be published shortly.

Both publications available from the Librarian, Daresbury Laboratory.

Biotechnology: SERC's strategy

Since the publication of the Spinks Report in 1980, there has been much said and written on the subject of biotechnology. Recently attention has been given especially to the question of a national UK strategy for the development of biotechnology and the role government should play in such a strategy. The Spinks Report suggested broad lines of advance for the subject and the leaflet issued by the Biotechnology Directorate of SERC identified a number of areas of research that the Council wished to encourage in the national interest. However, this does not add up to a strategy in the sense, for example, that Japan has developed a strategy. Is there in fact general agreement as to what a strategy comprises?

Let us assume that a strategy is a plan for action that covers the whole spectrum of activities, from basic research and training through to development and production in industry, with the overall aim of maximising the benefit to the UK of new discoveries and innovations in biology. In short, a desirable strategy is a set of unifying objectives to which the majority of the relevant community can subscribe, and which will yield maximum benefit to the UK, directly or indirectly. SERC, through its Biotechnology Directorate, can play a key role in sustaining the academic contribution to such an overall aim.

Before considering the suggested SERC component of such a strategy, it is necessary to make some assumptions and air some prejudices:

- Biotechnology is a broad set of activities built on many different disciplines; it is of interest to many different sectors of industry, but it is *not* in itself an industry. It consists of a range of possible processes, process aids, routes to new products and devices, all of which fit into the existing food, agricultural, chemical, pharmaceutical and medical industries.
- Each aspect of the field is moving at a different rate. The pharmaceutical field and medicare generally are moving fastest, followed by developments in agriculture and the production of fine chemicals. Perhaps last of all will be the large scale production in the UK of basic organic chemicals using a biological route.
- Most of the relevant research knowledge still resides in academic and research council laboratories. British industry must ensure that it has extremely good contacts and communication with these laboratories, and that vigorous and far-sighted policies are adopted to exploit rapidly the research work being carried out in them.
- Biotechnology is not labour intensive, although certain skills are liable to be in short supply.

A framework for SERC strategy

Reflecting these views of the development of biotechnology, the Directorate and its management committee have adopted a strategy on three levels:

Basic underpinning: support of basic research, postgraduate students plus any central facilities.

Priority sectors: support of identified sectors of biotechnology where it is essential to maintain a national capability.

Priority targets: support for research aimed at specific target products or processes, using SERC's Cooperative Grants Scheme.

The priority sectors chosen as being of key importance to the development of UK biotechnology and therefore meriting special support are:

- Biocatalysis, including immobilised enzymes and cells
- Plant genetics and biochemistry
- Large scale growth of mammalian and plant cells
- Fermentation technology especially new reactor design and microbial physiology
- New concepts in downstream processing
- Sensors and bioelectronics generally
- Recombinant DNA technology.

The Biotechnology Directorate will not only provide the stimulus and encouragement needed to implement this strategy, it will also provide the essential focus and coordination required to maintain coherent research programmes related to the broader national scene.

W G Potter
Director, Biotechnology Directorate

MSc course in remote sensing

The Natural Environment Research Council and SERC have agreed to support jointly a one-year MSc postgraduate course in Remote Sensing, in recognition of the increasing national and international requirements for Earth resources data during the next decade and beyond. The course will be organised jointly by University College London and Imperial College of Science and Technology, as the combination of expertise at these institutes will provide the course with a balance between the scientific principles of remote sensing and its applications. The course is expected to begin in October 1983.

Students will be taught the basic principles, not only of image processing and data handling techniques but also of the physics of sensors and space platform design, and the fundamental principles of electromagnetic radiations and their behaviour in the atmosphere. The course will also cover the many applications of remote sensing data such as the location of mineral resources, environmental monitoring, hydrology, crop prediction, oceanography and meteorology.

The course will provide personnel trained in the remote sensing techniques needed to deal with data from NASA's latest high resolution satellite, Landsat 4, and will prepare them for the new generation of sophisticated Earth remote sensing satellites to be launched later in this decade and beyond, including the ocean monitoring satellite of the European Space Agency, ERS-1, and also the satellites to be launched by France, India and Japan. The course is expected to be of particular interest to UK industry specialising in data processing software, image analysis and interpretation and also to a wide range of commercial data users concerned with mineral exploration, the offshore industry, weather forecasting, fisheries and many others.

The course will be open to suitably qualified applicants for NERC and SERC studentships in addition to other sponsorships which may become available. Further details may be obtained from the course convenor, Professor E H Brown, Department of Geography, University College London (tel 01-387 7050 ext 542).

Information technology

In the last *Bulletin it was announced that the Council was about to launch a major programme in information technology on a scale that would permit support of much of the research work proposed in the Alvey Committee report. Various actions have now been taken to initiate this programme.**

New directorate

The establishment of a special directorate to manage the information technology programme has been proposed by the Council and is currently under discussion with the Department of Education and Science. The directorate would be responsible for all information technology activities within the remit of the Engineering Board. These activities would encompass the major new directed programmes in the area of software engineering, intelligent knowledge-based systems (IKBS), man–machine interface and very large scale integration (VLSI) and the Board's existing specially promoted programmes (SPPs) in the information technology area. The directorate would provide stronger links between the academic community and industry and aim to weld together areas where there is duplication, particularly in the software disciplines. It is envisaged that the SERC directorate would be closely integrated into the national management scheme proposed by the Alvey Committee.

Training

One of the key elements of the information technology programme is to provide trained manpower to strengthen the UK's industrial and commercial capability. Within the overall increases shown on page 3, £3.55 million has been allocated for training and will provide an additional 1120 postgraduate studentships in 1983-84.

Most of the awards will be used to encourage graduates who have not trained in information technology subjects during their first degree to convert to the new discipline. This will be achieved through SERC's programme of one-year postgraduate 'conversion courses'; about 500 studentships will be available for take-up in the polytechnics and about 400 in universities. Proposals for new courses have been invited from polytechnic and university information technology departments and revisions to existing courses are being evaluated.

For those already trained in information technology subjects there will be an extra 100 advanced course studentships during 1983-84 for specialist courses. There will also be an extra 120 research studentships in 1983-84 to provide three-year training in research on information technology.

An extra 45 research fellowships will be awarded during 1983-84 to allow senior researchers experienced in information technology to devote themselves full-time to research for periods up to five years. The number of such fellowships is expected to reach 150 by 1985-86.

* Vol 2 No 7, Spring 1983: page 11.

New directorate proposed for manufacturing engineering

A new directorate concerned with all aspects of research into better flexible manufacture has been proposed by SERC. The proposal follows the success of SERC's Industrial Robotics Initiative (see page 12).

The 'ACME' directorate (Application of Computers to Manufacturing Engineering) should ensure that research into 'second generation' robotic systems is effectively integrated with all the other important aspects of flexible manufacture, such as computer aided design of a product, automatic process planning and appropriate systems for management information and control. The new Directorate would bring together three existing SPPs currently supported by the Engineering Processes Committee – Industrial Robotics; Application of Numerical Control to Manufacture; and Efficiency of Production Systems. These areas would be combined, with a major body of research in computer aided engineering, into a single programme. Research on individual aspects would continue, but within the wider context. The inter-relationships between such aspects are seen as particularly important.

Manufacturing transforms inputs of labour, materials, energy and capital resources into marketable products. It comprises equipment, its layout and relationship to the products produced, and work practices. A manufacturing system consists of planning and control routines, order generation methods, and interfaces with marketing, as well as design and finance. Past research has led to computing being applied usefully to these individual functions. It is clear that even more benefit will be obtained by linking these computer aids, particularly in the context of manufacturing small batches of, say, five to 50.

The Council considers that its large – and growing – investment in information engineering requires practical, applied research in its wake to help convert it into jobs and profit. Advanced research can only make a limited contribution to national wealth until industry uses it in the economic manufacture of products which appeal to customers.

The main aim of the proposed programme would be to promote highly innovative, medium-term research in universities and polytechnics with a fruition time of three to eight years, closely integrated with undergraduate and postgraduate training. This would help to fill a gap in British research – between fine long-range work in universities and the development work to be found in industrial laboratories which must produce results in one to three years – and at the same time teach young engineers the skills needed to work in this crucial area.

The programme would be managed by the proposed Directorate in the closest collaboration with industry, the Teaching Company and the Department of Industry. As part of the programme, it is envisaged that these bodies would collaborate in a number of national pilot projects demonstrating the new technology as early as possible in a real production environment.

Further details of the new programme will be published in the next issue of the *SERC Bulletin* (Autumn 1983).

Industrial Robotics Initiative

The Industrial Robotics Initiative, the largest of the Engineering Board's Specially Promoted Programmes, has from the outset followed a policy of making the award of large grants conditional on the formation of partnerships between academic groups and firms using, or building, robotic equipment. In forming a partnership, it is required that the proposed research should be an important part of the corporate strategy of the firm. A large contribution by the company is required (contributions range from 25% to more than 50%) but emphasis is put on the contribution of management skill by the firm in the form of assistance in planning projects, defining targets and seconding engineering staff to work in the university group, rather than on straightforward cash support.

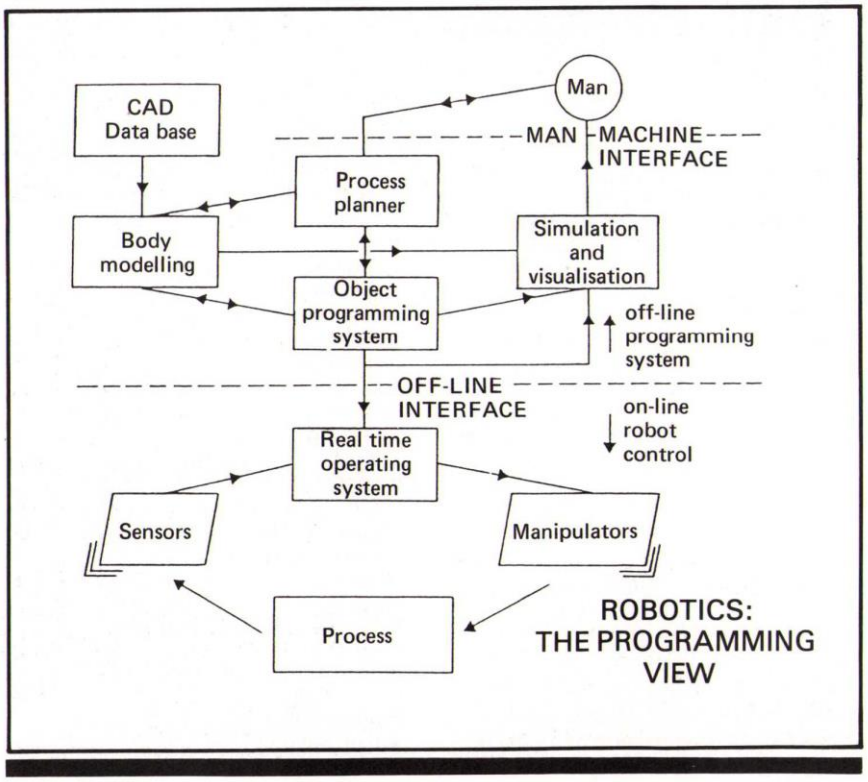
The Initiative is now supporting 33 major partnerships in 22 institutions. The total funding so far is £4.1 million (including non-partnership grants and the cost of capital equipment on loan from the robotics pool).

The programme is also aimed at bridging two serious gaps in UK engineering culture today. First is the gap prominent here, but almost absent in countries like Japan and Germany, between engineers in higher education and their counterparts in industry; and second that between information engineering and production engineering. The two latter disciplines are both seen as having a crucial part to play in the development of factories able to operate unmanned for long periods, expected within the next decade.

'Second generation' robots

The technical objective of the programme is to develop the technology required for 'second generation' robotic devices. Physically these may resemble assembly stations on a transfer line or unmanned vehicles – mobile robots – as well as the usual anthropomorphic manipulator. The aim is to make such machines more effective in the context of flexible manufacture in the factory by being able to cope accurately with minor deviations in their surroundings – especially in the parts and processes they are handling.

Robotics research today covers fields as apparently diverse as better dynamic control of manipulators, navigation for mobile robots, advanced sensors, and techniques for processing and understanding the images they produce as well as off-line programming systems. However, a clear framework is now becoming visible which shows the inter-relationships between the different aspects of this research. One view of this framework – the programming view – is shown in the flowchart. Seen from this viewpoint, the functions that require development, in order to achieve an off-line programming system, appear dominant. But it is equally important to bear in mind that the overall system can be looked at from different viewpoints, with the focus on, for example, the behaviour of a complete robotic system; or the means of building cheaper and optimally controlled manipulators; or the design of sensors and of cheap, fast image processing and pattern recognition procedures which can be used to control the robot.



Grantees' conference

The highlight of the Industrial Robotics Initiative during 1982 was the first Grantees' Conference held at Birmingham in September. There was widespread support for making the conference a regular event, with as selected an audience as possible, and it is to become an annual feature of the programme. The conference proceedings are available from the Coordinator on request. Some projects starting to produce results are described here.

Loughborough

A group at Loughborough University has worked with Martonair Ltd to study problems in designing and controlling a modular robot system whose individual elements, both electrical and mechanical, could be put together in simple or complex configurations as required by the manufacturing engineer concerned with a particular application. A product based on this work is now envisaged by Martonair.

Oxford

A group at Oxford University (in partnership with BL Technology, GEC Electrical Projects and Fairey Automation) has tackled a classic problem – that of studying sensor systems suitable for controlling arc welding robots so as to make reliable joints in thin sheet metal even when the edges of material to be joined are several mm away from their nominal positions. The group has shown that it is possible to build a compact vision sensor, packaged right around a welding torch containing a laser and semi-conductor camera chip, able to survive within a few cms of the welding arc itself.

— highlights of a joint research programme

Hull, Cranfield, Salford

Assembly is seen as one of the largest and also one of the hardest growth areas for the application of robots. Three groups, at Hull (with GEC & Marconi), Cranfield (with several partners) and Salford (with Fairey Automation), have adopted different approaches, ranging from vision-guided assembly of difficult electronic components; through use of a specially adaptive hand originally conceived for prosthetic purposes; to work on design for robotic assembly.

Edinburgh, Newcastle, Liverpool

Several groups, including Edinburgh University's Artificial Intelligence Department, Newcastle University and Liverpool Polytechnic, have obtained important results on the dynamic control of heavily loaded manipulators. These approaches are exciting because they look feasible to compute in real time on the type of processors which will be incorporated into tomorrow's robot controllers.

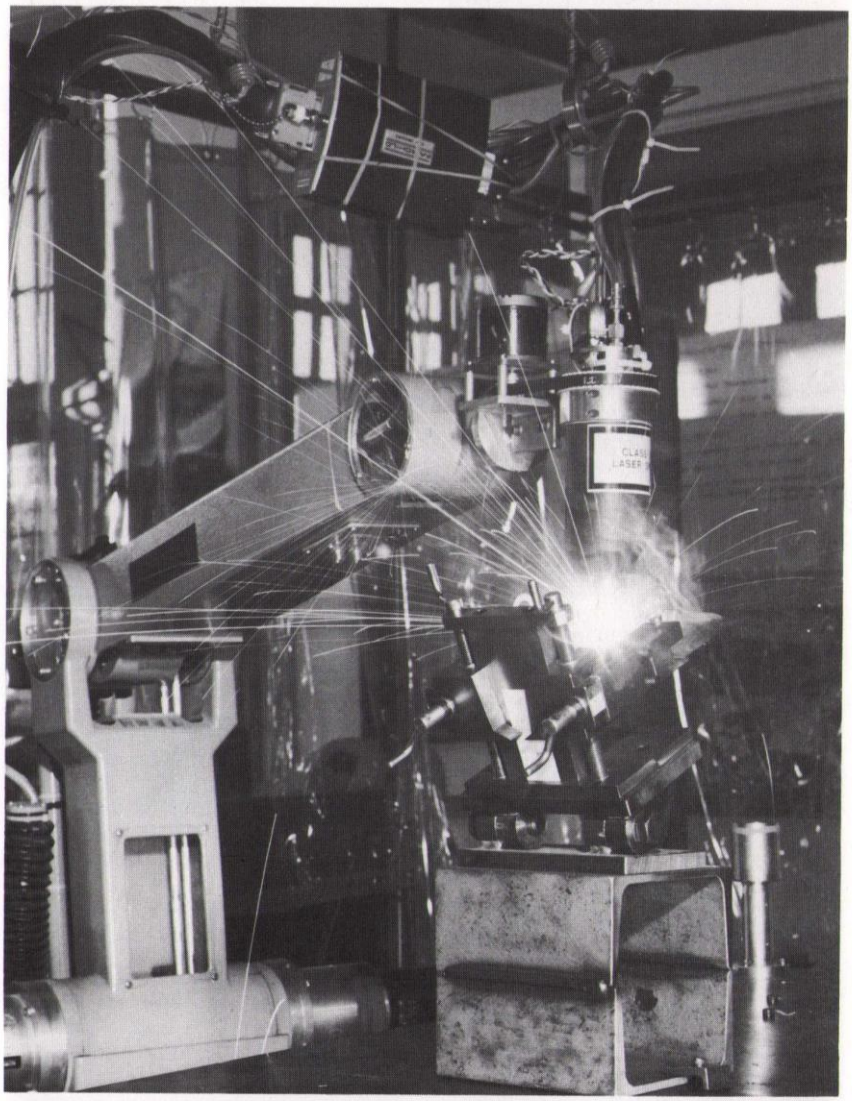
Robot Language Working Party

Important long-range work on several of the modules required for off-line programming, and shown in the flowchart, is being done by the AI Department at Edinburgh. This work is being steered by the Council's Robot Language Working Party, comprising a 'club' mainly of potential industrial users, helping to guide the programme in return for gaining access to early prototypes of the software for assessment. Future plans of the Robot Language Working Party will, it is hoped, lead to joint effort towards developing and eventually standardising parts of a complete off-line programming system between the UK, France and Germany.

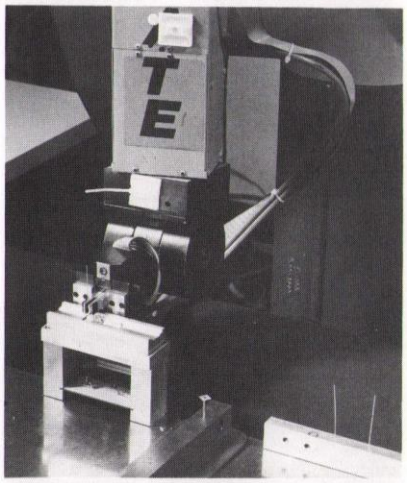
The future

Two important strands in the future evolution of robots will be the application of robotic principles in support of improved flexible manufacturing systems; and the wider use of robots outside the environment of piece-parts manufacture in small batches. It is expected that these developments will be an integral part of the new ACME initiative (see page 11).

Peter Davey
Coordinator, Industrial Robotics Initiative

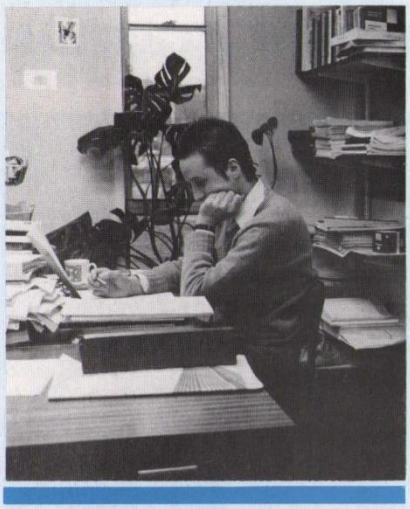


Above, a novel sensor-guided arc welding robot system developed at Oxford University with support from SERC and three UK partner firms. The design of the robot's vision software was influenced by artificial intelligence research results.



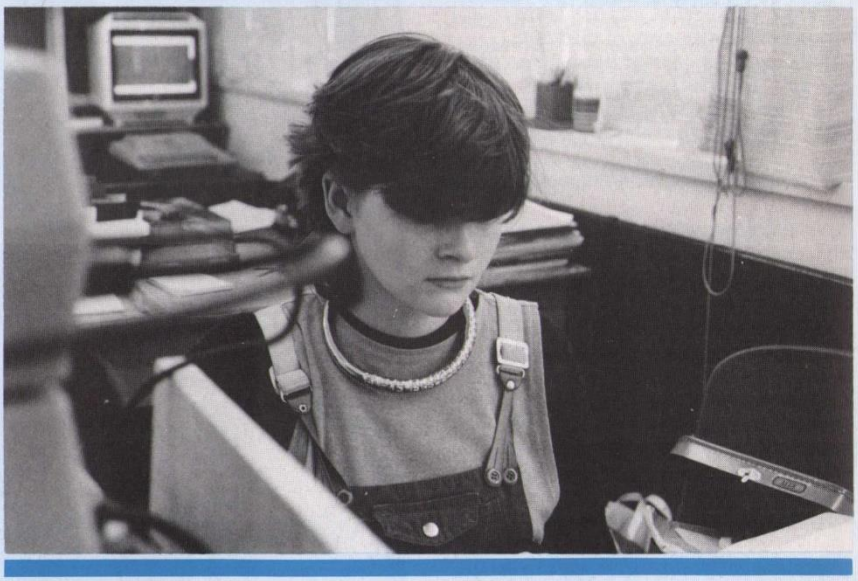
Right, Hull University's vision-guided robot system inserting a 0.5mm-diameter gate wire into a 0.7 mm-diameter hole in a Thyristor assembly jig. A low-resolution dynamic RAM camera is mounted on the gripper. The SERC-funded research is being carried out in collaboration with GEC/Marconi, Chelmsford, and the component parts are by courtesy of GEC/MEDL, Lincoln.

Human—computer Leicester



André Schappo, research assistant, at work in one of the suite of offices that accommodate the Unit, bringing together skills from a range of departments.

Leicester Polytechnic was awarded a major SERC research grant in September 1982, to establish a centre for man — machine interface research.



A secondary school student receiving help with her English in a project that is developing and evaluating computer-based material providing activities ranging from spelling practice to story writing.

As we have moved into an era in which non-computing experts increasingly use computers directly, the problems of designing and building computer systems have become, more and more, problems concerned with human factors and the human–computer interface. Thus the centre of concern for interactive computing is often seen as the user interface. Computing research at Leicester Polytechnic has concentrated on this, from various points of view, for nearly fourteen years.*

The interface is seen as a separate and possibly substantial component in computer systems. In some respects it can be said that the interface embodies the user's model of the system. The work at Leicester is directed towards building a software environment for user interface construction. To do this, one needs to be concerned with certain basic capabilities, such as speech input, with the management of the dialogue between user and machine and with the monitoring and evaluation of the system's performance in respect of its usefulness to the user. This is a multi-disciplinary task and the team at Leicester includes people with significant research experience in signal processing, ergonomics, psychology, logic, computer science, statistics and linguistics.

Evaluation

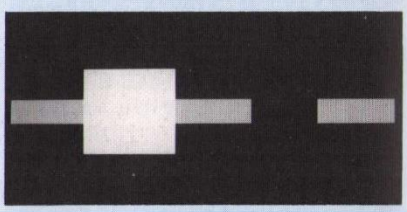
The evaluation of human–computer interfaces involves hardware, software and cognitive ergonomics. In each case methodologies for experimentation and analysis are required. If they are to serve interface designers in practice, they need to be based upon efficient techniques and to operate both during the initial design phase and during the operation of a live system. The unit is concerned with methodology and with the supporting software and hardware tools that make it possible to put the methodology economically into practice.

Dialogue management

A sophisticated dialogue management system has already been developed. It is powerful enough to handle significant subsets of English. The application program only communicates with the user through this dialogue-program. The dialogue description includes specific commands indicating when the application program should be evoked and what information should be passed to it. Unilever Research at Port Sunlight are using the Leicester software to help them in their work on expert systems to support their scientists.

Basic capabilities

One project is concerned with the interactive synthesis and handling of images. The importance of the visual image as a means of communication is evident from its use in advertising, publishing, television, textiles and education. The increasing demand for graphics displays suggests that the role of the image in communication will become increasingly important. However, the development of interactive software for the synthesis of images has not kept pace with graphics hardware. The unit is working towards redressing this inbalance by producing tools and techniques which take greater advantage of the capabilities of modern displays. The approach is to concentrate on the development of image handling techniques which operate



Right: A simple digitised image. The computer has no direct knowledge of the shapes in it, only the tone of each point.

*In 1982 a special issue of the International Journal of Man–Machine Studies (Volume 16 number 3) was devoted to work done by the group.

interface research at Polytechnic

This grant represents one of the largest ever awarded by the Council to a polytechnic and will support research in one of the key areas of information technology.

The GEC 4090 computer that is the main machine in the unit and a node on SERCNET, keeping the Unit in touch with other researchers.

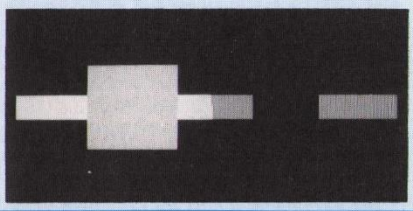
directly on the digitized image. This means that the user must provide information about the elements perceived in the image and the transformations required, in order to handle an image. Given this information, the relevant features can be extracted and the transformations effected; handling the image as the *user* sees it.

The Continuous Speech Input project is following two main paths of enquiry. One branch of the project is concerned with determining and providing prototyping systems, both hardware and software, as tools which will facilitate the development and testing of ideas. The Leicester palantype symbol-to-English text translation system, used by the BBC for sub-titling in real time, forms the core to which other tools can be attached. The other avenue is that of exploring the ways in which existing methods can be applied to the problem. In particular, the unit is attempting to read 'visible speech' spectrograms using image recognition techniques. Image processing techniques are being developed and used in both the graphics and the speech projects.

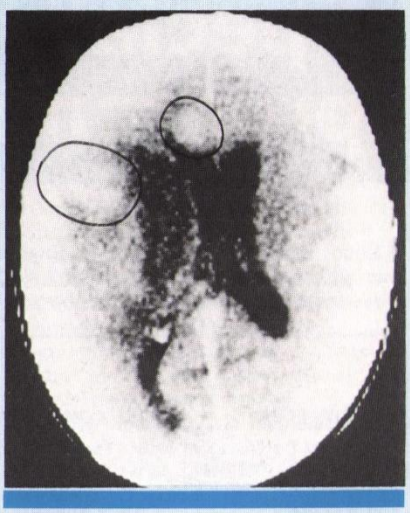
In support of the research in basic capabilities, some work is underway with the cooperation of Marconi Radar Systems Ltd on high performance computer architectures.

Applications

It is thought to be important to be involved in applications' projects at the same time as the more fundamental



Left: A user has pointed to the leftmost rectangle and the computer is in the middle of extracting the shape. Having identified the rectangle it has found a second rectangle that is perceived as being connected even though it is not in contact.



An image produced from a C T scanner of someone possibly suffering from a cerebral tumour. The marked regions are possible lesions. Data from such scans are fed into an expert system to assist in diagnosis.

research is conducted. The image processing team, for example, is involved in the implementation of an automatic machine tool breakage inspection system for Kearney & Tracker Marwin Ltd. Similar work is being done with the textile industry. With the support of Leicestershire Education Authority an exploration is underway of the use of computers in schools as individual learning tools for English language studies.

A project in conjunction with Professor G du Boulay of the Institute of Neuroradiology, National Hospital and supported by International General Electric is working to improve the accuracy and efficiency of the diagnosis of cerebral disease using information from CT (computer tomography) scan images. The current research effort is concentrating on the development of a comprehensive suite of programs to provide aid and advice on both interpretation of scan images and the diagnosis of disease.

In order to provide training opportunities to people in the information technology industry, a sandwich-style MSc course is run dealing with the issues relating to the unit's research interests. In the context of the Japanese 'fifth generation' computing initiative and the Alvey Committee's proposals, work at Leicester Polytechnic can be seen to be well on the way to providing one component of future computers, the all important user interface.

Ernest Edmonds
Professor Edmonds is Professor of Interactive Computing and Head of the Human–Computer Interface Research Unit at Leicester Polytechnic.

Specially promoted programmes ... a round-up

It is more than two years since the Engineering Board's policy of selective support through Specially Promoted Programmes (SPPs) was introduced in the *Bulletin* (Vol 2 No 2, Spring 1981). Some programmes have since been concluded, some extended into full-scale Directorates and several new ones have been set up. The list we published then has now been entirely revised.

COORDINATOR	SERC CONTACT*
Environment Committee	
Construction management	
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Energy in buildings	
Dr T J Wiltshire Building Science Section School of Architecture The University Newcastle upon Tyne NE1 7RU Tel 0632-617049	Mr N Williams ext 2353
Application of information technology to transport	
To be appointed	Mr N Williams ext 2353
Machines and Power Committee	
Coal technology	
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Combustion engines	
To be appointed	Mr J Farrow ext 2117

COORDINATOR	SERC CONTACT*
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Medical engineering	
Dr E A Mason 10 Warren Court, Frodsham Warrington, Cheshire WA6 6EN Tel 0928-31511	Mr S D Ward ext 2110
Engineering Processes Committee *(see also page 11)*	
Particulate technology	
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COORDINATOR	SERC CONTACT*
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Device fabrication facilities	
Mr L Manns Flat 23 Sherwood, Herne Road, Surbiton, Surrey KT6 5BU Tel 01-390 0425	Mr A Kurzfeld ext 2161 Mr W Turner RAL (Chilton)† ext 5286
Radio communication systems	
Mr F Grimm 85 Beaumont Road Cambridge CB1 4PX Tel 0223-246202	Mr G J Day ext 2235 Mr S K Barton RAL (Chilton)† ext 6556
Distributed computing systems	
Mr F B Chambers Logica Ltd 64 Newman Street London W1A 4SE Tel 01-636 5440 ext 242	Mr M Hotchkiss ext 2260 Dr D A Duce RAL (Chilton)† ext 5511

*At SERC Central Office
tel Swindon (0793) 26222

†At Rutherford Appleton Laboratory,
tel Abingdon (0235) 21900

Coordinator for electroactive polymers SPP

Professor T John Lewis has been appointed coordinator of the new specially promoted programme in Electroactive Polymers. The SPP has been set up to encourage research into polymeric materials with novel optical and electrical properties. The programme is expected to add about £1 million to the Materials Committee's budget from 1982/3 to 1986/7. The purpose of the SPP is to stimulate a coherent and timely UK activity in the science and technology of electro- and photo-active polymer systems for applications in new photoelectronic, reprographic and microelectronic devices (see *SERC Bulletin* Vol 2 No 6, Autumn 1982).

Professor Lewis has been Professor of Electrical Materials Science at University College of North Wales, Bangor, since 1966. His research interests have been in the electronic transport and dielectric properties of weakly conducting solids such as polymers and oxides, especially in thin film form. Recently these interests have extended to studies of the electronic properties in biopolymers including Langmuir and bilayer membranes. He is Honorary Editor of *The Journal of Physics – D. Applied Physics.* He will manage the programme, promote interdisciplinary research projects within the SPP, and liaise with interested government departments (such as the Department of Industry and Ministry of Defence), other SERC bodies (particularly the Solid State Devices Subcommittee of the Information Engineering Committee), and UK 'end user' industries which might exploit the technology for the national good.

Close involvement between university science and industrial development is seen as vital for the ultimate success of the SPP. Another important requirement will be the development of interdisciplinary programmes in the universities involving close collaboration between chemists synthesising the materials, physicists characterising and measuring their electrical properties and electronics engineers evaluating their potential use.

The Council is keen not only to encourage currently supported research groups to expand their activities in the required direction but also to attract the skills of researchers who may not previously have worked in the field.

Joint optoelectronic research

The exciting area of optoelectronics research will in the future allow the engineer to produce a wide range of devices, which can perform operations on optical signals similar to those presently performed by integrated electronic circuits. The primary advantages of using optical technology are: speed; resistance to interference; the ability of an optical fibre to handle larger bandwidths (ie more information) with inherently lower signal loss than conventional copper conductors; and, of course, the economic advantages of silicon over copper. Altogether, these present a very attractive alternative to traditional integrated circuit technology.

Several recent reports, not least of which was the ACARD report on Information Technology, have recognised the importance of optoelectronics to the UK economy, not only for the long-term future of the UK telecommunications industry but also in computing, control and instrumentation where developments in optical system technology have opened up a new generation of possibilities.

Against this background, SERC and the Department of Industry (DoI) have jointly agreed to provide additional, earmarked funds to encourage collaborative research in the field of optoelectronics – the Joint Optoelectronic Research Scheme. A total of £15 million over the next five years has been set aside for the programme: £10 million from DoI to support the industrial partners in a collaborative venture through 50% grants and £5 million from SERC to support the academic partners. The programme is primarily to support fundamental research programmes in integrated optics; fibre technology; displays; optical sensors; optical data storage and novel optoelectronic materials. Application forms and further information from Mr A Kurzfeld at SERC Central Office, Swindon (ext 2161).

Image processing

Computer processing of images is becoming increasingly important. Applications are developing in which it would be desirable to assist or replace human eye-to-brain perceptual processing, in such diverse areas as robot vision and interpretation of images of planets visited by spaceprobes. New sensors are being devised all the time and data not originally in image form (such as from synthetic-aperture radars and ultrasonic microscopes) are increasingly being displayed pictorially, thus expanding the scenic world beyond that normally perceived.

All four boards of the Council support research in image processing and the more general topic of pattern recognition. The Engineering Board funds fundamental and applied image processing work, whereas the other boards concentrate on applications of the techniques. The Board's Information Engineering Committee and Computing and Communications Subcommittee last year sponsored a survey of image processing research funded by SERC and the other research councils. The objectives of this survey were to review the research funded; to consider what scope existed for greater cross-fertilisation between the user disciplines and basic computer science; and to make recommendations on the coordination and stimulation of further research.

A follow-up research-area review meeting was held at Rutherford Appleton Laboratory (RAL) in December 1982, attended by some 200 people. Many more had applied, demonstrating the subject's popularity and importance.

There were 22 invited talks, ranging over many disciplines: astronomical image processing; remote-sensing analysis; industrial uses; high-energy physics applications; pattern recognition and image processing in crime detection and surveillance; artificial intelligence and vision; and military uses of image processing.

The state of the art in pattern recognition and image processing methodology was also reviewed, and there were three discussion sessions on future needs for the image processing community. The meeting was chaired by Professor J R Ullmann, head of the Department of Computer Science at Sheffield University, and chairman of the British Pattern Recognition Association.

The survey report and a volume of abstracts and notes from the meeting are available from Mr G J Day at SERC Central Office, Swindon (ext 2235).

Graduate development scheme grows

With the agreement of the Department of Education and Science, the pilot phase of the Integrated Graduate Development (IGD) Scheme has been extended to include a fifth programme on Information Systems Design. The programme will be run by the School of Electronic Engineering and Computer Science at Kingston Polytechnic, and the cost of supporting a single intake of 30 students will be shared equally by ICL and SERC. ICL will recruit students both from their own employees and from organisations with which it has close links.

Arrangements for the course have been made in record time. Following initial contacts between the parties in May 1982, Council and DES approval were obtained in November and MSc status was granted by CNAA in January 1983. Contracts with ICL and SERC were signed a few days later. In May, students were due to arrive for the first module of a set of up to 18, to be spread over two years.

The course is structured to provide practical instruction to students from a wide range of commercial and industrial fields and comprises both compulsory and elective course units. The human component of information systems design has been given particular emphasis; compulsory units include those on man-machine interfaces and human, social and economic factors. Decision support and its inter-relationship with management structure is also an important element in the course design and a full-time industrial psychologist is on the staff.

Total commitment by SERC on IGD programmes now amounts to £1.4 million. The Technical Change Centre has been commissioned to assess the value of the scheme, and Council is expected to consider its report later this year.

For further information contact Dr D P Jones, SERC Central Office, Swindon (ext 2108).

PERQ progress

The advent of cheap high-power Single User Computer Systems, providing quality graphics and good interaction as well as significant processor power, enables a new *style* of computing to be done. The number of types of such systems will increase rapidly over the next few years.

To take advantage of the power offered by such systems, while preventing the inevitable massive software duplication that would result from uncoordinated supply, SERC decided to institute a common base policy, which recommended both hardware and software standards for SERC researchers using such Single User Systems. In brief, the software common base consists of the UNIX operating system, Fortran 77 and Pascal compilers, and the GKS graphics system. The hardware common base consists of ICL PERQ computers, connected by fast Cambridge Rings locally, and by the X25 network nationally. We describe here the PERQ, the software which is now available, and the way in which their use will greatly improve the interaction between man and computer.

PERQ hardware

The PERQ consists of:

- A powerful *central processor* capable of approximately one million high-level instructions per second.
- A high-quality A4 size *display*, with 1024 x 768 pixels giving a screen resolution of 100 pixels per inch. The display refresh rate is 60Hz, non-interlaced, providing smooth picture movement.
- 24 Mbyte Winchester disk providing local *filestore*, as well as a 1 mbyte floppy disk.
- Input via 2D *tablet* as well as *keyboard*, giving superior user interaction.

PERQ software

The UNIX* operating system for the PERQ – called PNX – is now available (PNX is a virtual memory version of UNIX, with a full 32 bit address space). UNIX is a powerful multi-process operating system with many user-oriented tools known as utilities. There are 104 of these standard UNIX utilities available, with a further 13 either specific to PNX or that have required modification in some way.

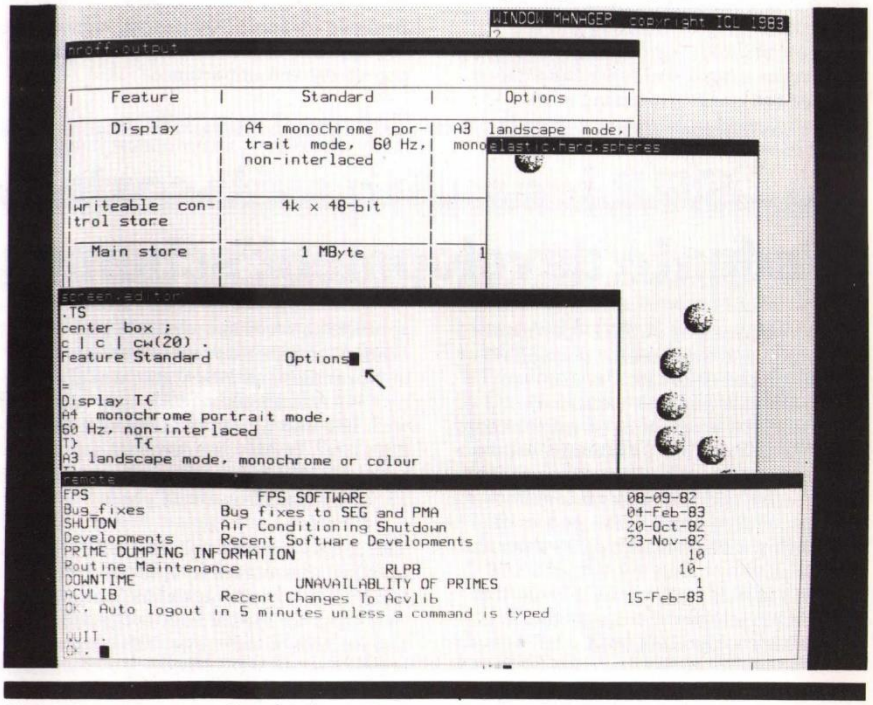
The PNX 'window manager' provides an essential element of the new style of computing environment. A 'window' is a rectangular area either wholly or partially on the screen; windows may overlap, one (or more) partially obscuring the contents of others. Typically, each window is used as the output 'device' by separate processes running at the same time in PNX. The window manager, as well as allowing creation and deletion of windows, also permits windows to be moved or changed in size. Further, windows can be 'pushed' or 'popped' relative to other windows; this means that a window which obscures other windows can be lowered in visual priority so that a window at the top can be placed below others, and vice versa. (An analogy is a number of documents on a desk, partially overlapping; each document corresponds to a window, with the desk top as the PERQ screen. A letter, say, can be 'popped' to the top of the pile – and thus made wholly visible – by lifting it out of the pile and placing it on top). The window manager also keeps track of information which is obscured so that, if a covered window is uncovered, the information formerly not visible is still available for display.

The figure on this page shows the power of the combination of a multi-process operating system such as UNIX together with such a window manager. A photograph of a session which has five windows generated is shown; one of these windows – at the top right-hand corner of the screen – is for communication with the window manager itself. At the top left-hand corner, the window entitled 'nroff.output' contains information generated by the UNIX 'tbl' and 'nroff' utilities – in this case a table describing PERQ features. The window immediately below (labelled 'screen.editor') shows the 'thief' screen editor editing the input file for 'tbl'. Thus, as errors in the output window are identified, they can be immediately corrected by editing the input file.

Output from two other processes is also shown; one a simulation of perfectly elastic colliding spheres in a container. The other shows the use of the 'chatter' utility to access one of the Prime computers at Rutherford Appleton Laboratory to obtain the message of the day prior to initiating a file transfer.

The simple session described above shows the strength of PNX in a programming development environment. Equally, large and complex applications such as occur in computer aided design can be very effectively managed, with several types of input and output information available to the designer and under his direct control. It should be stressed that powerful single user systems and their associated software – as described above – are important because they provide vastly improved communication between the user and the computer. Over the next few years, developments in this area will revolutionise SERC researchers' view of computing.

Dr K Robinson
Computing Division, RAL



Multiple processors and multiple windows with PERQ/UNIX

* UNIX is a trademark of Bell Laboratories.

First glimpse by IRAS

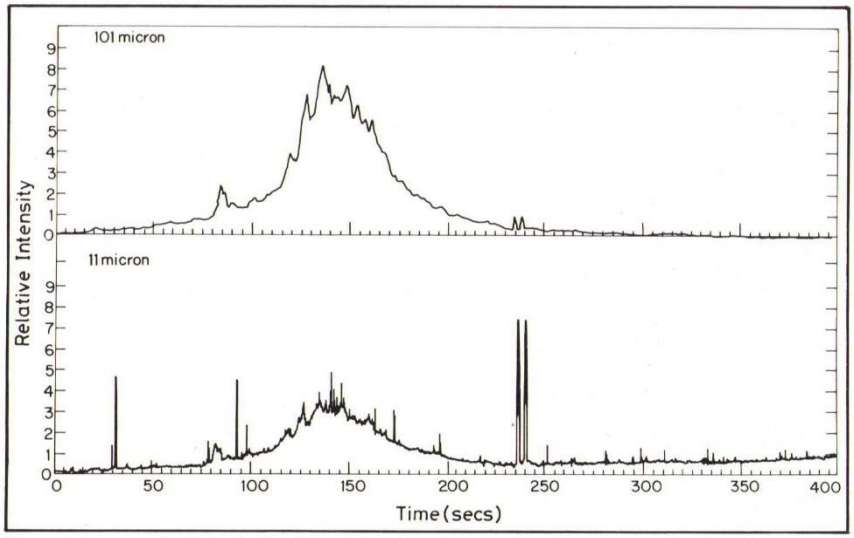
The telescope on board the Infrared Astronomical Satellite (IRAS) returned data from its first look at the Universe only days after the satellite was launched on 26 January. In its first day of operation while viewing the sky, the telescope performed a series of half circle scans, which included two passes over our Galaxy, the Milky Way. The observations show that the Galaxy, as expected, is heavily populated by stars and other objects that strongly emit infrared radiation.

IRAS is a major international mission involving the Netherlands, the United States and the UK (see *SERC Bulletin* Vol 2 No 7, Spring 1983). It was launched by NASA from the Vandenberg Air Force Base in California. It is controlled and its data received through the IRAS Operations Control Centre located at the Rutherford Appleton Laboratory. Scientists and engineers from the three countries are conducting the mission and performing a preliminary analysis of the data at RAL. A final catalogue of infrared sources and a map of the infrared sky will be assembled from the data at the Jet Propulsion Laboratory in Pasadena, California.

The first scan by IRAS included a 25-degree sweep from south to north at a 45-degree angle across the plane of the Galaxy in the constellation Crux, the Southern Cross. The initial scans were a minute portion of the systematic survey that IRAS is now conducting of the entire sky in four wavelength bands, from 8 to 120 microns.

The emission in the longest wavelength band is dominated by 100 micron wavelength radiation from cold dust associated with the material out of which all stars in the Galaxy are formed. The observation indicates the presence of individual clouds of dust and molecular gas hundreds of light years across.

The emission in the shortest wavelength band is mainly due to the energy from billions of stars. An intense broad signal is seen from the centre of the Milky Way due to the dense concentration of stars. Another early observation was of the Large Magellanic Cloud (see front cover).



Data from a scan of the Milky Way taken by the IRAS telescope on its first day in operation. The tracings show data taken in one 400-second scan by two of the 62 detectors in the focal plane of the 57-centimetre telescope and represent about 25 degrees in the sky.

Both tracings show a pronounced bulge on crossing the Milky Way, with cold dust mainly responsible for the 100 micron emission and stars at 11 microns.

The two spikes on the right side of the central peak in both figures are from a calibration source within the telescope and indicate the relative scales of the two graphs.

Nimbus 5 : ten years in space

World weather research programmes are still using data from a SERC-supported British instrument which went into orbit on a research satellite ten years ago and is working well after 300 million operations.

Launched in December 1972, NASA's Nimbus 5 weather research satellite carries six instruments in a 600 nautical mile orbit around the Earth and provides sea ice pictures in the arctic regions and valuable data on atmospheric temperatures. One of the instruments for the satellite – the Selective Chopper Radiometer – was provided by Oxford, Reading and Heriot-Watt Universities and the Rutherford Appleton Laboratory.

The instrument is able to determine global temperature structure, cloud cover and the humidity of the atmosphere from the Earth's surface to a height of 45 km.

The Selective Chopper Radiometer makes remote atmospheric temperature soundings by measuring the infrared emission from carbon dioxide and water vapour present in the atmosphere. Cells of carbon dioxide gas and optical multilayer filters are used within the instrument to select different parts of the infrared emission. In all, 16 channels are observed. For temperature sounding in the upper atmosphere, good vertical resolution is obtained by using a differencing technique between adjacent channels. This is the 'selective chopping' principle from which the instrument takes its name.

The measurements depend on a number of small mechanisms driving four rotating filter wheels which stop at one-second intervals. These mechanisms still continue to operate satisfactorily even after over 300 million operations.

World weather programmes are designed to expand observational capability and promote both our understanding of atmospheric processes and our ability to predict them. The data received at Oxford University, for example, have been used for studies of the dynamics of the atmosphere, the statistical distribution of different cloud types, global variations in humidity and various other atmospheric phenomena including waves and airglow. Many institutions in the UK, Europe and the USA have made use of the data.

UK Schmidt Telescope surveys the southern skies

The UK 1.2m Schmidt Telescope (UKST) is located on Siding Spring Mountain in New South Wales, Australia on the same site as the Anglo-Australian 3.9m telescope and is operated by a team of resident astronomers from the Royal Observatory, Edinburgh. The basic parameters of the telescope are the same as those of the Palomar 48-inch Schmidt telescope. The UKST was commissioned in 1973 with the primary purpose of extending to southern declinations the sky survey carried out by the Palomar Schmidt in the 1950s; this Southern Sky Survey is being done in collaboration with the European Southern Observatory 1m Schmidt telescope in Chile. The UKST (blue) half of the survey is now 99% complete, and the telescope is fully used taking photographs for other surveys or for the research programmes of individual astronomers.

Two full-aperture, thin objective prisms are available which can be used to record the spectra of 100,000 stars and galaxies on a single photograph. The first, low dispersion prism came into use in July 1976 while the second (intermediate dispersion) prism was first mounted on the UKST in March 1982.

Most plates taken with the old prism were on blue sensitive emulsion and this prism was particularly successful at identifying emission-line quasars with high redshifts. The 'redshift' of a quasar or galaxy is a measure of the velocity with which it is moving away from us: since the whole universe seems to be expanding away from some initial 'big bang', the objects with the highest velocities are those which are now most distant. Hence very large redshift corresponds to enormous distance. However, the dispersion of the old prism was too low to allow accurate spectral classification of stars. Knowing the spectral type of a star allows the astronomer to determine its temperature and, in many cases, its mass and absolute brightness. Different spectral types are recognised by the presence, or absence, of lines of different elements. Therefore, soon after the first plates taken with this prism had been analysed, a scientific case was made for the provision of a higher dispersion prism to allow both accurate spectral typing and, if possible, the detection of higher redshift quasars. A contract for the new prism was placed in June 1978 with Grubb Parsons of Newcastle who also made the original prism.

The Hewitt camera

Standing beside the UK Schmidt building is the Hewitt satellite tracking camera and buildings belonging to Aston University's Earth Satellite Research Unit (ESRU). The Hewitt camera is now fully operational and the first good quality photographs were obtained in late 1982. It is operated by two observers at a time who come to Australia for periods of about two years from Aston University. The staff of UKST have worked closely with their Aston colleagues over the past two years in order to overcome severe problems associated with setting up the camera. The optical alignment has been checked and adjusted by UKST personnel, several severe technical faults have been rectified and the appropriate photographic techniques have been developed for the requirements of the camera. The research programme of ESRU is led by Dr Clive Brookes of Aston and includes studies of the earth's gravitational field, upper atmosphere dynamics, ocean tide effects and polar motion.

The new prism gives a useful dispersion out to much longer wavelengths than the old prism so that red sensitive emulsions can be used. Unfortunately it has not proved easy to identify high redshift quasars with the new prism.

A wide range of stellar spectral types are, however, extremely successfully identified on plates taken with the new prism. The spectra reveal a variety of features including:

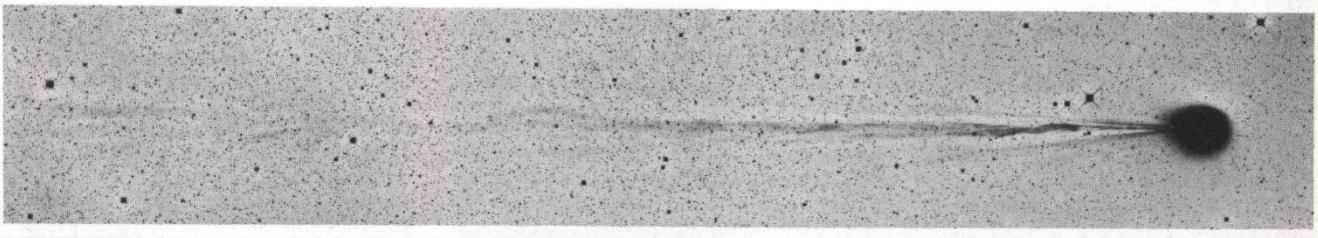
- bright emission lines clearly visible in Wolf-Rayet stars;
- the Balmer series of hydrogen lines in absorption in A-type stars;
- the absorption bands caused by molecules such as CN, completely dominating the spectrum of the cooler stars.

In addition to photographing the most distant objects in the Universe, the UKST is also used to photograph members of our own Solar System. Photographs of comets and asteroids are taken fairly frequently; these plates can often be obtained in poorer weather conditions than are required for most programmes.

On the subject of comets, the staff of UKST had very mixed feelings when the announcement came that Comet Halley had been detected on the night of 24 October 1982 using a CCD on the Palomar 5m telescope. Several attempts have been made over the past few years to obtain the first confirmation of this return of the comet. On the night of recovery the magnitude of the comet was around 24.2, well below the limit of detection on the UKST. However, the telescope will be taking part in the 'Halley Watch' programme over the next few years and some dramatic photographs are expected.

Sue Tritton
Plate Librarian
Royal Observatory, Edinburgh

This dramatic photograph of Comet Austin (1982g) is from a 10 minute exposure on the UK Schmidt Telescope taken on the night of 2 April 1982. The head of the comet is in the Northeast corner of the original plate and the tail extends diagonally across the plate to the extreme Southwest – a distance of about 8.5°. Rodney Austin, an amateur astronomer in New Zealand, discovered the comet on 18 June 1982 as a faint (10th magnitude) object in the constellation Horologium, where it was travelling north eastwards at about 0.3° per day. At the time of this photograph the comet was nearly at its brightest, about fifth magnitude.

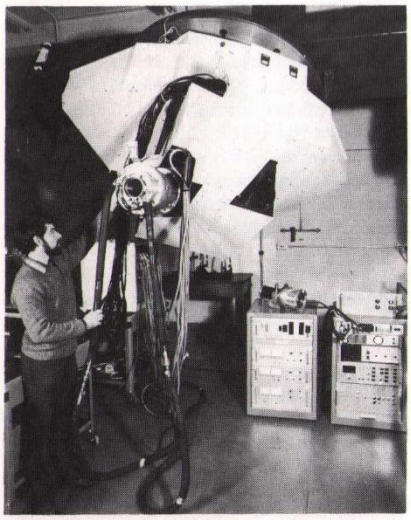


New instrumentation for the Isaac Newton Telescope

When the 2.5m Isaac Newton Telescope (INT) becomes fully operational on its new site in the Canary Islands,* it will have an advanced high-technology instrument package providing world-class facilities for the astronomers who use it.

Even before the telescope made its last observations at Herstmonceux in March 1979, project teams of scientists and engineers at the Royal Greenwich Observatory (RGO), actively supported by colleagues in universities and at other observatories, were already designing the new instrumentation.

A large telescope such as this needs a range of auxiliary equipment which will be versatile not only for the observational problems to be tackled now, but capable of taking advantage of future technological progress and allowing application of novel techniques. At RGO, engineering and optical design studies, investigation of computer-control systems, use of microprocessors and an intensive research programme on photon-counting and silicon array detectors have formed the basis of instrument development for the La Palma telescopes. In considering the effectiveness of the telescope for detecting faint objects, the clear, stable skies at the site are extremely important, but the astronomer cannot request 'more light' and expect the night assistant to increase the brightness of his source! Precious starlight must be jealously guarded, coaxed through carefully chosen auxiliary instrumentation and finally detected with the highest possible efficiency. All the functions of the equipment must be 100% reliable, any changes must be effected quickly, easily and preferably remotely, and instruments which are to be carried on the telescope itself must be light and rigid enough to avoid flexure during what may be many hours of a single observation. These are tall orders and, with everything specified to very tight tolerances, arranging these components within their casings makes getting the proverbial quart into a pint pot seem a trivial problem. However, the first of the RGO's principal instruments for the INT has now emerged from the workshops and laboratories and has been assembled for testing on the telescope simulator at Herstmonceux.



The detector being fitted to the Cassegrain Spectrograph

The photograph shows a detector being fitted on to the Cassegrain Spectrograph in December 1982. The triangular structures immediately underneath the large circular mounting face contain the TV camera and guide probes of the Acquisition and Guidance Unit. This allows the astronomer to identify his target object and then lock in an autoguider so that the telescope will track very precisely on it as the object moves across the sky. Auxiliary equipment for data calibration is also housed within this structure. Below this unit is the Cassegrain Spectrograph itself which will be used in the measurement and analysis of light from stars and galaxies. Its multiform layout, shown schematically in the drawing, means that this common-user spectrograph provides a wide variety of operational modes. In the main part of the spectrograph, a parallel beam of light illuminates a reflection grating, the spectrum is imaged by one of two cameras and then recorded by the Image Photon Counting System (IPCS) or by a cooled Charge-Coupled Device (CCD). The versatile nature of the system permits various combinations of gratings, cameras and detectors to acquire spectra in the wavelength range 3000-12000Å at dispersions ranging from 200 to 6 Å/mm at high signal-to-noise ratios. A novel, fixed format 'faint object spectrograph' is a recent addition which has been designed specifically for the detection and analysis of light from the very faintest sources. It has few air/glass surfaces from which light could be lost, and camera and detector are totally housed in a cryostat.

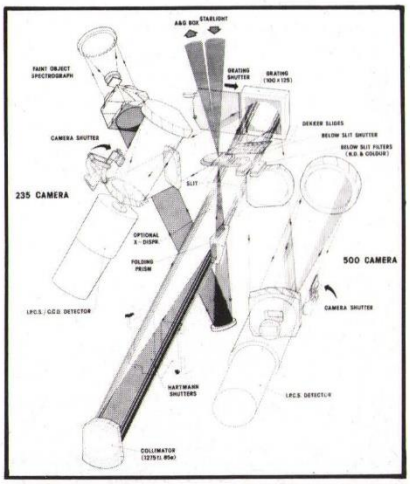
A computer system will control all instruments 'remotely', initially from terminals in the dome control room, but later stretching the control link from some 20 yards to about 2000 miles and operating the telescopes from Sussex. (see *SERC Bulletin* Vol 2 No 7, page 8). In some cases, on-line reduction of the data will be possible, so that the astronomer can make informed decisions about the progress of his observations while they are actually being made. He will also have the enormous resources of STARLINK at his disposal for more detailed analysis later.

Another instrument which has reached the test-bed is the photometer for the INT. It has seen starlight through the 36-inch telescope at Herstmonceux, and has already been operating in three of its four possible modes. Construction of the prime focus capsule, designed to carry the coma corrector for wide-field direct photography and a CCD for direct image recording, is also at an advanced stage and the hardware is now undergoing computer control tests.

Now that some of this apparatus for the INT is nearing completion, project teams are again at work designing the next generation of instruments and detectors for the 4.2m telescope. Construction of the 4.2m telescope on an altazimuth mounting means exciting new possibilities for instrument builders but also brings its quota of new problems. Activity is again centred at RGO with our international collaborators very much to the fore and with vigorous support from the UK astronomical community.

Dianne Harmer
A project scientist for La Palma Instrumentation

* See 'First Light at La Palma Observatory' *SERC Bulletin* Vol 2 No 7, Spring 1983



The Spectrograph optical systems

Schemes to support international collaboration

The Council attaches great importance to the international dimension of its activities. Here we remind readers of SERC's arrangements and schemes which can be used to develop international collaboration in any of the disciplines which fall within SERC's remit.

Much of the Council's international activities arise from its participation, on a full partnership basis, in large-scale international facilities or its partnerships with overseas countries in time-sharing arrangements on major national facilities. In addition, a good deal of international collaboration is developed and supported through the normal SERC schemes and at very modest cost. For example, in 1981/82 about £1.4 million of the research grants monies was committed on travel and subsistence expenses and on Visiting Fellowships for international visits and exchanges. This sum enabled approximately 400 research projects (out of a total of about 2000 new research grants awarded that year) to proceed with some element of international involvement.

As well as its continuing emphasis on the need to strengthen contacts with research groups in Western Europe, SERC has also, in the past two years, been developing closer working links with the National Science Foundation in the USA and with the Ministry of Education, Science and Culture in Japan. In the case of the US, the discussions have aimed at strengthening and developing our long tradition of good collaboration; in the case of Japan, the aim is to develop collaboration generally but, initially, the areas of molecular sciences, space science and biotechnology have been identified for special attention.

The schemes which can be used to foster collaboration are summarised below. Further details are given in the booklets *SERC Research Grants, SERC Studentships and SERC Fellowships.*

SERC and NATO research and advanced course studentships tenable abroad are to support students spending one to three years on postgraduate studies abroad. They are subject to the same general conditions as those tenable at institutions in the UK. Their basic values plus entitlements to allowances are the same as awards in the UK. Allowances are also paid for higher costs of living overseas, travel and tuition fees (including fees for intensive language courses, where needed). An overseas award may be converted into an industrial studentship.

Existing holders of SERC studentships in the UK: A head of department may apply at any time for approval for a student to spend a period of training at an overseas institution. The additional costs of approved visits will be met.

SERC and NATO postdoctoral research fellowships tenable abroad are for postdoctoral study for periods of up to two years. They may be held wholly or partly overseas. Allowances for travel and any higher living costs will be paid.

Note: for awards tenable in Europe the Royal Society and SERC operate a joint selection procedure.

SERC advanced fellowships are made for periods of up to five years to outstanding research workers who do not yet hold academic tenured posts. They may, by agreement, be held for some part in an academic institution overseas. Salary is paid on the first twelve points of the University Lecturer scale according to age plus appropriate allowances for cost of approved travel and subsistence.

Industrial visiting fellowships are designed to enable suitably experienced people from industry, commerce, local government or academic institutions in the UK to work in advanced industrial firms (excluding a parent or subsidiary company), R & D organisations or institutes of technology in overseas countries, normally for between six and 36 months. Periods shorter than six months will be considered in special cases. The costs of the fellowship will be shared by SERC and the fellow's employer in agreed proportions.

European short visits grants (ESVGs) are short term grants for up to 21 days' duration to support visits by research workers in the UK to institutions in Europe for the purpose of formulating collaborative proposals in research or training. SERC postdoctoral fellows wishing to explore the possibilities of spending all or part of their awards at a specific institution in Europe may apply for an ESVG prior to the start of their fellowship for a preliminary visit to that institute. The ESVG will cover the travel and subsistence costs of the visits.

Research grants can be used to further international collaboration in the following ways:

- To provide any of the staff posts, equipment, materials, travel and subsistence needed for a project in a UK department which is planned collaboratively with a research group overseas. The overseas group would seek any necessary funding from their own national sources.

  Note: Research assistant posts can be held by postdoctoral research workers from overseas.

- To provide travel and subsistence expenses alone to enable UK research workers to spend periods in institutions abroad working with overseas research groups and equipment.

Visiting fellowships (VFs) are to support scientists of acknowledged standing from abroad to spend up to one year in a UK institution to give full-time advice and assistance in fields in which they are expert.

Advanced research meetings are usually of short duration (two or three days) between a small group of research scientists (say five to ten) from the UK and a matching group from an overseas country to discuss specified areas of common interest and possible future collaboration. SERC pays the expenses of UK participants. Applications may be initiated by SERC Committees or individual groups. In the latter case, early notification of intended proposals would be appreciated, particularly for meetings involving the USA.

Enquiries about any of these schemes should be made initially as follows (at SERC Central Office, Swindon):

Research grants and VFs – the appropriate subject Committee Secretariat with whom you normally deal.

Studentships – Mr J M Middlecote ext 2415, Mr S D Greig ext 2216.

All Fellowships except VFs – Mr P W Black ext 2352, Miss S C Midwinter ext 2172.

European Short Visits Grants and Research Meetings – Mrs G Ford ext 2402, Mrs S Dodson ext 2308.

The British Council and the world of science

The British Council's role in the promotion of Britain's scientific work and achievement is not widely known, yet it absorbs many times the resources devoted to the Council's better known role of promoting the arts. Well over a third of the people who are brought to this country to study or who are sent overseas to teach or advise under British Council schemes are involved in science.

Given the importance of science and technology to the development of future prosperity for all countries, including our own, and Britain's high reputation in scientific education and research, the high proportion of science work done by the Council is hardly surprising. It is also quite in keeping with the Council's aim of promoting an enduring understanding and appreciation of Britain through cultural, educational and technical cooperation. Indeed Britain's high reputation in science creates a great demand overseas for information about British experience and achievements, for collaborative relationships and exchanges and for assistance in the development of overseas manpower resources and institutions in the developing world. These are needs which the British Council is well placed to meet with its network of overseas offices in 80 countries, 20 of which have scientifically qualified officers. The overseas offices are backed up by the headquarters staff, which includes a team of specialists in its Science, Technology and Education Division responsible for maintaining close contact with the science community in Britain.

Information
One of the British Council's principal roles is to facilitate the movement of scientific information. It answers thousands of individual enquiries, provides advice through the media of films, books and exhibitions and produces special information packs designed to promote a knowledge of and interest in the wide range of British educational and training opportunities in scientific fields. In some countries, Poland and Brazil for example, special information services, including the provision of terminals which provide access to British databases, are being developed to meet particular needs.

Long-term training in Britain
Awards in science and technology dominate the Overseas Development Agency-funded Technical Cooperation Training Programme and the British Council's own Scholarship Scheme. About 1,800 awards are given annually. An additional 1,000 trainees funded by other agencies come to Britain each year. The Council is responsible for their administration and for selecting their places of study and specialist programmes.

Short visits to Britain
Each year the Council sponsors and part-funds some 1,000 scientific and technological visitors to Britain and over the years some of the world's most distinguished and influential scientists and science policy makers have visited Britain with British Council help.

British specialists abroad
Many scientists and engineers receive advice and logistic support from the Council when planning and organising overseas visits. Some 1,100 receive direct financial support.

Project work
In recent years the Council has increasingly acted as an identifier, organiser and administrator of packages of British training and consultancy services for major science-based projects funded by international development agencies like the World Bank. The coordinating role helps to ensure that British institutions receive business and contracts in such projects which might otherwise go to organisations in other countries. The Council undertakes such work on a full cost-recovery basis. Two recent examples are a project to develop training and manpower at all levels in the construction industry in Sri Lanka and a project undertaken in cooperation with ICL to develop a centre for computer studies in Singapore. By such work the British Council has been able to generate an appreciable and increasing revenue.

Institutional links
Science and Technology feature prominently in the Council's work for promoting supporting links between institutions. These range from broad-based links between entire institutions (for example, universities in developing countries) to support for individual groups wishing to collaborate over quite specific research projects. One example of this diverse activity is the large number of small research links between British and Italian scientists arising from a joint funded agreement which the British Council has with the Italian Science Research Council.

The Council receives direct advice on its scientific work from the British scientific community through three Advisory Committees: science; engineering and technology; and agriculture and veterinary science. In addition, close contacts are maintained with the Royal Society and the research councils. The British Council tries to assist these bodies with their overseas work whenever possible; for example, the British Council has recently worked with the Royal Society and SERC on a programme to develop closer scientific links in a number of key areas between Britain and Japan.

Dr Brian Lavercombe
Head of Science and Technology Group, The British Council
10 Spring Gardens, London SW1A 2BN; telephone 01-930 8466.

Malaysian study tourists visiting the Rolls Royce College, Bristol, during their one month programme to study curriculum development and technical education.

Studentship numbers 1982/83

1982 report

Council's target for awards in 1982 was 3178, of which 800 were directed specifically to the CASE scheme. This total represents 62 fewer awards than in the previous year.

At the Appeals stage more than 1300 applicants, including 120 with first class degrees, contended for the 91 available awards: 31 candidates with first class degrees failed to get an award (62 in 1981).

Applications from CASE candidates were again considered on receipt so that all available awards in Engineering had been committed by the end of July and in Science by mid-September. With demand greatly exceeding supply, unsatisfied applications were queued and awards offered only as previous nominees withdrew. As announced to the community in August 1982, a system of closing dates for the submission of projects and the nomination of students to approved projects has been reintroduced for 1983.

Table 1 compares the distribution of studentships taken up at November 1982 with the original target.

Plans for 1983

A target of 3337 studentships is set for 1983, 177 more than in 1982 but 263 less than in 1981. Direct responsibility for the funding of studentships and for the allocation of studentship numbers now rests with Boards but their decisions resulted in few changes compared with 1982. The most noticeable change is the increase of 137 Advanced Course Studentships supported by the Engineering Board with only a small decrease (17) in the Board's provision for standard research awards. Provision for research studentships in the field covered by the Biotechnology Directorate is increased from 21 to 55.

Table 2 sets out the distribution of studentships to be made available in 1983. (It is to be noted that the table does not include those awards for Information Technology to be made available under the 'Alvey' programme, see page 11).

Table 1: Distribution of 1982 awards taken up at November 1982

(1982 provision agreed by Council in brackets)

	ASR	Engineering	NP	Science	Polytechnics	SERC/SSRC	Biotechnology	TOTAL
Research studentships								
Standard	65*(64)*	381*(390)*	51*(51)*	755*(750)*	13*(21)*	34*(35)*	9*(9)*	1308*(1320)*
CASE	7 *(8)*	312*(312)*	5 *(5)*	447*(447)*	-	8*(16)*	12*(12)*	791 *(800)*
CTA	-	13	-	5	-	-	1	19 *(10)*
Instant	3	21	-	69	-	-	-	93 *(100)*
Total RS	**75**	**727**	**56**	**1276**	**13**	**42**	**22**	**2211***(2230)*
Advanced course studentships								
Standard	21*(20)*	394*(353)*	-	307*(302)*	8*(10)*	54*(46)*	25*(29)*	809 *(760)*
Instant	-	108	-	18	-	13	2	141 *(150)*
Total ACS	**21**	**502**	-	**325**	**8**	**67**	**27**	**950** *(910)*
Awards tenable overseass	-	**10**	**1**	**5**		**3**		**19** *(20)*
Board total	**96**	**1239**	**57**	**1606**	**21**	**112**	**49**	**3180***(3160)*

Note Council's targets for awards tenable overseas, Instant and CTA schemes were not broken down between Boards.

Table 2: Allocations decided by Boards etc for 1983

	ASR	Engineering	NP	Science	Polytechnics	SERC/SSRC	Biotechnology	TOTAL
Research studentships								
Standard	65	373	53	757	21	35	30	1334
CASE	8	312	6	448	-	2	25	801
CTA	-	15	-	5	-	-	-	20
Instant	3	20	2	70	-	-	-	95
Advanced course studentships								
Standard	27	490	-	304	10	56	35	922
Instant	1	110	-	21	-	13	-	145
Awards tenable overseas								20
Board total	**104**	**1320**	**61**	**1605**	**31**	**106**	**90**	**3337**

PhD submission rates

Here are the results of the third annual survey of the number of research students supported by the Council who submit a PhD thesis. This time the survey relates to students whose awards began in 1978.

Institutions were asked to give information on (i) the number of students who had formally submitted a thesis by October 1982 and (ii) the number of students who remained registered for a PhD at that date.

The information thus obtained is set out by institution in Table 1 and by SERC subject area in Table 2.
These data must, of course, be treated circumspectly. The overall performance of an institution can mask wide differences between departments and, within departments, the results can reflect, for instance, the nature of the research interest and, most importantly, the ability and motivation of individual students.

While the Council has always seen its awards as made to provide a training in research, and not necessarily for the attainment of a degree, it remains strongly of the view that writing up results within a reasonable timescale is an integral and important part of research training. Thesis submission provides an effective measure of whether this part of the student's training has been satisfactorily accomplished.

Following the favourable reception last year by the academic community of the publication of the booklet, *Research Student and Supervisor: a discussion document on good supervisory practice,* the Council has decided that the booklet, after some editing to take account of comments received, should be issued each year to research students in conjunction with award letters. A re-issue of the document to academics will be made in due course.

The Council hopes that this, and its other initiatives in the area, will lead to an improvement in the submission rate.

Table 1: PhD submission rates etc by institution

Universities	Number of students registered	Number submitting by 1.10.82	Number still registered at 1.10.82
Aston	62	26	21
Bath	40	19	9
Birmingham	67	42	18
Bradford	34	14	8
Bristol	65	36	27
Brunel	15	7	7
Cambridge	140	98	32
City	14	5	2
Cranfield Institute of Technology	10	3	4
Durham	20	10	9
East Anglia	29	11	16
Essex	18	4	9
Exeter	22	10	12
Hull	19	10	8
Keele	8	6	0
Kent	25	5	14
Lancaster	23	12	5
Leeds	95	40	44
Leicester	38	19	12
Liverpool	68	35	29
London:			
Bedford	9	3	4
Birkbeck	12	4	8
Chelsea	16	7	8
Imperial	137	67	48
Kings	24	14	6
Queen Elizabeth	21	3	16
Queen Mary	37	11	25
Royal Holloway	13	2	8
University	52	23	23
Westfield	9	4	5
Other Institutions	33	14	13
Loughborough	25	8	14
Manchester	94	59	29
UMIST	55	20	9
Newcastle	56	24	30
Nottingham	72	46	22
Open	8	0	5
Oxford	132	89	30
Reading	33	11	16
Salford	41	19	17
Sheffield	69	32	31
Southampton	62	23	30
Surrey	32	19	11
Sussex	46	21	20
Warwick	36	16	13
York	28	13	14
University of Wales:			
Aberystwyth	18	12	5
Bangor	24	8	8
Cardiff	37	15	15
Swansea	28	6	22
UWIST	10	4	4
Aberdeen	21	11	7
Dundee	13	9	3
Edinburgh	44	20	21
Glasgow	45	22	12
Heriot-Watt	24	10	11
St Andrews	21	16	4
Stirling	7	4	1
Strathclyde	40	22	14
Queens Belfast	1	1	0
Total universities	2297	1124	868
Total polytechnics*	100	35	51
Other institutions*	8	1	4
Grand total	2405	1160	923

* The numbers of students at polytechnics and other institutions were generally too low to make individual detail meaningful

Table 2: PhD submission rates etc by SERC Board

	Number of students registered	Number submitting by 1.10.82	Number still registered at 1.10.82
Science Board	1446	775	513
Biological Sciences	555	257	237
Chemistry	541	330	164
Mathematics	150	80	41
Physics, Neutron Beam & SBA†	200	108	71
Engineering Board	729	275	326
ASR Board	78	42	27
NP Board	58	44	11
SERC/SSRC Committee	54	11	27
Other	40	13	19
Total	2405	1160	923

† Science-based Archaeology

Short course : multinuclear magnetic resonance

The Chemistry Committee is sponsoring a short course on Multinuclear Magnetic Resonance, to be held at Sheffield University from 11-16 September 1983. The Course Director is Dr B E Mann of the Department of Chemistry at Sheffield. The course, for up to 50 students, aims to acquaint research students with modern applications of nuclear magnetic resonance (nmr) spectroscopy to chemical problems in both solution and the solid state. The course will be tailored to the needs of research students who have spent one year in research where nmr spectroscopy is not the primary tool (eg synthetic work) but is a valuable aid to obtaining a detailed understanding of their particular problem. At the end of the course, the students should have a sound understanding of the strengths and limitations of nmr spectroscopy.

Priority will be given to SERC students, for whom SERC will pay the full cost, and to UK self-supporting students. Further details and application forms may be obtained from Dr B E Mann, Department of Chemistry, Sheffield University, Sheffield S3 7HF; telephone Sheffield (0742) 78555 (ext 4491).

Autonomous electricity generation using wind/diesel systems

RAL wind turbine test facility, to be used in initial wind/diesel integration experiments.

Wind energy is presently one of the more promising renewable energy forms, and although most recent emphasis has been on grid connection of large wind turbines (rated in the MW range), an important role exists for small scale machines (5 to 200 kW), to provide autonomous electricity supply to grid isolated communities. Significant markets exist, predominantly in the developing countries, for suitable systems which are viewed primarily as savers of now very expensive diesel fuel.

A comprehensive assessment of the technical, logistic and economic aspects of systems integrating wind and diesel generators, and incorporating energy storage, has been carried out by a joint Rutherford Appleton Laboratory/Reading University team*.

The Energy Research Support Unit at RAL has been instrumental in initiating another relevant study, this time involving the collaboration of teams from RAL, Imperial College and Hawker Siddeley Power Plant Limited who are leading suppliers of small diesel generating sets and who wish to develop and market a wind/diesel package. The new project will concentrate on the transient behaviour of such systems and will make extensive use of both digital and analogue computer simulation techniques. An important role is foreseen for microprocessor control of the wind/diesel systems, in order to achieve the optimum trade-off between wave-form quality of the electricity supply, and the overall efficiency of generation.

Further information on this work may be obtained from Professor N H Lipman or Dr D G Infield, Energy Research Support Unit, RAL, telephone Abingdon (0235) 21900, ext 5302.

* A useful compilation of this work may be found in a report for the Department of Energy, ***Wind generated electricity for isolated communities: a study of integration strategies,*** published independently. Copies are available from Miss Joy Clancy, Department of Engineering, Reading University, Whiteknights, Reading RG6 2BU, price £10.

Applying science in archaeology

Although archaeology has traditionally been regarded as one of the humanities, scientific techniques are increasingly being employed in the study of man's past. SERC's Science-based Archaeology Committee (SBAC), set up in 1976 on the initiative of the Advisory Board for the Research Councils (ABRC), exists to promote the development and use of scientific methods in archaeological research. A committee of the Science Board, the SBAC provides support for a wide range of research and training activities in archaeological science.

The Committee's most substantial enterprise so far has been the support of the accelerator-based Radiocarbon Dating Facility in the Research Laboratory for Archaeology and the History of Art at Oxford University. A research project of international importance, the facility will allow the dating of samples up to at least 70,000 years old, and the study of samples a thousand times smaller than those possible by conventional methods. Half of the time on this facility when fully operational is to be made available by SERC to users from other institutions. Dating on the facility is now beginning, and a Programme Advisory Panel has been set up by SBAC to promote and monitor archaeological dating programmes using the facility.

In 1982, work supported by the Committee attracted international acclaim when a calibration scale for conversion of radio-carbon 'dates' to calendar years, developed by Mr Gordon Pearson at Queen's University Belfast, was adopted as an International Standard. Over the past seven years dendrochronologists at Belfast, with SERC support, have built up a tree-ring chronology for British Isles oak which is now almost complete and is the longest series in Europe, extending back to beyond 5400 BC. Samples from this series, which is itself a reference standard, have been taken to prepare the radiocarbon calibration scale, using a high-precision liquid scintillation technique specially developed for the purpose.

The SBAC recently reviewed its activities over the past three years, and considered its priorities for future support. The Committee is anxious to encourage the penetration of new scientific concepts and techniques into archaeology, and would like to see more collaboration between archaeologists and their colleagues in science departments in universities and polytechnics, both to encourage scientists to apply their knowledge to archaeological problems, and to allow archaeologists access to scientific expertise and equipment.

Although anxious to support timely and innovative research in any area of archaeological science, the Committee has identified some areas which it would particularly like to see develop. One of these is the application of computational and statistical techniques in archaeology.

A successful five-day short course for archaeology and archaeological science postgraduate students in Computer-based Data Management was held at Bath University in 1982, and a similar course on Sampling is to be held at Leicester University in September this year.

Further information about the Science-based Archaeology Committee and its activities, and copies of the SBAC *Annual Review* and the *Review of Activities 1978-81* can be obtained from the Committee Secretary: Mr A G Game, SERC Central Office, Swindon (ext 2361).

Major new grants

October 1982 - January 1983

ENGINEERING BOARD

Professor K G Stephens (Surrey University): £299,600 plus use of facilities at a notional cost of £12,000 over four years, for continuation of support for the Ion Implantation Microelectronics Facility at Surrey.

Professor P N Robson and Dr P A Houston (Sheffield University): £1,013,600 plus use of facilities at a notional cost of £36,000 over four years, for continuation of support for the III - V Materials Microelectronics Facility at Sheffield.

Professor E A Ash FRS, FEng, Professor D E N Davies FEng and Professor J R Forrest (University College London): £884,000 plus use of facilities at a notional cost of £318,000 over four years, for continuation of Special Grant, 1983-87, for Microwave Research Unit.

Professor E G S Paige, Dr L Solymar and Dr C J R Sheppard (Oxford University): £450,900 plus use of facilities at a notional cost of £97,200 over four years, for Device Aspects of Analogue Information Processing.

NUCLEAR PHYSICS BOARD

Grants to support Nuclear Structure experimental groups at:
Oxford University (£1,018,000) and
Glasgow University (£389,000) each over three years.

Some new publications from SERC

Climatology directory

The Natural Environment Research Council and SERC have published jointly a *Directory of UK research in climatology*. The Directory provides details of UK expertise in climate studies within the context of the World Climate Research Programme and gives an assessment of the strength of climatology research; it looks at the areas of research which could be provided nationally within the WCRP and at the sources of funding for UK research programmes.

Copies are available from Dr E M Forster, SERC Central Office, Swindon (ext 2367).

Planning nuclear physics

The report made by the Working Party on Future Facilities to the Nuclear Structure Committee, *A long range plan for nuclear physics* has been published and copies are available from the Committee Secretariat, SERC Central Office (ext 2223).

Particle Physics Experiments, 1982

The annual report, *Particle Physics Experiments 1982*, is a compilation of progress reports on all experiments approved by the Particle Physics Experiments Selection Panel, and records their present state of completion and the results achieved during the year. Copies are available from the Library, Rutherford Appleton Laboratory (ext 5384).

Current grants in chemistry

The 1982/83 issue of *Current Grants in Chemistry* is now available. This document provides a list and brief description of research grants recommended by the Chemistry Committee which were current on 1 June 1982. To increase its usefulness, a subject index has been added to this edition. Copies are available from Dr John Wand, SERC Central Office Swindon (ext 2263).

PED publications

PED Newsletter: A regular (three times a year) newsletter on the work of the Polymer Engineering Directorate, including examples of current projects.

The extent of polymer teaching in engineering academy: Report of a survey of selected university and polytechnic engineering departments.

The further development of training in polymer engineering: Interim report on the use and usefulness of short courses to industry.

Loughborough review 1983: Papers for the PED review meeting at Loughborough containing summaries of current PED research projects.

PED report and review 1983: A report covering the activities of the Directorate in 1981 and 1982.

Copies of all of these publications are available from PED's offices in London, telephone 01-930 9162.

Engineering committee reports

The following Engineering Board Committee annual reports for the year 1981–82 are available from the relevant Committee Secretariat at SERC Central Office, Swindon:

Engineering Processes Committee (ext 2100);
Materials Committee (ext 2124);
Machines and Power Committee (ext 2202); and
Information Engineering Committee (ext 2203).

The pattern of support for engineering

The Engineering Board is aware of some feeling in the engineering community that the criteria to be adopted in assessing grant applications in engineering ought to be different from those adopted in supporting scientific research and that, in particular, advanced engineering design does not fit easily into the present pattern of support. The Board has therefore set up two Working Parties to advise it on how to proceed. The Engineering Design Working Party, chaired by Dr R L Lickley F Eng, is looking at the particular problems of support for advanced engineering design and postgraduate training in design. The Needs of Engineering Working Party, chaired by Professor G D Sims, Vice Chancellor of the University of Sheffield, will examine the postgraduate needs of the engineering profession and the way in which the Council's resources are deployed in meeting those needs.

At the Project UNIVERSE stand at Info '83, Mr William Shelton MP discusses a point with Dr James Merriman, Chairman of the project's steering committee, and Professor J F C Kingman FRS, Chairman of SERC.

High technology communication

Project UNIVERSE, an advanced telecommunications research network involving satellite links, was inaugurated on 22 February 1983 by Mr William Shelton, MP, Parliamentary Under Secretary of State for Education and Science, at the INFO '83 Exhibition at the Barbican Centre in London.

The project involves British Telecom, Cambridge University, the Department of Industry, GEC-Marconi, Logica, Loughborough University of Technology, SERC and University College London. It is coordinated at Rutherford Appleton Laboratory (RAL), and was originated through SERC and the universities. Congratulating the project partners, Mr Shelton said, "Never before has a consortium of industry, Government and the universities achieved such a feat in local and trunk communications networks."

He added: "This project has already established itself in the first division of telecommunications research in the world. It has indeed been cited as an example of an area of information technology where the research lead is passing to the UK."

Project UNIVERSE (UNIVersities Expanded Ring and Satellite Experiment) combines ground-based Cambridge Rings and other types of local area network with satellite links to form a powerful new technique for high-bandwidth transmission of data between computers. Six sites in the UK are equipped with an earth station consisting of a 3 metre diameter dish aerial, 14 GHz radio transmitter and 11 GHz receiver. Together these will provide a two-way link from each site to the Orbital Test Satellite. This satellite, operated by the European Space Agency, is positioned in a geostationary orbit 36,000 km above the Equator. The six sites are at the Universities of Cambridge and Loughborough, at University College London, Marconi Research Centre at Chelmsford, Essex, British Telecom Research Laboratory at Martlesham Heath, Suffolk, and RAL, Chilton. A high-speed terrestrial link connects the rings at UCL with the ring at Logica.

The Minister with Mr Bill Tuck (University College London) at the Project UNIVERSE stand at Info '83.

At each site a cluster of computing devices connects into a network directly coupled to the earth station at that site. In this way, each computer at a particular site can communicate with all computers at the same site via the local area network, and with any computer at one of the remote sites via the satellite links. These links pass digital data between sites at the rate of 1 million digital bits per second (1 megabits/sec). This should be compared with transmission rates on today's leased telephone lines which are 100 times slower.

The high-bandwidth network of Project UNIVERSE enables entirely new concepts in computer science to be researched for the first time. Individual computers at separate sites can be made to work collectively and simultaneously on a single problem just as though they were all located in a single room. The high transmission capacity of the links enables a distant computer, perhaps of a very specialised type, to be accessed remotely with no penalty in performance over that available to local users. The speed of the network also allows slow-scan TV pictures or illustrations and photographs to be transferred quickly and efficiently from one site to another. Voice communication can also be carried over the network.

The project is based largely on British equipment. The satellite link uses earth stations from GEC-Marconi Communications Systems and link-driving computers from GEC. The Cambridge Ring components are supplied by Logica VTS and SEEL. BBC microcomputers from Acorn-Orbis are used extensively. On the academic side, studies on satellite channel encoding have been performed by Manchester University and on satellite systems by Essex University.

The operational life of the Orbital Test Satellite is expected to extend at least until the end of 1983. The funds committed to the project are close to £4 million, being provided by industry, SERC and the Department of Industry. Developments with the project are available to the industrial partners for commercial exploitation.