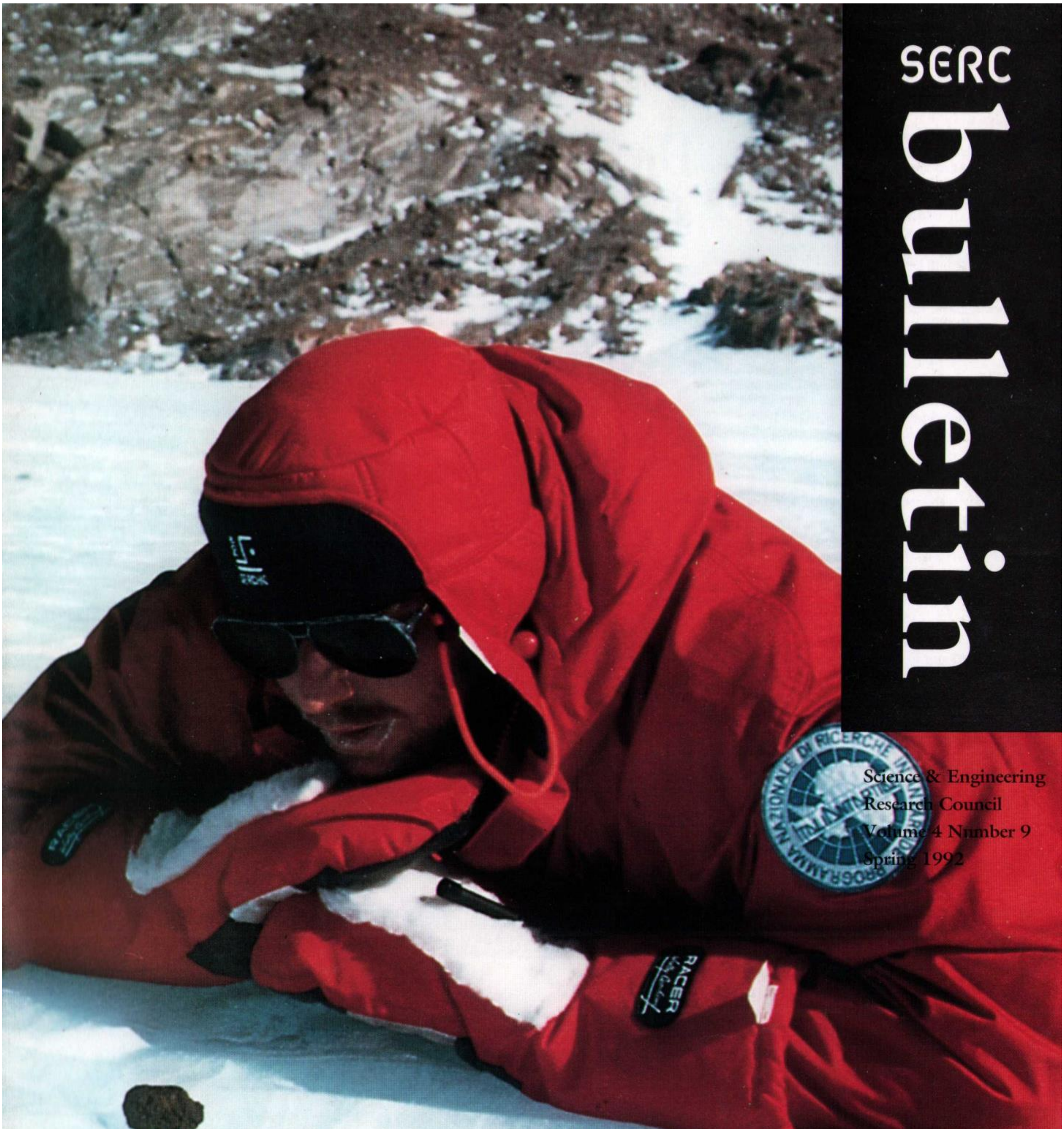

SERC bulletin

Science & Engineering Research Council
Volume 4 Number 9
Spring 1992

Interstellar dust in meteorites

SuperCOSMOS

The civilised city

Safety Critical Systems Programme

Electronics for the Zeus Central Tracking Detector

SERC

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

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Front cover picture

A little piece of heaven: Dr Ian Franchi contemplates the possibility of extracting interstellar dust from an Antarctic meteorite collected by the 1991-1992 Euromet expedition. **See page 18.**

Dr TG Pickavance CBE FRS 1915-1991

Gerald Pickavance

Thomas Gerald Pickavance, the founder Director of the Rutherford Appleton Laboratory, died on 12 November 1991 at the age of 76. Dr Pickavance played a leading role in the development of university research in nuclear physics in the United Kingdom. He studied Physics at Liverpool University and in 1946 joined AERE Harwell. Here he contributed strongly to the construction and operation of the Harwell cyclotron and led Harwell's first Accelerator Group before becoming Deputy Head of the General Physics Division. In the 1950s, largely at the instigation of Sir John Cockcroft, then Director of Harwell, Dr Pickavance became involved in plans for the establishment of the National Institute for Research in Nuclear Science which was set up to provide particle accelerators for nuclear and particle physics research.

In 1957 Dr Pickavance became the first Director of the Rutherford High Energy Laboratory which built and commissioned the 50 MeV Proton Linear Accelerator for nuclear structure studies and the 7 GeV proton synchrotron Nimrod for particle physics research.

In his 12 years as Director of the Rutherford Laboratory he established an ethos that remains to this day. The Laboratory was established to support university research and, under its subsequent directors, it has continued to fulfil Gerry Pickavance's vision.

In 1969 he was appointed Director, Nuclear Physics, of the Science Research Council with overall responsibility for all the Council's Nuclear Physics interests. In this capacity he played a vigorous role in the development of CERN and became for a period the Chairman of the European Committee for future accelerators.

Sadly, his career came to a premature end when, at the age of 57, he suffered a massive stroke. The resulting partial paralysis and speech impairment were burdens that he carried bravely and cheerfully for the remaining 20 years of his life. He is survived by his wife and three children.

Dr P R Williams
Director, Rutherford Appleton Laboratory

IN THIS ISSUE

Council news

Boost for student research awards

An interim increase of 4% in the maintenance grants awarded to post graduate students was agreed by the Council at its meeting in November. This will raise the grant to £4,300 in April 1992, helping to preserve its value in relation to graduate pay levels. The value of an award in London will be £5,400 from the same date.

The Council also agreed to pay students living in their parental home the full grant, ending the practice of paying a reduced rate, from April 1992.

Studentships

The Council's biennial review of SERC studentships was approved, providing for awards totalling 5235 in 1991, 4910 in 1992 and 4763 in 1993. The decrease over the next two years is mainly attributable to the effects of SERC's financial situation particularly on the Engineering Board and Science Board.

For Cooperative Awards in Science and Engineering, an increase in the mandatory minimum contribution by industry, from £1,250 to £1,500 was approved, to apply from October 1992. (See also page 26).

New centre on data from the Sun

A new centre to coordinate data from four satellite-borne instruments in the SOHO/Cluster mission, a programme to investigate the Sun and its impact on Earth's environment, was agreed by the Council. The £1.85 million centre will offer a cost-effective focus for collaborative studies by providing validated data from the satellite in a standard format. It will allow British space plasma physicists access to multi-instrument, multi-spacecraft data of unique quality.

Isis: Australian agreement

A Letter of Intent relating to the use of neutrons in condensed matter research was signed on 17 December 1991 by Dr P R Williams, Director of the Rutherford Appleton Laboratory (RAL), and Dr D J Cook, Executive Director of the Australian Nuclear Science and Technology Organisation (ANSTO).

Low energy neutrons are a powerful tool in the study of condensed matter. They are able to reveal the intricate details of the geometrical arrangement and the minute vibrations of atoms and molecules in everyday materials. These materials cover a vast range from railway lines and industrial polymers, to novel magnetic substances, liquid crystals, hydrogen storage alloys and anaesthetics.

The pulsed neutron source Isis at RAL is the most powerful in the world, and is equipped with a comprehensive set of instruments for research into the structure and dynamics of solids, liquids and gases using neutrons as probe. Australian scientists have a high standing in this field of research. The Letter of Intent establishes that SERC and ANSTO will enter into negotiations leading to a collaborative arrangement providing access to Isis by Australian scientists sponsored by ANSTO.

Surface engineering coordinator

Dr David Whittaker has been appointed as coordinator in surface engineering jointly by SERC and the Centre for the Eploitation of Science and Technology (CEST).

The appointment follows a CEST report highlighting the importance of surface engineering to the future competitiveness of many British manufacturing industries and an SERC-Department of Trade and Industry report on the requirements of materials users. The role of the coordinator will be to help define an academic research and development strategy on surface engineering, focusing on the UK industrial need.

Dr David Whittaker

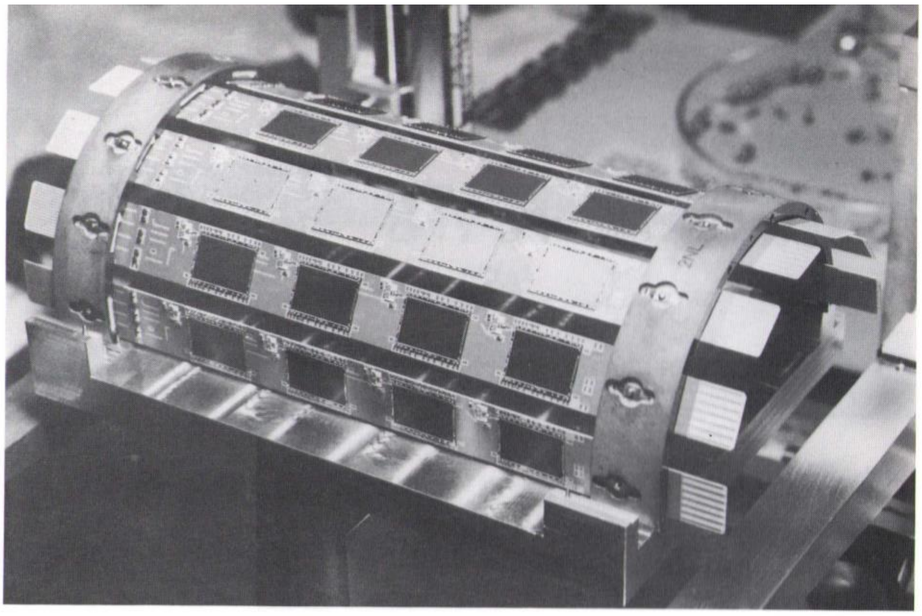
Surface engineering encompasses a range of processes enhancing properties such as wear, corrosion, thermal, optical or electromagnetic performance. Examples range from established treatments such as case hardening of steel gears to vapour deposition of magnetic materials on to audio or video tape.

Dr Whittaker, a consultant metallurgist, can be contacted at 231 Coalway Road, Merry Hill, Wolverhampton WV3 7NG; telephone (0902) 338498.

Turing Award

The premier prize in the field of computer science, the A M Turing Award, has been given to Professor Robin Milner FRS of Edinburgh University for his outstanding contribution to the field. The award, which is given each year by the Association for Computing Machinery, will be formally presented to Professor Milner in Kansas City in March when he gives the Turing Lecture.

In 1986, along with Professors Gordon Plotkin and Rod Burstall, Robin Milner set up the Laboratory for Foundations of Computer Science in Edinburgh University. Under his direction this has grown into one of the largest and best respected computer science research groups worldwide, now running some 15 SERC-supported research projects, mainly through the Information Technology Directorate.



One of the eight half barrels of the Vertex detector which consists of four nested concentric full barrels. Each strip is about 9 cm long and contains four CCDs on the outside and four inside.

Vertex detector flies to USA

Tony Gillman (right) of RAL shows some of the detector's electronics to visitors from Brunel University and Johnson Matthey, two of the project's collaborators.

A new advanced Vertex particle detector designed and built at the Rutherford Appleton Laboratory (RAL) was shipped to the Stanford Linear Accelerator Centre (SLAC), USA in October 1991 and installed in December. When it comes into use later this year it will detect particles containing charm and beauty quarks from high energy reactions at the SLAC Linear Collider. These quarks are two of the most basic known constituents of matter and they decay rapidly — lasting only about a million millionth of a second.

In order to detect these particles and record their very short flight paths before decay, the design incorporates 480 charge coupled devices (CCDs) in a mosaic. Each CCD consists of a matrix of charge storage elements; in all there are 120 million of these elements. This is the first time that so many CCDs have been used together in a single detector, giving it its unique tracking precision of five thousandths of a millimetre.

The project lasted over six years. After an extensive research and development stage, the detector was built at a cost of four million dollars which was largely paid for by the USA. It involved project scientists and engineers from RAL, Brunel University and the University of Santa Barbara, California, and was led by Chris Damerell (RAL). An important feature of this project was the close cooperation with industry (principally in the UK) on many R & D issues as well as the production of many of the high technology components. More than 20 British companies were involved, and their skill and dedication was a vital ingredient in the successful development of this novel detector.

The final meeting of the Vertex detector project took place at RAL on 24 September when 80 visitors and

UK to negotiate on the ILL

Following the Council's review of neutron science last year Dr Ron Newport, the UK Associate for the Institut Laue-Langevin (ILL) announced in November future SERC plans for participation in the ILL neutron facility.

Speaking at the ILL Steering Committee meeting in Grenoble Dr Newport, SERC's Associate Director of Programmes, said that the UK's aim was to reach agreement with our French and German partners on a new ILL Agreement to take effect from 1 January 1994.

Referring to the technical problems with the ILL reactor which have led to the facility being out of commission until at least the end of 1993, Dr Newport said that he hoped agreement could be reached on a plan for repair and on a new basis for partnership when the facility was reopened.

Dr Newport stated:

“As the Associates will be aware, SERC has conducted a review of relative scientific priorities for future Council support, having regard to known future resource availability. The Council has now concluded that financial expenditure on the neutron sources at ILL and Isis should be reduced by £5 million a year beyond previously planned levels with effect from 1994-95. The resources so released would make possible the support of other high priority science.

In the light of its recent review of UK neutron science, the Council has further decided that financial support for the Isis facility (at the Rutherford Appleton Laboratory) should remain broadly in line with currently planned levels. Accordingly SERC has advised the UK Government that it will need to seek a reduction in the level of the UK's contribution to the ILL, after 1993.

At present the ILL is out of commission for repairs, and is likely to remain closed for a considerable time. Subject to a satisfactory outcome to the present assessment of refurbishment costs for the reactor; agreement on how these costs should be met; and on future terms for membership, the UK would hope to see the refurbishment proceed and to remain a partner following recommissioning.

It has to be emphasised, however, that the UK, with other Associates, will need to be finally satisfied about the level of refurbishment costs and the extent to which these can be met from within existing available resources.

For these reasons, the UK will be seeking to hold formal discussions with the other Associates on the nature of the Agreement to apply at ILL from 1994 onwards.”

The ILL Associates are already in discussion about the future of the facility because of the stoppage of the reactor and the technical options being studied for its refurbishment.

The two neutron facilities, at ILL and the Isis at RAL, are both suppliers of high flux beams of neutrons which are used for a wide variety of experiments in, for example, materials science, structural physics, chemistry and biology. They differ in that ILL is based on a reactor and provides a continuous beam whereas Isis is based on an accelerator and provides a pulsed beam. The costs to the UK are currently some £11 million a year for each facility.

SERC announced earlier in 1991 that it could not continue to support both the ILL and the Isis facilities at the current levels. A Neutron Review Panel was established to assess the UK's requirements for neutrons over the coming years and the most effective way of providing them. In the light of the Panel's recommendations, SERC announced in July 1991 that it intended to reduce its expenditure on neutron facilities by some £5 million a year from 1994-95. The bulk of this saving was expected to come from a reduced participation in ILL.

Vertex detector (continued)

members of the project were given a final chance to see the instrument before its journey to the USA.

Too fragile and important for conventional transportation, the detector occupied three aircraft seats on a flight to San Fransisco, plus two for the accompanying scientists. The same project team, together with their collaborators, have now installed it in the heart of the 4000 tonne SLD experiment at SLAC.

Within the next year scientists will use it for research into the fundamental constituents of matter. CCD mosaics are of relevance in many areas of science, and the experience gained on this project is already paying dividends in other fields.

Visitors feeling the temperature of the outer surface of the Vertex detector (see left). The inside of the detector will operate at -100°C.

Rutherford
— a personal view

It is just 80 years since Ernest Rutherford discovered the atomic nucleus — an event of immense fundamental and practical importance. However in his after-dinner speech given on 13 September 1991 at the Rutherford Appleton Laboratory Summer School for Young High Energy Physicists, Professor Peter Kalmus of Queen Mary and Westfield College, London, takes a more personal view of 'Rutherford'.

In the 1940s, I travelled to school daily by train, and first saw the words *Lord Rutherford of Nelson* on the large metal nameplate of a railway engine. Only later did I realise that the locomotive had been named after a physicist. On making enquiries this year I found that Rutherford officially opened the LMS Railway Research Laboratory in Derby on 10 December 1935. He and a party of dignitaries, including William Bragg and James Jeans, travelled up from London in a first class dining saloon pulled by a new engine, which was first given the physicist's name by his small grandson. The brand new engine steamed badly and arrived late in Derby causing some embarrassment in high places.

In the 1950s, when I was a student, physics in the UK appeared dominated by the ghost of Ernest Rutherford, not always in a healthy manner, and this continued for at least a decade. To me the 'string and sealing-wax' approach no longer seemed appropriate in the post-war era. (Today of course we might try again, using superstrings and supersealing-wax!). Most professors of physics in the 1950s had worked with Rutherford at some time or other, or so at least it seemed to me, and it was common for after-dinner speakers at physics gatherings to reminisce on the general theme of 'Rutherford and I'. As Rutherford had died when I was only four years old, I would, I thought, never be able to give this type of after-dinner speech.

Many years later, in 1978, at the commemoration following the closure of the Nimrod accelerator at Rutherford Laboratory, I was interested to hear from Denys Wilkinson, whom I regarded as the epitome of the British Physics Establishment, that he too had never met Rutherford. But he had been a member of the Board that named this laboratory after him. At that Board meeting he had wondered openly whether Rutherford, the string and sealing-wax man, the man who had tickled the nucleus into revealing its secrets as one might a trout, would wish his name to be associated with the sledge-hammer that Nimrod was designed to be. But Patrick Blackett assured the Board. Incidentally, the written Proceedings of the Nimrod closure were held up for a long time, because someone thought that Denys's remarks might violate the '30 year rule' and should be regarded as state secrets!

As a student, I had of course read some of Rutherford's original papers, and for my PhD at University College London, I helped design and build a 28 Mev microtron, an electron accelerator with which we hoped to measure nuclear radii which were not known at that time — an extension of Rutherford's work. However, we were overtaken by Robert Hofstadter's group at Stanford. Hofstadter received the Nobel Prize and I got my PhD, which was perhaps a fair measure of our relative contributions to physics.

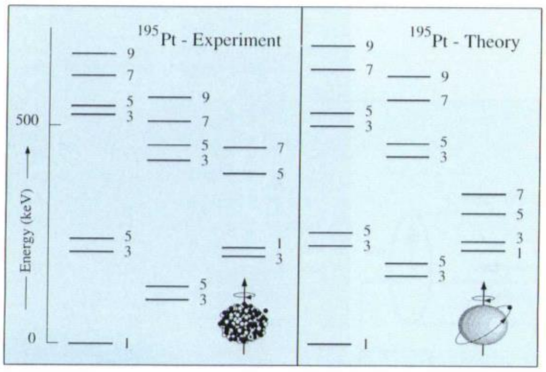
In 1957, just before obtaining my PhD, I met Gerry Pickavance, the first Director (see page 2) who was recruiting young people for what was soon to become the Rutherford Laboratory. I had the dubious distinction of being the first person to reject a Rutherford Laboratory job. Perhaps the laboratory was lucky, but in the long term it was unable to avoid the Kalmus clan.

After a period in the USA, I joined the Queen Mary College (now QMW) in 1964 and have been a user of the Rutherford Laboratory facilities ever since. I began my very fruitful collaboration with Alan Astbury, and the QMC-Rutherford collaboration worked throughout the lifetime of Nimrod, as well as at CERN. In 1977 our groups, together with John Dowell's Birmingham group, joined a large international collaboration which Carlo Rubbia was assembling at CERN. Carlo had persuaded CERN Management to convert the super proton synchrotron into a proton-antiproton collider, and this was achieved by 1981 using the stochastic cooling technique invented by Simon van der Meer. The UA1 collaboration, as it was called, built a large general-purpose detector with which to study this new energy domain. The W and Z particles were discovered in 1983, providing the evidence for the unification of the electromagnetic and weak forces.

Rubbia and van der Meer received the Nobel Prize, and this time I got more than a PhD — I was fortunate to be awarded the Rutherford Medal and Prize from the Institute of Physics (IOP) together with John Dowell, and following Alan Astbury. So yet another connection with Rutherford! The presentation, by IOP President, Dr Godfrey Stafford, a former Director of Rutherford Appleton Laboratory, took place in the Rutherford Room of the IOP. The medal itself has a portrait of Rutherford on one side, and the famous scattering diagram on the other. I read again Rutherford's papers on the discovery of the nucleus: work beautiful in its simplicity and elegance and in the clarity of its conclusion. Rutherford certainly deserved a Nobel Prize, which he had already received, perhaps strangely for chemistry. One of the many results from our UA1 experiment showed the equivalent Rutherford scattering of partons within the proton, and gave rise to enjoyable coffee-time discussions on how Rutherford got it right using the classical inverse square law and knowing nothing about vector boson exchange.

At the time of my birth, Rutherford was President of the Institute of Physics, and previously of the British Association, organisations in which I am now very active. So I seem to keep digging up all sorts of connections with Rutherford. A few years ago, as Chairman of the Rutherford Appleton Users Advisory Committee, I on behalf of the Users had to advise the Laboratory. The person receiving the advice was the Associate Director, my brother George, attending his first meeting in that capacity. It was my last meeting on that committee, and I thought that perhaps Kalmuses were fermions. However this has not prevented my son John joining the RAL Informatics Department. To my surprise I found that there was also an earlier family connection with Rutherford. In 1939 when George and I first came to the UK from Czechoslovakia with our parents, our father, who was a biologist, was supported financially by the Society for the Protection of Science and Learning, which had been set up in the 1930s to help refugee academics find grants and jobs. Ernest Rutherford had been the first President of that organisation.

Professor P I P Kalmus
Department of Physics
Queen Mary and Westfield College, London



Experimental and theoretical levels in platinum-195. The numbers beside the levels are twice the spin value.

Symmetries in the structure of nuclei

The word 'symmetry' is derived from the Greek expression meaning 'with proportion' or 'with order'. In modern theories in physics it has acquired a definition much more precise but the general idea of seeking to order physical phenomena still remains, writes Piet Van Isacker of Daresbury Laboratory.

Simple examples of symmetries are familiar from our everyday experience. For instance, we know that a snooker ball, whichever way rotated around its centre, remains unchanged in appearance. Expressed in jargon: a snooker ball is an object with three-dimensional rotational symmetry.

The symmetries that occur in physics are very much like that of the snooker ball. In some instances, in fact, they are just that but more often they require an extension of concepts: instead of applying transformations in three-dimensional physical space (such as the rotation of a snooker ball) one considers transformations in an abstract model space which properly summarises the state of the physical system under consideration. Also, the transformations of interest do not necessarily leave the physical system itself unchanged but rather some of its properties — most importantly, its energy. In the search for symmetries in the structure of an atomic nucleus this amounts to finding transformations that leave the energy of the nucleus unchanged.

Although useful, one often finds that the idea of a symmetry is too restrictive and, specifically, that many transformations exist that only approximately leave the energy unchanged. However, in several applications the idea of symmetry can be conveniently extended. The situation is not unlike replacing our snooker ball with a marked billiard ball: in general, rotations around its centre have a visible effect (follow the mark) but are clearly related to those of a snooker ball. In the same way many transformations of the nucleus do change its energy — and hence are not symmetries — but they are of interest because they connect the different states in which the nucleus can exist. The concept associated with these more general transformations has been named 'dynamic symmetry'.

Some 15 years ago Arima and Iachello proposed the use of dynamic symmetries — until then predominantly applied to particle physics — in the description of 'collective excitation' of nuclei (nuclear states that involve simultaneous movements of large numbers of nucleons). Their approach has two key elements: the choice of a model space appropriate for collective nucleus excitation, and the classification of all transformations in this space. A combination of these two aspects leads to a realistic yet simple model of the different types of collective motion (rotations, vibrations and combinations of them) observed in nuclei. Although originally proposed to deal with nuclei with even numbers of neutrons and protons, the model was later extended by Arima, Iachello and Scholten to nuclei with odd numbers of neutrons or protons.

The figure illustrates the use of symmetry ideas in nuclear structure with the example of a platinum isotope with 195 nucleons (78 protons and 117 neutrons). This nucleus can be studied experimentally by bombarding platinum-194 with neutrons and subsequently analysing the emitted gamma rays. One finds that platinum-195 can occur in a number of states (or levels) each with a definite energy. Each state is also characterised by a 'spin' value (numbers alongside the levels in the figure) which tells us how fast the nucleus is spinning. In this way the experimental level scheme shown on the left hand side of the figure is obtained. A calculation of this nuclear level scheme from first principles is tremendously complicated involving not only the interaction of 195 nucleons but also different types of collective motion, such as the rotation of the nucleus as a whole around an axis, as illustrated on the left hand side of the figure.

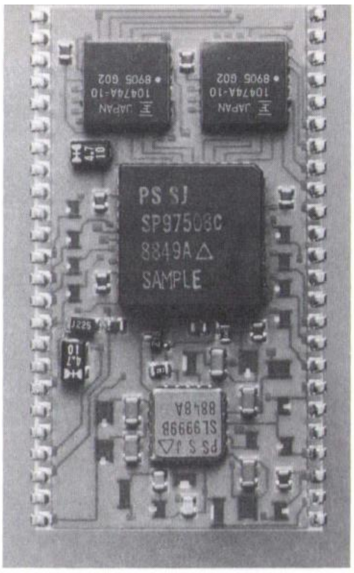
However, after making some natural assumptions regarding the abstract model space in which to describe platinum-195, symmetry arguments reduce this calculation to one for the proverbial back of the envelope. The theoretical results shown on the right hand side of the figure can be obtained without the use of any computer at all and simply follow from the application of certain transformations on the ground state of platinum-195. Experimental as well as theoretical levels are arranged in a pattern to make a comparison of results easy and this shows that levels with the correct spin values are calculated at approximately the correct energies. Note that all experimental and all theoretical levels below an energy of 600 keV are included in the figure and that a one-to-one correspondence between them exists — a stringent test of the model.

More properties than just level energies can be studied in this way: in the case of platinum-195 an extensive comparison between calculated and measured electromagnetic decay properties of the levels shown in the figure has been carried out, in general showing a good agreement.

Although the entire calculation is cast in an abstract framework, it is always possible to derive an intuitive, albeit approximate, picture. For platinum-195 this picture consists of a neutron whizzing around a nuclear 'fluid' with an ellipsoidal shape which itself is rotating around one of its axes. These neutron and fluid rotations can occur in various combinations (shown on the right of the figure) giving rise to the levels of platinum-195.

Perhaps the most appealing aspect of this approach is the scope it gives for unification. A simultaneous description of many levels in a nucleus such as platinum-195 is obtained by introducing transformations that link these levels together. This idea can be pushed further by proposing more general transformations, and so increasing the number of calculated levels — even levels belonging to *different* nuclei. In this way it has been possible to describe simultaneously nuclear species with vastly different properties and hence introduce some 'symmetry' or 'order' into our understanding of nuclei.

P Van Isacker
Surrey University
(formerly Daresbury Laboratory)

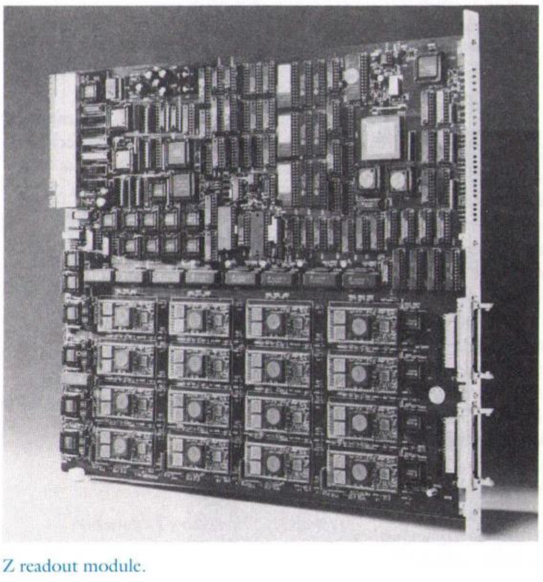


The FADC hybrid circuit used to digitise signals from the detector's wires.

Electronics for the Zeus Central Tracking Detector

The Zeus experiment is being installed on the new HERA electron-proton collider at the DESY laboratory in Hamburg. The electronics system for the Zeus Central Tracking Detector comprises more than 18 racks of equipment costing £2 million and in addition requiring 40 man-years of design, development, manufacturing and test effort at Rutherford Appleton Laboratory (RAL). Most of the system will be installed and ready in time for first running of the HERA machine early in 1992. This is one of the largest projects ever undertaken by RAL Electronics Division, writes Steve Quinton of RAL.

Handling a project of this scale and with its particular technical problems — the front end pipelines, their associated timing and synchronisation, and the possibility of overlapping events in the detector — demonstrates the expertise of the Electronics Division and is providing experience that will be invaluable for the design, production and commissioning of future data acquisition and trigger systems.



Z readout module.

A collaboration between British universities (Oxford, Bristol, University College London and Imperial College of Science, Technology and Medicine) and the Rutherford Appleton Laboratory has the responsibility for the Zeus Central Tracking Detector (CTD) and its associated electronics. The Electronics Division at RAL is working closely with the university teams in the design and production of this electronic system.

The CTD is a gas-filled cylindrical drift chamber, 2 metres long and 1.6 metres in diameter. The chamber has 4608 longitudinal sense wires arranged in eight wire cells defined by field wires. Charged particles passing through the detector ionise the gas molecules and leave a track of electrons which are drifted in an electric field towards the sense wires. The electric field at this point is intense and the electrons avalanche to produce pulses on the wires. Detecting these pulses gives a crude indication of the track position, measuring the drift time to the wire (a maximum of 500 nanoseconds in the CTD) allows a more accurate calculation to be made. In this way, the track positions in the Rø plane (a slice through the detector where R is the radius and phi the angle) can be measured to an accuracy of 120 microns. A further measurement is the pulse-size which gives an indication of the detected particle's energy. Track positions in the Z direction, along the chamber wires, are given by measuring the difference in time of arrival of the pulses at each end of the wire. Timing precision of 200 picoseconds gives a positional accuracy of 3 cm. By setting some of the sense wires slightly off the longitudinal axis ('stereo' wires) a more accurate Z measurement can be derived later from the Rø information.

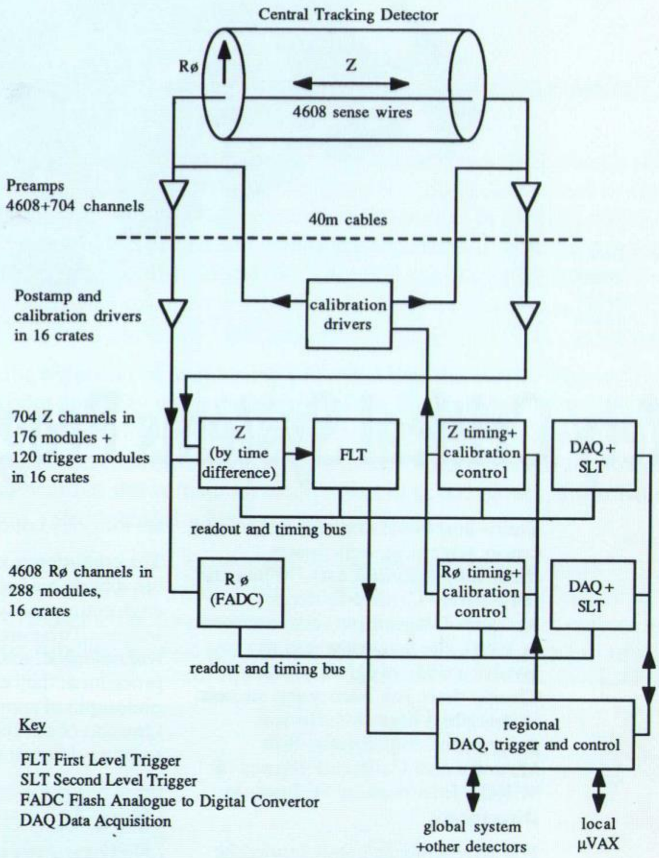
The main data acquisition system follows the classical high energy physics approach in that physics event selection is made on line by a hierarchy of 'trigger' processors in order to reduce the total volume of data to be written to tape for off-line analysis. A particular feature of the HERA machine is the high rate of electron-proton bunch crossings, 10.4 MHz. Events can be produced every 96 ns — insufficient time for a first level trigger decision to be made on an event before the next event arrives. To overcome this problem events are stored in 5-microsecond pipelines at the front end.

All the modules in the system employ multilayer printed circuit boards which were designed on RAL's Daisix CAE system. Production manufacture has been carried out in industry with the Electronics Division providing a prototyping and specialist fabrication service. All functional testing is carried out at RAL and, after installation, at DESY. For the Rø and Z modules in-circuit automatic testing has been employed to ensure the highest possible quality.

The 16 Rø and 16 Z/trigger crates are custom-designed for the 367 mm high 400 mm deep modules and feature high-density Teradyne connectors, multilayer backplanes and integral switching power supplies. The same design of rack is used for the whole experiment, developed at RAL from a design used at CERN. Cooling is by recirculating air through chilled water radiators and extensive cooling tests have been carried out at RAL as a full Rø crate dissipates more than 2kW.

Electronics Division at RAL is one of the world's leading centres for the support of advanced research and development activities. It is deeply involved in projects in the UK, Europe and the USA, drawing on many years' experience in this field. The Zeus project has made, and continues to make, excellent use of the facilities and staff of the division, with the division continuing to provide on-site support activities during the operational phase.

S P H Quinton
Rutherford Appleton Laboratory



A block diagram of the electronic system. Preamplifiers for each sense wire are mounted on the detector. For each of the 704 sense wires where Z measurements are made, a second preamplifier is mounted at the other end of the wire. Because the amplifiers will be in an enclosed space and inaccessible they must have high reliability and low power consumption. Discrete component hybrid amplifiers have been developed which terminate the sense wire signals and drive the 40 m cables off the detector to the main electronics area. The hybrids are mounted eight channels to a printed circuit board and are cooled by water pipes on the endplates of the CTD. Postamplifiers at the far ends of the cables provide most of the voltage gain and condition the pulse shape for the Z and Rø circuits. The postamplifiers are based on video amplifier integrated circuits and use surface mount technology to allow the optimum printed circuit layout to be achieved.

The Rø system uses 8-bit, 100 MHz flash analogue-to-digital converters (FADCs) to digitise the sense wire signals; these values are then stored in a digital pipeline based on emitter-coupled logic memories. If an event is selected by the first level trigger, the relevant portion of the pipeline is transferred to a buffer memory and the data is then processed by a digital signal processor (DSP). The DSP calculates the drift time, with respect to the bunch crossover, and the pulse integral. The results are transferred to an output buffer. A single Rø module handles 16 channels, and each FADC and its associated buffer amplifier and memories are built on a hybrid circuit to simplify the overall module layout.

In each crate of 18 Rø modules a local timing control and calibration module (LTCC) generates the pipeline addressing and synchronisation signals, and controls the associated calibration drivers. The calibration drivers transmit pulses of programmable size to the preamplifier inputs which are passed back through the data acquisition chain allowing variations in gain and timing to be calculated for each channel. A transputer-based read-out controller (ROC) transfers the processed data from the Rø modules along a bus which is essentially the buffered transputer memory expansion port. The ROCs are connected to each other and to the central data acquisition system by the transputer serial links. The second level trigger is implemented on the ROC modules using additional transputers running track finding algorithms.

The Z system uses time-to-voltage converters followed by the same type of flash analogue-to-digital converters as used in the Rø system. A critical component in this circuit is the constant fraction discriminator which generates an accurate timing edge from the input pulse; a full custom application-specific integrated circuit designed by RAL is used for this purpose. Each module handles four channels with on-board data pipelines and buffers. Again to simplify board layout the input circuits are designed as plug-in components, in this case as conventional through-hole printed circuit daughterboards. As well as providing data for later analysis the Z modules generate data for the first level trigger (FLT) which is housed in the same crates. The FLT looks at tracks in the Z view and selects events which come from the expected bunch crossover interaction, this helps to eliminate 'false' events from the particle bunches interacting with the beam pipe walls or residual gas. The processor, which itself has to be pipelined to handle the event rate, uses Xilinx field programmable gate arrays and look up tables to execute the trigger algorithm. The utilisation of the gates in the arrays is effectively doubled by reconfiguring them either to load the look-up tables or to access them when running. The outputs of these local processors are combined with other detectors' outputs by the regional and global FLT systems to generate the overall FLT decision for the experiment. The LTCC and ROC modules in the Z/FLT crates perform comparable functions to those in the Rø crates. In this case calibration is used to set up automatically and check continuously the zero and full-scale settings of the Z front end circuits.

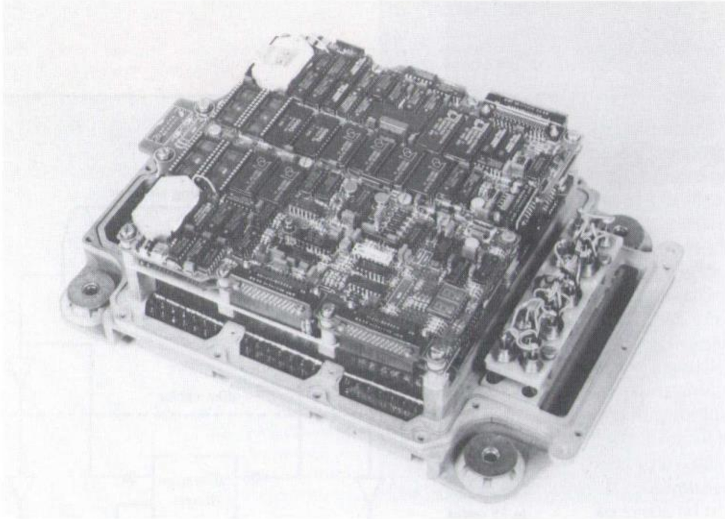


Figure 1: Digital electronic control unit developed for the T55 engine (see box 1).

Safety Critical Systems Programme

Trains and boats and planes . . . and cancer screening, helicopters, chemical plants and cars. When the JFIT Safety Critical Systems Research Programme was launched in 1990, the intention was to involve a wide range of sectors. Clearly there has been some success, as described here by technical programme coordinator Bob Malcolm and Catherine Barnes of SERC's Information Technology Directorate.

The programme is jointly funded by IT Directorate and the Department of Trade and Industry. It began with a growing awareness of the rapid introduction of computer-based systems into safety critical applications which have, hitherto, used tried and tested electro-mechanical techniques. Although computers themselves can be very reliable, there is still concern about their programming. This has led in recent years to a continuing and sometimes confused debate in both industry and academic institutions over different software development techniques and how appropriate they are for safety critical applications.

The confusion is compounded by the big differences between safety engineering practices in different sectors. These are not just technological, terminological, and procedural: they embody different philosophical approaches to safety. One aim of the research programme is to bring different sectors together, both in the programme as a whole and even within cross-sector projects. The intention is that by comparing and contrasting their approaches, the reasons for their differences will become more apparent, as will the ways in which they could be the same. On the basis of this understanding, the UK will then be well placed to push for international harmonisation.

In order to resolve the software techniques debate, a second ambition for the programme is to bring together not only different sectors, but different software techniques. Then, again by comparing and contrasting the ways in which they tackle the design problem, industry will come to understand better what new techniques can contribute in what way to what kind of application and, most importantly, why.

Some 18 projects have so far received outline approval, and the majority are near to starting work. There is considerable diversity in techniques. Projects are developing special purpose languages in sectors such as mining engineering, gas-turbine engine management (see box 1), and the process industries. In another approach, executable specifications are to be used in the development of an automatic cervical cytology system.

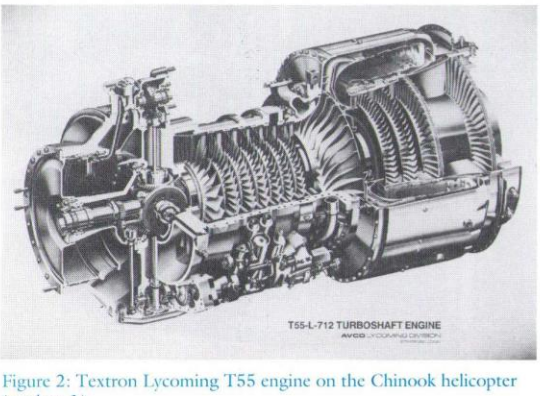


Figure 2: Textron Lycoming T55 engine on the Chinook helicopter (see box 1).

Box 1: Safety critical research for engine control systems (Project SCRECS)

Hatfield Polytechnic, Hawker Siddeley Dynamics Engineering, Alsys Ltd

The overall objective of the SCRECS project is to investigate and develop techniques for use in designing and implementing safe aero engine control systems. The basis for the investigation will be the digital electronic control unit (DECU 80186, figure 1) which has been developed for the Textron Lycoming T55 engine (figure 2) on the Chinook helicopter (figure 3). The flight characteristics of this helicopter are dependent on the engine's relationship to the rotors, and thus it can be difficult to control.

The DECU is involved in control of the engine during normal functioning, and also in the prevention and management of engine failures. Much of the software for the DECU makes use of a well established library of program components, and is programmed with a special-purpose language. This approach offers many advantages for reliability, but the technology in which it is implemented is becoming outdated. The method also looks at only a part of the engine management problem — and a diminishing part, as engines become more sophisticated and their control more complex.

The SCRECS project will develop a design system which tackles the whole problem, using a more modern programming language and with a more modern style of program design, without losing the virtues of the existing approach.

These are all in addition to investigations of the way in which the traditional approach, using conventional programming languages, might be supported by more recent mathematical methods.

To put paid to the myth that artificial intelligence is not acceptable for real-time systems, one project is attempting to improve upon the design of helicopter flight control (see box 2). Another project is looking at formalising the reasoning about the correctness of medical diagnostic systems. Yet another combines both artificial intelligence and special purpose languages via an expert system which generates the special code for railway signalling.

Already it is clear, from the list of just some of the applications so far represented, that the ambition to involve a wide range of sectors has been achieved. As for comparison and contrast, even before contracts have been signed two of the projects are meeting to see if the component-based approach being developed for mining engineering can be used in automotive applications.

It will be apparent that there is a deliberate industrial bias in this programme, both to get as much of industry involved as possible, and to try to ensure that projects are driven by the real problems facing industry. It has been emphasised that projects should be driven by 'application need' rather than 'technology push'.

However, it was recognised in the workplan that though industry may own the problem, academics may be harbouring potential solutions, and that many of the problems would require interdisciplinary working with researchers well outside the computer science field. The programme has indeed succeeded in generating interest in other departments. They tend, though, to be outside the field of most engineering organisations, and with less certainty of directly usable contributions — psychologists looking at causes of human error, mathematicians using category theory to compare different design techniques, operational researchers analysing risk. Establishing collaborations between these departments and companies has not been easy.

However, there is scope for quite a few more projects yet, and another call for proposals is being announced. Ideas for additional projects are being discussed already. They include hazardous materials handling, motorway signalling, and mathematical modelling for water treatment. Cranes and roads and drains?

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Catherine Barnes
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Telephone (0793) 411071.

Box 2: Inductive software solutions for applications in the flight environment (Project ISSAFE)

Hatfield Polytechnic, Turing Institute, British Aerospace Commercial Aircraft, Royal Aerospace Establishment, ERA Technology Ltd

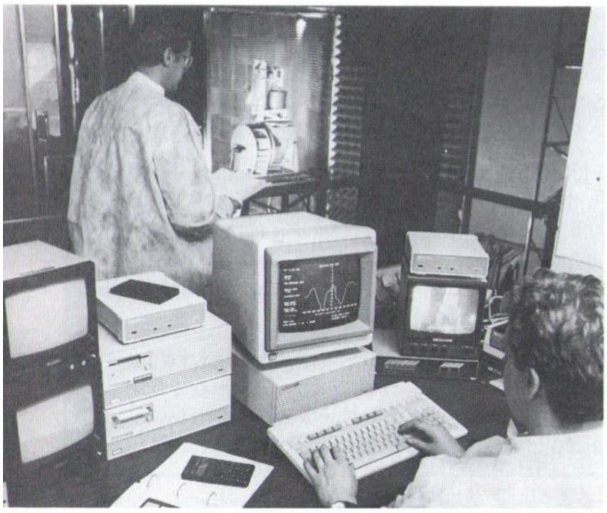
One of the major factors affecting the safe operation of helicopters is the demands placed on the pilot at critical times in a mission. The workload is partially determined by the training and skill of the pilot, and the degree to which the control of the helicopter is automated. The partners in this project will investigate the extent to which control tasks can be automated in association with pilot skills. They will use innovative software techniques in order to effect a major contribution to safety by a reduction in pilot workload.

Previous work on the reduction of workload has revealed that this can be achieved by, for instance, reducing pilot authority when the aircraft is near the boundary of its 'safe flight envelope'. Reduction of authority in this way is, however, difficult, as it depends on the combination of manoeuvres that the aircraft is performing. Recent work at the Royal Aerospace Establishment has shown that advanced computing techniques, in particular the use of expert systems, offer potential solutions to this problem.

Research at the Turing Institute has revealed that rules for expert systems might be captured directly from monitoring a skilled pilot's actions. The principal objective of the ISSAFE project is to examine the construction and use of rule-based expert systems in improving helicopter handling systems and in automating mission task elements of

Figure 3: Chinook helicopter (see box 1).

Compact antenna test range opened



Engineers in the Compact Antenna Test Range control room, which overlooks the range's test chamber. The chamber can be seen centre top. Equipment to be tested is mounted on the precision positioning turntable and can be seen through the open loading bay door. (Photo: BAe).

The first UK millimetre-wave Compact Antenna Test Range (CATR) was opened at Queen Mary and Westfield College, London, on 12 November 1991 by Dr Alan Rudge of British Telecom, who is a former member of SERC's Information Technology Advisory Board (ITAB). The facility has been constructed with the financial support of British Aerospace Systems Ltd and is housed within the Antenna Laboratory. Funding for the Antenna Laboratory has been provided mainly by SERC through ITAB's Communications (now the Communications and Distributed Systems) Committee under a £750,000 rolling grant programme.

The CATR enables radiation characteristics of spacecraft antennas to be measured in a clean-air environment at frequencies of 200 GHz and above. It principally consists of special reflector panels, a custom-built transparent tenting and air conditioning system and a rail-mounted positioning system and turntable, all housed in a purpose-built anechoic chamber which is air-conditioned to provide a dust-free environment suitable for the measurement of space qualified hardware. The CATR reflector is a single offset antenna of 5.4 metres focal length with a sector shaped aperture which can contain a 3 metre diameter circle. The reflector is constructed from 18 high-precision panels which were developed and manufactured at SERC's Rutherford Appleton Laboratory for the James Clerk Maxwell Telescope. The facility is the only independent one of its kind and is one of only two 200 GHz ranges in Europe.

Antennas still play a key role in advanced communication systems using the radio spectrum. They provide the spatial filtering of the radio signal enabling specific regions to be covered by satellite for telecommunications. The accurate beam shape and electronic scanning of the beam's direction, possible with modern antenna design techniques, enable satellite-based radiometers to map the Earth to determine resources and climatic changes, as well as lay the foundation for future satellite-based global cellular personal communication.

Dr C Parini
Queen Mary and Westfield College, London.

SPEECH AND LANGUAGE TECHNOLOGY

"Of course, in the next decade you'll be able to talk to your toaster — but not about anything very interesting". This deadpan maxim by Mitchell P Marcus continues to inspire researchers in speech and language technology, now known in the UK as 'SALT'. And in September 1991 the Joint Framework for Information Technology announced a new programme of support for the field, to the level of £7 million over the next four years.

Underlying the research is a determination to abolish a major language barrier — not between nations, but between people and their own information processing machines. Among ourselves, we use language to communicate, and we also use it to articulate reasoning in our own minds. But although we have machines that can help with both these tasks, we have to drop language and use special codes to get them involved. Programming languages and keyboards can be seen as barriers to a free flow of ideas between ourselves and our own machines.

With that barrier down, new vistas for achievement will open up. Spoken language offers a much easier means of controlling machinery, especially as human technology becomes more complex and pervasive. Remote interaction using telephones extends the potential for this enormously. And written records too will become much more accessible, with their content as well as their form on the page immediately available for search, summary and perusal.

Projects funded will involve collaboration on various dimensions: SERC with the Department of Trade and Industry, academic with industrial researchers, and, perhaps most challengingly, speech scientists with natural language analysts. Within SALT, speech is the study of the vocal and acoustic aspects of language, while natural language considers the complex ways in which words and sentences express meaning. The strange fact is that although both aspects are predominantly found together in nature, our present understanding of them derives from quite different bodies of knowledge: signal processing on the one hand, formal logic on the other. A major challenge is to uncover the bridges which unite the two, both at a theoretical level and as a basis for technology.

British scientists are among the leaders in speech and language processing. Furthermore, as EC surveys have shown, the largest national group of companies exploring the new technology in Europe is British. With the SALT programme, SERC and the DTI aim to bring these two strengths together.

Dr Nicholas Ostler
Department of Trade and Industry

Electrostatically charged particles in pesticide sprays are attracted to the leaf of the plant, improving spray efficiency, reducing drift into the environment and the amount of pesticide used.

Clean technology research targets

SERC plans to commit up to £10 million by mid-1992 on research towards three major targets for new clean technologies. The Agriculture and Food Research Council (AFRC) is committing substantial complementary funds, depending on the outcome of the 1991 public expenditure survey.

The first three targets are:

♦ Clean synthesis of 'effect' chemicals

The synthesis of single pure products by new routes, for example biosynthesis of a suitable intermediate coupled with subtle chemistry and subsequent processing to achieve a desired end product, avoiding harsh reagents and extremes of temperature and pressure.

♦ Harnessing photosynthesis

New routes based on photosynthesis in plants and bacteria to generate fine chemicals, feedstocks, raw materials or possibly fuels. (This target does not include research on the photosynthetic apparatus as such, although of course SERC and AFRC will continue to support research proposals on that on their individual merits).

♦ The redesign of farming as an engineering process

An engineering approach to the control of the environmental impact of farming practices and the use of farm products.

Reports suggesting topics where fundamental research is needed to attain each of these three targets are available from the Clean Technology Unit.

If you have an idea for research towards any of these three targets, you are strongly encouraged to send, in the first instance, a short outline of your proposal to the Clean Technology Unit. The Unit's staff will then advise you on whether and how to formulate a full proposal which will satisfy the objectives of the clean technology programme. Within SERC, all proposals will then have to pass the usual competition of being rated as alpha quality by the relevant subject committee. The Unit's budget will be used to 'gear' the subject committees' budgets for research relevant to the announced targets.

In addition to proposals directed at these three specific targets, the Unit is encouraging research on three underlying themes which are relevant to clean technologies in general. These generic themes are:

- fundamental work relevant to major advances in clean combustion (but not, for example, incremental advances in technology for scrubbing flue gases);
- electrochemistry, for example as applied to novel fuel cells;
- novel methods of analysis and measurement, particularly of trace quantities of pollutants.

Outside these specific targets and underlying themes, Nicholas Lawrence, the Director of the Unit, remains keen to hear from academic staff who have a really novel idea that could form the basis of a new clean technology, or possibly even become a future major target for the Unit. A small part of the Unit's budget will be reserved for unexpected highly innovative ideas of this sort. Ideas which cross the boundaries between the conventional scientific and engineering disciplines are particularly welcome.

Meanwhile, SERC has already backed a portfolio of 75 grants (total awarded grant value of £6.5 million) on such topics as catalytic combustion, solid polymer fuel cells, immobilised cell reactors for detoxification of industrial wastewaters, on-line microbiological monitors for pollutants and investigations into the possibilities of modifying horseradish peroxidase so that it will digest lignin.

The AFRC-SERC Clean Technology Management Committee has further prospective targets in view, but is still considering whether and how to pursue them. Two 'possibles' are

- some aspect, still to be defined, of waste management and recycling;
- a holistic approach 'towards the sustainable city', to be pursued in consultation with the Economic and Social Research Council (ESRC).

Until the Management Committee reaches decisions about these targets, individual proposals which may be relevant to them will be considered on their merits.

The Unit is also discussing with ESRC the scope for jointly funded research on a key area necessary for any discussion of clean technology — the systematic costing of environmental effects.

The Clean Technology Unit's strategy remains unchanged. It is to coordinate and focus research aimed at new technologies which prevent or forestall pollution, or, at a lower priority, fundamental redesign of existing processes so that they are inherently cleaner. Research on the clean-up of pollution from the past ('retrofits') and 'end of pipe' technology to remove pollutants is clearly important, but will not usually require special encouragement. Indeed such research can and will continue to feature in the programmes of existing SERC subject committees as part of their own portfolio of environmentally-related research grants.

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Clean Technology Unit
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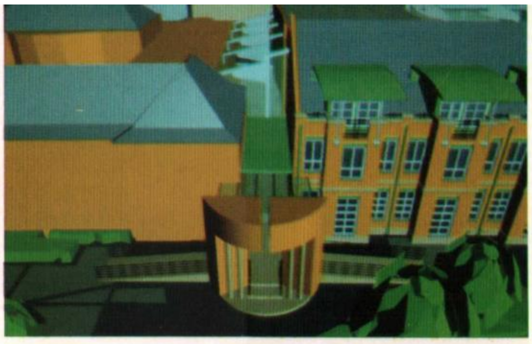
Malcolm Anderson at AFRC,
telephone (0793) 413200.



Computer-aided visualisation of the Graduate Business School at Strathclyde University, by Abacus Simulations Ltd.

The civilised city

The theme for the 1991 meeting of the British Association for the Advancement of Science was 'The Quality of Life'. SERC used this theme as the basis for a display centred on the *Civilised City*, a concept being developed for the Clean Technology Programme.

The 'civilised city' theme focuses on the interactions between the different aspects of the urban environment. This will help in assessing the knock-on effects on the whole environment of changes in any one aspect. Specific topics chosen for display at BAAS were the sick building syndrome, Computer aided Visual Impact Analysis, the development of lean burn engines and route guidance. The theme was further developed by two speakers at the SERC press conference held on the opening day of the meeting, Dr Margaret Bell of the Transport Research Group at Nottingham University and Professor Tony May from the Institute of Transport Studies at Leeds University.

Transportation systems and the urban environment

Pollution levels have risen significantly as the number of vehicles on our roads has increased and public awareness of the detrimental effect of both air and noise pollution from traffic has grown. The most effective but the most expensive way of reducing noise pollution from vehicles is at source. However the noise of a vehicle has to be reduced considerably and the majority of vehicles made 'quiet' before a perceptible decrease in overall noise level of a traffic stream is achieved. Safety may be reduced as people rely on noise to warn them of an approaching vehicle.

Traffic management techniques redistribute traffic, thereby improving conditions at congested junctions. This does not however solve the problem of air emissions as they are simply spread around the network. The most successful way of reducing air and noise pollution in urban areas is to reduce the number of journeys made.

Traffic operators at Leicestershire County Council, by adjusting the traffic signal timings, alleviate congestion observed on closed circuit television. Research funded by SERC at Nottingham University Transport Research Group is investigating the effect of congestion control on air pollution and noise levels. The feasibility of automatic remote monitoring of the environment integrated with traffic monitoring is being investigated in collaboration with Siemens - Plessey.

Public transport

Public transport has a valuable role to play, but persuading the driver to switch to public transport is not an easy task. 'Light rapid transit' systems are being considered by many local authorities for improved city centre access. Provision for strategically positioned and convenient park and ride stations with direct access to reliable, frequent, low cost public transport is essential. Even so, drastic changes in policy may be necessary to ensure success. For example 'public transport only' areas may need to be imposed for city centres.

Pedestrians and cycles

As the car has taken a more dominant role in our lives so have our aspirations for place of work, education and leisure, shopping and so on. Without the car, people tended to live close to their jobs and schools. Over the past 20 years, land-use planning (such as hypermarkets on city peripherals, hotels near motorways) has developed in response to car availability. For the future, land-use planning may have to change radically, to become more environmentally friendly and promote the use of cycles and mobility on foot.

Freight distribution

In Britain over the past 20 years there has been a shift towards moving goods by road rather than rail. In particular, building a comprehensive motorway and trunk road network has encouraged more commercial and industrial centres to be built strategically alongside motorways for quick access to fast roads. Moving goods by road over recent years has become the more cost-effective alternative. In future reversing this trend may prove to be more environmentally friendly.

Effect of pollution on people

Until recently opinion seemed to suggest that pollution in this country was not critical. However, carbon monoxide levels exceeding those suggested by the World Health Organisation have now been measured in Britain. Up to now, legislation has been introduced as a preventive measure, to provide an overall more pleasant environment, rather than as an emergency move to reduce dangerously high levels of certain substances. This situation may change.

Investment in research such as that at Nottingham University to learn more about the environmental impact of traffic pollution in the world and on its people is a positive way forward.

Route guidance. The system being developed by the Transport and Road Research laboratory will include a dashboard mounted visual display showing a map of the route to be taken, distance to destination and direction of travel at each junction.

In-car route guidance

It is accepted that, whatever steps are taken to transfer freight and passengers from road vehicles to other forms of transport, most travel will be by road and there will continue to be congestion problems.

One way of easing the problem is by interactive in-car route guidance which will tell drivers about any problems on the roads and the best route to take.

Route finding is a complex task for drivers, and research indicates that more than 5% of all travel is a result of drivers taking routes which are longer than the optimum. Destination finding in unfamiliar areas is even more demanding, and some estimates suggest that in such situations drivers may travel twice as far as necessary., The annual costs to the community from both these sources have been estimated at more than £500 million.

As congestion increases, the task of finding the best route becomes more difficult; conditions change rapidly, and even experienced drivers may not know that they can save travel time by avoiding unusual traffic conditions ahead. If they use rat runs, this may well create environmental or safety problems. Even on main roads, it is possible that sending some drivers on slightly longer journeys will reduce the journey time for all drivers. This introduces the concept of system optimality, where this guidance is designed to optimise benefits for all travellers, rather than solely those being guided.

Possible solutions

With the advent of information technology, there are now several ways in which drivers can be helped in these tasks, and the overall road system managed more efficiently and safely. One approach involves providing current information through, for example, radio messages or the Trafficmaster system which is now in operation on the M25. A second approach involves giving drivers guidance as to the best route to take in current conditions. Variable message signs and directions to the best car park are examples.

One of the most advanced systems, already in operation in Berlin, and to be piloted in London under the name Autoguide, involves roadside 'beacons' which communicate with an on-board computer. The driver keys in his destination, and his computer determines the best route and gives him directions at each junction. As he travels, his computer reports to each beacon the time he has taken on the previous section of his route; this is used by a central computer to determine the best routes in current traffic conditions. As more people use the system, the quality of the guidance improves, but the guidance task becomes more complex. Sending everyone on the same route could be counterproductive!

Research issues

The design of route guidance systems raises a number of interesting research issues. Driver behaviour is fundamental; if drivers receive information which they do not want, cannot use or do not trust, the guidance is worthless; if they do not consider the system cost (of perhaps £100 a year) worthwhile, fewer drivers will use it, and guidance will be less reliable. The optimisation of a traffic system in which some drivers are guided (and may or may not follow guidance) and others are not presents a substantial systems engineering challenge, and one which calls into question the adequacy of existing computer models of traffic. Finally, issues of public policy arise; a commercially operated system, as proposed for London, will be primarily concerned with benefits to the user, and may pay less attention to the impact on other traffic or on the environment.

All of these issues are being studied in a four-year SERC grant awarded to Leeds and Southampton Universities. The research team, which includes engineers, transport planners, psychologists, mathematicians and physicists, has worked closely with the Berlin field trial, advised on the design of the London pilot, and is in close touch with researchers elsewhere in Europe as well as in Japan and the US.

Some research findings

Several interesting conclusions have already arisen from the research.

- Drivers prefer information on familiar journeys, but need guidance on unfamiliar ones. The ideal system should provide both and enable the driver to chose.
- Drivers will follow guidance on the majority of journeys, even if occasional guidance is poor. However, guidance which appears counter-intuitive rapidly reduces compliance. Extra information to justify the guidance will help.
- Even when drivers value the guidance given, the actual time saving may be small. In Berlin, day-to-day variations in travel time masked any savings obtained.
- Guidance to safer routes may reduce accidents, but safety is also affected by the complexity of the information provided.
- At lower levels of take-up, those not receiving guidance may suffer increased travel times; as take-up increases, benefits increase, but may fall for individual equipped drivers. System optimal guidance produces higher overall benefits, but fewer benefits for equipped drivers. This has important implications for commercially operated guidance.

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Professor A D May
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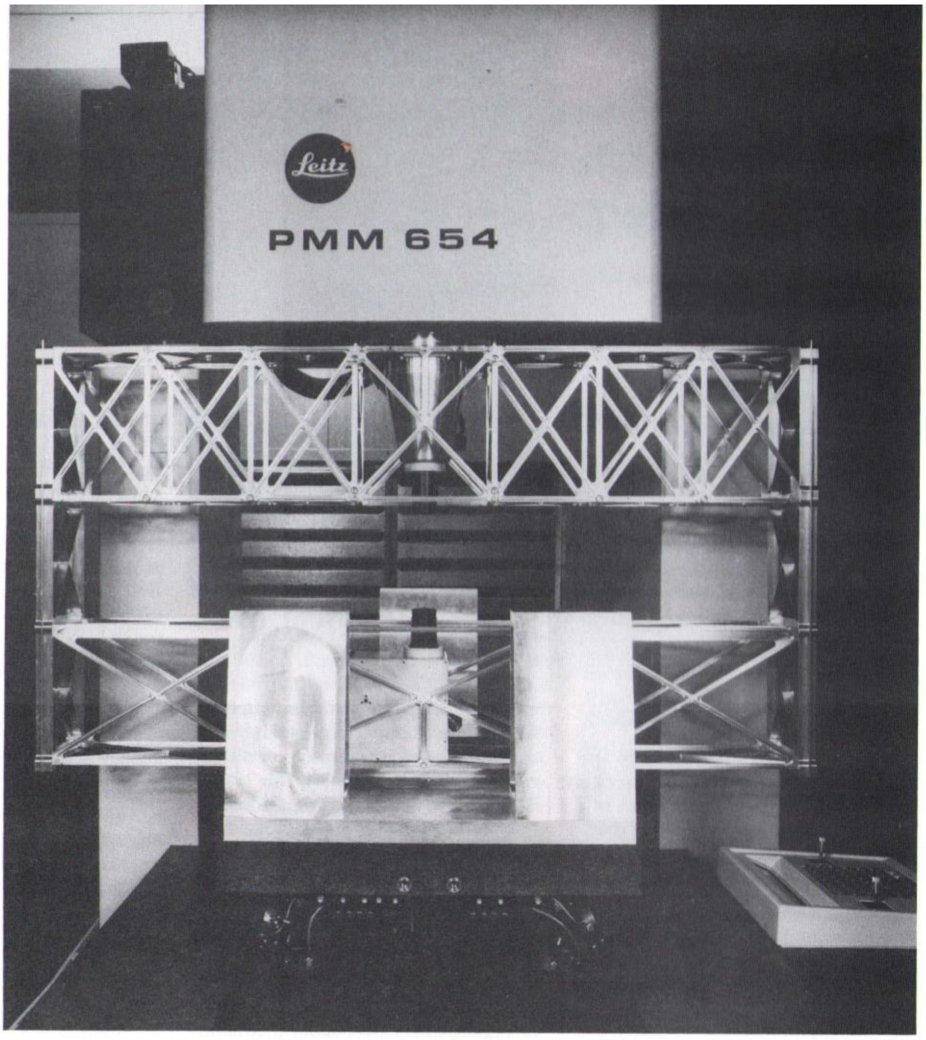


The SuperCOSMOS machine: the partially completed machine, comprising the Wild-Leitz measuring platform and a lightweight bridge structure, manufactured at the Royal Observatory, Edinburgh, which carries the illumination system below the plate to be measured and the CCD camera above it. The plate itself sits on the large blocks between these two optical components. Ventilation for the temperature-controlled chamber can be seen in the background.

SuperCOSMOS

A key component of observational astronomy is a capability to survey the sky so that samples of particular types of object may be selected and observed further. At optical wavelengths this is carried out by accurately digitising photographic plates, which can record large areas of sky. Dr Lance Miller, a member of the SuperCOSMOS team at the Royal Observatory, Edinburgh, describes this new facility which can measure plates with unprecedented accuracy and speed.

Wide-field astronomy

Systematic surveys of the sky have been a vital preliminary to our understanding of the Universe. A major advance at optical wavelengths occurred in the 1950s with the production of the Palomar photographic sky surveys covering the entire Northern hemisphere, obtained with the Palomar Schmidt wide-field telescope. The opening of the UK Schmidt telescope in Australia in 1973 allowed equivalent surveys to be made in the Southern hemisphere, and by then greatly superior photographic materials were available.

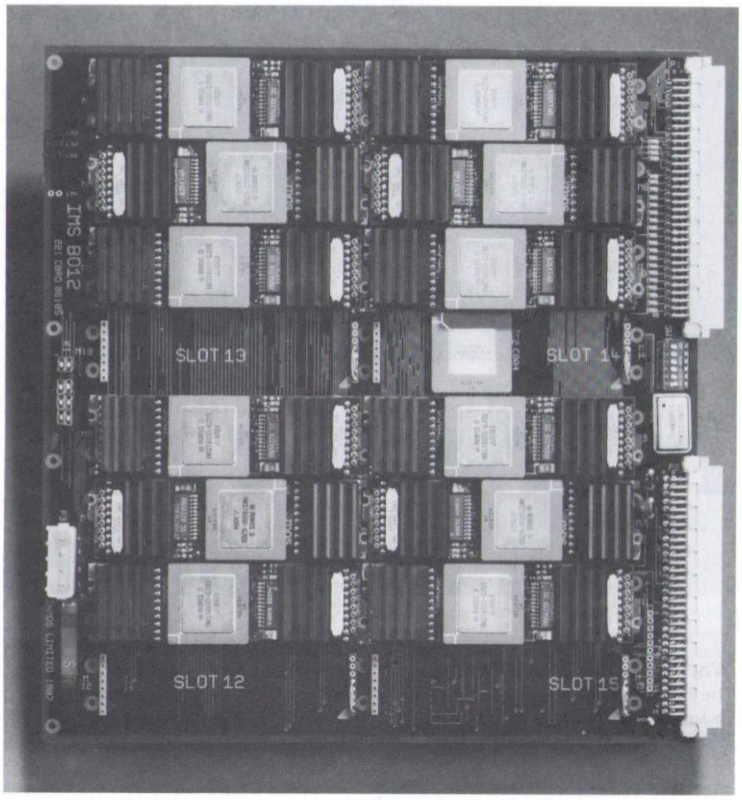
The huge advantage that the photographic surveys have over other media, even today, is the ability to cover extremely large sky areas. Atmospheric fluctuations limit the resolution of any ground-based telescope to typically about 1 arcsec, so there are about 5×10^{11} resolution elements covering the sky. Although rapid advances are being made in the sizes of solid-state detectors (CCDs), the largest still contain fewer than 10^7 pixels, whereas the Schmidt telescopes can survey the entire sky at about 2 arcsec resolution with just 1800 photographic plates. We can then digitise those plates to high accuracy, and the UK presently leads the world with its two high-speed machines, COSMOS at the Royal Observatory, Edinburgh, and the Automatic Plate Measuring Machine at the Royal Greenwich Observatory, Cambridge.

The SuperCOSMOS facility

The aim of the SuperCOSMOS project is to replace the existing COSMOS machine by one which is three times faster to cope with increasing volumes of data, ten times more accurate to enable the apparent motions of stars to be measured, and with 100 times the dynamic range in the measurement of the brightness of pixels.

The heart of the machine is a commercially available measurement platform, purchased from the Wild-Leitz company in 1990. This machine has an absolute accuracy of ±0.2 µm along each axis over a measurement region of 600 x 500 mm. The repeatability of measurements is a factor of two better. This accuracy is achieved by using a granite table mounted on air-bearings, with independent motion of its axes. The machine is enclosed in a class 100 clean room whose temperature is controlled to ±0.05°C.

Measurements are carried out by suspending a glass photographic plate horizontally on the table, and focusing an illuminated slit on to the emulsion (this is necessary to eliminate scattered light). The illuminated portion of the plate is then imaged on to a linear CCD detector, 2 cm long, which is fixed on to one axis of the machine. The CCD is read out every 8 milliseconds, collecting data from 2000 pixels on each readout, as the table continuously moves the plate through the optical path. A complete plate is measured by scanning in a number of such 2 cm-wide strips. The linear CCD has the advantage of having high dynamic range and cosmetic perfection: the maximum possible data rate is governed by the speed of analogue-to-digital conversion rather than by the number of pixels in the CCD. A complete plate from the UK Schmidt telescope can be scanned in less than two hours, in which time it will have been digitised into 10^9 pixels, each 10 µm square, with intensities stored as 15-bit values.

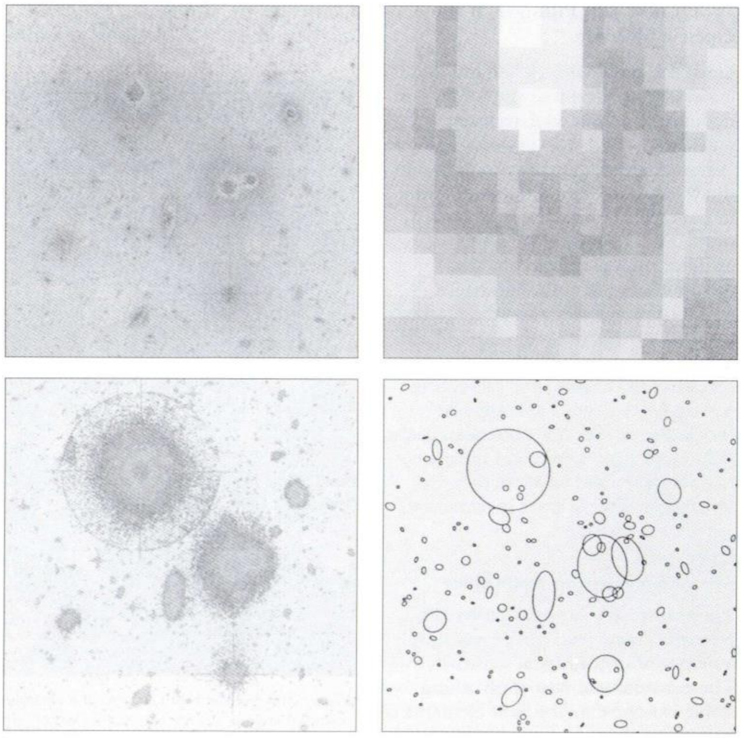


The transputer front-end: modern astronomy is making greater use of faster data rates. The SuperCOSMOS system needs to process 2 x 10^5 pixels/sec. The CCD data need to be collected, to be corrected for the instrumental response, have a continuously monitored dark current subtracted and to be corrected for variations in light intensity and integration time, which are also continuously monitored. Data are converted from the transmission value through the plate to the inferred intensity of incident light during the photographic exposure, and the thresholding and grouping of pixels (see 'Object detection', below) is performed. A transputer system, shown here, is used to provide that processing. The transputers also control the table movement. The present system can execute more than 400 million instructions a second. A requirement to handle such data rates is being increasingly made, not only for indirect astronomical measurement systems such as SuperCOSMOS, but also for instruments attached directly to telescopes, such as the new generation of infrared instrumentation.

Applications of SuperCOSMOS

This new facility will be completed during 1993. The primary applications will be astronomical, digitising both the archive plate material and new sky surveys which are presently being photographed in both northern and southern hemispheres. These surveys contain a great wealth of information, enabling the selection of astronomical objects, such as quasars and both the hottest and the coolest stars, by their colours, and also for the first time giving a long-time baseline between the archive plate material and the new surveys, enabling the measurement of the transverse motions of about one-third of the brighter stars in the galaxy: a database of some 4 x 10^7 stars which will be used to study the structure of our galaxy. Individual projects making use of smaller sky areas and specially requested photographic plates will also be supported. The new facility is also a valuable resource both for other sciences in the UK and for earning income from industry, as it will be able to measure to unprecedented accuracy photographic materials from a wide variety of applications.

Dr L Miller
Royal Observatory, Edinburgh



Object detection: the stages of the detection of objects in an astronomical image. First, the background brightness is estimated as a function of position by applying a spatial median filter to the raw data. Next, those pixels which are significantly brighter than the background are selected, by specifying a critical threshold brightness. The selected pixels are then grouped together into objects, and finally parameters such as total brightness, shape, extent and position are derived for each of those objects. A critical part of the object detection is the ability to demerge objects which are sufficiently close together that they appear linked at the detection threshold.

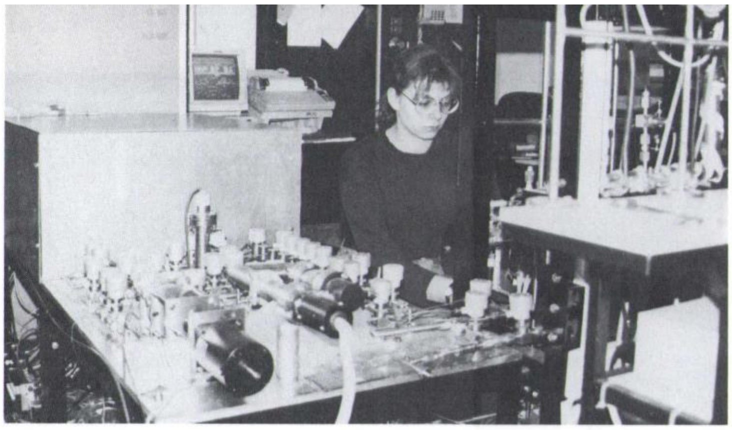


Figure 1: Research student Sara Russell operates a static vacuum mass spectrometer used for making carbon isotope measurements at the picomole level.

Interstellar dust in meteorites

When, in 1805, Jane Taylor wrote the nursery rhyme: "Twinkle, twinkle, little star, how I wonder what you are, up above the world so high, like a diamond in the sky", little did she realise the accuracy of her closing line. Nowdays it is routine to extract grains of stardust from certain meteorites where they became trapped at the time of formation of the Solar System some 4.55×10^9 years ago. Thus, diamond and silicon carbide, and some as yet unidentified species, shed by highly evolved carbon-rich stars, are now available for laboratory study to test astrophysical theories, writes Professor Colin Pillinger of the Open University.

Until the end of the 1970s, it was generally accepted that the solar nebula was a hot and extremely efficiently mixed cloud of dust and gas. It was believed that there could be no direct memory of processes occurring in stars which existed before the birth of the Sun. A basic flaw in this assumption was revealed by the recognition of isotopic anomalies (compositions that cannot be reached from an average Solar System value by simply mixing or fractionisation mechanisms) in primitive meteorites having no evidence of thermal or shock events. Specific anomalies in the light elements (carbon and nitrogen) have been tracked to allow the separation of some pure specimens of interstellar material.

Isotope measuring techniques

The reason why isotopic anomalies were not discovered earlier was simply a matter of instrumental sensitivity. The conventional way of obtaining stable isotope data for light elements is to convert them to a gaseous species (CO_2 for carbon; N_2 gas itself for nitrogen). A comparative measurement using a dynamic, continuously pumped mass spectrometer is then performed, switching repetitively between sample gas and a laboratory standard to afford high precision results. This concept, which has been the basis of all commercial instrumentation produced since the 1940s, is inherently wasteful of sample. In a radical departure from the accepted methods, we have constructed a series of increasingly refined static (closed vacuum system) mass spectrometers (figure 1) which use a thousand times less gas to provide isotopic information. Consequently, sample and standards can be compared in picomole amounts with a duty cycle of only 1-2 minutes. The full capabilities of these instruments have still to be realised because it is not yet possible to prepare samples without blank contributions larger than the minimum amount needed for data acquisition.

Isolating interstellar dust

Samples of carbonaceous chondrites (figure 2) have long been thought of as most representative of the bulk composition of the solar nebula; indeed they are used to provide a measure of solar elemental abundances. Finding the interstellar dust grains surviving within such material involves destroying most of the meteorite, by treatment with a sequence of increasingly violent reagents: hydrochloric and hydrofluoric acids to remove silicates, carbon disulphide to dissolve sulphur precipitated from sulphides, chromic acid to degrade organics and finally perchloric acid to destroy graphite and amorphous carbon. Although only the last operations are oxidative, the overall process is like burning down a haystack to find the proverbial needle.

Even after such an involved procedure, the residue for any particular meteorite (less than 0.1% of the starting material) is a complex mixture of some 40% carbonaceous species and 60% refractory oxide minerals. Now, however, combustion comes into its own as a means of distinguishing components within the mixture. Small samples of acid residues are heated in the presence of oxygen by increasing the temperature from 20° to 1300°C

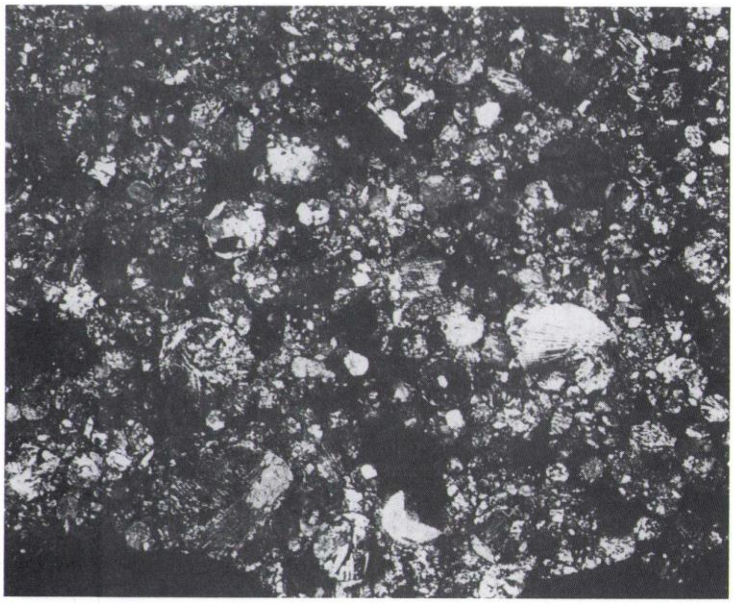


Figure 2: A polished thin section of a chondritic meteorite observed in transmitted light; the rounded objects are the chondrules which give rise to the name. Interstellar dust is hidden in matrix which appears dark because light cannot penetrate this very fine-grained part of the meteorite.

in a stepped fashion. The gases produced are separated, purified, quantified and subjected to isotope analysis. Profiles for the release of carbon and nitrogen, together with their isotopic composition as a function of temperature, demonstrate a multiplicity of species, some major, some minor (figure 3). Characteristic combustion temperatures help identify the various phases but further separations relying on density or grain-size properties have been carried out to show unambiguously the presence of diamond and silicon carbide.

Diamond

Interstellar diamond, which is probably produced by a process similar to chemical vapour deposition in red giant stars, has several rather novel properties. First, it is extremely fine-grained having an average crystal size of only 3 nm. Secondly, it is apparently functionalised, the presence of carboxylic acid groups providing a means of taking the diamond into colloidal solution. Thirdly, it is the carrier of nitrogen highly enriched in ^{14}N and a component of xenon with an isotopic composition requiring a supernova origin. Diamond must be extremely abundant in the interstellar medium since it can be found in amounts up to 500 ppm in some of the meteorites studied. But it cannot all have derived from a single source since it can vary by a factor of about six in nitrogen abundance, depending on the type of meteorite from which it is extracted.

Silicon carbide

The average $^{12}C/^{13}C$ ratio for silicon carbide for a substantial number of meteorite samples is about 37 ± 1, providing a reasonably close match to the mean of present day carbon-rich stars and the interstellar medium. This in itself is a paradox since $^{12}C/^{13}C$ should have evolved with time due to nucleosynthetic reprocessing. Silicon carbide has a much wider size distribution than diamond, ranging from 10 nm up to 10 μm which means that some particles are sufficiently large to be measured individually (figure 4). Ion microprobe studies at the University of Washington, St Louis, reveal $^{12}C/^{13}C$ values from 2.5 to 150 demonstrating, not surprisingly, that the debris of many stars contributed to the early Solar System. Silicon carbide is unfortunately far less abundant than diamond, typically less than 5 ppm in the meteorites which have to be destroyed to find it. Nevertheless, the way forward is clearly for individual grains to be isolated and fully characterised, both chemically and isotopically for major, minor and trace elements. Already it is known to be the host for elements produced by s-process nucleosynthesis. We hope to be able to contribute to the characterisation using an ion probe recently purchased with Astronomy and Planetary Science Board and Open University funds.

Other kinds of interstellar dust

The relative ease with which interstellar diamond and silicon carbide can be isolated from meteorites is attributable to their great chemical resistance. Isotopic analyses of less processed residues regularly afford more than a hint of the presence of other forms of interstellar carbon (figure 3) and a variety of nitrogen-containing species. Less drastic procedures will have to be found to purify and concentrate these minor components for characterisation. At present the minerals being identified as intersellar dust grains are not those seen in abundance by astronomical observers. Isotopic measurements will undoubtedly help in the recognition of presolar silicates, if these have been survived in primitive meteorites. Just how one goes about separating an interstellar silicate fraction from a cosmic blend of Solar System siliceous material is an open question.

Future sources of interstellar dust

Given that intersellar dust is going to be abundant in the most unprocessed regions of the solar nebula, the obvious place to look for it is a comet nucleus, which should be a veritable cornucopia. The return of a cometary sample, however, looks a slim prospect until at least the end of the first decade of the 21st century.

Until that time we will have to make do with what can be painstakingly separated from primitive meteorites, of which there are all too few available for destruction on a large scale. A new source of meteorites is the Antarctic ice cap (see cover). Non-polar deserts may however be a much more prolific source of large specimens (figure 5). The prospect of setting out to recover interstellar dust from amongst the sand dunes is not as daunting as it may first seem, especially if one is used to looking for a needle in a haystack.

Professor Colin Pillinger
Planetary Sciences Unit
Department of Earth Sciences
Open University

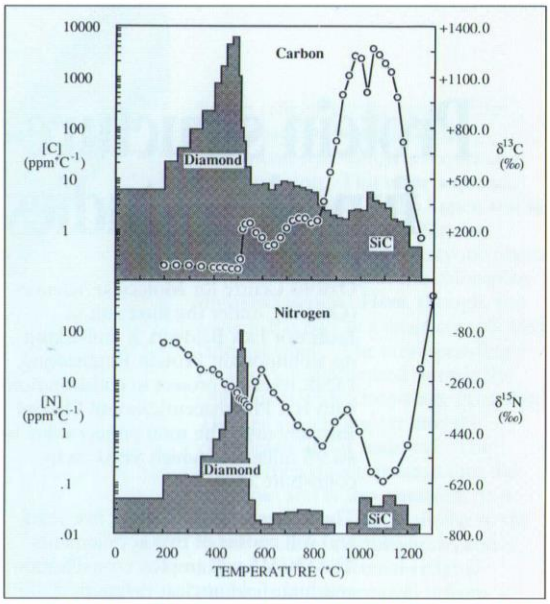


Figure 3: Carbon and nitrogen released by stepped combustion of an acid residue from the meteorite Cold Bokkeveld. The histogram gives yield; the points are a measure of isotopic composition in per mil units relative to an international standard.

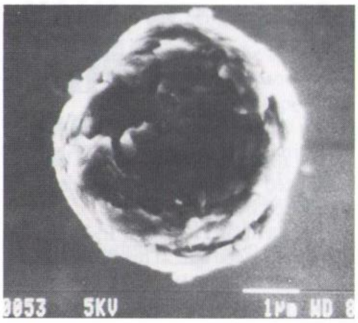


Figure 4: A silicon carbide dust grain isolated from the Murchison carbonaceous chondrite; its carbon and silicon isotopic composition distinguishes it as debris from a carbon-rich star.

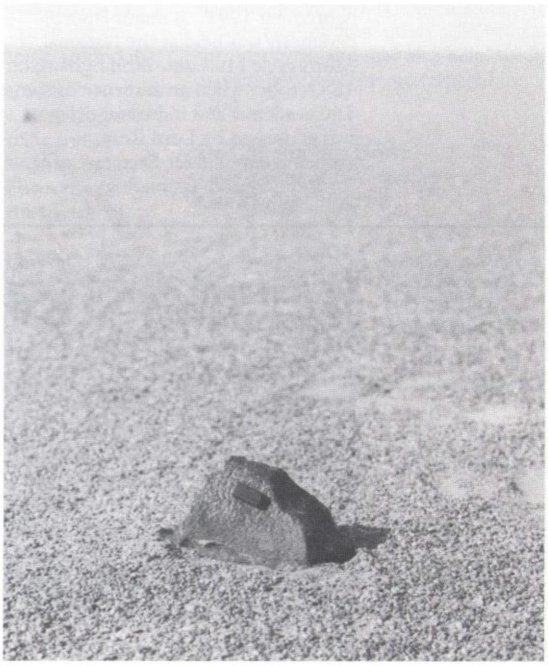


Figure 5: Deserts have accumulated as much as 40,000 years of meteorite infall and there could be a kilogram-sized specimen every 5 km^2 in regions where wind activity has removed the fine sand.

Protein structure-function studies

Oxford Centre for Molecular Sciences (OCMS), under the direction of Professor Jack Baldwin, is embarking on an important Protein Engineering LINK research project in collaboration with ICI Pharmaceuticals and Oxford Instruments. The total project value is £3.95 million of which SERC is to contribute £500,000.

The project is planned over five years and will consist of two key elements. The OCMS will employ crystallisation and high-field nuclear magnetic resonance (NMR) techniques to determine the structures of several proteins of pharmaceutical and agrochemical interest including dioxygeneses, cell adhesion molecules (selectins and immunoglobulins), and tyrosine kinases and phosphatases. This work will be possible through the second major element which is the development of a high-field (750 MHz) NMR spectrometer, the first in the world of this size.

Oxford Instruments, already a world-leader in the development and production of NMR magnets, will construct the 750 MHz magnet for which the OCMS will contribute to the development of the probe and instrumentation. The resulting machine should be capable of resolving the structure of molecules in the 30-40 kDa (kiloDaltons) size range, a significant advance over the maximum of 20 kDa that the largest presently available 600 MHz instruments are capable of.

This major research programme has been widely judged to be of strategic importance to the UK in the field of protein research and will significantly enhance the already substantial world lead of the UK in NMR magnet and instrument technology. The skills and expertise of each group across a range of disciplines has been brought together by this project to form the necessary multi-integration and momentum that joins the science base and industry and is at the heart of the LINK philosophy.

LINK programme in enhanced engineering materials

A new £20 million programme on Enhanced Engineering Materials, supported by SERC and the Department of Trade and Industry, has recently started. This Programme, the thirtieth to be launched under the LINK Initiative, was announced by the Secretary of State for Trade and Industry, Peter Lilley, on 17 September 1991. A major launch ceremony was held at the National Motorcycle Museum, Birmingham, on 18 October when an audience of some 150 academic and industrial delegates was addressed by Lord Reay, Parliamentary Under-Secretary of State for Industry and Technology.

The programme will support research into a wide range of conventional and advanced materials, with the intention of significantly improving critical technical parameters to allow wider application and better processing capabilities for industry. The objective of the programme is to integrate a better scientific understanding of the properties of the materials with improvements in the design and manufacturing processes.

Outline applications for projects can now be accepted by the secretariat for consideration at the next Programme Management Committee Meeting.

The Coordinator will be pleased to hear from any organisation who might be interested in collaborating on a project. As with all LINK Programmes, any project must have both academic and industrial partners.

The Programme Coordinator is: Professor Gordon Brown, 34 Bellencroft Gardens, Merry Hill, Wolverhampton WV3 8DT; telephone (0902) 761430.

A full information pack relating to the programme is available from:

Robert Higman, LINK Enhanced Engineering Materials Secretariat, Manufacturing Technology Division — Branch 2, DTI, 151 Buckingham Palace Road, London SW1W 9SS; telephone 071-215 1547; or **Dr Jenny King**, Materials Commission, SERC Swindon Office; telephone (0793) 411166.

Parallel supercomputing at Daresbury

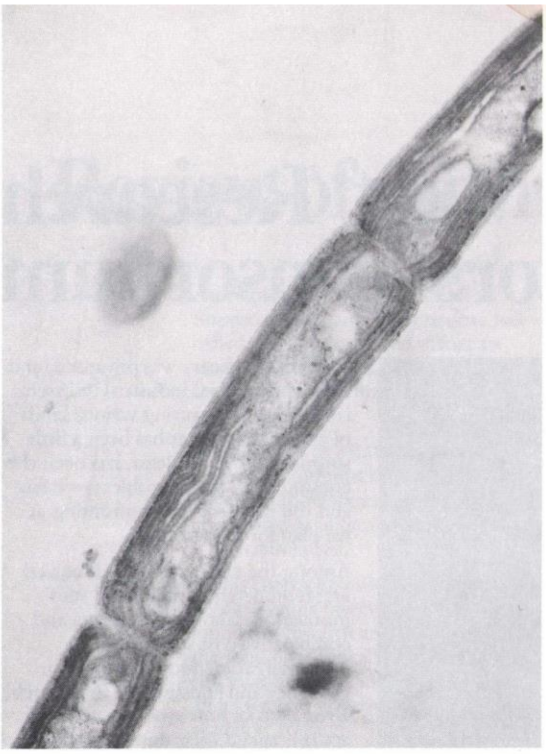
Daresbury Laboratory operates a number of powerful parallel computing systems of which the focus is the Intel iPSC/860. This is a 32-processor system with 16 MBytes memory on each processor and a peak speed of 1.9 Gflops (in double precision). The iPSC/860 has been at Daresbury for one year, during which time a great deal of development has been done. Many real scientific codes (often from the Collaborative Computational Projects) are now running very successfully in parallel versions (eg GAMESS, CRYSTAL, LMTO, KKRCPA, Car-Parrinello codes, CASCADE, DLXANES, XPLOR, EIKONXS, several molecular simulation and fluid dynamics codes, and many more described in a directory of parallel supercomputing projects available on request).

The parallel supercomputers at Daresbury are now being made available under peer review to the scientific community, and substantial bids have already been received. For further information contact:

Dr Francis Yeung (telephone (0925) 603178, Email address: H.K.F.Yeung@uk.ac.daresbury;

Dr Martyn Guest (telephone (0925) 603247, Email address: M.F.Guest@uk.ac.daresbury; or

Dr Paul Durham (telephone (0925) 603263, Email address: P.J.Durham@uk.ac.daresbury.



Electron micrograph of the filamentous cyanobacterium *Phormidium laminosum*. The cells are approximately 0.7 µm wide. Concentric layers of thylakoid membrane can be seen within the cytoplasm. (Photo: D P Hill Cambridge University).

Biological membrane function in cyanobacteria

Cyanobacteria, a group of oxygen-producing photosynthetic bacteria also known as blue-green algae, have had a bad press recently, because of their ability to form spectacular growth ('blooms') on lakes and reservoirs. Although inconvenient for sailors, anglers and others, the main concern with such blooms is that many of the cyanobacteria are toxic, killing livestock and possibly causing skin irritation, pneumonia and other diseases in humans. Against this poor public image, Dr Chris Howe of Cambridge University reminds us that cyanobacteria are responsible for a large part of global oceanic carbon dioxide fixation (some estimates put their contribution as high as 50% or more) and they, or something very like them, were the first organisms to produce oxygen.

Cyanobacteria are widely believed to be simple, as fossil evidence for very similar organisms comes from formations 3.5 billion years old, but that view is far from accurate. Many species can fix nitrogen. Often this is done inside specialised non-photosynthetic cells — heterocysts — within filaments of photosynthetic cells. This division of function between different and specialised cell types is rare in many-celled prokaryotes, or 'simple organisms'. Many species can 'fine-tune' the spectral characteristics of their photosynthetic pigments according to the quality of the light they receive, to make the best use of it. And unlike most prokaryotes, cyanobacteria maintain two different membrane systems — the thylakoids (rather like a series of plastic bags) inside the cell, and the plasma membrane around it.

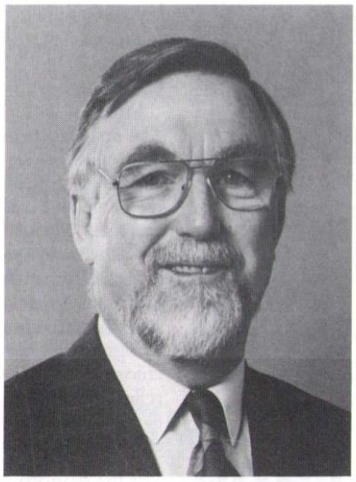
With support from the SERC Biological Membranes Initiative, we are studying how proteins end up associated with the correct membrane. We and others have shown that proteins destined for the thylakoid lumen (effectively the inside of the plastic bag) are synthesised as precursors, with an extra sequence at the beginning. This extra sequence directs the protein to the lumen and is removed in the process. Similar sequences are used in eukaryotic plants to direct proteins into the chloroplast thylakoid lumen. Here, though, the sequence is part of a more complicated 'address label'. The corresponding proteins are synthesised outside the chloroplast with a two-stage extension. The first directs import into the chloroplast and is removed. The second then directs passage into the thylakoid and is also removed. It is this second stage that is similar to the 'label' used by cyanobacteria, and indeed a cyanobacterial enzyme preparation that removes it from cyanobacterial proteins will also recognise and remove it from chloroplast proteins. Such similarity reflects the origin of chloroplasts from oxygenic photosynthetic bacteria engulfed by non-photosynthetic cells.

But the cyanobacteria pose a more subtle problem. The sequences directing proteins to the thylakoid are also similar to those that in other bacteria (and evidence suggests in cyanobacteria too) would direct them to the *plasma* membrane. Yet cyanobacteria are able to regulate the protein composition of their membranes independently. Some proteins occur just in one; some in the other. Some are in both, in a proportion that the cell can control according to its physiological needs. Understanding how this is achieved is the next goal, and may also help explain how proteins are targeted in plant cells.

Dr Christopher Howe
Department of Biochemistry
Cambridge University

Shoreline of Rutland Water, showing a bloom of toxic *Microcystis* in 1989.

North West Research Directors' consortium



Alan Leadbetter

In the Autumn of 1988, just after Alan Leadbetter moved to Daresbury as Director of the Laboratory, the inaugural meeting took place of a group of Research Directors from laboratories situated in the North West. The meetings have continued twice a year since then. Initially the group comprised, in addition to Daresbury, the Heads of the Research Laboratories from ICI Runcorn, UK Atomic Energy Authority, Risley, Pilkington Bros at Lathom, Unilever at Port Sunlight, the Electricity Council Research Centre at Capenhurst and Shell, whose David Parkes initiated the meetings, at Thornton Research Centre, Chester. The group has since grown and now involves also British Nuclear Fuels, Risley and Albright and Wilson, Oldbury. The idea has been to meet informally for three hours or so and to discuss issues of common interest, some of which are described here by Professor Leadbetter.

There is I suppose a tendency for each type of laboratory to consider that it is in some sense unique. Daresbury is after all an SERC establishment, mostly publicly funded and existing primarily to provide large facilities for the use of the academic research community. The AEA laboratories were in the process of becoming part of an agency; BNFL, although concerned with the nuclear industry, is a private company; during the course of our meetings, the Electricity Council Research Centre at Capenhurst became the Electricity Research and Development Centre when that industry was privatised, and the remainder are industrial research laboratories supporting various kinds of businesses. What has been a little surprising, to me at least, has been the commonality of the problems we face and the issues we are confronting as we plan for the future.

Among the topics we have discussed are: remuneration policy and staff motivation; laboratory budgets and comparative cost structures; industrial/academic collaboration; efficiency and effectiveness in research; an analysis of how research scientists actually spend their time; practical advice for first line managers and the management of change. Each meeting is held in a different laboratory and the host generally leads the discussion which is unfettered and informative — certainly I and my colleagues have learnt a great deal from our interaction with the other laboratories.

Perhaps the most notable example of a rapid learning curve initiated by these discussions is that relating to the concept of 'total quality' and how it might be implemented in a research organisation. Two years ago we were almost wholly ignorant on these matters and looking back from our present situation this now seems unbelievable. We have been brought into contact with the ideas of the various management gurus like Crosby and Peters, we know that quality means 'conformance to requirements', we can identify our customers and we know that their interests come first.

In seeking to implement ideas for improving quality, excellence, communications, flow of suggestions at all levels in the organisation, we sought professional help and this led to the famous (or infamous) 'MAD Campaign' at Daresbury. MAD stands for Make A Difference, and this was a one month campaign with follow-up for many months afterwards which was led by our paid advisers, but in which all the real work was done by our own staff. This indeed is an essential part of the programme, for the idea is to involve everyone in the laboratory. The campaign was aimed at individual job quality, work output quality and customer/contractor interaction. Some 97% of staff took part, submitting 2,560 ideas, of which several hundred have been implemented: mostly small but significant changes making a difference to the job of the individual or the interaction with the customer. The campaign was very successful, although like all such campaigns it must be followed up by continuing attention to quality, which has to be the responsibility of every individual.

Of course one pays for professional advice, and it doesn't come cheaply, but the deal was that if the suggestions made did not result within one year in savings which exceeded the fee, then the fee would be refunded. We were well able to demonstrate that we really saved no money from the many suggestions which were made, even though many of them were useful: most suggestions of course cost money to implement. We did get our refund, so in external costs at least we got the campaign free. I like to believe that, despite the huge number of suggestions coming forward, the reason that none of them led to significant savings is that we run a pretty tight ship already!

The decision to close the Nuclear Structure Facility at Daresbury has been pretty traumatic for us and we are having to plan for major change. But there is a recession out there for everyone and in addition AEA has been acquiring agency status and reducing its staff numbers significantly. The meeting we had to discuss the management of change was very timely for us, and it was most helpful to find how others have faced up to the problems of major change in general and reduction of staff in particular. The problems and the means of solving them are fairly common. Unfortunately the financial package available for staff taking early retirement or severance under the SERC's Civil Service terms is not as good as that available elsewhere.

All the laboratories are facing up to questions about how best to motivate staff; how to use the time of highly qualified scientists most effectively so that they are doing science and not for example attending useless meetings; how to help, with practical advice, scientists who also have to manage; and how to measure efficiency and effectiveness in research. In particular, we need to know how to distinguish between the two, for efficiency tends to be the thing that is easy to measure, and effectiveness is what is really important. Let me mention a few things that stand out from all these discussions for Daresbury and the other SERC establishments compared with industry. First salaries; it may come as a surprise to learn that for the normal career grades salary maxima are roughly the same everywhere. Formal reporting systems are universally used, as is some element of performance pay.

continued from page 22

Differences are that in industry starting salaries are much higher, the reporting system is open and more senior people do much better for both salary and perks. Comparison of staff numbers, budgets and related things tend to be difficult because of different definitions, but a few rough conclusions can be drawn and they are interesting. For example, Daresbury overheads costs compare favourably with those of the other laboratories. Average staff costs are on the low side, capital expenditure is high but travel is low and training expenditure is lower than everywhere else by between a factor of 2 and greater than 4.

An interesting analogy may be made between the role of the SERC establishments and industrial laboratories in relation to their primary customers. The corporate industrial laboratories must serve the various businesses and they have to obtain their funds from these businesses and satisfy their requirements for research. In the same way the SERC establishments must serve the requirements of their various Boards and we obtain our funds through the Boards. However, it is common practice in industry for the corporate laboratory to add a 10% levy to its charges to the businesses. This levy is used to fund research chosen by themselves and is regarded as essential for healthy functioning of a research laboratory. This may be compared with the Council policy of encouraging up to 10% of direct staff effort in its establishments to be devoted to in-house research. Unfortunately, however, this is not achieved, at least in the larger establishments, because of difficulties in setting aside the required resources. In my view if we wait for better times we will wait for ever to achieve this and so perhaps we should take a leaf from industry's book and have a financial levy on the Boards to fund in-house research in our establishments. The quality of this would, of course, have to stand up to peer review judgement, but the establishments would have no fears on this score.

In conclusion I can say that these informal meetings between Heads of Research Laboratories of superficially very different character have been highly enjoyable, have broadened our perspectives and have taught us a lot. Long may they continue.

Professor A J Leadbetter
Director
Daresbury Laboratory

Review of superconductivity

A review of the UK National Superconductivity Programme has called for a determined effort to ensure that the UK remains at the forefront in this important area of science.

The review was conducted by the National Committee for Superconductivity under the chairmanship of Sir Martin Wood, who commented:

" This challenge calls for a determined national effort involving faith in the long term rewards and commitment to the long haul. It calls for increased risk investment by industry as well as an increase in government funding for academic research. I have a foot in each camp — in industry and in fundamental research — and the urgent need for support in both camps is very clear to me. If we meet the challenge and succeed, our manufacturing industry can look forward to participating in a raft of new and exciting markets and our scientific efforts will remain in the front line. "

Superconductivity is the loss of all electrical resistance. Conventional superconductors show this only at extremely low temperatures (below -240C). The new high temperature superconducting materials exhibit this property at about -180C. This enables liquid nitrogen coolant, or more conventional cryogenic engineering, to be employed rather than the expensive and cumbersome liquid helium coolant required for conventional superconductors. Substantial commercial advantages are therefore gained.

The joint Department of Trade and Industry-SERC National Committee for Superconductivity (NCS) was established in 1987 to formulate and review policy and strategy and to oversee government-funded research in academic institutions and industry. Sir Martin Wood has since handed over the chairmanship to Professor Colin Gough. The Committee also appointed a National Coordinator for the programme. The Ministry of Defence, although running its own internal programme and supporting both academic and industrial projects, is represented on NCS and has contributed to its work.

A national research programme for superconductivity was produced by the NCS early in 1988. It set out a plan which would enable UK research to achieve world standing in the field and in turn to ensure that UK industry acquired the knowledge and expertise required for successful exploitation.

The review has identified a number of areas where efforts should be focused and these are given in the *Executive summary and recommendations* section of the report. Among the principal recommendations are:

- During the current two-year extension of the DTI-supported industrial programme, special encouragement should be directed towards projects involving the construction of large demonstrator prototypes, and towards methods of involving more academic collaboration.
- Plans should be initiated for a new DTI-supported programme to begin when the current one finishes, to give continuity to the overall development of industrial R&D.
- DTI staff and consultants and the NCS coordinator should continue to take active steps to increase the interest and involvement of industrial and commercial organisations.
- The academic research programmes relating to low and to high temperature superconductivity should be continued and reinforced — subject to peer review — and there should be a substantial increase in research related to enabling technologies and applications.
- The level of funding for the SERC research grants (outside the IRC) should be increased to £3.4 million a year (at 1990-91 prices) in order to be able to maintain the front line position of UK academic research and to be able to provide an effective partnership with industry. There should be a special equipment fund of £1.4 million to be spent during the next two years to upgrade the overall laboratory standards so that SERC-funded research can be pursued efficiently.
- The Interdisciplinary Research Centre for Superconductivity in Cambridge University should be strengthened as the foremost superconductivity research centre in the UK, and it should further increase its links with industry and the rest of the academic programme.

New scientific programmes launched by ESF

The1991 General Assembly of the European Science Foundation (ESF), held in Strasbourg in November, approved the launch of three new scientific programmes relevant to SERC. They are the European Neuroscience Programme and the Programmes on Developmental Biology and Kinetic Processes in Minerals and Ceramics. Scientific programmes such as these are administered by the ESF but are funded from special contributions paid by interested member organisations.

The European Neuroscience Programme will run for a period of five years and will replace the European Training Programme in Brain and Behaviour Research which has been running since 1976. It will foster interdisciplinary collaborative work with the aim of improving our understanding of human intelligence and of mental and neurological diseases.

The key feature of this major £1.9 million programme will be the creation of European Neuroscience Research Nuclei — consortia of existing laboratories collaborating on specific, strategically chosen projects. To aid the creation and operation of these nuclei, and to promote European collaboration in neuroscience in the wider sense, the programme will provide European Research Grants to fund reciprocal visits between collaborating teams; short-term fellowships to support visits of up to three months by postdoctoral researchers; pre-doctoral fellowships; and funds to arrange week-long advanced technical courses.

The Programme on Developmental Biology will replace the Scientific Network on this topic which ran from 1989 to 1991. This five-year programme will focus on the molecular mechanisms of embryonic induction and pattern formation. In particular, it aims to elucidate the genetic and signalling hierarchies underlying embryonal axis formation and regional differentiation and to establish novel experimental approaches to reveal the interplay between these systems.

With a budget of around £1.1 million, it will comprise study workshops, advanced research workshops, travel grants to support short working visits to collaborating laboratories and short-term (up to three months) and long-term (up to two years) visiting fellowships. It will also set up an ethical panel to assess and devise guidelines for the use of transgenic methods in animal embryo research.

The Programme on Kinetic Processes in Minerals and Ceramics will run initially for two years with a budget of £80,000. The programme's objective is to achieve a better understanding of the formation of the frequently complicated microstructures of minerals and of the degradation of ceramic materials. It will focus on three main areas of interdisciplinary research: the structure and dynamics of interfaces; the effect of hydrogen and hydrogen-related defects on the kinetics of transport properties; and the improvement of *in situ* techniques and instrumentation. The money will be used for a series of workshops and for short (one to three weeks) exchanges of postdoctoral scientists between participating laboratories.

These three new programmes double the number of current ESF scientific programmes in areas relevant to SERC. The existing programmes are:

Chemistry of Metals in Biological Systems — a five year programme launched in 1991. It aims to stimulate and coordinate interdisciplinary collaborative research projects on the role of metal ions in biology and involves a series of workshops and conferences. There are also plans for a fellowship scheme.

Study Centres in Non-Linear Systems — a four-year programme launched in 1991. It will comprise seven study centres, each focusing on a particular aspect of non-linear mathematics, but attracting scientists from a wide range of disciplines.

Dynamics of Gas-Surface Interactions — a five-year programme launched in 1991 with the aim of promoting European collaboration in the study of dynamic and kinetic events at solid surfaces. It provides funds for short visits, workshops and summer schools.

Further information on these programmes is available from Dr J H Kock (for Neuroscience and Developmental Biology) or Dr M Mahnig (for the others) at the ESF, 1 Quai Lezay Marnesia, 67080 Strasbourg Cedex, France (Tel: 010 33 88 76 71 00); or from the chairmen of the committees (see below). General information on the ESF and its activities is also available from the International Section at SERC's Swindon Office.

Contact points for ESF Scientific Programmes

European Neuroscience Programme
Chairman of Steering Committee: Professor M M Burger, Friedrich Miescher-Institut, PO Box 25, 4002 Basle, Switzerland.

Developmental Biology
Chairman of Steering Committee: Professor S de Laat, Hubrecht Laboratory, Netherlands Institute for Developmental Biology, Uppsalalaan 8, 3584 CT Utrecht, The Netherlands.

Kinetic Processes in Minerals and Ceramics
Chairman of Coordinating Committee: Professor F Seifert, Bayreuth University, 8580 Bayreuth, Postfach 101251, Germany.

Chemistry of Metals in Biological Systems
Chairman of Steering Group: Professor H Sigel, University of Basle, Petersplatz 1, 4003 Basle, Switzerland.

Study Centres in Non-Linear Systems
Chairman of Coordinating Committee: Professor N Riley, School of Mathematics and Physics, East Anglia University, Norwich NR4 7TJ.

Dynamics of Gas-Surface Interactions
Chairman of Steering Committee: Professor D A King, Department of Chemistry, Cambridge University, Lensfield Road, Cambridge CB2 1EP.

Professor Gareth Roberts FRS (left), Vice Chancellor of Sheffield University, and Jean Gabolde, Head of Science Policy of the EC's DG XII programme, in discussion at the SERC display at the new office.

European Office opened

The UK Research and Higher Education European Office (UKRHEEO), formed by the merger of the previous similar offices of the Research Councils and the British Council, was officially opened in Brussels on 11 October 1991. The opening was performed by Professor John Knill, Chairman of the Natural Environment Research Council, Sir Richard Francis, Director-General of the British Council and Dr Jean-Pierre Contzen, Deputy Director General for Science, Research and Development (DG XII) in the European Commission and Head of the EC's Joint Research Centre.

In his speech Dr Contzen welcomed the opportunities for dialogue and discussion between the Commission and the science and education bodies and practitioners in the member states which the establishment of liaison offices such as UKRHEEO represented. He noted the expanded UK presence as an indication of the increasing contribution of British workers in EC programmes. Sir Richard Francis stressed the role of the British Council in fostering the networks and links, both within and beyond the Community, which were essential to EC activities. Professor Knill foresaw the development of UKRHEEO as reflecting the increasing importance of the European Community in research and education and the growing interdependence within Europe in these fields as we move to the next century.

The opening was attended by more than one hundred guests, mostly from the European Commission, and featured small exhibitions of the European and other activities of the Research Councils, British Council and UK higher education institutions.

UKRHEEO exists to promote British participation in EC research and education programmes. It provides information, advice and guidance on European opportunities and how to exploit them, to Research Councils and academic institutions on a subscription basis. Further information about UKRHEEO can be obtained from:

Dr Alf Game
Head of UKRHEEO

Rue de la Loi 83, BP10,
B-1040 Brussels, Belgium.
Telephone (010 32) 2 230 5275,
fax 2 230 4803,
e-mail SAGGO@UK.AC.RL.IB.

BRITISH COUNCIL SCHEMES

Acciones Integradas Hispano-Britanicas

This programme was established in 1983 and is jointly run and financed by the British Council and the Spanish Ministry of Education and Science with the aim of initiating scientific and cultural collaboration between universities, polytechnics and public-sector research institutes of the two countries.

The programme provides grants for travel and subsistence costs only, for exchange visits which are an essential part of the collaborative project. Each application should be for one year's support as the scheme is intended as 'pump-priming' for research links which should subsequently be maintained using funding from other sources.

All applications (closing dates apply) must be made concurrently by both the British and Spanish groups which propose to collaborate. Further information for British applicants is available from:

Assistant Director, Science and Exchanges (Acciones Integradas)
The British Council
Almagro, 5
28010 Madrid
Spain.

UK-Dutch joint scientific research programme

This is a new programme, established in 1990, jointly run and financed by the British Council and the Netherlands Organisation for Scientific Research (NWO) with the aim of stimulating scientific and academic research collaboration between higher education institutes of the two countries.

The programme provides grants for travel and subsistence costs only for visits of between two weeks and two months. Project proposals can be submitted by scientists and academics attached to institutions of higher education in either country to work in the same field of research or in different disciplines which complement each other. Proposals for visits aimed at drawing up collaborative projects may also be considered.

Proposals should be submitted at least three months before proposed visits are due to take place.

Further information for British applicants is available from:

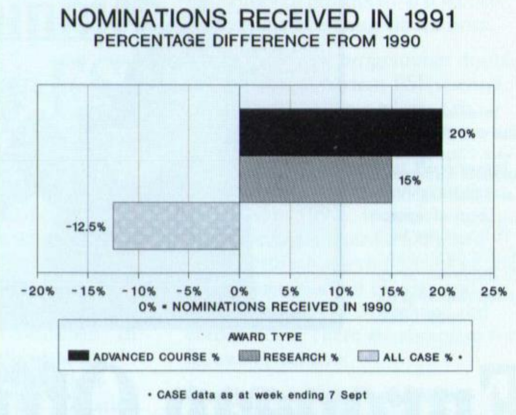
Exchanges Officer
The British Council
Keizersgracht 343
1016 EH Amsterdam
The Netherlands.

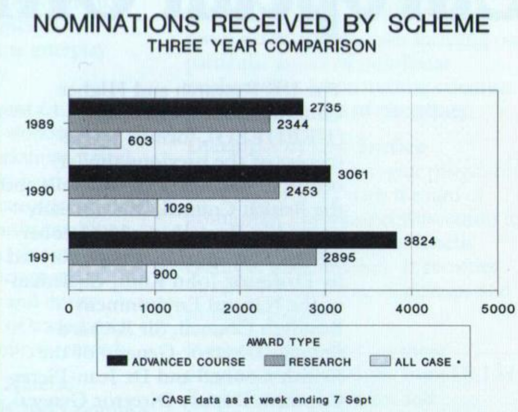
SERC awards 1991-92: increased demand for studentships

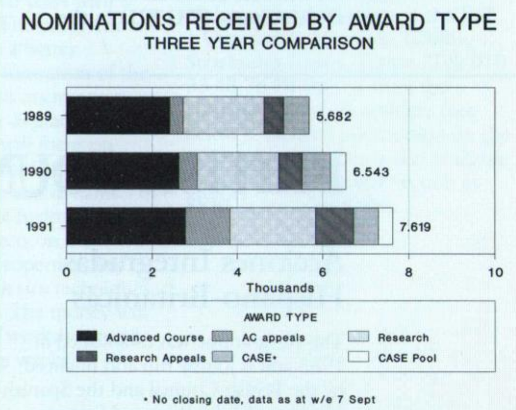
The number of applicants for SERC awards in 1991-92 continued the increase evident in 1990-91. At the conclusion of the summer awarding exercise, standard research nominations were up by 15% and those for advanced courses by 20%. It is likely that the present difficulties in the job market have contributed to the number of graduates opting for postgraduate training, with a preference being shown for one-year vocational and conversion courses at Masters level.

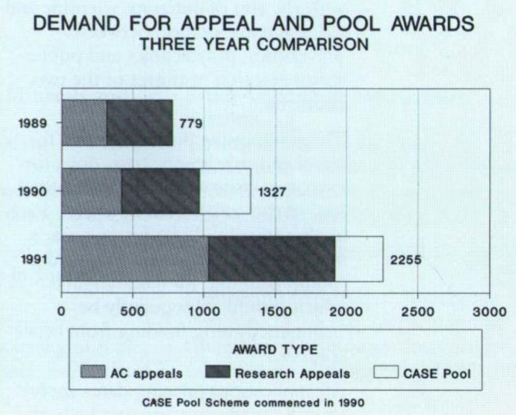
Nominations for Cooperative Awards in Science and Engineering (CASE) are down 12.5% compared with the same period last year. However, demand in 1990 had been stimulated by the introduction of the CASE Pool scheme, which has been restricted this year, and other measures which enhanced the value of these awards. The present level of applications remains satisfactory, with a 33% increase over this period in 1989.

Financial constraints and buoyant demand for studentships have placed severe pressure on the appeals exercise this year. In addition to the expected nominations for quota awards, applications for all types of appeal studentships have increased by 41% over the equivalent period in 1990. Consequently only the highest category of applicants have been offered awards.









Some new publications from SERC

Unless otherwise stated, all publications are available free of charge from SERC Swindon Office, telephone (0793) 41 + extension number or (0793) 411000.

SERC annual report and fact sheet

Copies of the *Science and Engineering Research Council report for the year 1990-91* and of the *Fact sheet and statistics 1991* are available from Janet Edwards, Public Relations Unit, ext 1256.

Corporate plan

Copies of SERC's *Third corporate plan* and a summary of the plan are available from Janet Edwards as above.

What is SERC?

A new illustrated leaflet introducing SERC has been produced. Copies of *What is SERC?* are available as above.

Core science

Copies of *A strategy for support of core science* are available from Rachel Pike, ext 1314.

Particle physics

Copies of both *Particle physics 2000: a report by the SERC Particle Physics Committee* and a summary of the report are available from Pamela Money, ext 1057.

Materials

Copies of three publications are available from the Materials Commission: *Enhanced Engineering Materials* information pack, from Dr Jenny King, ext 1166; Magnetism and Magnetic Materials Initiative's *MMMI newsline*, from Attila Emecz, ext 1110; and *Superconductivity: review of the UK National Superconductivity Programme* from Dr Irene Scullion, ext 1338.

ACME Directorate

Copies of *Successful manufacturing research: case studies in academic-industrial collaboration* are available from Gay Ford, ext 1106.

Teaching Company Scheme

Copies of the *Review of the Teaching Company Scheme* (the report of a panel chaired by Professor B E F Fender to the Engineering Board) are available from Deirdre Ackland, ext 2092.

Engineering

Copies of *The engineering doctorate: an SERC working party report* are available from Dr Richard Liwicki, ext 1429; and the *Coastal Engineering Research Programme* leaflet from Dr Paul Meakin, ext 1155.

Clean technology

Three reports — *Farming as an engineering process; Harnessing photosynthesis;* and *Clean routes to effect chemicals* — are available from Dr N Lawrence, ext 1122.

SERC enquiry points

To make it easier to find the right person when you telephone our administrative offices in Swindon (or elsewhere), we have updated our list of key contact points. Except where otherwise stated, all extension numbers are at SERC Swindon Office. The switchboard number is Swindon (0793) 411000 (for extensions beginning 2); or dial Swindon (0793) 41+ extension number. The central fax number is Swindon (0793) 411400.

ASTRONOMY AND PLANETARY SCIENCE DIVISION

Studentships and fellowships — RC Hodgon, ext 1267

Ground-based Programme Committee

International activities — Miss RL Sirey, ext 1417

UK activities — Dr PB Sharma, ext 1416

Research grants — RC Campbell, ext 1195

PATT awards — Mrs S Fuller, ext 1259

BRITISH NATIONAL SPACE CENTRE

Space Science Programme Board and Earth Observation Programme Board
(SO: Swindon Office; DBH: Dean Bradley House, 071-276 + extension)

UK activities — Dr RLT Street, SO ext 1265

Research grants — RC Campbell, SO ext 1195

International activities — P Bradbury, DBH ext 2429

Microgravity — Mrs Y Windsor, DBH ext 2441

ESA fellowships & Young Graduate Trainee scheme — A Richardson, DBH ext 2438

ENGINEERING DIVISION

Construction — A Coates, ext 1487

Geotechnics; water, environmental & coastal engineering — Dr P Meakin, ext 1155

Transportation — Dr A Rawlins, ext 1353

Electrical and power industries — Dr C Brodey, ext 1350

Aerospace industries — R Bond, ext 1143

Machinery, plant and vehicle industries — H Thurbon, ext 1117

Particulate and coal coal technology; chemical engineering — Dr NV Pratt, ext 1484

Separation processes — Miss H Wray, ext 1476

Joint ESRC-SERC; engineering design — Mrs J Sullivan, ext 1431

Education and training — Dr R Liwicki, ext 1429

Interdisciplinary Research Centres — Miss D Ackland, ext 2092

Clean technology — Dr N Lawrence, ext 1122

DIRECTORATES

ACME (Appliacation of Computers to Manufacturing Engineering) — Mrs G Ford, ext 1106

Biotechnology — J McIlherron, ext 1310

Information Technology

JFIT — Miss FE Smith, ext 1478

Systems engineering — Dr MH Crowther, ext 1260

Control and instrumentation — Dr LA Thompson, ext 1401

Communications and distributed systems — Ms C Ewart, ext 1436

Advanced devices and materials; optoelectronics — Miss A-M Hilder, ext 1346

VSLI technology — PN Burnell, ext 1161

Systems architectures — J Baird, ext 1125

Education and training — Mrs S Griffiths, ext 1456

IT publicity — Mrs L Tracey, ext 2041

Marine Technology — BG Richardson, 071-321 0674

Teaching Company Faringdon (0367) 242822 — Miss K Enifer, ext 208

NUCLEAR PHYSICS DIVISION

Particle physics; studentships and fellowships — Miss C Armstrong, ext 1278

Nuclear structure — Dr H Simmons, ext 1331

CERN — M Bowthorpe, ext 1271

SCIENCE DIVISION

Biological sciences — Dr SJ Milsom, ext 1136

Mathematics — Dr I Cameron, ext 1264

Physics; science-based archaeology — NL Williams, ext 1261

Chemistry — PD Tomsen, ext 1496

Synchrotron radiation facility; laser facility — AG Buckley, ext 1061

Pharmacy; Science Board — Dr GLl Richards, ext 1323

Neutron facilities; Science Board — Dr ER Boston, ext 1113

Computing Committee Education and training — E Sparkes, ext 1369

MATERIALS COMMISSION

Ceramic and inorganic materials — Dr JA King, ext 1166

Metals and magnetic materials — AVR Emecz, ext 1110

Polymers and composites — R Startin-Field, ext 1435

Medical engineering and sensors — Dr A Thomas, ext 1108

Semiconductors and superconductivity — Dr IM Scullion, ext 1338

Molecular electronics — Miss M Burke, ext 1124

General enquiries — RE Hobbs, ext 1277

FINANCE

Account queries (Swindon) — Mrs AB McKeown, ext 1434

RESEARCH GRANTS

Most enquiries should be addressed to the appropriate subject committee.

Terms and conditions; supply of forms — ext 1445

STUDENTSHIPS

Applications

Advanced course studentships. — ext 1414

Research studentships — ext 1030

Studentships tenable abroad, including NATO.

CASE — ext 1138

General enquiries — ext 1041

Current awards

For current studentships, give the switchboard the name of your institution.

FELLOWSHIPS

Postdoctoral (home, overseas, NATO); advanced and senior fellowships. — ext 1172/1403

Royal Society/SERC Industrial. — ext 1206/1352

CERN — ext 1057

ESA — 071-276 2438

Visiting fellowships on grants:
Enquiries should be made to the appropriate subject committee.

INTERNATIONAL COLLABORATION

European Community, Japan, NATO fellowships — RD Cann, ext 1315

ESF, NATO, rest of world — Dr A LeMasurier, ext 2085

General enquiries — ext 1121, 1498

UK Research and Higher Education European office — Dr A Game, 010-322-230-5275

CENTRAL COMPUTING

Dr B W Davies, Rutherford Appleton Laboratory, Didcot (0235) 821900 ext 5547

INDUSTRIAL AFFAIRS UNIT

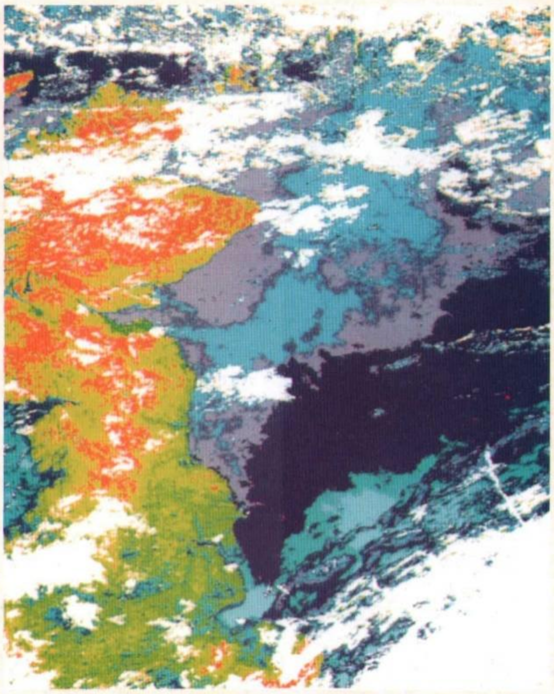
Dr R Burdett — ext 1173

LINK — A Medland, ext 1162

SERC BULLETIN PRESS ENQUIRIES

ext 1120
ext 1257/1256

Further addresses appear on page 2.

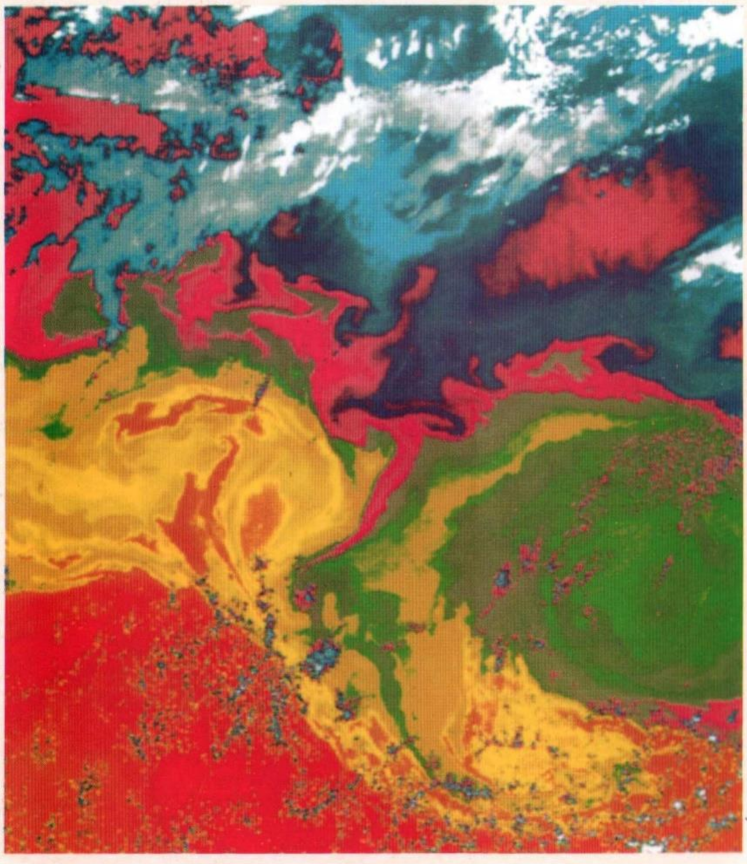


Thermal infrared image of Britain and the North Sea produced by the SERC-made ATSR instrument on the ERS-1 satellite.

The ATSR's infrared sensors detect thermal emissions given off by the land, sea and cloud surfaces.

The image was produced using false colours which show the land as green, the sea as blue and the clouds as white. The scene is 500 km wide. (Image processed by RAL Informatics Dept).

Measuring sea-surface temperature from space



This infrared image, of thermal radiation at 3.7 μm wavelength, shows part of the Atlantic Ocean off the Northeast US Coast (South of Cape Cod). Warm water from the Gulf Stream can be seen meeting cold water from the Labrador Current and the formation of a giant eddy structure (200 km in diameter) at the interface between these two.

This image shows a 15°C range of measured brightness temperatures over a distance of 500 km.

In this false colour representation warm objects appear red and cold objects (clouds) appear white. Land temperatures fall in the middle of the range and the characteristic shape of Cape Cod can just be discerned centrally at the top of the image. (Image processed by RAL Space Science Dept).

On 16 July 1991, a European Space Agency Ariane rocket successfully carried the first European Remote Sensing Satellite, ERS-1, into polar orbit. On board was SERC's Along Track Scanning Radiometer (ATSR), a new infrared imaging radiometer designed to make precise measurements of the temperature at the surface of the global oceans, a parameter of great importance to climate research.

ATSR is designed to achieve very high levels of accuracy (about 0.3K) required for modelling the behaviour of the global climate. This is a key geophysical variable for research into climate and the global energy balance, and recent concerns regarding the enhanced greenhouse effect have highlighted its importance. Following its switch-on on 1 August, ATSR's detectors were cooled to their operating temperature of 80K, using the new miniature space-qualified Stirling Cycle Cooler, specially developed for space applications by Oxford University and Rutherford Appleton Laboratory. Soon after switch-on ATSR was producing infrared images of outstanding quality, processed by the RAL teams using a software system specified and written in house.

ATSR is the first in a series of instruments that will continue these measurements into the next century. The next, ATSR-2, is currently being built for the ERS-2 mission (to fly in 1994) and will have all the same characteristics of the first instrument but will also carry visible channels for use in land remote-sensing in addition to the ATSR infrared channels. For this, it will be necessary to develop new data-processing software and work has started on consulting the user community on the requirements for this. Scientists and engineers at RAL have been involved in the early definition of a third ATSR instrument, the Advanced ATSR, which is likely to fly on the European Polar Platform around the turn of the century.

ATSR was produced for the European Space Agency by a consortium of research institutes (including Oxford University's Department of Atmospheric, Oceanic and Planetary Physics, University College London's Mullard Space Science Laboratory, and the UK Meteorological Office) led by RAL, with substantial contributions from Australia and France.

Dr D Llewellyn-Jones
Rutherford Appleton Laboratory