SERC BULLETIN

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In this issue

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The Science and Engineering Research Council is one of five councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through the provision of grants and studentships and by the facilities which its own establishments provide for academic research. The *SERC Bulletin* summarises topics concerned with the policy, programmes and reports of SERC.

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

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SERC's new Secretary

Dr J A Catterall became Secretary of SERC on 1 November 1983 in succession to Mr Brian W Oakley CBE who returned to the Department of Trade and Industry in June 1983 to head the Alvey Directorate.

Educated at Imperial College, London (1946-52), where he studied metallurgy and physics, Ashley Catterall has been Deputy Chief Scientist and Head of Energy Technology Division, Department of Energy, since 1981. He has been in Government service since 1952 when he joined the National Physical Laboratory, carrying out research into alloy theory, solid state physics and superconductivity.

In 1974, he moved from NPL to the Department of Industry headquarters where, in 1977, he became the Under Secretary heading the Research and Technology Policy Division. His responsibilities included management of six of the DoI Research Requirements Boards, research policy and long-term strategy.

At the Department of Energy, he was responsible for the research budget which covers programmes on alternative energy sources, offshore energy technology and energy conservation. The budget also covers the work of the Energy Technology Support Unit and the Marine Technology Support Unit at Harwell. He was, in addition, concerned with research strategy, with the provision of policy advice to other parts of the Department, and with various other matters including relations with nationalised energy industries' research and development and with the Research Councils.

Dr Catterall is a Fellow of the Institution of Metallurgists, a Fellow of the Institute of Physics and Chartered Engineer.

Dr Ashley Catterall

Royal Medal for Prof Kingman

Professor John Kingman

Professor John Kingman FRS, Chairman of SERC and Professor of Mathematics at Oxford University, has been awarded one of the Royal Society's three Royal Medals for 1983, in recognition of his distinguished researches on queuing theory, on regenerative phenomena and on mathematical genetics.

STOP PRESS
Professor Kingman has recently accepted the position of Vice-Chancellor of Bristol University. He will take up the appointment on 1 September 1985 and will thus be leaving the SERC one year earlier than previously expected. He will succeed Sir Alec Merrison FRS who will be retiring in September 1984.

Front cover picture

Putting up the Dewar of the Lancaster University nuclear refrigerator *(see page 4).*

Ewing Medal winner

Professor P J Lawrenson FRS FEng, Chairman of the Council's Electrical Engineering Subcommittee, has been awarded the James Alfred Ewing Medal for his research into new electrical motors suitable for a wide range of applications.

Council commentary

Postgraduate training policy

In September 1983, Council devoted a full day to an informal discussion on its policy and practice in studentship matters. The discussion was wide-ranging and afforded Council and its guests the opportunity to consider at length such matters as the resources devoted to postgraduate training, the numbers of awards in the various categories, the allocation system and levels of stipend. The discussion would inform Council's future consideration of its training policy in general. The particular decisions reached included

- that the academic qualifications for the award of advanced course studentships should remain unchanged;

- that, should Boards so wish, they should include limited proposals for 'earmarking' research studentships to identified research grants in their bids to Council for studentships;

- that consideration should be given as to how student choice might be increased in allocating awards;

- that there should be no move by SERC towards differential levels of student stipend.

Estimates and Forward Look

To deal with the likely fluctuations in exchange rates which may lead to changes in the levels of international subscriptions, Council decided to create a reserve fund of £3 million in 1984/85. This reserve would be returned to Boards at intervals during the year depending on the behaviour of the exchange rates.

Council also agreed that the Forward Look for the period 1985/86 to 1989/90 should be based on the Council's submission to the ABRC. At the same time it set lower guidelines to provide up to £6 million in 1985/86 and £9 million per year thereafter for possible transfers of funds between Boards and to cover possible fluctuations in exchange rates.

Future of the Integrated Graduate Development scheme

In October, Council reviewed the operation of the IGD scheme. It agreed that the scheme, in which the Council played a pump-priming role, was valuable and that it should continue although efforts should be made to find an appropriate body to fund the scheme in the longer term.

Fellowship and Special Replacement Awards for 1984

Also in October, Council decided that it should provide the following numbers of Fellowships and Special Replacement Awards in 1984:

Postdoctoral Fellowships	65
Advanced Fellowships	18
Senior Fellowships	1
Industrial Fellowships	7
Special Replacement Awards	7

New Council members

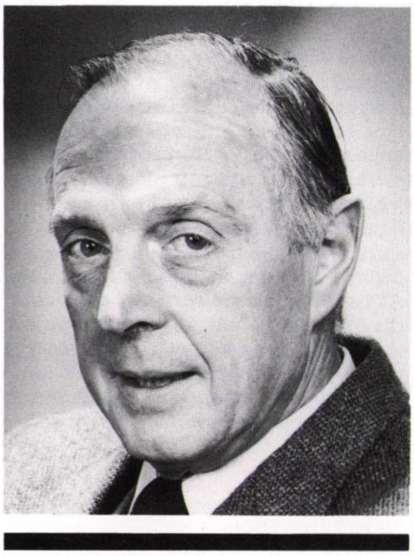
Sir Keith Joseph, Secretary of State for Education and Science, has appointed two new members to the Science and Engineering Research Council. They are Professor Richard Norman FRS, Chief Scientific Adviser to the Ministry of Defence, and Professor Derek Colley, Professor of High Energy Physics at Birmingham University. The appointments took effect from 1 October 1983.

Professor Norman and Professor Colley replace Dr Anthony Challis, former Chief Scientist at the Department of Energy, and Professor Ian Butterworth FRS, Professor of Physics at Imperial College of Science and Technology, London, whose terms of office expired on 30 September 1983. Professor Norman's appointment will run until 31 July 1986 and Professor Colley's until 31 July 1987.

Professor Richard Norman

Professor Norman, aged 51, was Professor of Chemistry at York University from 1965 until he joined the Ministry of Defence in 1983, having been University Lecturer in Chemistry at Oxford for seven years before that. He was President of the Royal Institute of Chemistry from 1978 to 1980 and is Director of Salters' Institute of Industrial Chemistry. His publications include *Principles of Organic Synthesis* (1968) and, with D J Waddington, *Modern Organic Chemistry* (1972), besides papers in the *Journal of the Chemical Society*. Professor Norman served on SERC's Chemistry Committee from 1973 to 1977 and on the Cooperative Research Grants Committee from 1979 to 1982.

Professor Colley, aged 53, who is Chairman of SERC's Nuclear Physics Board, has for many years been a prominent member of the British community of high energy physicists and remains an active experimental researcher in the subject. At Birmingham University he built up a large centre for research in particle physics specialising in bubble chamber experiments. He has been a member of several CERN committees, including the Research Board and Science Policy Committee, and from 1977 to 1980 was the principal UK delegate to the European Committee for Future Accelerators (which played a key role in setting up the LEP project). Professor Colley has also been Chairman of the SERC Particle Physics Grants Subcommittee and of the Particle Physics Experiments Selection Panel.



Professor Derek Colley

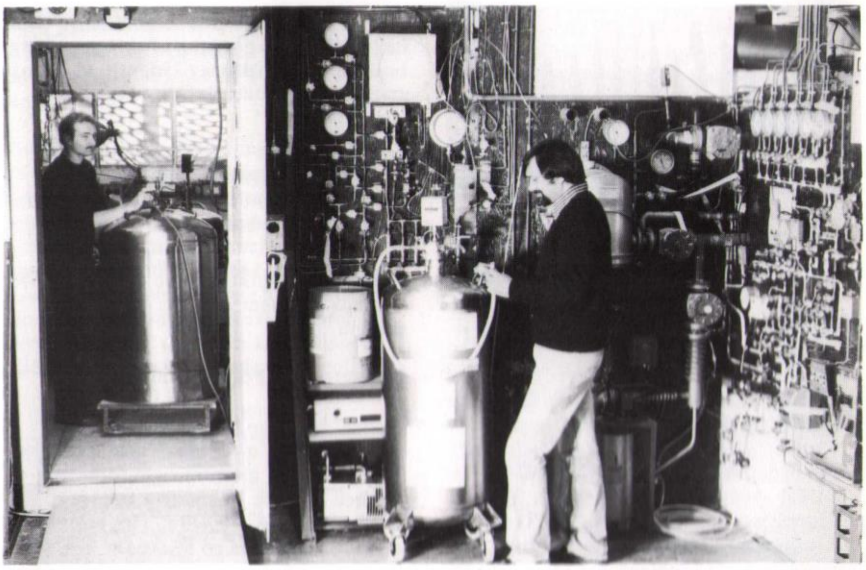
Near the unattainable: Closer to

Superfluids have a unique place in condensed matter physics. They afford us the opportunity of looking at collective ground states which, with their long-range correlations, manifest purely quantum phenomena on a macroscopic scale. Until relatively recently we have had only superfluid ^{4}He and the electron gas in superconductors to study. However the last decade has seen the discovery and large-scale study of the 'new' phases of liquid ^{3}He which are not only superfluids but also exhibit geometrical structure (see box 1).

Since ^{3}He becomes superfluid only in the millikelvin range, any research effort into these fascinating states of matter requires a major investment in advanced refrigerators capable of maintaining submillikelvin temperatures for long periods of time. There are four groups in the UK funded for work on superfluid ^{3}He and related subjects: two groups at Sussex University (Sussex and a Bedford-Sussex collaboration) and two groups in the north-west, at Manchester and Lancaster Universities. The Lancaster group, led by Dr A M Guénault and the author, sacrificed a rapid entry into the subject for the longer-term strategy of building up a more advanced facility by using new techniques introduced by ourselves. This strategy is now beginning to bear fruit after five years of development.

The group tuned up the equipment by studying dilute solutions of ^{3}He in ^{4}He. These solutions are very difficult to cool but are of great potential interest since the ^{3}He component should show a superfluid transition (see box 1). The methods which were developed for cooling these solutions when applied to pure ^{3}He show spectacular improvements on current performance (see box 2). At Lancaster we have cooled liquid ^{3}He to 125 μK which represents at present the lowest temperature to which a liquid has been cooled. At these temperatures the ^{3}He exists essentially as pure condensate (only one atom in 10^5 is unpaired). We have been able to perform mechanical experiments on the condensate which paradoxically is not only a perfect liquid but owing to the long-range correlations also exhibits the behaviour of a highly non-linear elastic solid (see graph). At Lancaster we are currently extending the condensate studies since ours is probably the only facility worldwide which can reach the low temperatures necessary. We are also putting together a new refrigerator for extending our studies of spin-polarized systems.

George Pickett
Dr Pickett is Senior Lecturer in the Department of Physics at Lancaster University.



The gas-handling system, being operated by SERC research associates Dr Vepan Keith and Mr Simon Mussett.

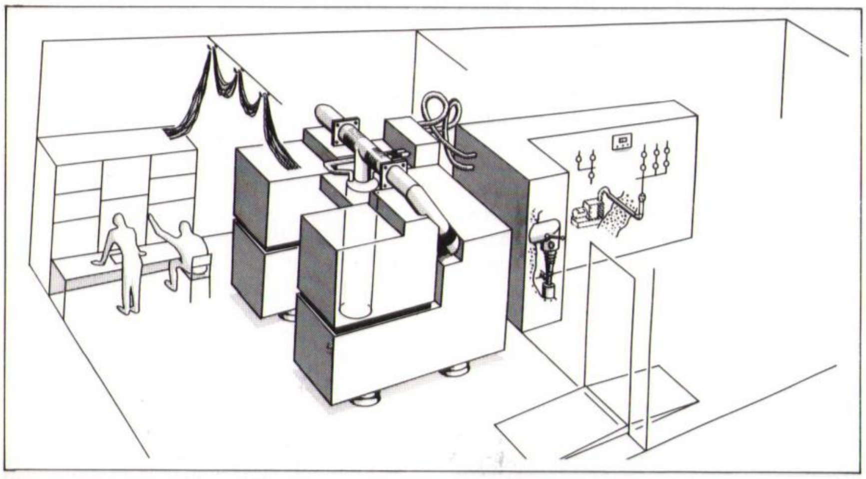
1 ^{3}He: The universal condensed-matter working substance

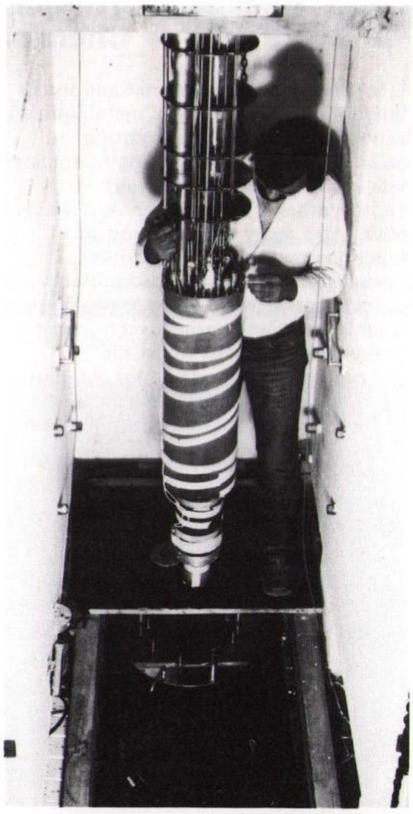
At low temperatures liquid ^{3}He is a Fermi liquid since the ^{3}He atom is a fermion. At from 1 to 3 millikelvin, depending on pressure, the liquid becomes superfluid. In analogy with the superconducting transition in the gas of conduction electrons in a metal, at sufficiently low temperatures two fermions can couple to form a 'Cooper pair' which is a boson. Below this transition temperature the paired ^{3}He atoms make up a zero entropy condensate (the superfluid) while the unpaired atoms retain their normal fermion properties. As the temperature is further reduced the number of unpaired atoms falls rapidly until at $T_c/10$ virtually all the liquid is in the pair condensate. Unlike the pairs of electrons in a superconductor, which have zero spin and zero angular momentum, the Cooper pairs in superfluid ^{3}He have parallel nuclear spins giving S=1 and the component atoms orbit each other giving L=1. It is this structure in the Cooper pairs which makes superfluid ^{3}He so interesting. Since the condensate is highly correlated, the directions of L and S of all the pairs are constrained to be parallel over macroscopic distances. The superfluid thus has a 'texture', that is to say it has directional properties similar to, but more subtle than, those of liquid crystals. The textures can be influenced by surfaces, magnetic fields (via the nuclear magnetic moment) and by flows. The microscopic theory of superfluid ^{3}He is well developed and the textures are fairly well understood theoretically whereas experimental confirmation of their properties is largely lacking since appropriate experiments are difficult both to devise and to realize.

However, ^{3}He has more surprises. If ^{3}He is dissolved in small quantities in liquid ^{4}He, the ^{3}He component forms a Fermi gas with a very low Fermi temperature. It should be possible with currently accessible temperatures and magnetic fields to polarize completely the spins of this Fermi gas. Spin-polarized Fermi systems are of considerable interest at present since the polarization should have a catastrophic effect on the transport properties because the normally dominant spin up/spin down scattering processes are naturally precluded.

Furthermore, at some sufficiently low temperature (highly theoretician-dependent but probably at $T < 0.1$ mK) the Fermi gas of ^{3}He atoms dissolved in ^{4}He will also form Cooper pairs and become superfluid. This system would be absolutely unique in consisting of two interpenetrating (and independent?) superfluids.

absolute zero at Lancaster



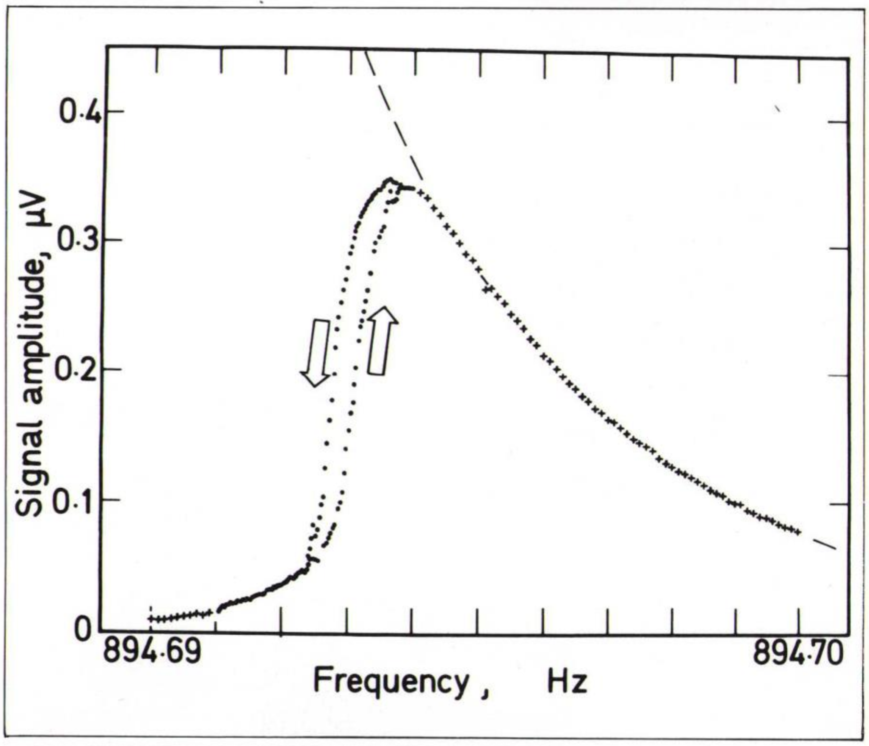


Above: A general view of the refrigerator. The experiment is situated inside an electrically shielded room for RF isolation and is suspended in the centre of a 20 tonne concrete block for isolation from vibration. (Reproduced by permission of **Cryogenics***)*

Right: Dr Vepan Keith putting on the vacuum jacket of the nuclear refrigerator.

2 Achieving the low temperatures

In the Lancaster experiment, the submillikelvin temperatures are achieved by the adiabatic demagnetization of the paramagnetic copper nuclei in metallic copper. The copper refrigerant is magnetized in a field of 6.5 tesla and then cooled by a dilution refrigerator to around 10 millikelvin. The field is then slowly turned down to about 15 millitesla which reduces the temperature of the nuclear spin system to a few microkelvin. The overriding difficulty in the experiment is transferring this low temperature to the liquid to be cooled since the liquid supports so few thermal excitations capable of carrying a significant current of heat. Large slabs of sintered silver containing many square metres of area increase the thermal contact to the liquid. Since the final temperature of the liquid is governed almost entirely by the random heat leak into the liquid from the outside world it is important that this is reduced as much as possible. In our experiments (see above), the heat leak into the innermost 20 cm^3 sample of liquid is only 5×10^{-11} Watts (this is roughly the power released when an ant falls one wavelength of visible light per second in the earth's gravitational field). We are currently able to cool liquid ^3He to around 125 μK (the liquid reaches its lowest temperature about three days after demagnetization). Since the number of excitations which can carry heat falls off exponentially with inverse temperature, the random heat leak would have to be reduced by at least a factor of ten for any significant further reduction in temperature to be achieved.

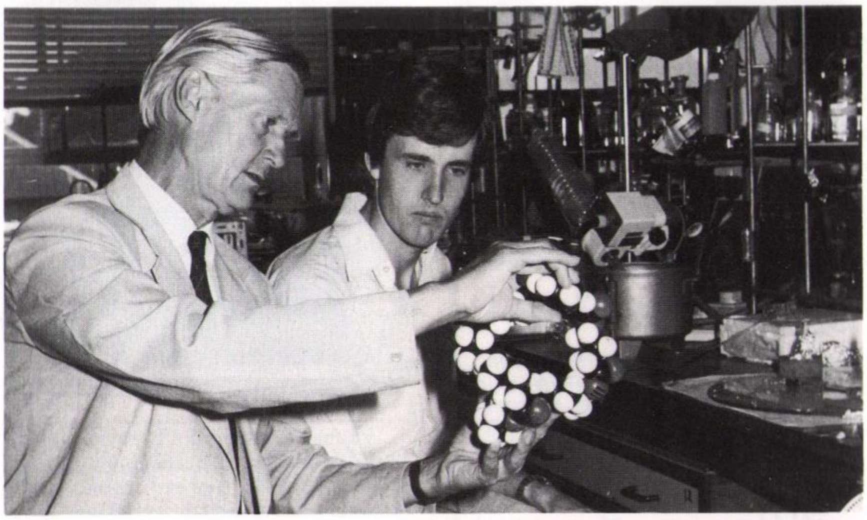


The mechanical response of the condensate: the highly non-linear resonance of a mechanical resonator situated in superfluid ^3He at 125 μK.

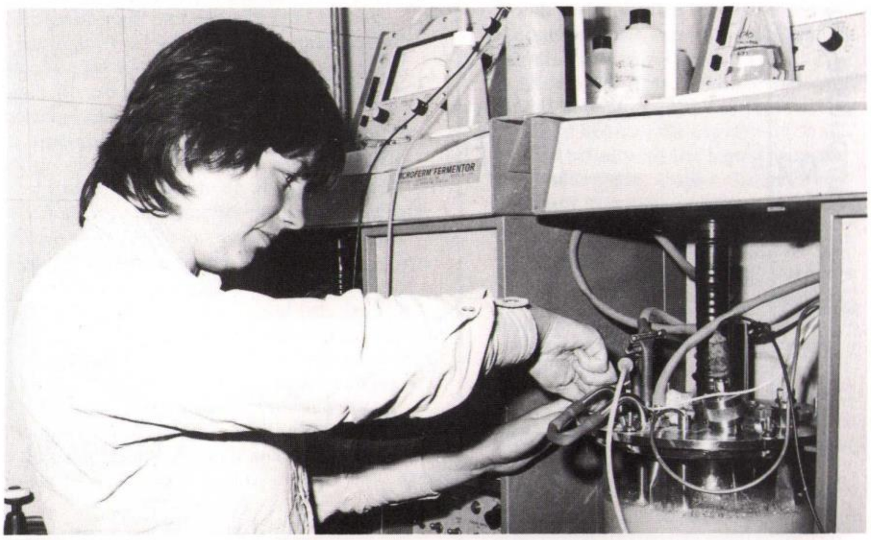
Biosynthesis of the pigments of life — a major research programme at the University Chemical Laboratory, Cambridge

Life depends for its existence and for its functioning on a variety of metal ions held as complexes within tetrapyrrolic macrocycles. Chlorophyll (Mg^{II} complex) acts as the foundation; without photosynthesis, life as we know it would cease. Also many vitally important functions are carried out by other complexes, for example, haemoglobin and several of the cytochromes (both Fe^{II} complexes); these, respectively, transport oxygen and electrons whilst the anti-pernicious anaemia factor, vitamin B_{12} (a complex of Co^{III}) mediates subtle rearrangement reactions. These few cases, and there are more, emphasise the central importance of such tetrapyrrolic substances for living systems and this has led to the title 'Pigments of Life'.

Since 1968, the major effort of the team led by the author at Cambridge has been aimed at the elucidation of all the many steps in the biosynthesis of these tetrapyrrolic pigments. Such an understanding is of obvious fundamental importance for our knowledge of the synthetic pathways used by living organisms. But, in addition, only by having a detailed knowledge of the normal biosynthetic processes can one pin-point the failures which cause disease, for example certain of the porphyrias.



Professor Alan Battersby (left) and Simon Bartholomew discuss the properties of a molecule which mimics the natural haem system.



A regular supply of microorganisms is essential for the biosynthetic research. Here Miss Jeanette Brown adjusts the fermenter.

The researches have required the weaving together of a wide-range of approaches from across the broad sweep of organic chemistry and on into biochemistry. It was realised almost from the outset that nuclear magnetic resonance using carbon-13 labelling offered enormous possibilities for solving problems in this area. Indeed, the necessary syntheses of ^{13}C-labelled precursors was started well before a spectrometer with ^{13}C-capability was available in Cambridge. It was hoped that SERC would later fund such an instrument; fortunately this support was given, first with an instrument operating at 25.2 MHz for ^{13}C, and more recently at 100.8 MHz. As a result, knowledge of the biosynthesis of the pigments of life has been transformed during the past 15 years.

It turns out that all the natural macrocyclic pigments are produced enzymically from one parent macrocycle, uroporphyrinogen-III (1), shortened to uro'gen-III. For that reason, research on the biosynthesis of this vitally important parent ring-system has been a central theme of research in Cambridge. But there is another reason. A remarkable feature of the uro'gen-III structure is its unexpectedness. It is biosynthesised by joining together four units of a monopyrrolic building block and the straightforward way of assembling these units would lead to an isomer of structure (1) having the acetate and propionate side-chains on ring-D exchanged in position. How does Nature do it? By now almost all the details of the pathway have been uncovered including extensive information concerning the enzymes involved.

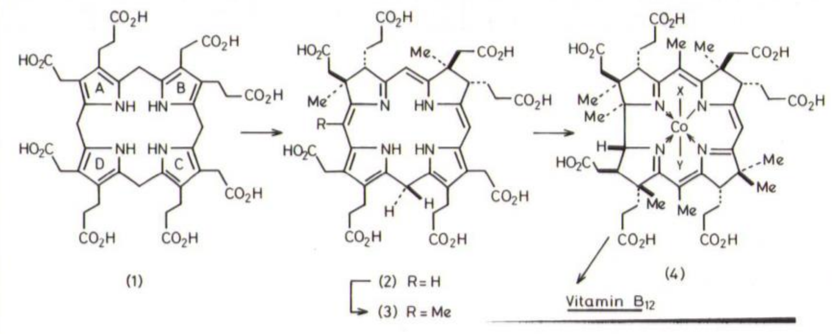
A fascinating further aspect of what has been discovered so far is its interest in relation to knowledge of and ideas about evolution. The ubiquitous parent macrocycle, uro'gen-III (1) does not form complexes with metal ions. Nature has developed two ways (and perhaps more?) to generate effective ligands from it. Starting from uro'gen-III (1), one approach is *oxidative* and leads eventually to haem, for example for haemoglobin and the cytochromes. The second method is used for macrocycles which almost certainly evolved before oxygen appeared in the atmosphere; it is non-oxidative and relies on *C-methylation*. Shown above are a few steps in the intensively studied pathway to vitamin B_{12} where the *C*-methylation method reigns supreme. Moreover, the aromatised form of the dimethylated system (2), as its iron complex, is the prosthetic group of sulphite reductase; this enzyme squeezes oxidising equivalents from sulphite and in so doing generates sulphide. It thus seems as if one macrocycle which had developed at a particular evolutionary stage could then be further modified at a later one to yield different ligands for new biochemical tasks. Nature appears to operate by moulding the available clay.

Though work on the biosynthesis of the pigments of life forms the major part of the programme in Cambridge, there is a smaller effort on synthesis of non-protein molecules designed to mimic at least some of the chemistry carried out by the natural materials such as myoglobin or the cytochromes. These model systems are of necessity medium-sized molecules (about 1500 daltons) because the macrocyclic ligand, a cavity for binding oxygen or a substrate and a firmly attached basic or sulphur ligand must all be assembled in the one molecule correctly disposed in space. Successful models have been synthesised for haemoglobin-myoglobin, cytochrome b_5 and the active site of cytochrome P-450. A key feature of these models is that they can be modified, or 'tuned' synthetically to check the effects of precisely defined changes. Such modelling can help test ideas about the mode of action of the natural substances; thus synthesis is being used to ask and answer important questions.

The progress which has been made in all these areas has resulted from the efforts of a compact team of postdoctoral chemists and one enzymologist, together with research students. This team is backed up by the full range of spectroscopic, chromatographic and enzymic equipment and, importantly, ample working chambers for handling oxygen-sensitive substances in inert atmospheres. Though the synthetic expertise of the team is of paramount importance, the members cannot be synthetic specialists; they must in addition be skilled in the isolation of natural materials, in structure determination, structural transformations and the use of isotopes with advanced nmr analyses. This is best seen for one of the most complex biosynthetic problems, that of the anti-pernicious anaemia factor. By the time the citadel of vitamin B_{12} biosynthesis is finally taken, there can be little doubt that every weapon in the organic chemical armoury will have been pressed into the battle line. By now, more than two thirds of that pathway is known; the years ahead will reveal the remainder.

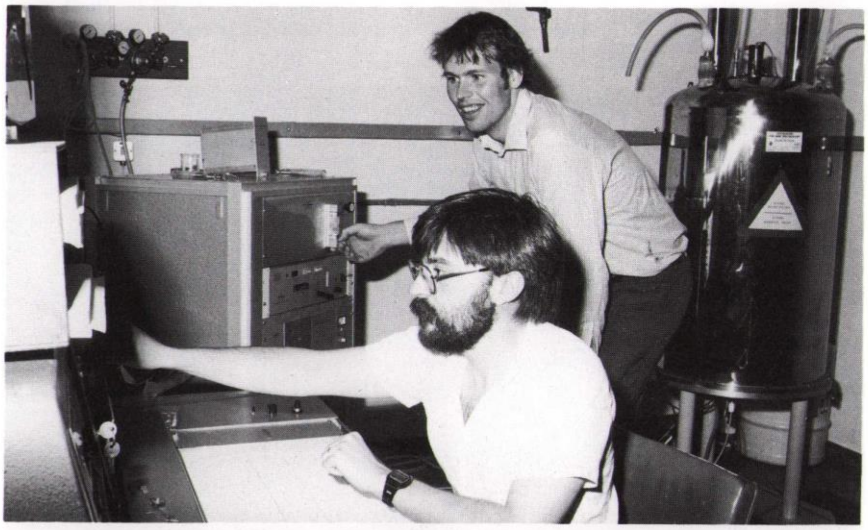
Alan Battersby
Professor A R Battersby FRS is Professor of Organic Chemistry, Cambridge University.

A full bibliography covering these researches on the pigments of life is available from Professor Battersby at the University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW.



Biosynthesis of vitamin B_{12}: some of the known intermediates

Dr Hans-Ullrich Hoppe working with oxygen-sensitive intermediates on the biosynthetic pathway to vitamin B_{12}.



High-field nmr spectroscopy is central to all the biosynthetic work. Operating the 400 MHz instrument are Dr Adrian Carpenter (foreground) and Dr Finian Leeper.

Pictures by University Chemical Laboratory, Cambridge.

Further signs of the SNS

A progress report at 5 December 1983

The Spallation Neutron Source at the Rutherford Appleton Laboratory is expected to produce its first neutrons in the last quarter of 1984. It completed its first commissioning phase with successful operation of the linear accelerator injector to produce 70 MeV ions in January 1983. Subsequently a beam of 70 MeV ions has been successfully transported through the transfer line from the injector to the entrance to the main accelerator, an 800 MeV, 50 Hz synchrotron.

A brief description of the accelerator part of the SNS facility was given in *SERC Bulletin* Vol 2 No 4, Spring 1982. Intense pulses of protons from the accelerator hit a depleted uranium target to produce fast neutrons which are moderated to the energy range (one to several thousand meV) required for their use as probes for condensed matter research.

Progress on the accelerator

Injector

The injector system consisting of the ion source, 665 kV pre-injector and 4-tank Alvarez type linear accelerator gave its first 70 MeV H^- ion beam in January 1983. It has been operated since then to improve beam quality and to tune to reduce beam losses along the length of the linac. The beam quality (emittance) is as expected and beam losses are within acceptable levels when scaled to full power operation. Duty cycle from the linac under test condition has to be limited to about 2% of the final performance to avoid unnecessary irradiation of components. This is achieved by reducing the repetition rate to 1 pulse per second.

The transfer line from the injector to the point where the H^- ions enter the synchrotron has been installed and beam successfully transported along its length.

Synchrotron

The next phase of commissioning work, planned for the end of 1983, will be to inject H ions into the synchrotron and convert them to protons in the stripping foil for injection and trapping studies. This requires a complete evacuated synchrotron ring with all magnets installed and powered by the 50 Hz magnet power supply. Two of the six eventual RF cavities will be used for the trapping studies. All of the components for completing the ring for this phase are available including the ten main dipole magnets all of which have now been delivered.

The 10 straight sections containing the main and trim focusing magnets and a large number of diagnostic devices have been installed and vacuum joints made. The available main dipoles have also been installed and joined to the adjacent straights. Work on the power supply for the magnet system is on schedule, being in the final stage of connecting up. The four pulsed dipole magnets which allow controlled injection into the synchrotron have been installed and powered from their 14,000 A power supply which was delivered at the end of September. A batch of stripping foils has been successfully made.

The two RF cavities required have been installed in the synchrotron with their 250 kW power amplifiers and have been successfully run up to full power with the frequency programmed to follow the correct relationship with the 50 Hz magnetic field in the magnet system. This uses a 50 kW hi-fi amplifier for each system.

The control system for the facility is being progressively installed. Much useful experience has been gained by the operation of one of the four eventual systems to control the injector and transfer line.

Work for later milestones

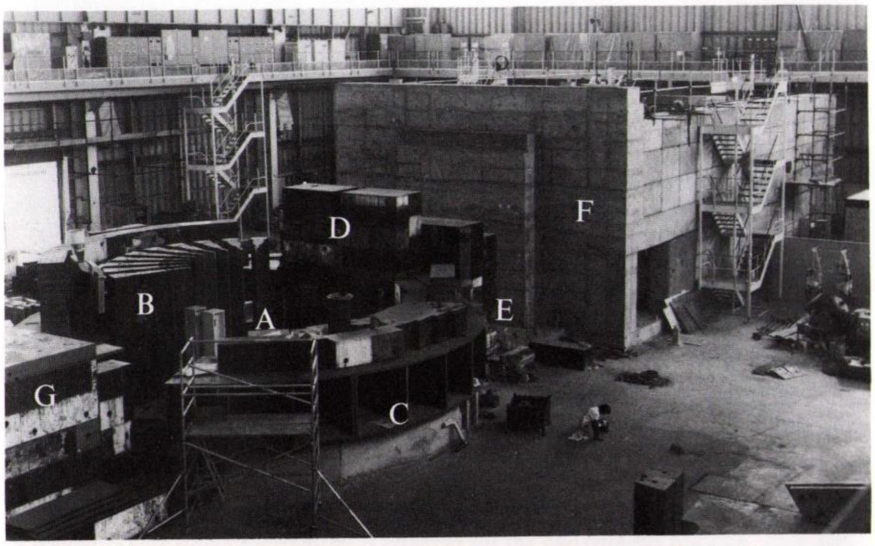
Work on parts of the machine for the following stages is continuing. The remaining four RF systems are in various stages of building. One of the three extraction system pulsed power supplies has been successfully run into a prototype kicker magnet. Components for the extracted proton beam have been delivered, or are being manufactured.

The shielding tunnel which contains the extracted beam has been about two-thirds completed.

Target station

The SNS target station consists of the following main components:

- A target made of uranium plates, cooled by heavy water, from which about 25 fast (about 1 MeV) neutrons are produced for each incident proton.



Building up the target station

Key: *A Target position*
B Wedges for supporting shutters
C 'Inserts' to allow hand-stacking to make neutron holes
D Part of main shield
E Remote handling cell position
F Services area shielding
G Extracted proton beam tunnel

Moderators above and below the target slow the neutrons to the required energy. A reflector consisting of beryllium rods in a heavy water tank returns some neutrons to the moderator which might otherwise escape in unwanted directions. The target/moderator/reflector is contained within a stainless steel vessel with helium atmosphere to minimise absorption of neutrons and to provide an inert atmosphere for the moderator liquids.

- A massive iron and concrete shield absorbs radiation from the target. This is about 2.5m thick. As shown in the figure, there are nine neutron holes on each side of the target station. Neutrons can be stopped from going down an individual neutron line by 2m-thick shutters which move up and down guided by wedge-shaped steel shielding pieces. On the outside of the shield, at neutron beam level, the neutron holes can be tailored to suit a particular experimental requirement by 'hand-stacking'. This is achieved by the use of tapered boxes, called inserts, in the permanently installed target shield.

- There is a remote handling cell into which the target/moderator/reflector assembly can be withdrawn to be taken apart using remote manipulators when the target has finished its useful life, expected to be about nine months. After a cooling period it can then be disposed of.

- Behind the remote handling cell is the services area, a concrete building containing the water, cryogenic and other services for the target/moderator/reflector. The concrete is sufficiently thick to reduce the radiation from the services area to an acceptable level.

Target station progress

The target station work is currently on schedule for producing first neutrons in the last quarter of 1984.

Target assembly

Following successful development work on the cladding of depleted uranium plates, an order has been placed for plates for two complete target modules. The vessels for holding the plates and providing heavy water cooling are being manufactured. The moderator vessels have also been ordered. For the reflector, the beryllium rods and the containing vessel are being manufactured. The large stainless steel void vessel, designed and built to exacting reactor safety standards, was delivered in late November and is being installed.

Radiation shield

The foundation for supporting the 6,000 tonne radiation shield has been built for some time and the walls have been built up from available steel blocks after rough machining to above insert shielding. The shielding wedges supporting the shutter were installed, pre-aligned and removed to allow installation of the void vessel. The shutters themselves are at the end of the production run.

Remote handling cell

The foundation is complete and the concrete walls built up. The remote manipulators for taking apart the target/moderator/reflector assembly have been ordered. They are of a new British design adopted by the UKAEA and others. The zinc bromide windows to allow viewing with radiation shielding are being installed. All components fitted to the target assembly undergo stringent tests in a test remote handling cell.

Services area

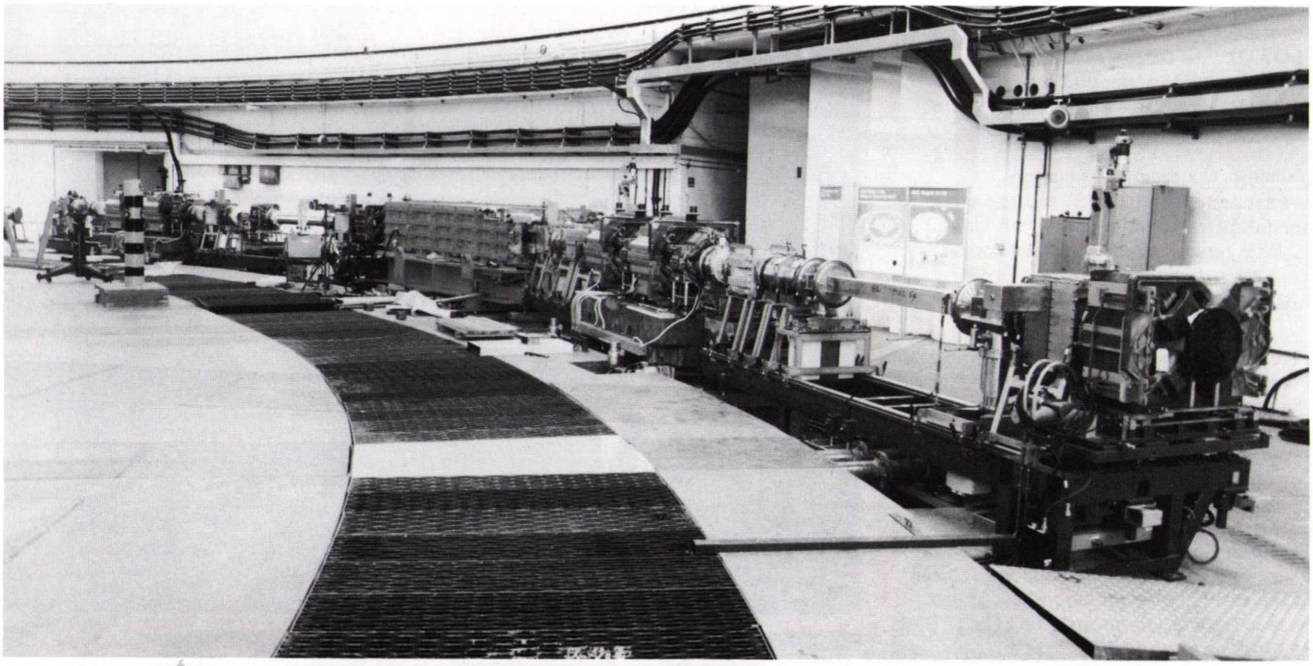
The concrete walls have been built up for this area which is 24m long by 10m wide and 8m high. The floor of the whole of the shield, handling cell and services area has a stainless steel liner and drainage system to collect radioactive liquids in the unlikely event of a spillage. The target assembly, a door weighing 90 tonnes to close up the shielding, the water cooling services and the refrigerators for the moderators are carried on a train. The rails for this have been installed and aligned. The water cooling services and the refrigerators are being delivered.

The control room for the target station has been built. The algorithms for control of the target station are being developed. The electronic control equipment is being built up.

Safety assessment

A safety assessment of the SNS, involving independent assessors, has been completed and confirms that the SNS will be safe to operate. Of particular note is the fact that the target plates will not melt (from radioactive heating) providing the proton beam is switched off as soon as a fault or potential fault is detected.

D A Gray
Head of the SNS Division, RAL.



The Synchrotron: Part of the SNS synchrotron showing two of the 10 straight sections joined up to one of the bending magnets.

Briefing for potential SNS users

The first investigators should be using the Spallation Neutron Source at Rutherford Appleton Laboratory later this year. In preparation, more than 100 potential users attended a Users' Meeting at RAL in September 1983. The meeting was designed to inform principal investigators of the progress on construction of the SNS machine, target station and neutron scattering instruments and about procedures for applying for time on the facilities.

First neutrons are expected at the end of the year with 10% of maximum intensity to be achieved very soon after start up, which would immediately make the SNS the world's most intense pulsed neutron source. Build-up to full intensity of the source is expected to take up to two years.

Wide scientific range

Initially there will be six instruments available plus three development instruments. The six instruments are designed to cover a wide area of scientific application: a diffractometer for studying the structure of liquid and amorphous materials and of crystal powders with moderate resolution (LAD), a very high resolution powder diffractometer (HRPD), three instruments for studying inelastic and quasielastic scattering over a wide range of energy and momentum transfers (IRIS, HTIS and HET), and a spectrometer for studies at very low scattering vectors (LOWQ). The three development instruments are being built to explore new areas of science and for techniques new to pulsed sources; they are the eV spectrometer (eVS) for very high energy transfers, the polarised neutron spectrometer (POLARIS) and the single crystal diffractometer (SXD) which will explore time-of-flight Laue methods.

Instrument User Groups

Potential users should join the appropriate Instrument User Group which will oversee the commissioning of instruments and the selection and scheduling of the early experiments. In order to have experiments considered for inclusion in the programme the investigator must have his research programme approved by the Neutron Beam Research Committee. It is hoped that as many users as practicable will be involved in the early commissioning phases both to help with the commissioning (eg writing of software for scientific data analysis) and to disseminate pulsed neutron experience into the scientific community as quickly and efficiently as possible.

Chairman and secretaries of the Instrument Users Groups

Group	Chairman	RAL Secretary (and Instrument Scientist)
Liquids and Amorphous Materials Diffractometer (LAD)	Professor J E Enderby (Bristol)	Dr W S Howells (ext 5680)
High Resolution Powder Diffractometer (HRPD)	Dr A K Cheetham (Oxford)	Dr M W Johnson (ext 5418)
High Throughput Inelastic Spectrometer (HTIS), plus Time Focusing Crystal Analyser Option (TFCA)	Dr D K Ross (Birmingham)	Dr J Penfold (ext 5681)
High Energy Transfer Spectrometer (HET)	Dr J Howard (Durham)	Mr B Boland (ext 5679)
High Resolution Inelastic Spectrometer (IRIS)	Professor S Clough (Nottingham)	Dr C J Carlile (ext 5684)
Low Q Spectrometer (LOWQ)	Dr R J Stewart (Reading)	Dr D J Cebula (ext 5682)
Polarisation Spectrometer (POLARIS)	Dr B Rainford Southampton	Dr R Cywinski (ext 5683)
Electron Volt Spectrometer (eVS)	Professor E W J Mitchell (Oxford)	Dr R J Newport (ext 5682)
Single Crystal Diffractometer (SXD)	Dr R J Nelmes (Edinburgh)	Dr J B Forsyth (ext 6116)

For detailed information contact the appropriate secretary and for general information contact: Professor A J Leadbetter, Head of the Neutron Division, Rutherford Appleton Laboratory (ext 5124).

Professor George Bacon, Professor Emeritus in the Department of Physics, Sheffield (left), and Professor Sir David Phillips FRS, Chairman of the Advisory Board for the Research Councils, at the SNS Users' Meeting.

Producing energy with ion beam fusion

The concepts of inertial confinement fusion (ICF) are probably less familiar than those of magnetic confinement fusion but both approaches aim to produce energy from the thermonuclear burn of deuterium-tritium mixtures. These nuclei are chosen since they are the easiest to fuse, producing an alpha particle and a neutron, so releasing a net binding energy of 17.6 MeV per reaction. The coulomb repulsion of the nuclei involved causes the cross-section for the processes to decrease to a vanishingly small value at low reaction temperatures. At D-T plasma temperatures of 10 KeV (2 x 10^8 K) or above, the ions at energies 30-60 KeV in the maxwellian distribution in the plasma have a reaction cross-section which is large. Fusion energy is released but the D-T fuel must first be highly compressed.

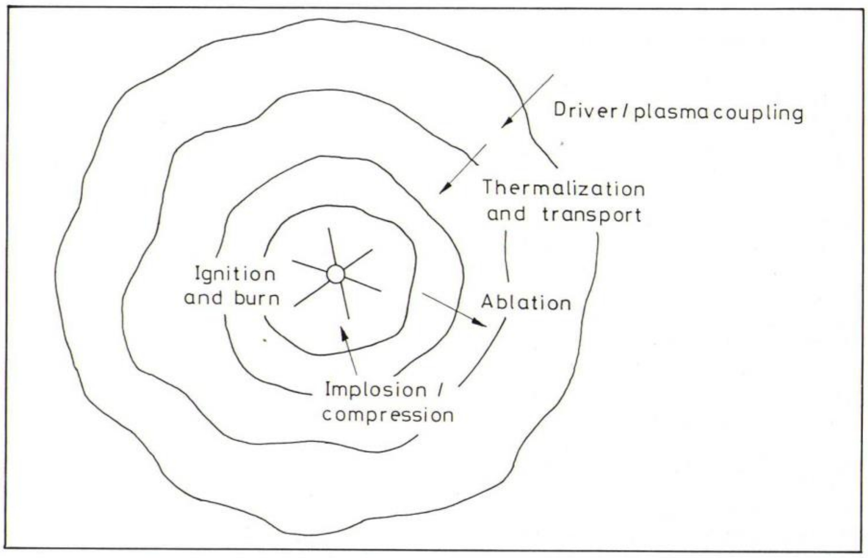
To achieve the required density and temperature, energy must be delivered to the target, a small pellet a few mm in diameter, at the rate of 5-10 MJ in a few tens of nanoseconds, corresponding to a target illumination of about 10^{15} W cm^{-2}. This energy rapidly heats the outer regions of the pellet and couples into the resulting plasma. The energy is then thermalized and transported into high density material to what is termed the ablation front. Here, heated dense matter blows off to lower density, depositing momentum in the remaining material which is accelerated inwards and, acting as a piston, compresses the fuel to the required density (about 100g/cm^{-3}) and temperature for thermonuclear fusion to begin. If all works well, the thermonuclear energy released is sufficient to produce a net energy gain. This mechanism is illustrated right.

One way to obtain this energy-flow on to the target is to use powerful lasers as fusion drivers and large programmes are presently underway in the USA and the USSR. An equally attractive driver is an accelerator producing intense beams of light ions or heavy ions which are eventually focused on to the target. Two possible accelerator scenarios exist for heavy ion fusion (HIF). The first uses conventional heavy ion linear accelerators feeding its particles into large storage rings similar to the Intersecting Storage Ring (ISR) at CERN. When sufficient current has been accumulated in the rings it would be formed into short bunches, extracted along beam lines arranged as arrays of magnets and focused on to a target. The other scenario is based on an induction linear accelerator some 3 km long capable of accelerating and compressing in time the whole of the required current.

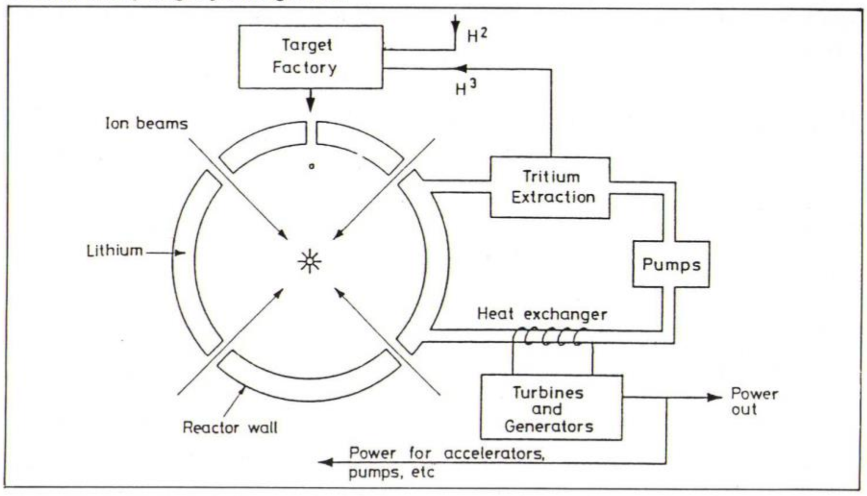
In the UK, ion beam studies have concentrated on HIF using the linear accelerator/storage ring concept which requires, typically, 10 kA and 10 GeV uranium ions focused on to a target. After initial accelerator studies at the Rutherford Appleton Laboratory in 1977 the programme has rapidly expanded to include a wide spectrum of studies. These include charge-exchange physics at Newcastle, Belfast and Durham Universities and Royal Holloway College, London and target studies which associated dense plasma physics at Birmingham University in conjunction with the Laser Division at RAL and with suppprt from Glasgow University. Experiments are soon to start, in collaboration with West German scientists, using the Spallation Neutron Source (SNS) accelerator at RAL to investigate the properties of injection and beam bunching in the SNS storage ring. This accelerator is probably unique in the world for such studies.

The technological and scientific problems of HIF are indeed daunting but the rewards, in terms of availability of controlled thermonuclear power, guarantee that the challenges are being met with enthusiasm.

T D Beynon
Dr Beynon is Senior Lecturer in the Department of Physics, Birmingham University.



Mechanism of target pellet ignition



Essential components of power station

Professor Sir Harrie Massey FRS

The death of Professor Sir Harrie Massey FRS on 27 November, at the age of 75, brings to an end an era in the development of science.

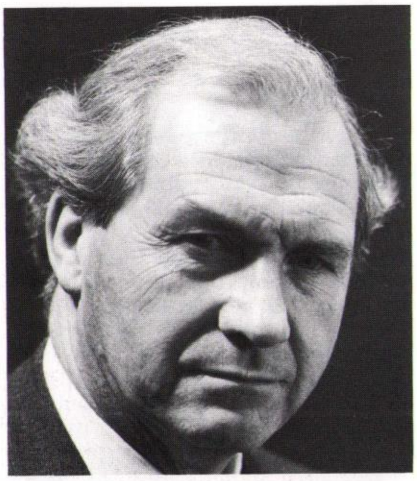
Sir Harrie will be remembered for an extraordinary range of qualities and achievements. He was an eminent scientist but at the same time he led a large and active department at University College London; played a major role in central arrangements for science in the UK, as Chairman of the Council for Science Policy; was very active in the Royal Society; and, in addition to all these things, was enormously influential in bringing nations together in science, for example in Europe leading to the formation of ESRO (now the European Space Agency and CERN).

Sir Harrie was born near Melbourne, Australia and came to Britain in 1929 when he was awarded a travelling scholarship to Cambridge University, to work with Lord Rutherford.

In 1933 he was appointed as an Independent Lecturer in Mathematical Physics at Queen's University, Belfast, where he became interested in the physics of the upper atmosphere. He was appointed Goldsmid Professor of Applied Mathematics at University College London in 1938. During the war he worked for the Admiralty before joining the DSIR mission to California, concerned with the development of the atomic bomb.

After the war he returned to UCL and in 1950 he was appointed to the Quain Chair of Physics at University College London. Here he used his influence to stimulate research in a wide range of topics including astrophysics and space physics. With the initial development of space vehicles in the mid 1950s he ensured that Britain should take advantage of the new opportunities opened up for space science and that these should be exploited predominantly in the universities; and, indeed, was primarily responsible for the Government's new space science programme for a number of years before the SRC was formed in 1965.

Within SERC he will be remembered for his clear insight into and lucid exposition of complex problems and his appreciation of the balance between basic and applied science. He was always available to give valued advice and guidance whether at Council or Committee Secretary level. At various times he has been the Royal Society Assessor to the Council and to the Astronomy, Space and Radio Board and its committees. With his strong interests in astronomy and the Australian scientific scene he was a cornerstone in establishing the very successful Anglo-Australian Observatory and recently served as Chairman of its governing board.



Dr J H Weaving

Coordinator for Combustion Engines SPP

A new Coordinator has been appointed for the Combustion Engines Specially Promoted Programme. He is **Dr John Weaving**, formerly Chief Engineer – Advanced Studies, at BL Technology Ltd.

The need for coordinated research into cleaner, quieter engines with improved fuel economy and tolerance while maintaining performance was recognised in 1980 by the creation of the SPP in Combustion Engines Research. Conventional gasoline and diesel engines in particular were deemed to have considerable scope for improvement.

A mid-term review has recently shown that, as a result of the creation of the SPP, the level of grant support has increased approximately threefold, with the involvement of a large number of academic institutions. Further applications are welcome, especially where these include an interdisciplinary approach, industrial relevance and speculative ideas.

Applicants are invited to discuss their proposals with Dr Weaving, who may be contacted at: 150 Chessetts Wood Road, Lapworth, Solihull, West Midlands B94 6EN; telephone Lapworth (05643) 2817. For advice on applying for SERC support, contact Mr J Farrow at SERC Central Office, Swindon (ext 2117).

Short courses: enzyme chemistry

Mechanisms, inhibition and pharmaceutical importance

The Chemistry Committee is sponsoring a short course on Enzyme Chemistry to be held at Strathclyde University from 23 to 28 September 1984. The Course Directors are Professor H C S Wood and Dr C J Suckling of the Department of Pure and Applied Chemistry at Strathclyde University.

The design and development of drugs has progressed in the last 20 years from an essentially empirical art to a science in which the interaction of chemistry, both organic and physical, and the life sciences is at its strongest. A major focus of this interaction is in the chemistry and inhibition of enzymes because the function of an enzyme *in vivo,* as well as its chemical mechanism of action, can often be understood in depth. Many students will have had the opportunity to study some of these topics independently.

However, it is most important in medicinal chemistry to be able to bring together aspects of organic chemistry, physical organic chemistry and the relevant life sciences in an active partnership. This course, for up to 50 students, aims to inform students on the current state of the basic science and to give them the opportunity to experience interactions between chemistry and living systems with particular relevance to drug design. The course will cover fundamental enzymic catalysis and inhibition, the rationale for enzymes as targets for drug action, biology and metabolism in relation to enzyme inhibitors as drugs, and a series of detailed case studies.

Priority will be given to SERC students, for whom SERC will pay the full cost, and to UK self-supporting students. Further details and application forms may be obtained from Professor Wood or Dr Suckling, Department of Pure and Applied Chemistry, University of Strathclyde, Thomas Graham Building, 295 Cathedral Street, Glasgow G1 1XL; telephone 041-552 4400 (ext 2275).

Chemical Engineering and Production Committees

The Engineering Board has recently set up a new committee to take responsibility for chemical engineering and to oversee the support of polymer engineering.

The Committee, whose responsibilities were previously part of the Engineering Processes Committee which has now been disbanded, was introduced in September 1983 under the Chairmanship of Professor G S G Beveridge FRSE. Professor Beveridge has held the Chair of Chemical Engineering at Strathclyde University since 1971 and is President-elect of the Institute of Chemical Engineers.

The Committee will be concerned with the support of research and training in chemical engineering related to the needs of industries such pharmaceuticals, chemicals, oil and gas, minerals and polymer processing. It is also responsible for the Specially Promoted Programme in Particulate Technology. The Polymer Engineering Management Committee will report through it to the Engineering Board.

The remaining responsibilities of the former Engineering Processes Committee are now assigned to another new body, the Production Committee, chaired by Professor C Andrew of Flamgard Ltd. The Production Committee's remit covers manufacturing processes and manufacturing systems including three Specially Promoted Programmes in Industrial Robotics, Efficiency of Production Systems and Application of Numerical Control to Manufacture as well as Computer Aided Engineering aspects related to manufacturing. It is expected that these four areas will form the basis of the proposed initiative in Application of Computers to Manufacturing Engineering (ACME) (see *SERC Bulletin* Vol 2 No 8 Summer 1983).

Franco-British collaboration on gas discharges

SERC supports many famous international collaborations but one which is not so well known is the very successful Franco-British collaboration on gas discharges which has been under way for the last six years. The collaboration involves five British universities (Cardiff, Leeds, Liverpool, Strathclyde and Swansea), five French universities and two associated European laboratories in Switzerland and Norway.

Electrical breakdown and electrical discharges continue to be a challenging and dynamic area of research with many modern applications ranging from microcircuit fabrication to lasers and very high power switchgear. However, an understanding of many of the fundamentals is still lacking and the theoretical base which would avoid the necessity for much expensive empirical testing and design studies is far from complete. The reasons for this lie in the lack, until very recently, of adequate theoretical and experimental techniques to solve the problems involved. For example, until the availability of today's high-speed digital computers, the ability to deal theoretically in a quantitative manner with the influence of space charges, which are significant at some stages in the development of all discharges, did not exist and the very short time-scale in which discharges are established posed major problems for all experimentalists.

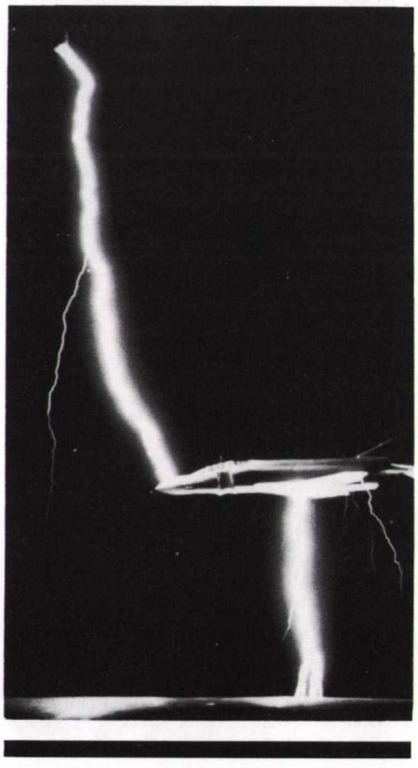
As a result of work in recent years, in which members of the Franco-British group have played a leading part, there has, however, been rapid development both in theoretical techniques (such as those based on the Boltzmann equation, the Monte-Carlo approach and the macroscopic continuity equations) for the simulation of discharges and in the experimental methods available for the study of high speed phenomena.

Thus the base is now established from which a considerable increase in our understanding is likely to result from a further concerted fundamental study of gas discharge phenomena which are important in a wide range of practical situations. For example, amongst the current important industrial problems addressed by the studies of the group are:

- Compressed SF_6 insulation systems including dielectric failure processes in high current SF_6 circuit breakers.
- Discharge interaction with surfaces including plasma oxidation and reactive ion etching.
- Design of air insulation systems for power systems and associated long spark problems such as lightning discharge effects.

Since large-scale collaboration began in April 1977, SERC funds have provided numerous opportunities for short-term working visits, frequent and effective communications and six-monthly group meetings held alternately in the UK and France. These group meetings have been used partly for oral and written submissions of progress in individual projects during the previous six months and partly for small groups planning for subsequent work and interchanges. At the same time, to ensure that the situations studied are of interest in the real world, the group has had a valued interaction with the CEGB and Electricité de France. In the future it is hoped to extend this industrial collaboration in a more direct way and to concentrate on aspects of gas discharges where large space charges and surfaces play a major role. The group has been found to be particularly useful in extending and modifying each laboratory's own programme as well as in stimulating genuine joint collaborative experiments.

For further details, contact Dr P A Chatterton, Department of Electrical Engineering and Electronics, Liverpool University.



Simulation of lightning strikes to aircraft (Photo: Department of Electrical Engineering, Strathclyde University).

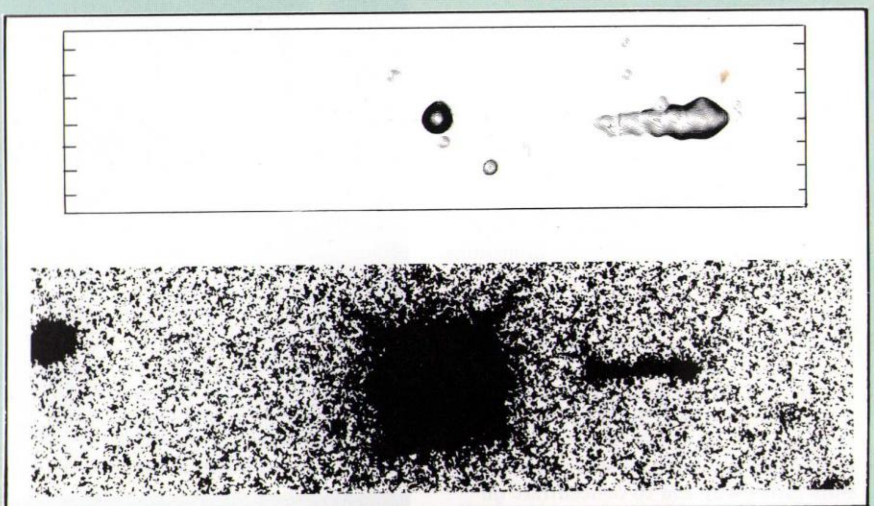
MERLIN at Jodrell Bank

The Jodrell Bank Multi-Element-Radio-Link-Interferometer-Network (MERLIN) has been in operation less than three years and has already contributed very significantly to astrophysical research, in particular to our understanding of active galactic nuclei and quasars. In the study of hydroxyl (OH) radical in star forming regions and the circumstellar shells surrounding infrared stars, MERLIN has a unique capability, which could lead to the establishment of an accurate distance scale in our galaxy.

Originally conceived in 1973 as an improvement and extension of the Long Baseline Interferometry at Jodrell, MERLIN now comprises five 'outstation' telescopes and one of the two 'home' telescopes, Mk IA (76m) or Mk II (25 x 37m). The existing telescopes at Defford (25m) and Wardle (25 x 37m) were up-graded, three new 25m telescopes were built at Knockin, Darnhall and Tabley respectively and all the telescopes were permanently linked to Jodrell. Distances from Jodrell Bank are: Tabley 11 km; Darnhall 18 km; Wardle 25 km; Knockin 68 km; and Defford 127 km.

Each pair of telescopes forms an interferometer which, at any instant of time, measures a component of the two dimensional Fourier transform of the radio emission from the sky within the primary reception pattern or field of view of an individual telescope. As the earth rotates, the separation and orientation of the pair of telescopes, which determine the Fourier component measured, appear to change 'as seen by the source of radio emission'. Thus, by tracking a source during the period of a day for which the source is above the horizon, and correctly combining in a Fourier transform process all the data from each of the 15 interferometers which can be formed from the six telescopes of the system, it is possible to 'synthesise' a telescope of diameter equal to that of the most widely spaced pair, which are Defford and Tabley (134 km apart). The synthesised telescope therefore has a size of 134 km. In practice, the Fourier transform of the sky radio emission is not fully sampled and the data are affected by the atmosphere and ionosphere. Consequently, iterative computing techniques, known as hybrid-mapping, are used to produce the final maps of radio source intensity, which typically have a dynamic range of 500:1.

The 25m E-Systems dish at Knockin. The L-Band and Microwave Link communications dishes are on the tower adjacent to the building.



3C 273, the nearest quasar. The 408 MHz MERLIN map shows finer detail in the jet than an optical picture.

Although an outstation telescope may be controlled either locally on site or remotely from Jodrell independently of the MERLIN system, all the telescopes and receivers are usually under the control of a single Circe computer at Jodrell. There are three links between each normally unattended outstation and Jodrell. The first is a modem/telephone line link between the outstation telescope control computer, which actually drives and takes care of the safety of the telescope, and a Micro-Circe at Jodrell, which is used for input of command data, the transmission of control messages from the Circe computer and reception of telescope and receiver status information from the outstation. The other two links are a microwave link and an L-Bank link. The microwave link 'carries' the radio source signals back to Jodrell, the links being standard commercial devices with a bandwidth of 10 MHz. It is this link bandwidth which limits the operational bandwidth of the instrument. A time division multiplex L-Band link system is used to measure the path lengths of the microwave links to the outstations, so that changes in the phases of the signals due to variations in these lengths, resulting from changes in the troposphere, can be removed. Of more importance, the L-Band link is also used to phase-lock the receiver local oscillators at each outstation. Pulsed signals at 1486.3 MHz are transmitted to each outstation and back again, each outstation being 'serviced' in turn, and all the telescopes are serviced 88 times per second.

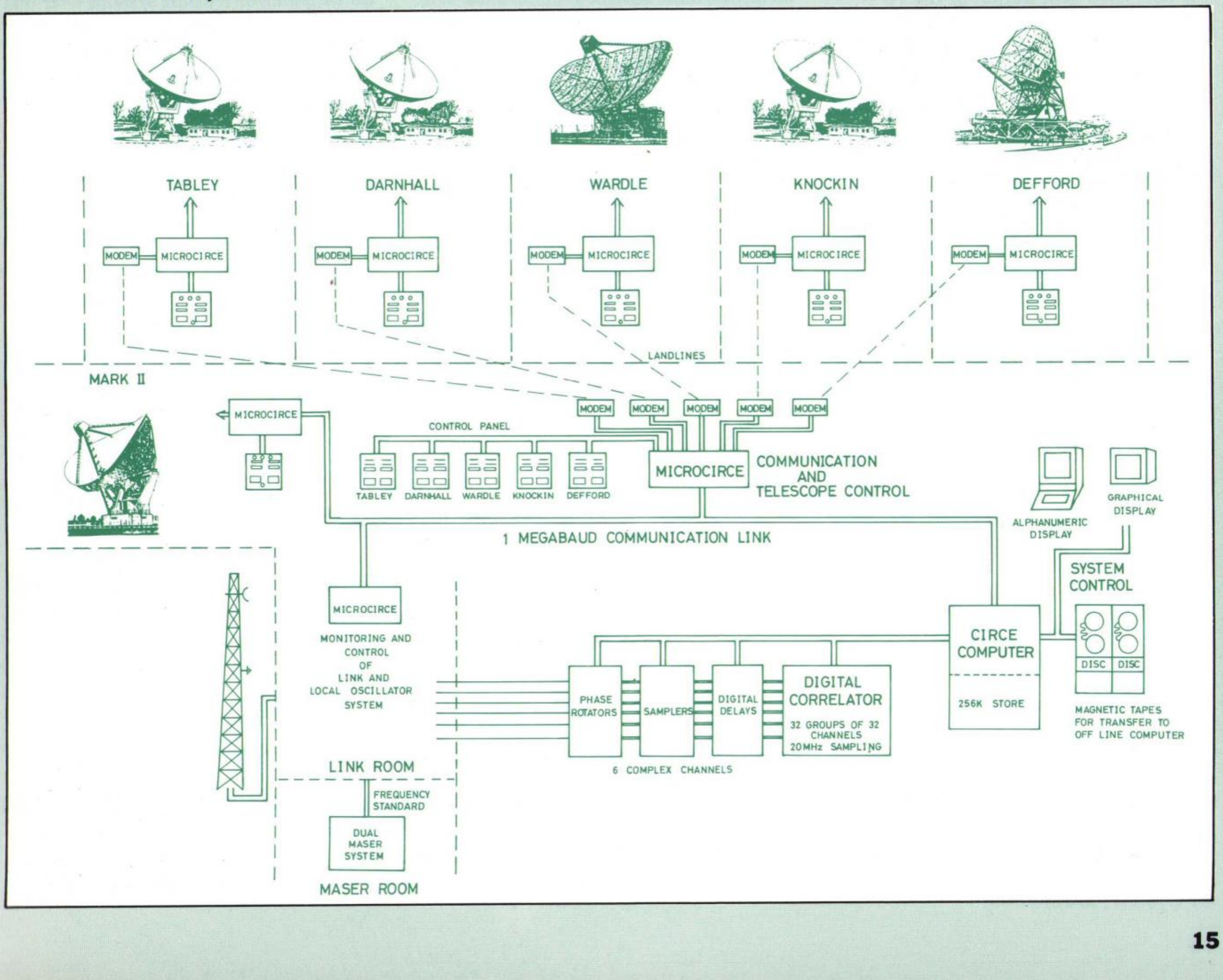
The frequencies of operation of MERLIN range from 151 MHz to 22.2 GHz and the resolution at all but the lowest frequency of operation is as good as or up to two orders of magnitude better than the 1 arc second achievable by earth-based optical telescopes. The optimum operating frequency for the study of quasars and galaxies with the present MERLIN configuration appears to be 1666 MHz. At this frequency, the low frequency extended structure is still just visible with the present system sensitivity and there is sufficient angular resolution (0.25 arcsec) to 'see' the beams or jets which transport energy from the central regions to the outer radio lobes and which are now thought to be one of the keys to understanding these objects. Most of the telescope time has been devoted to the study of these sources, and so successful have the observations been that astronomers from the USA, USSR, Japan, Germany, France, Italy, Sweden, Holland, Poland as well as other UK observatories have applied for and been granted time for their experiments. (All requests for observation time are submitted to the Director and 'refereed' by a Programme Committee – up to the present time, approximately 40% of MERLIN observing time has involved an 'external' observer). As a spectral line instrument, MERLIN's most remarkable success so far has been in probing the circumstellar shells surrounding OH/IR stars – late-type variables, which are losing mass at relatively high rates (about 10^{-5} solar masses per year) and which are characterised by maser emission at 1612 MHz arising from the OH radical. MERLIN has provided the first concrete evidence for the structure and dynamics of these circumstellar shells. Since the OH masers are pumped by the variable infrared radiation from the central star, they too vary, but because of the finite light travel time across the shell, the near side of the shell appears to lead the far side. Careful monitoring of the OH spectrum thus yields the linear diameter of the shell which, when combined with the measured angular diameter, gives a purely geometrical determination of the stellar distance.

The quality of the maps produced by MERLIN is dependent on the coverage of the Fourier transform plane which, with the present system is poor for low declination sources. However one of the advantages of MERLIN is that it is easily extendable and if a telescope were to be sited in the South-East of England, considerable improvement in the coverage for these sources could be obtained. Such a telescope would also improve the resolution and sensitivity of MERLIN, such that it would be comparable at the lower frequencies with the optical Space Telescope (resolution about 0.1 arcsec) due to be launched within the next few years.

It is possible to achieve even higher resolution by linking together radio observatories in different parts of the world to form Very Long Baseline Interferometers (VLBI). This has in fact been done by recording the signals from a radio source on magnetic tape and later combining them in a special processor. A European VLBI Network (EVN), to which the Jodrell Mk 1A telescope regularly contributes, has already been set up. However, the EVN has a minimum spacing between telescopes of about 300 km and therefore cannot be used for observations of sources whose size is greater than about 0.05 arc seconds at 1666 MHz. The inclusion of a telescope to give baselines of 200 km in MERLIN and the EVN would give a continuous series of baselines from a few kilometers up to about 2500 km and thus enable MERLIN and EVN data to be combined to make maps of sources with a resolution of about 0.001 arc seconds. The central cores or power houses of galaxies and quasars and their relationship to the radio jets already discovered could be then investigated in detail.

Dr Peter Thomasson
University of Manchester
Nuffield Radio Astronomy Laboratories, Jodrell Bank.

The MERLIN control system.



Quasar research at RGO

Part 2 : Quasars and their optical spectra

This is the second of three articles describing research at the Royal Greenwich Observatory on QSOs (quasi stellar objects, or 'quasars'), a class of faint blue star-like objects whose optical spectra show broad emission lines with wavelengths dramatically shifted from rest wavelengths towards the red end of the spectrum.

It is the redshifts of QSOs which provide their mystery and fascination. The emission lines are shifted to wavelengths longer than rest wavelengths by amounts $\triangle\lambda$ where $\triangle\lambda/\lambda$ (z, or the redshift) ranges from 0.1 to 3.78, the present redshift record. If – as most astronomers believe – these redshifts are due to QSOs partaking in the general expansion of the Universe, their distances are of order several times 10^9 light years, and the light we received from those at the largest redshifts was emitted when the Universe was one-tenth of its present age. As cosmological probes they are compelling but the astrophysics is even more irresistible. The luminosities involved are up to 100 times greater than that from the combined light output of the 10^{11} stars in a giant elliptical galaxy; observed constraints on the size of QSO emission regions suggest that most of this luminosity is generated in regions not much larger than our Solar system, some one hundred million times smaller than the extent of an elliptical galaxy. Supremely efficient energy-generating mechanisms are required, most scenarios invoking black holes surrounded by accretion disks fuelled by infalling stars or gas.

The first article (*SERC Bulletin* Vol 2 No 9, Autumn 1983) showed some results from direct deep exposures with a CCD (charge-coupled device) camera. Here, results from programmes of optical spectroscopy are described.

QSO absorption lines

The Image Photon Counting System (IPCS), first developed with SERC funds at University College London (UCL), has revolutionized the field of spectroscopic observations. Its high sensitivity, resolution, linearity and negligible noise enable detailed and quantitative spectral analysis of very faint objects, and a major achievement of the instrument lies in the study of QSO absorption lines. The spectra of high redshift QSOs show many narrow absorption features in addition to the broad emission features defining the redshift of the object. Figure 1 shows a notable example. Most absorption features at wavelengths longer than Ly α emission are due to the common ionization stages of the most abundant astrophysical elements; these so-called 'metal lines' occur at redshifts close to that of the QSO down to much lower redshifts. Most of the features shortward of Ly α emission are due to Ly α absorption in hydrogen clouds; collectively these features are known as the 'Ly α forest'. The astronomical community has been split over the interpretation of these lines. One view is that the absorption lines are formed in material ejected from the QSOs (the 'intrinsic' hypothesis), the differing redshifts implying that velocities of ejection up to 0.7 of the speed of light are involved. The second view (the 'intervening' hypothesis) is that the absorptions arise in intergalactic gas (for the Ly α forest) and the interstellar gas of intervening galaxies (for the metal line systems) located along the lines-of-sight to the QSOs. This explanation requires that QSOs are situated at the 'cosmological' distances implied by interpreting their emission-line redshifts as due to Doppler shifts in an expanding Universe. It also requires, for the metal line systems, that the gaseous haloes of galaxies be much larger than their optical sizes.

A major collaboration between UCL/RGO and Caltech astronomers, using an IPCS in an extensive programme on the Palomar 5-metre telescope, has provided firm support to the 'intervening' hypothesis, Observations of homogeneous and unbiased samples of absorption lines in QSOs show that metal-line systems are uniformly distributed in redshift, as expected if they arise in intervening galaxies randomly distributed along the line-of-sight. There is no clumping of redshift systems near that of the QSOs, as might be expected if the absorbers were ejected from them. For the lines in the Ly α forest, on the other hand, the statistical distribution points to the presence of primordial matter distributed at random in intergalactic space. However, some 5 to 10% of QSOs show very broad absorption 'troughs', and a statistical analysis shows that in these special cases ejection does occur; the requisite ejection velocities in these cases are moderate, reaching up to one-tenth of the speed of light.

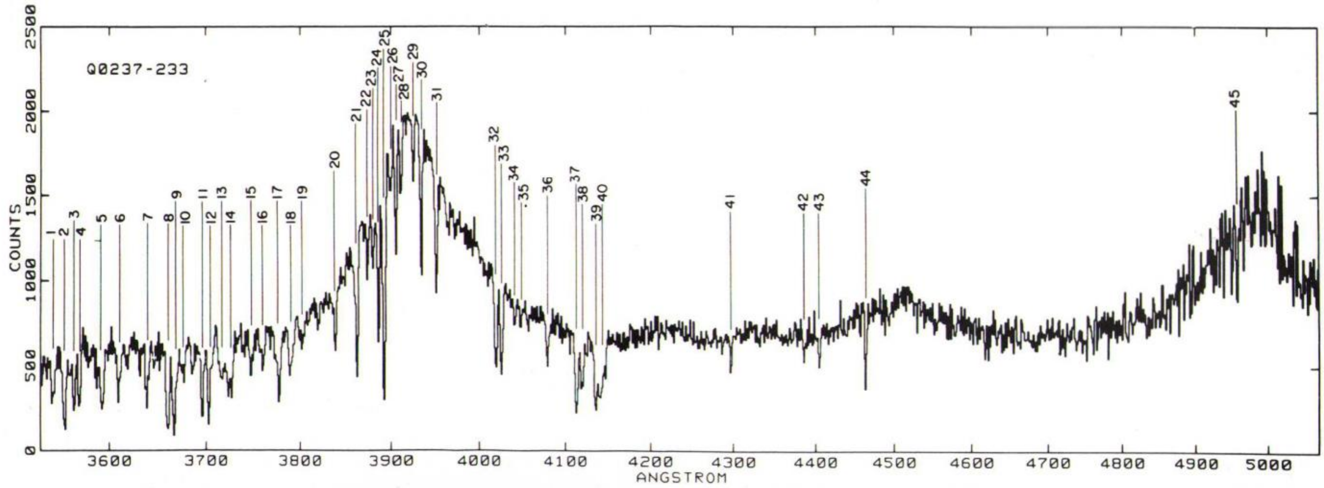


Figure 1: The optical spectrum of QSO PKS 0237-23, as obtained with the Image Photon Counting System on the Palomar 5-metre Telescope. The broad emission lines at λ3920, 4510 and 4990 are HI Lyα, SiIV + OIV, and CIV, at rest wavelengths λ1216, 1400, and 1549; the mean redshift $z = \triangle\lambda/\lambda$ is thus 2.22. The absorption lines constitute 'metal-line systems' and (shorter than Ly α) the 'Ly α forest', as described.

PKS 0215 + 015, a probe of the early Universe

Scientists at the RGO, Sydney University and the Space Telescope Science Institute, Baltimore, USA, recently began a programme of absorption-line studies complementary to the statistical studies. The approach is to consider in detail the physical properties of the gas producing the absorption lines in cases of particular interest, using spectra of far higher resolution than possible when dealing with large samples of QSOs.

PKS 0215+015 is an object rich in absorption lines and is very luminous and highly variable; since its discovery close to the detection limit of photographic plates, it has brightened by a factor of 20 in luminosity, and has occasionally flared up by a further factor of 5. Using the 26-in refractor of the Equatorial Group of telescopes at Herstmonceux, the variability has been carefully monitored to determine the highest luminosity phases. During these times, spectroscopic observations have been obtained at UV wavelengths using the International Ultraviolet Explorer Satellite, and at optical wavelengths using the IPCS detector on the spectrograph built at the RGO for the Anglo-Australian Telescope. Observing at the brightest phases enabled high-resolution spectra to be obtained, an achievement impossible with the object in its quiescent state.

Initial results are exciting. One particularly well-defined absorption system is present at z = 1.345. The absorption lines in this system are almost identical to those produced in the spectra of bright and distant stars by the disk and halo gas of our own Galaxy; similarities in chemical composition and ionization conditions are striking. The conclusion is that galaxies very similar to our own existed at z = 1.345, when the Universe was only one quarter of its present age.

Two other systems, at z = 1.549 and 1.649 are important, showing strong, broad doublet lines of triply-ionized carbon. The CIV lines in the z = 1.549 system are shown in figure 2. The line structure is exceptionally complex, and new STARLINK software developed at RGO and ROE has established at least seven discrete components. The z = 1.649 system is produced by *nine* separate CIV clouds. Triply-ionized carbon is a major constituent of the halo of our Galaxy; so many components in narrow velocity ranges suggest that the line-of-sight to 0215+015 intersects two rich clusters of galaxies at z = 1.549 and z = 1.649. Clusters of such richness are rare at present epochs, and it is interesting to speculate that the observation has detected two young clusters of gas-rich galaxies or protogalaxies undergoing gravitational collapse.

QSOs and nearby galaxies

QSOs work as probes of objects much nearer to us than embryonic galaxies at high redshifts, and in particular they have been used successfully to explore the halo of our own Galaxy and of nearby galaxies. For our own Galaxy, it is obvious that we see the QSO light through its halo. Absorptions (at zero redshift), produced by the common ionization species of the most pervasive elements, have yielded considerable detail on gas conditions – velocities, temperatures, ionization conditions. For nearby galaxies, a very few QSOs lie close enough to them on the sky to have lines-of-sight intersecting their haloes, and absorptions in the QSO spectra at the redshifts of the galaxies again allow exploration of gas conditions. The first detection of this kind, by UCL and Caltech astronomers, confirmed the enormous distances to which galaxy haloes extend.

To carry out halo-probing of nearby galaxies systematically, a group of scientists from the RGO and the Space Telescope Science Institute have initiated a search for QSOs near to bright galaxies. Objective-prism plates were taken for the programme by ROE staff at the SERC UK Schmidt Telescope in New South Wales and were searched at the RGO for possible QSO candidates. Confirmation was then carried out by observing the candidates with the 1.9-metre telescope at the South African Astronomical Observatory, using a spectrograph equipped with a new reticon photon-counting systems recently built at the RGO. Figure 3 shows the confirmed QSOs providing a grid of background objects around the bright southern spiral NGC 253 which will enable its halo to be examined in far greater detail than before. We await the detailed spectroscopy of these objects with excitement; the history of QSO research shows that excitement is the only valid prediction.

Dr J V Wall
Head of Astrophysics and Astrometry, RGO.

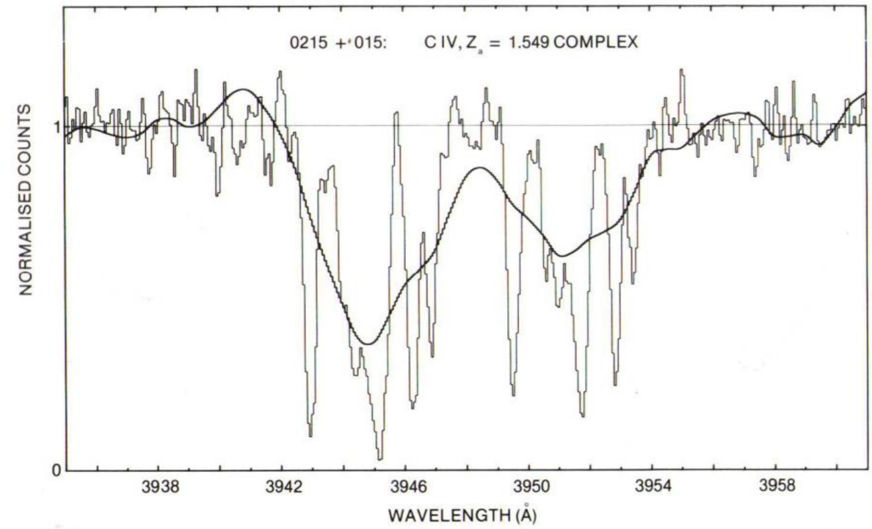


Figure 2: A portion of the high-resolution spectrum of PKS 0215 + 015, obtained with the IPCS detector on the RGO spectrograph of the Anglo-Australian 4-metre Telescope. The region of spectrum contains the doublet lines of triply-ionized carbon λ1548, 1550. The thick line shows the appearance of the complex at a 'standard' IPCS resolution of 1.5 Å; at the high resolution (thin line), the complex breaks up into some seven components in each doublet line.

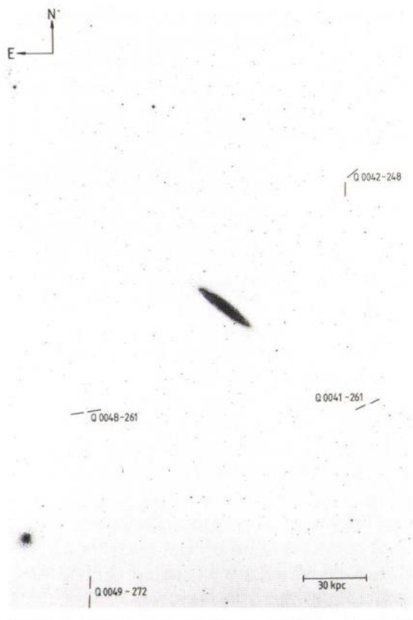


Figure 3: Print from SERC UK Schmidt Telescope plate, showing the bright southern spiral NGC 253 together with background QSOs discovered in a search of a UK Schmidt Telescope objective-prism plate. The QSOs will be used to explore the extent and physical conditions of the gas surrounding NGC 253.

Astronomy in China

In July and August 1983, my family and I travelled to China as guests of the Chinese Academy of Sciences and the Beijing Observatory. The main objectives were for me to deliver a series of lectures to the Beijing Observatory and to the other observatories of China at Kunming, Xi'an, Shanghai and Nanjing and to see the work and facilities of these observatories. I also explored areas of collaboration between UK and Chinese astronomers. In addition, as a family we had a spectacular time visiting many of the outstanding sights of China and learning a little about Chinese life.

Astronomy has a distinguished and ancient history in China but, like many academic disciplines, it suffered very badly during the period of the Cultural Revolution and its aftermath, 1967 to 1977. During these years, all pure science, including astronomy, effectively ceased, the only aspects of astronomy which continued to be actively pursued being those of practical application, for example the time and latitude services which form a prominent part of all the observatories in China. Since 1977, there has been a great upsurge of interest in astronomy as academics have been rehabilitated and the whole of China has embarked on a massive programme of modernisation.

The five observatories and the Nanjing Astronomical Instrument Factory are funded by the Chinese Academy of Sciences which performs a similar function to the USSR Academy of Sciences. The astronomical sciences compete for funds with other branches of the physical sciences but the costs of manpower are essentially guaranteed as part of that budget. Thus, the main problems facing Chinese astronomers are those of obtaining funds for major new projects.

Most astronomy is carried out by members of the five observatories. There are only a few astronomy faculties in the Universities, the principal ones being at the Beijing Normal University, Nanjing University, the University of Science and Technology of China and Yunnan University. The intake of students into the astronomical sciences and then on to postgraduate research is largely determined by the number of positions which are expected to become available in the observatories.

Chinese astronomers are very aware of the terrible loss represented by the 10 to 20 barren years when communication with the rest of the world was virtually impossible and essentially no astronomy was carried out. They realise the problems of re-establishing Chinese astronomy in the front rank of research and are seeking to learn as much from foreign astronomers as possible. The problem is compounded by the fact that so much of contemporary astronomy depends upon advanced technologies in telescopes, instrumentation and their detecting elements. Many of the components they require are produced in the USA and can be obtained only if export licences are approved. In addition, as yet there are few computers in China which are capable of handling the requirements of modern astronomical data reduction.

Despite the problems, there is a determination to overcome them and build up a new generation of astronomers who will eventually become world leaders by the 1990s. The attack on the problem will centre on a number of new facilities which, it is hoped, will become operational in a year or two.

The Astronomer Royal for Scotland (in white hat, carrying his daughter) on the Great Wall.

These will be:

- A 2.1m optical telescope at the Beijing Observatory's observing station at Xing-long.
- A 25m radio telescope and a Mark III VLBI (Very Long Baseline Interferometry) terminal at the Shanghai Observatory, principally dedicated to VLBI work in collaboration with American, European and Australian radio observatories.
- A 13.7m millimetre telescope to be operated by the Purple Mountain Observatory at a remote site 3000 km to the north west of Nanjing.
- The development of astronomical image processing through the acquisition of a VAX 11/780 computer with an extensive array of peripherals.
- Modest facilities for infrared astronomy, including 1m telescopes at the Xing-long station of the Beijing Observatory and the Yunnan Observatory in Kunming.

In theoretical astronomy, the main activity is associated with a relatively new group led by Professor Fan Li-zhu at the University of Science and Technology of China at Hefei which is close to Nanjing. It is hoped that this will become the Chinese centre for theoretical astrophysics and that members of the observatories can spend time working with the theoreticians.

An integral part of the plan for astronomy is collaboration with foreign astronomers and observatories. Even when the above set of facilities is fully operational, Chinese astronomers will be dependent upon foreign observatories for access to the largest (4m class) optical and infrared telescopes as well as to facilities such as large Schmidt telescopes, large synthesis radio telescopes (such as the Very Large Array in New Mexico), high speed measuring machines and submillimetre telescopes. Current policy is to send abroad the best astronomers for periods of up to two years in order that they become familiar with modern techniques and gain access to large facilities. At present, there are about 20 astronomers abroad each year on such missions.

In the longer term, there is the possibility of constructing major new astronomical facilities but my impression is that at present this is no more than a gleam in the eyes of the astronomers. At least, they have begun to make a step in the right direction by the foundation of the Yunnan Observatory at Kunming which is in the south-west corner of China and provides a base for the use of high dry sites which are known to exist in Tibet.

We had an extremely interesting and stimulating visit. We were looked after very well everywhere we went. Perhaps the most lasting impression I have is of the friendliness and openness of everyone wherever we went. I am sure that the presence of our two energetic children did a lot to promote the friendly informal atmosphere we found everywhere.

Scientifically, my visit was exploratory and educational. I was impressed by the fact that, despite the years of great difficulty, there is a lively and very intelligent community of astronomers who are bound to make a major impact on world astronomy in the longer term. It is in everyone's interest to foster scientific collaboration between China and the UK. I would urge all astronomers to bear in mind this potentially invaluable resource when planning future research programmes.

Malcolm S Longair

Professor Longair is Director, ROE and Astronomer Royal for Scotland.

The European Retrievable Carrier (EURECA)

EURECA is an unmanned, free-flying re-usable space platform being developed by the European Space Agency (ESA) as part of the ESA Spacelab Follow-on Development Programme (to which the UK subscription is provided by the Department of Trade and Industry).

The first EURECA mission is scheduled for launch by the NASA Space Shuttle in 1987 and will carry a total payload of about 1200 kg. The core payload will constitute 70-80% of this total comprising several multi-user facilities for experiments in the fields of materials and life sciences to be carried out in conditions of near weightlessness (microgravity).
There will also be two categories of experimenter-supplied 'add-on' hardware, one to exploit the microgravity environment provided by the carrier (about 200 kg) and the other for non-microgravity space science and technology related disciplines (about 100 kg).

Information about the first mission and an invitation for scientific proposals have been widely circulated to the scientific communities of ESA member states. ESA and the national funding agencies of the member states are, concurrently, evaluating the many responses to this invitation; the results of this exercise will be important in the determination of the final configuration of the total EURECA payload.

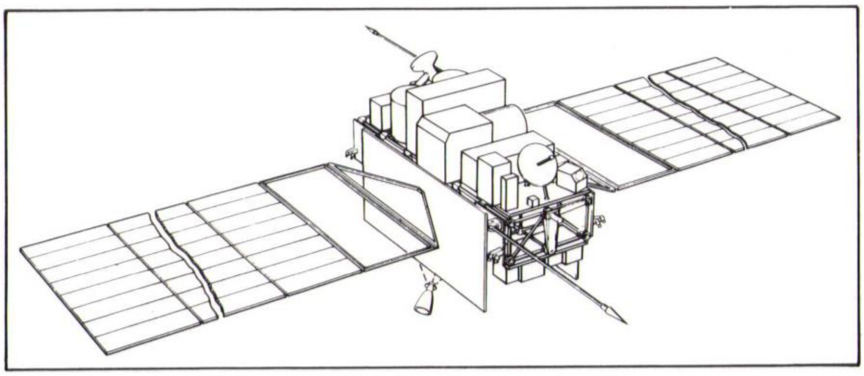


Figure 1: Possible concept of EURECA

EURECA will have a deployment/retrieval orbit of about 300 km and a circular operational orbit of about 500 km with an inclination of 28.5°. During its operational period of some six months, EURECA will be controlled from a ground station under the command of the European Space Operations Centre (ESOC) at Darmstadt, West Germany.

Retrieval of the carrier will depend on the Space Shuttle flight schedule but EURECA can remain in a dormant mode for a period of two months after which it will be returned to the Shuttle orbit for collection and return to earth.

It is envisaged that future generations of the EURECA platform will be developed to achieve a higher orbit capacity (up to 900 km), to provide a carrier in low earth orbit on which payloads can be changed in space, and to provide a carrier system which could co-orbit or cooperate with a future manned space station.

Present plans are for EURECA to be flown at two-yearly intervals. Although the first mission is primarily dedicated to microgravity research, EURECA will eventually have the capability to carry a wide range of payloads (eg astronomy, geophysics, earth observation, technology).

For further information contact: Mr R F Rissone, ESA Section, ASR Division, SERC Central Office, Swindon (ext 2320).

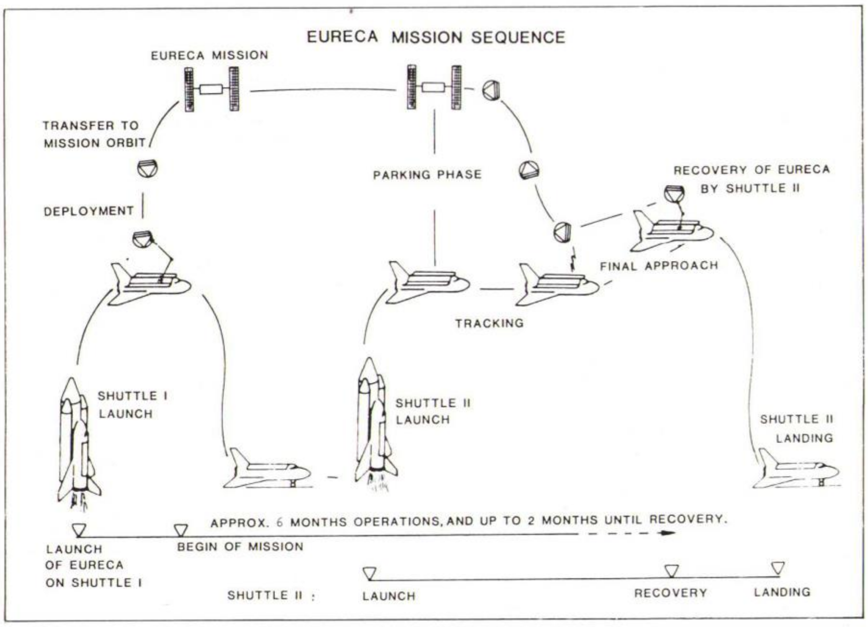


Figure 2: EURECA mission sequence

Edinburgh University City Days

To celebrate the 400th anniversary of its foundation, Edinburgh University opened a large number of its departments to the public at the end of September 1983.
At the Astronomy Department, which is housed in the Royal Observatory (half a mile from the King's Buildings where most of the other science and engineering departments are located) there were demonstrations not only of the teaching of astronomy but also of the research facilities provided by SERC for astronomers at Edinburgh University and at the other centres of astronomical research in this country. About 380 members of the public took the opportunity to visit areas not normally open to them, such as the ROE Plate Library where the large and very detailed photographs of the night sky taken in Australia with the UK Schmidt Telescope are stored and studied.

The 300 days of IRAS

The Infrared Astronomical Satellite (IRAS) made its last astronomical observations on 23 November 1983, 100 days later than predicted at its launch in January 1983. As the superfluid helium coolant ceased to flow, the telescope focal plane quickly warmed and useful operations came to an end. The refrigerant had been cooling the telescope to a temperature of about 2.5° above absolute zero (−455°F), making the instrument the coldest man-made object ever flown in Earth orbit.

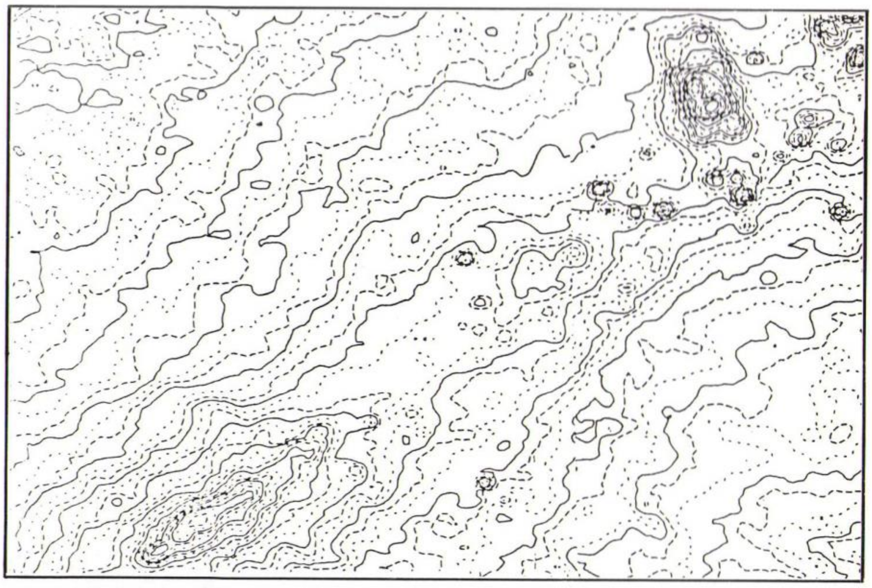
During its 300 day life, IRAS continued to map out the sky in the largely unaccessed part of the electro-magnetic spectrum between 10 and 100 microns, pin-pointing 200,000 infrared objects. It completed its primary goal of carrying out an all-sky survey on 26 August and made a wealth of important discoveries. These include the detection of a ring of solid material around the star Vega, seven new comets, bands of dust around the Sun between the orbits of Mars and Jupiter, and many objects, previously unknown, whose nature is still a mystery.

Our own Galaxy, the Milky Way, proved to be the source of many exciting discoveries. Stars of about the Sun's mass at a very early phase of their evolution have been observed within their natal dust clouds. Detailed maps of the central areas of the Milky Way have been produced which are in agreement with equivalent maps at radio frequencies, showing that the gap in the electro-magnetic spectrum has really been filled and that we now have data extending from the shortest γ and α rays to the longest radio waves.

A further discovery in our Galaxy was of a shell or ring of large particles surrounding Vega, the third brightest star in the sky, which is only 26 light years from the Earth. It is thought that this material could be a solar system but, since Vega is less than a quarter the age of the Sun, it may be at an earlier stage of evolution than our own system.

Finally, IRAS observed many thousands of extra-galactic objects ranging from relatively close objects such as the Large Magellanic Cloud and the Andromeda Galaxy to the very distant quasars. These observations will permit, for the first time, a classification of those objects according to their infrared properties.

IRAS collected a vast quantity of information – roughly 7 x 10^8 bits per day – and the discoveries made so far result from a detailed examination of only a small fraction of that data-base. Discoveries will continue to be made for many years as the information is examined by astronomers world-wide. At the present time we have, as it were, been collecting the books for the reference library but we have not so far had time to do more than flick through the pages.



A contour map of the infrared surface brightness, of a region of sky close to the centre (seen bottom left-hand corner) of our Galaxy. The map is generated from a spline fit to the IRAS data.

Polymer Supply and Characterisation Centre at RAPRA

The Polymer Supply and Characterisation Centre (PSCC) provides a broad service for the molecular weight (mass) characterisation of polymers based on Gel Permeation Chromatography (GPC). This service can accommodate a wide range of polymer types by the selection of suitable working conditions such as solvent and temperature.

The principal GPC system with its range of detectors (refractive index, ultraviolet and infrared) allows the characterisation of many polymers in tetrahydrofuran (THF).

A high temperature instrument is available for the analysis of polyolefins using the solvent 1,2-dichlorobenzene and an infrared detector. Sample turn-around times of less than three weeks would be expected under normal circumstances and urgent samples can be handled more rapidly upon special request.

The PSCC can also accept samples for the recently commissioned GPC/low-angle laser light scattering (LALLS) system. Through this, the molecular weight distribution of a polymer can be produced without the usual calibration procedures required for GPC. This system should be particularly useful for less common polymers where the Mark-Houwink parameters are not known. The GPC/LALLS will normally be used with THF as the solvent. The technique will normally be limited to polymers with a molecular weight greater than 10,000. Up to a gram of polymer may be required for ancillary measurements such as dn/dc. Discussion of the characterisation considerations and the interpretation of the results with the PSCC staff is encouraged. A limited GPC service for copolymers and blends is available, also characterisation in other solvents is possible and enquiries are invited.

Enquiries should be directed to Dr S R Holding or Mr L J Maisey, Polymer Supply and Characterisation Centre (PSCC), Rubber and Plastics Research Association, Shawbury, Shrewsbury, Shropshire SY4 4NR; telephone Shawbury (0939) 250383; telex 35134.

The service is free to projects eligible for support by SERC.

New European Community science and technology programmes

Two new EC programmes were announced for 1983 which will be of particular interest to academic research groups.

The first is a stimulation action designed to improve the efficacy of European research and development. It will have an experimental phase over the years 1983-84. First submissions were called for by 1 October 1983 and a second call is expected in March. The level of funding available for the experimental phase is approx £4.6 million. For this phase the following seven scientific areas of activity have been identified: pharmacobiology; solid state physics; optics; combustion; photometry/photoacoustics; interface phenomena; and climatology, but the programme is also open to high quality proposals in other areas. The programme is intended primarily to foster mobility and collaboration between research groups in two or more member states through the provision of funds for travel, exchange visits, twinning of laboratories and meetings. The full phase (subject to approval by the Council of the European Communities) is planned to start in 1985.

The second programme is on basic technological research (BTR) which is aimed at promoting multisectoral technological research which, although still in the pre-competitive stage, nevertheless has clear industrial objectives. Normally, research institutes and universities should participate in a group with substantial participation (financial or otherwise) by industrial firms. Priority will be given to projects undertaken in cooperation between contractors from more than one Member State.

The principal areas of research proposed for the programme are: reliability, wear and deterioration; surface science and technology; laser technology and its applications and other new methods of metal shaping and forming; joining techniques; new testing methods including non-destructive on-line and computer-aided testing; CAD/CAM and mathematical models; polymers, composites and other new materials; membrane science and technology and problems in electrochemistry; catalysis and particle technology. Indications of interest were called for by 15 October 1983 and the call for firm submissions, subject to formal approval of the programme, is expected early this year. The total EC funding of the programme will be about £90 million over a four year period with support from the Commission not normally exceeding 50% of the costs of the individual projects. A separate but related programme is also planned for the application of new technology to the clothing industry.

Discussions in the EC are also well advanced on the proposed main ESPRIT programme and interested groups will be kept informed on the timing of the call for submissions.

Brief details of these programmes can be obtained from SERC Office, Swindon (ext 2121). Full descriptions of the programmes can be obtained by writing to:

Commission of the European Communities
Directorate General for Science
Research and Development (DG XII)
Rue de la Loi, 200
B-1049 Brussels, Belgium.

Remote sensing for civil engineers

The Environment Committee will be sponsoring a Postgraduate Summer School on Remote Sensing Applications in Civil Engineering at Dundee University, 19 August - 8 September 1984.

The school is intended for postgraduate students, postdoctoral workers, consultants, practising civil engineers, environmental scientists, and teachers in institutions of tertiary education. The emphasis will be on teaching engineers about remote sensing techniques and how to use them.

The subject matter will start by covering the general principles of remote sensing, the acquisition, processing and interpretation of data. After this, detailed consideration will be given to the various important areas of application of remote sensing techniques that are particularly relevant to people working on civil engineering problems.

Topics covered will include: the physical basis of remote sensing; remote sensing systems; data reception; archiving and distribution; data processing and interpretation; corrections to imagery; space cartography and survey; rural land use; geological prospecting; urban development and land use; industrial waste land; coastal engineering; pollution monitoring; snow and ice; bathymetry. In addition to the programme of formal lectures there will also be a substantial programme of practical work to give hands-on experience in processing and interpreting remote sensing data.

Further particulars and application forms may be obtained from Dr W M Young, Carnegie Laboratory of Physics, Dundee University, Dundee DD1 4HN, Scotland; telephone Dundee (0382) 23181.

Polymer Engineering Summer School

This September the Polymer Engineering Directorate will be sponsoring a further one-week summer school, the aim of which will be to give postgraduate research students engaged in the various aspects of polymer research the opportunity to gain a better understanding of polymer processing and technology and an awareness of how real industrial problems are related to their own research. In addition, PED encourages other students, in chemical engineering, mechanical engineering, physics and materials departments, not currently engaged in polymer research to participate in the summer school in order to extend their knowledge to the field of engineering with polymers. The emphasis of the summer school will be on the practical side of processing; students will operate a number of polymer processing machines and a number of industrial visits will also be arranged.

The summer school will be residential and will be run by the Institute of Polymer Technology at Loughborough.
Priority will be given to SERC students and their full attendance costs will be borne by the Council. Any surplus places may be allocated to non-SERC supported students on a first come, first served basis but these students will have to find their own financial support.

The dates of summer school are 3 - 7 September 1984. Nominations for students to attend the course should be made as early as possible.
Contact: Mrs H Lennon,
Polymer Engineering Directorate,
11 Hobart Place, London SW1W 0HL
Telephone: 01-235 7286

Synchrotron radiation news

The summer shutdown of the Synchrotron Radiation Source (SRS) at Daresbury Laboratory during July and August 1983 was used to install two new mirrors (for beamports 12 and 13), attach the 'front end' of the new beamline from port 8, install an RF isolator and carry out considerable maintenance work.

Unfortunately, during the first cycle after operation resumed in the autumn, the SRS suffered a series of cavity window failures, a problem well known in high-power storage rings and microwave valves, which put it 'off the air' for a considerable time. The windows in question seal off the storage ring vacuum vessel at the four apertures where the radio-frequency power is fed in. They are made of alumina, a ceramic material which is transparent to radio-waves. The cause of their cracking, with resultant loss of vacuum in the ring, was under urgent investigation at the time of going to press.

New experimental stations
First data on the powder diffraction station on the new wiggler x-ray beamline was obtained early in cycle 13. The data demonstrated the high resolution that can be achieved, making possible the refinement of structural parameters of powder samples. The next three of the eventual seven stations on the wiggler are now being commissioned and will cater for interferometry, protein crystallography and EXAFS.

Hutches for the EXAFS and small angle scattering stations on beam line 8 have recently been erected. These stations are part of the collaborative development of synchrotron radiation facilities between SERC and the Dutch organisation ZWO. Radiation is expected to be available at these stations in the first half of 1984.

Three shift working
Arrangements were made to embark on regular round-the-clock operation of the SRS in late 1983. Formerly a schedule of two eight-hour shifts per day had been operated, with the SRS being switched to a stand-by condition overnight. The changeover to three shifts per day was made to alleviate the shortage of available beamtime experienced by a great many users. Although reservations have been expressed by some groups as to their ability to cope with 24 hours a day of operation, one expected benefit is that more efficient and stable SRS operation will result.

EXAFS service
An x-ray absorption (or fluorescence) spectrum can be interpreted to yield valuable structural information (specific inter-atomic distances in materials). This has given rise to the technique known as EXAFS (extended x-ray absorption fine structure spectroscopy). Synchrotron x-radiation lends itself admirably to EXAFS measurements and a score of such research projects have already been funded.

The Synchrotron Radiation Facility Committee has now agreed to set up an EXAFS Service Scheme at the SRS to handle some of the growing demand for EXAFS data and interpretation. **Dr C D Garner** (Manchester University) is to be the Director of the Service, supported by two Research Assistants. Final details of the Service are expected to be announced in the New Year.

SRS users' meeting
Some 150 people attended the 1983 SRS Users' Meeting held at Daresbury Laboratory on 23 and 24 September 1983. Four talks by individual users on their research work highlighted the multi-disciplinary applications of synchrotron radiation. This was further illustrated by the 28 contributions to the poster session, ranging from the development of an imaging x-ray microscope to the use of the SRS for infrared spectroscopy and from EXAFS studies of supported osmium clusters to photoelectron spectroscopy measurements on metal overlayers on semiconductors.

A host of user concerns and future plans were discussed in eight concurrent specialist sub-group sessions and the various ideas were pooled in the closing session chaired by Professor R H Williams (Chairman of the Synchrotron Radiation Facility Committee).

Besides a study weekend on Synchrotron Radiation and Surface Science held in October 1983, the Laboratory will be holding a weekend on Structure, Function and Analysis of Biological Systems (March 24 and 25); the next annual users' meeting will be on 21 and 22 September 1984.

Dr K R Lea
Synchrotron Radiation Division, Daresbury.

Selling to CERN

A seminar organised by the British Overseas Trade Board, entitled 'Selling to CERN' was held in London at the end of September 1983 and was got off to a good start by some heartening news. It was announced that a few days before, a British firm, Tesla Engineering Ltd of Storrington, Sussex, had secured from CERN a contract to supply the main sextupole electromagnets for the LEP (large electron positron) project.

The contract is for a total of 510 sextupoles of two different types, with an option for a further 32 units at an overall price of just under 10 million Swiss francs (about £3.1 million). The magnets are designed to unusually close tolerances in order to give the very high quality of magnetic field distribution that the application requires. They are to be used to control and adjust the focusing of the beams of electrons and positrons that will circulate round the LEP machine inside a vacuum chamber.

Something like a third of the contracts for LEP are now either placed or at the stage of tender enquiry. The September seminar concentrated on an area in which the major part of the orders for equipment is still to come, namely the control system of the accelerator. One hundred delegates from the relevant sectors of UK industry attended the seminar, which was organised in conjunction with two trade associations, GAMBICA and ECIF.

It was also announced at the seminar that the Department of Trade and Industry has set up a task force chaired by Mr Roy Trowbridge, former Technical Director of Plessey, to offer help and advice to firms wishing to make tenders for orders from CERN, including those for LEP equipment.

High energy physics at Brighton

The UK was host to the major international conference on High Energy Physics in July 1983. It was the first conference to discuss the conclusive experimental evidence from CERN for the $W^{\pm}$ and Z° particles (see *Bulletin* Vol 2 Nos 8 and 9, Summer and Autumn 1983) and there were many other interesting experimental results from CERN, DESY and the USA expanding our understanding of the behaviour of quarks and gluons. Unexpected nuclear effects observed in muon, electron and neutrino scattering were discussed and a delegate from the USSR described new evidence for neutrinos having mass.

Over 600 people attended the sessions which were held at the Brighton Conference Centre. The conference was judged a great success and the SERC organisation highly praised.

The UK5000 gate array

Seven organisations from UK industry and government laboratories have collaborated to develop a system which totally automates the design of a digital integrated circuit (IC) containing up to 5000 gate equivalent circuits. This follows an initiative by the Department of Industry in 1981. Code-named UK5000, this powerful system is particularly useful to electronic researchers with no IC layout skills. Starting from the user's description of a logic circuit, the software suite produces a reliable layout on the uncommitted array together with a comprehensive test pattern to check the chip after fabrication. Partners in the project are British Telecom, GEC, ICL, Ministry of Defence, SERC, STL and TMC.

The novel array

The UK5000 gate array is a microchip containing a predefined pattern of transistors forming logic and latch (storage) elements. The elements are interconnected by two metal layers, using a suite of automatic design programs.

The gate array has been specially designed to produce thoroughly reliable and testable circuits. Since no feedback loops are allowed within the logic, the structure provides a simple timing criterion which guarantees hazard-free operation. The elements are arranged in rows which are connected to form a 'scan-path' loop for testing purposes. The layout contains 400 latch cells and 2560 logic cells which, with reasonable allowance for interconnections, can provide up to 5000 gates.

The chip design is based upon 3 microns, two-level metal, oxide-isolated CMOS technology. The collaboration has ensured that this technology will be available from industry in production quantities by early 1984. Present testing is performed using a prototype production line.

Automatic design software

The software suite performs the automatic design of a general-purpose chip, available for the first time to academic researchers. The programs check the user's circuit description for syntax errors and implement a layout on the UK5000 array. The circuit is simulated for various input conditions and the propagation timing delays through the logic are calculated. The programs automatically select the best way to place and interconnect the components. Mask patterns are produced for the two metal layers in a format suitable for easy translation into commercial formats such as Calma, Applicon and GAELIC. An automatic program generates a test routine for the logic, taking care to minimise the number of scan-path shift loop loads, and hence cuts down the test time.

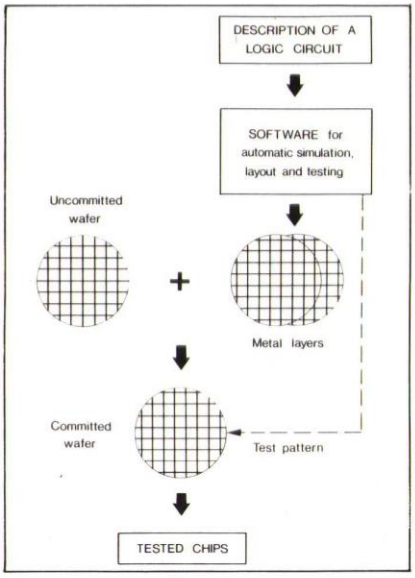
Test results

The project, in which about 35 man-years of effort have so far been invested, is now entering its testing phase. In response to an invitation to the academic community, five test projects are under way using the UK5000 array. Several circuits are at the design stage and one circuit has been manufactured on the British Telecom prototype production line.

The collaboration is extremely pleased with the progress of the project which is nearing a successful completion. The participants are convinced that, for 5000 gate circuits and beyond, systems must use hazard-free logic and be designed to be testable.

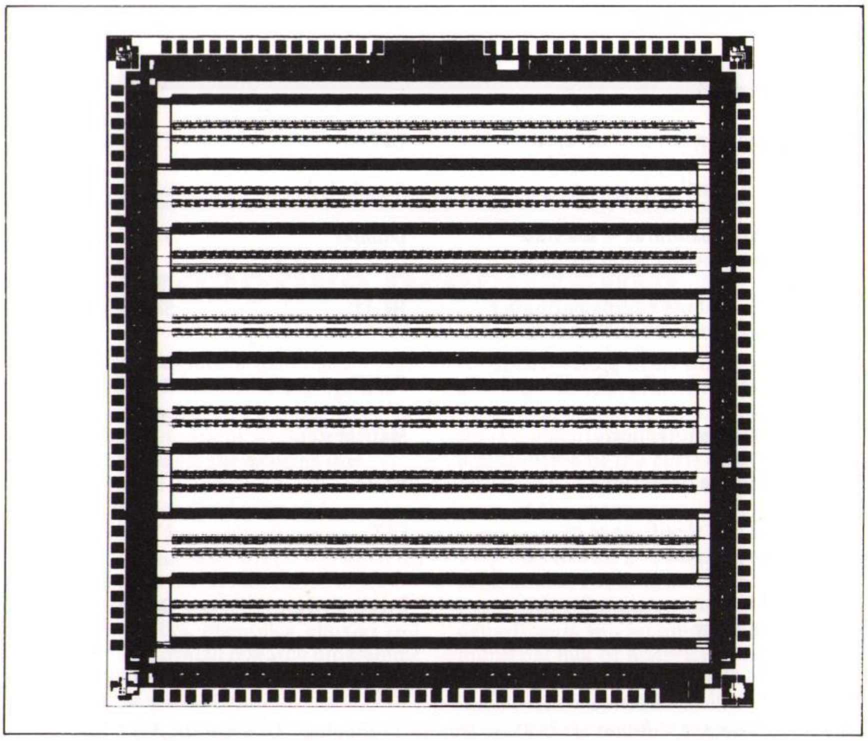
The UK5000 program suite is available on the Prime computers at Rutherford Appleton Laboratory. Staff at the Laboratory are available to give advice on the UK5000 design methodology, the use of the software suite, and on the procedures for committal and testing. For further information, please contact the author at RAL, telephone (0235) 21900 (ext 5276).

Dr J A McLean
Technology Division, RAL.



Schematic of the production of tested chips using the UK5000 array.

The gate array specially designed for the UK5000 project. The rows of predefined components are clearly visible on the 8mm by 8mm chip. The components are interconnected by two metal layers to implement the user's circuit containing up to 5000 gate equivalent circuits.



Marine technology short courses for 1984

Marine mineral resources	ICST	12-15 March
A positive role for microbiology in the enhancement of oil recovery	QMC	18-20 March
Oil and gas production systems	RGIT	26-30 March
Stress corrosion and corrosion fatigue of engineering structures	Newcastle	26-30 March
Vibrations in offshore plant	RGIT	27-29 March
Sour gas damage – a challenge	UMIST	27-29 March
Developing designs for floating offshore structures	Strathclyde	27-30 March
Materials and corrosion engineering	RGIT	March-April
Special concretes for offshore applications	Heriot-Watt	March-April
Non-linear finite element analysis in offshore structural problems	ICST	Spring
Offshore structures (various aspects)	Glasgow	Spring
Introduction to underwater video systems	RGIT	April
Marine biology and the civil engineer: impact and interaction	Liverpool	9-11 April
Corrosion control	UMIST	16-19 April
Probability and spectral techniques	Newcastle	Easter
Non-Newtonian fluid mechanics	RGIT	May
Flow induced vibrations	CIT	1-3 May
Dynamic analysis and fatigue of offshore structures	CIT	13-18 May
Safety shutdown systems offshore	CIT	22-24 May
Geophysical signal processing	Strathclyde	25-30 June
Meteorological satellites – sea state and offshore weather forecasting	Dundee	3-6 July
Mechanics of subsea equipment under the action of environmental forces	RGIT	September
An introduction to oil well drilling fluids	RGIT	3-14 September
Low cost coast protection	Manchester	12-14 September
Offshore drilling operations	RGIT	17-21 September
Assessment and significance of defects in structures	CIT	17-21 September
Electronic instrumentation for the offshore industry	Strathclyde	October
Underwater engineering	CIT	5-9 November
Pipelines for oil and gas	CIT	26-30 November

For further details, contact Mr C Bray, Marine Technology Directorate, 3-5 Charing Cross Road, London WC2H 0HW; telephone 01-930 9162.

Wire rope research within the Marine Technology Programme

In the past, designers were able to rely on codes or handbooks to choose wire rope for a particular application. Wire rope was often treated as dispensable since it was cheap compared with other items. However, today's offshore industry requires new and more demanding uses of wire rope. Moreover, the failure of wire ropes now has greater consequences in towing and anchoring because of the large potential losses. In addition, the maximum diameters of wire ropes have grown with projected designs for tethered buoyant platforms, for example, requiring wire ropes which cannot currently be tested to failure in tension, let alone in more realistic fatigue environment. Consequently, research into many facets of wire rope behaviour has become essential.

However, the subject was not fashionable in British universities until SERC launched its Wire Rope in Offshore Applications Programme. Now there are 13 coordinated projects in ten universities which are expected to cast some light on this important topic.

These include carefully instrumented tensile tests on typical wire strands found in the offshore industry, the object being to obtain reliable experimental results to calibrate and develop theoretical methods of analysis which, in the long term, could be used to design and assess the safety of new wire ropes. The theoretical and experimental behaviour of large-diameter strands having many individual wires is being examined in another project which has obtained excellent agreement between theory and observed behaviour. Failed and retired wire ropes are being gathered from offshore operators, providing statistical information on the residual strength and frequency of failure types in particular wire ropes. This study is complemented by experimental research on the influence of broken wires on the failure of wire ropes. The important topics of corrosion-fatigue and wear behaviour are being explored in several projects. Attention is also being given to dynamic effects including response related to stress, wave propagation and the generation of hydrodynamic coefficients needed for dynamic stability calculations, while work on an accoustic emission NDT method may lead to a new and reliable working tool in the offshore environment.

Laser monitoring of blood platelets

Blood transfusion centres should before long greatly benefit from a simple pilot experiment carried out by a team in the Laser Division at Rutherford Appleton Laboratory (RAL). The experiment is part of a project initiated by biologists and medical engineers at Oxford to study blood platelets and how they react and adhere to artificial blood-handling materials for use in cardio-vascular devices.

These very small and sensitive cells tend to be affected by most diagnostic tools and hence defy the efforts of research workers trying to study the mechanisms that trigger the clotting action in the blood which arrests bleeding and causes thromboses. Because the platelets react to chemical, physical and thermal stimuli, the initial RAL study was to discover whether an optical technique has value as a non-invasive test of platelet viability.

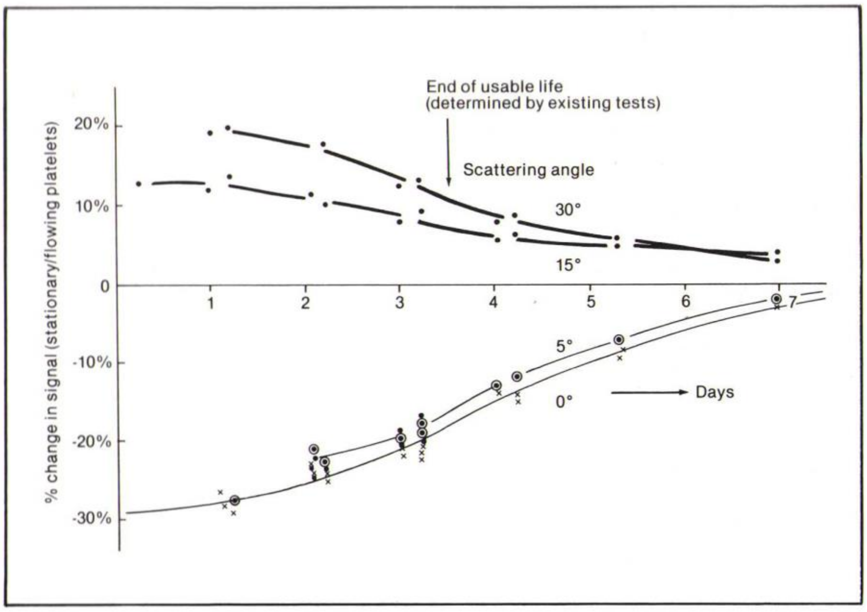
Transfusion centres store platelets from donors in platelet packs to be used in major surgery. The platelets in these packs remain effective for an average of three days but some survive only one day and others are still viable after perhaps five days. Because no non-invasive monitor is currently available, many 'good' packs are thrown away and others are not effective when used.

The optical test was to project a small laser beam through a 2mm thickness of platelet solution (in the platelet pack) and measure the angular intensity distribution of scattered light for two platelet conditions – stationary and in transverse laminar flow. The platelets are known to change from disc-shape to spherical as they age and consequently there is expected to be a change in their scattering properties and in their reaction to a laminar flow.

It was found that the 'flow' signal was generally different to the 'stationary' signal by an amount which reduces to zero as the platelets age. Hence the difference between the signals of stationary and flowing platelets can be used as a monitor on platelet viability. The illustration shows the results of an experimental run on a platelet pack.

These measurements were compared with standard tests (requiring a sample to be withdrawn from the pack) which showed this pack to have a life of three to four days. The large fall after this time of the difference signal has shown that the technique is a potentially valuable one in this medical application.

It is hoped that an engineered version of this test device will before too long provide a permanent on-line monitor for the dozens of platelet packs passing through transfusion centres every day.



Platelet survival

PED supported grant: reactive processing

Reactive processing (or Reaction Injection Moulding – RIM) of polymers is a new fabrication technique through which the constituents react/polymerise during the processing operation. This technique allows polymers to be processed on relatively low pressure moulding equipment, thus reducing energy costs, at the same time facilitating the incorporation of glass, fibre or mineral reinforcement, thereby reducing materials costs. RIM or RRIM (reinforced RIM) has many potentially important applications, particularly in the automotive and consumer durables markets.

PED has recently approved a two-year Cooperative Research Grant to the value of £185,000 to Bradford University (Departments of Manufacturing Systems and Polymer Science) for two projects; to consolidate their current work on RRIM of polyurethanes on the existing low temperature (80°C) machine, which will be enhanced; and for the design and construction of a novel 'hot' (up to 150°C) RRIM machine which will open up new avenues for the development of new high-performance materials such as polyesters, acrylics, phenolics, epoxies and polyamides. An overall research programme extensively backed by British industry will examine these possibilities.

In addition, shorter-term projects designed for collaborating firms will be considered as individual cooperative research grants. Some commercial contract work may also be undertaken, if time permits, a proportion of the costs of which will be returned to SERC to offset the total costs of the programme.

PED regards this as a particularly exciting programme, building as it does on the joint expertise of the University's two departments and incorporating a valuable industrial mix of materials suppliers, machine developers and end-users in the industrial consortium. Such a programme, if successful, should bring many dividends for the benefit of British industry.

ROSAT and AMPTE agreements

Britain and West Germany have signed contracts which will enable UK scientists to participate in two important space missions with West Germany and the USA. The agreements were signed in October by Professor John Kingman, Chairman of SERC, and Dr Hans-Hilger Haunschild, State Secretary of the Federal Ministry for Research and Technology, in the presence of Mr Peter Brook MP, Parliamentary Under Secretary of State for Education and Science.

The first mission, AMPTE (Active Magnetospheric Particle Tracer Explorers), will investigate how solar energy, carried by the solar wind, is intercepted and stored in the magnetic fields that form the Earth's magnetosphere. The AMPTE mission is expected to be launched in August 1984 and will consist of three spacecraft launched on a single Thor Delta rocket. The German spacecraft will release lithium ions into the solar wind at distances of around 20 Earth radii; the American spacecraft, orbiting closer to the Earth, will detect the arrival of the ions and note the expected increase in energy; the UK spacecraft will be a sub-satellite of the German spacecraft and will track it in tandem along the same orbit.

The UK groups taking part in the experiments are Imperial College, Mullard Space Science Laboratory of University College London (MSSL), SERC's Rutherford Appleton Laboratory (RAL), Sussex and Surrey Universities and the British Antarctic Survey. Data will be collected for at least four hours each 44-hour orbit and transmitted to SERC's 25m dish at Chilbolton, Hampshire, linked to the UK control centre at RAL. A 12m dish at RAL will be used for commanding and reception of spacecraft control data.

The second agreement concerns the German Rontgensatellit (ROSAT) which will carry a German 0.8 metre x-ray telescope and a UK Wide Field Camera (WFC). The German telescope will survey the whole sky with a sensitivity comparable to that of the deeper observations made by NASA's Einstein Observatory (1978 to 1981) while the British WFC will extend the energy band of the observations well into the extreme ultraviolet.

The WFC is being developed by a consortium of UK research groups led by Leicester University and including Birmingham University, Imperial College, MSSL and RAL. NASA will provide some instrumentation for the German telescope and will launch ROSAT on the Space Shuttle in August 1987. ROSAT will probably be the only large x-ray telescope in operation during the late 1980s and its data are expected to have a major impact on astronomy well into the next decade.

Cooperative Research Grants: royalties

SERC's present policy on the commercial exploitation of the results of Cooperative Research Grants is that the rights in any patents or other property arising from the research shall be vested in or be transferred to the cooperating organisation, on the basis of a revenue-sharing arrangement with the NRDC of the British Technology Group. SERC is maintaining this policy but wishes to clarify the basis on which royalty levels are fixed.

For all Cooperative Research Grants announced on or after 1 October 1983, the royalty will be based on half the royalty that would normally be payable by the cooperating organisation for a licence for an independently funded invention. In practice this will mean a royalty level of up to 2% on manufactured products, a figure giving a comparable return on the use of processes and, for computer software, a figure in the order of 15%. The Council recognises that difficulties can arise in this area and stresses that NRDC has assured us that their approach to royalty negotiations will be a reasonable one. Any revenue thus generated will continue to be shared between the academic institution and BTG.

Details of this clarified policy on royalties were notified to Finance Officers at institutions by letter RG 8/83 on 5 August 1983 and further information may be found in Section 6 of the booklet *SERC Research Grants 1983.*

Any enquiries on this subject should be directed to Mr R G Tidmarsh at SERC Central Office, Swindon (ext 2179).

Some new publications from SERC

SERC handbooks

A new handbook has been produced by the Marine Technology Directorate entitled *SERC marine technology programme: guidance for participants and advisers.* Copies are available from MTD's offices in London, telephone 01-930 9162.

Marine technology programme

The new editions of all three SERC handbooks are now available from the Registrar (or equivalent administrative officer) in each university or polytechnic or from SERC Central Office, Swindon: *SERC Research Grants 1983* (from ext 2405); *SERC Fellowships 1983-84* (from ext 2172); and *SERC Studentships 1983-84* (from ext 2137).

Current grants in chemistry

The 1983-84 edition of *Current grants in chemistry* is now available. It provides a list and brief description of each research grant awarded by the Chemistry Committee current on 1 June 1983. Copies may be obtained from Dr J Wand, SERC Central Office, Swindon (ext 2263).

Polymer engineering courses

The Polymer Engineering Directorate has produced a leaflet, *Short courses in polymer engineering 1983/84,* in association with the Plastics and Rubber Institute. Copies of this, and of the Directorate's latest *PED Newsletter,* are available from: Polymer Engineering Directorate, 11 Hobart Place, London SW1W 0HL; telephone 01-235 7286.

Council's annual report

The *Report of the Science and Engineering Research Council* for the year 1982-83 has been published. Copies are available from HM Stationery Office bookshops price £5.00 (ISBN 0 901660 55 8; ISSN 0261-7005).

Radio communications

A report has been produced by the Information Engineering Committee (now part of the Information Technology Directorate) entitled *Radio Communications Systems Specially Promoted Programme: an outline.* Copies are available from Mr J Hayes, SERC Central Office, Swindon (ext 2161).

SERC enquiry points

To make it easier to find the right person when you telephone our administrative offices in Swindon (or London), we present a list of the key contact points. We intend to update the list from time to time. Except where otherwise stated, all extension numbers are at SERC Central Office, telephone Swindon (0793) 26222.

Astronomy, Space & Radio Division

Solar, ionospheric magnetospheric and middle atmosphere physics, lunar and planetary sciences, remote sensing aeronomy	Dr R M Payne ext 2317
Radio, millimetre, x-ray cosmic and heavy particle astronomy	Dr J H Price ext 2265
Optical, infrared and ultra-violet astronomy	Dr K P Tritton ext 2417
European Space Agency and remote sensing	Mr R F Rissone ext 2320 Dr E M Forster ext 2367
PATT awards	Mr V M Osgood ext 2418
Research grants	Mr P G White ext 2359
Studentships and fellowships	Mr D J Morrell ext 2446
Computing	Ms C A Iddon ext 2321

Engineering Division

Medical engineering	Miss J Williams ext 2110
Materials	Dr S Milsom ext 2338
Environment	Mr N Williams ext 2353
Manufacturing processes	Mr J Monniot ext 2443
Manufacturing systems	Dr P Sharma ext 2106
Chemical engineering	Mr S D Ward ext 2101
Coal technology	Miss V Brown ext 2202
Fluid mechanics and thermodynamics	Mr J Farrow ext 2117
Applied mechanics Electrical engineering	Mr C Whitlock ext 2350
Joint SERC/ESRC	Mrs A Heselwood ext 2429
Regional Brokers Information dissemination	Mrs J Broughton ext 2238
Design	Mr A Spurway ext 2102

Directorates

Marine Technology	Mr C Bray 01-930 9162*
Polymer Engineering	Mrs E W Morgan 01-235 7826*
Teaching Company	Mr G Brooks ext 2335
Biotechnology	Ms J C Orme ext 2310

Information Technology

Alvey	Dr D Worsnip ext 2104
Control and Instrumentation	Mr W Bray ext 2401
Computing	Mr M Hotchkiss ext 2260
Communications	Mr J Hayes ext 2161
Education and training	Mrs P Kielty ext 2428

Nuclear Physics Division

Nuclear structure, Studentships & fellowships	Miss P C Davis ext 2331
Particle physics	Dr AEA Rose ext 2278
CERN	Mr J D Walsh ext 2271

Science Division

Biological sciences	Mr N Birch ext 2125
Computing	Mr D K Majumdar ext 2421
Mathematics	Mr F Hemmings ext 2312
Neutron facilities	Mr D M Schildt ext 2212
Physics	Mr A J Parsons ext 2261
Science-based archaeology	Mr A G Game ext 2361
Laser facility	Physics Secretariat ext 2215
Chemistry and pharmacy	Ms L C Gosden ext 2166
Synchrotron radiation facility	Dr E J Wharton ext 2222
Cooperative Grants (Science)	Mr D Harman ext 2214

Finance

Account queries	Mr S Pridding ext 2434

Research grants

Most enquiries should be addressed to the Committee Secretariat relevant to a particular project.

Terms and conditions/ supply of forms	ext 2405

Studentships: applications

Advanced course studentships	ext 2414
Research studentships	ext 2136
CASE	ext 2138
Studentships tenable abroad and general enquiries	ext 2137

Studentships: current

Ask switchboard for current studentships for your institution

Fellowships

Postdoctoral (home, overseas and NATO), advanced and senior fellowships	ext 2172
Special Replacement Scheme	ext 2352
Industrial Visiting	01-222 2688†
Royal Society/SERC Industrial	ext 2206
AAT	ext 2417
CERN	ext 2223
ESA	ext 2267

Central computing	Ms C A Iddon ext 2321
International collaboration (except NATO/postdoctoral Fellowships)	exts 2121, 2404 or 2253

* For London addresses, see inside front cover.

† All enquiries about Industrial Visiting Fellowships should in future be made to: Fellowship of Engineering, 2 Little Smith Street, London SW1P 3DL.

NSF inauguration at Daresbury

Daresbury Laboratory's Nuclear Structure Facility (NSF), the world's largest tandem Van de Graaff accelerator, was inaugurated on 27 September 1983 by the Rt Hon Sir Keith Joseph MP, Secretary of State for Education and Science.

The accelerator, housed in a steel pressure vessel 45 m high and 8 m in diameter, is contained in a 70 m high concrete tower. The NSF is designed to operate initially at up to 20 million volts (MV) on its high voltage terminal and there is considerable pride that it is currently operating up to that level – the highest voltage worldwide (see *SERC Bulletin* Vol 2 No 9, Autumn 1983). This type of accelerator is capable of producing intense ion beams from almost every element in the periodic table, from hydrogen to uranium, and the high quality beams, particularly of heavy ions, together with easy energy variability, make the NSF extremely versatile.

The atomic nucleus is a complex many-body system in which the strong, weak and electromagnetic forces combine to produce a rich array of phenomena. Most research in nuclear physics makes use of ion beams to probe nuclear behaviour and the recent availability of heavy ion projectiles is proving extremely rewarding. One feature of heavy ion collisions is that large, but controlled, amounts of internal and rotational energy can be added to the nucleus and the effects studied. Such collisions also enable new nuclei to be made in the Laboratory with properties far removed from those normally found in nature. The large electric field that surrounds a heavy nucleus permits new studies not only of electromagnetic properties but also of various atomic systems under extreme conditions.

A wide range of experimental equipment is already available and includes: a magnetic spectrometer used for high precision studies of nuclear reactions and which allows reaction products to be measured at different angles; the TESSA (Total Energy Suppression Shield Array) whose sophisticated gamma-ray detection system enables extremely complex decay schemes of nuclei to be studied to provide details of energies and spins of the states in the nucleus; the isotope separator which is designed to study the sizes, shapes, lifetimes and spins of nuclei with lifetimes of a second or more. This works in conjunction both with a dilution refrigerator and a laser interaction line which either allow nuclei to be implanted into a ferromagnetic host at extremely low temperatures or determine nuclear properties by studying the hyperfine structure in the atomic spectra. In the near future a special purpose recoil separator, designed to filter out particular nuclei produced in a reaction, will assist in searches for superheavy nuclei so far only predicted theoretically.

Professor Leslie Green, Director of Daresbury Laboratory, responding to Sir Keith Joseph's inauguration speech. Professor John Kingman, Chairman of SERC (left), looks on.

In the first six-month period of operation of the NSF, more than 20 experiments were completed. Scientists have already used more than 25 different ion beams including some, such as calcium-48, which occur at very low abundances in nature. To provide the required beam energies the accelerator operated at many voltages between 11 and 20 MV. Tritium and polarised heavy ion beams are planned and will further enhance the facilities offered by the NSF. Initial experiments, recently described in contributions to international conferences and in published papers, have led to new understanding of the behaviour of atomic nuclei. There have been over eighty proposals for experiments involving user groups from universities and other establishments in the UK, and Daresbury scientific staff. Several proposals include international collaborators producing a very welcome cross-fertilisation of ideas and experience.

After the inauguration ceremony the Secretary of State toured the Facility and at a subsequent press conference described the inauguration of the NSF, representing a £13m investment by SERC, as a 'day of pride for Britain'.

Professor Leslie Green and Dr Robert Voss explaining to Sir Keith Joseph (centre) how the 42 metre-long vertical insulating stack is constructed. This supports a 4.5 metre high terminal at its centre which can be charged up to 30 million volts by a special charging system called a laddertron.