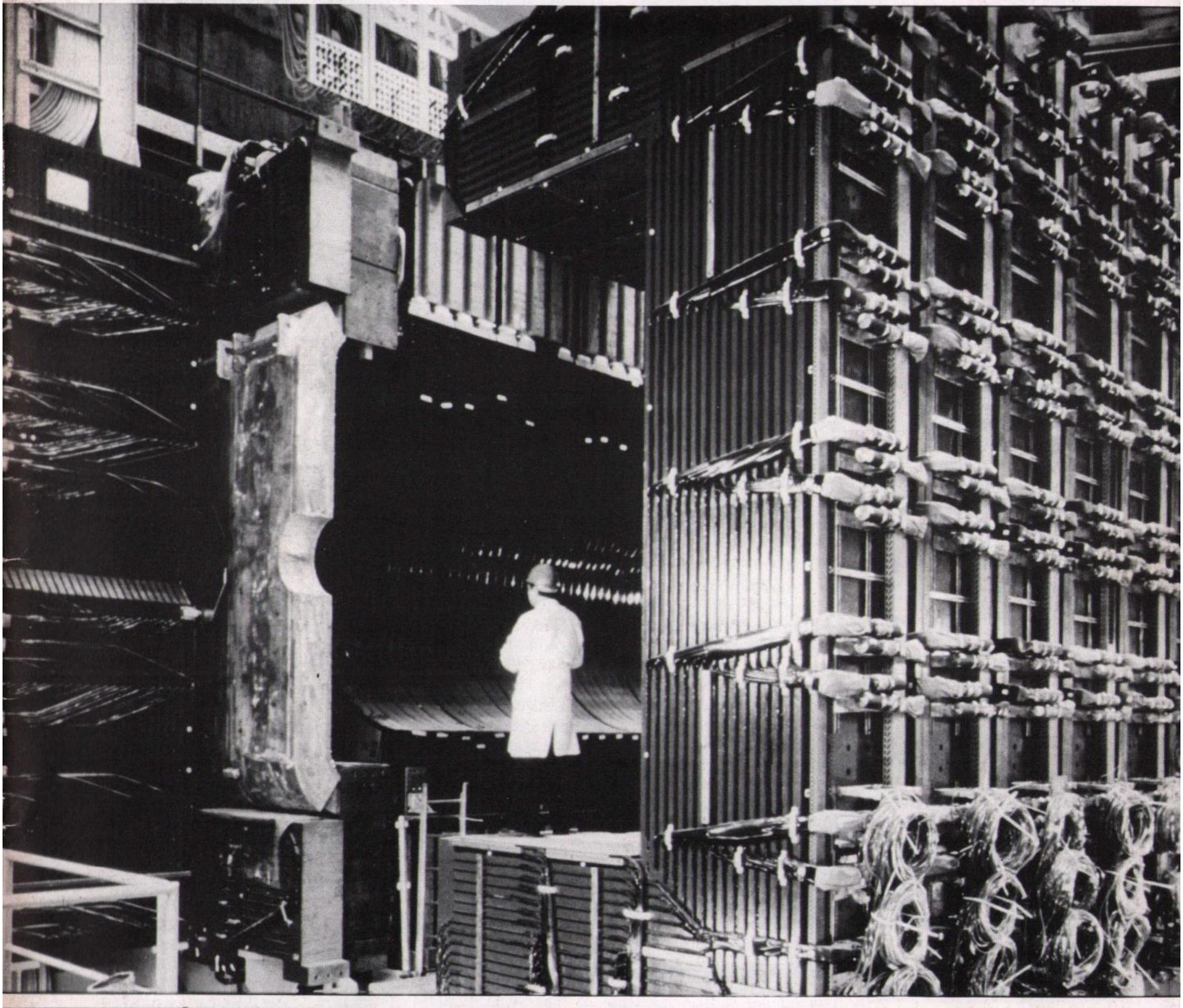
SERC BULLETIN

SCIENCE & ENGINEERING RESEARCH COUNCIL

Volume 2 Number 6 Autumn 1982



In this issue

Establishments of the Science & Engineering Research Council

SERC Central Office
Polaris House
North Star Avenue
Swindon SN2 1ET
Telephone (0793) 26222

SERC London Office
3-5 Charing Cross Road
London WC2H 0HW
Telephone 01-930 9162

Rutherford Appleton Laboratory (RAL)
Chilton, Didcot
Oxon OX11 0QX
Director Dr G Manning
Deputy Director
Professor J T Houghton FRS
Telephone
Abingdon (0235) 21900

Daresbury Laboratory
Daresbury, Warrington
Cheshire WA4 4AD
Director
Professor L L Green
Telephone
Warrington (0925) 65000

Royal Greenwich Observatory (RGO)
Herstmonceux Castle
Hailsham, East Sussex
BN27 1RP
Director
Professor A Boksenberg FRS
Telephone Herstmonceux
(0323) 833171

Royal Observatory, Edinburgh (ROE)
Blackford Hill
Edinburgh EH9 3HJ
Astronomer Royal for Scotland and Director
Professor M S Longair
Telephone
031-667 3321

Cover picture:

A view of the large magnetic detector in the UA1 experiment at CERN's Proton-Antiproton Collider (see page 12).

Photo: CERN

ISSN 0262-7671

Professor Alec Boksenberg and Mr John Pope show President Gayoom a model of the 4.2m telescope planned for La Palma and describe the altitude azimuth mounting.

Maldive President visits RGO

His Excellency M A Gayoom, President of the Maldive Islands, came to the Royal Greenwich Observatory on 14 May during his State Visit to the UK. The President is a keen amateur astronomer and had personally requested the visit. His party included Miss Aneesa Ahmed, Under Secretary in the President's Office, Sir John Nicholas, British High Commissioner to Sri Lanka and Ambassador to the Maldives, and Lady Nicholas together with other members of the Presidential Staff.

His Excellency was welcomed to the Observatory by the Vice Lord Lieutenant of Sussex, Major Bruce Shand, representing Her Majesty the Queen, and by Professor Alec Boksenberg FRS, Director of the RGO, and Mrs Boksenberg.

After a formal luncheon in the drawing room of Herstmonceux Castle the visitors were shown several displays representing various aspects of the work of the Observatory. Dr Paul Murdin and Mr John Pope described the work on the new observatory on La Palma and showed the President models of the various facilities being designed for the Island; Mr David Thorne gave an on-line demonstration of modern methods of image detection and processing using the CCD stand-alone system. Miss Janet Dudley and Mrs Lesley Murdin then showed him a small selection from the RGO's Airy Collection of rare books and from its archives and Mr Tony Bish, the Observatory's Conservation Officer, explained the efforts being made to preserve and restore both manuscripts and printed books.

The party were then taken round the gardens, the public exhibition and the Equatorial Group where Mr Peter Corben showed the 26 inch telescope: the President was able to see the star Procyon. Later he was shown examples of the 60,000 plates that have been taken with this, the oldest operational telescope at Herstmonceux, and discussed with interest the programmes of parallax and proper motion determination and, more recently, its use for the accurate positioning of radio source objects.

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 through the provision of grants and studentships and by the facilities which its own establishments provide for university research.

The SERC Bulletin summarises topics are concerned with the policy, programmes and reports of the 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.

Women and physics

Sixty fifth-form girls were given a three-day university experience in June/July this year. A residential school, entitled Women and Physics, was held at the University of Manchester, to encourage girls to take up physics at university in the hope of moving towards a sex balance nearer that achieved by France and Eastern Europe.

The school was financed by the first award from SERC's Holmes-Hines Memorial Fund, created in 1981 when the Council received a bequest under the Will of the late Miss Frances Hines. Miss Hines, a Modern Languages teacher, developed a life-long interest in scientific research after listening to Lord Rutherford lecture at Cambridge in the 1930s. She made the bequest to SERC to be used for any purpose which would help individuals achieve their scientific aspirations and to sponsor activities related to science for which public funds might not be available.

So many girls wanted to attend the school that the organisers arranged a one-day school for all the girls who would otherwise have been disappointed. And the school itself was so successful, with such enthusiastic reactions from all the girls who attended, that it is particularly hoped that other universities will take up the idea.

Twin themes were chosen for the course: Energy Resources and Man's place in the Universe. Besides attending lectures and tutorials, the girls were able to use highly sophisticated research equipment in the laboratories and were given tours of Jodrell Bank Radio Astronomy Observatory and the computer facility STARLINK in the Schuster Laboratory, which handles astronomical data.

Professor J C Wilmott, Director of the Physical Laboratories at the University of Manchester, who initiated the school, is hoping funds can be found to make the school an annual event.

Council commentary

Forward look

Council's major preoccupation at its February and March meetings was to determine the content of the 1982 Forward Look details of which were submitted to the Advisory Board for the Research Councils early in April. The funds available to Council under the ABRC's main guideline were £245 million (1983/84), £257.26 million (1984/85) and £257.26 million (1985/86), in cash planning terms. A consequence of these figures is that, if inflation continues to exceed the allowance made within the Government's cash planning calculations, SERC's financial position will steadily decline in real terms. International subscriptions present rather special planning difficulties, since variations in the rates of exchange totally outside the Council's control can affect the level of expenditure significantly, yet the result must be contained within the cash limit. In this difficult financial climate, Council determined to give first priority to the maintenance of high quality research in universities and polytechnics. The available funds are, nevertheless, insufficient for a properly balanced programme and, in particular, nuclear physics and space research are supported at a level well below that justified by the scientific opportunities.

Members were conscious of the need to back new projects even if Council's financial prospects do not improve. It decided, therefore, to consolidate within this year's main guideline provision for the new Directorate of Biotechnology, for a significant expansion of the Teaching Company Scheme, and for a major new effort in Civil Engineering. This could only be achieved at the expense of intensifying the pressure for funds across the programme as a whole, as well as by selectively reducing the support for certain areas. Resources allocated to the Marine Technology Directorate, for instance, decrease over the Forward Look period as more industrial funds are attracted into the programme, and the Polymer Engineering Directorate, launched in 1975, is planned to cease as a separate activity in 1984, after which the initiatives nurtured by the Directorate will be supported through the Engineering Board's normal mechanisms.

Council also identified a number of new programmes which are too large to be accommodated by reducing the broader based research support. These were, therefore, presented to the ABRC as bids for additional resources, two of which were closely related to initiatives being led by the Department of Industry (DoI) in information technology and in remote sensing. A committee under Mr John Alvey's chairmanship has been defining a possible five-year national programme in information technology embracing Government, industry and the universities which is intended to create a firm technological base for the computer and computer-related industries. SERC's particular contribution, which was discussed by Council more fully in July, is expected to concentrate on the research and teaching areas, where major programmes in novel computer architectures, expert systems and new approaches to the man-machine interface are likely to be instituted.

Council is actively involved in remote sensing and already spends approximately £1 million pa, the approval of the Along Track Scanning Radiometer for ESA's ERS-1 satellite being illustrative of this involvement (see page 4). Conscious of possible future scientific opportunities in remote sensing, Council agreed at its July meeting that these existing activities were a sufficient basis on which to participate formally in the emerging national programme which the DoI is establishing around ERS-1. Subject to ABRC's acceptance of the case for additional Research Council work in the field, Council, in concert with the Natural Environment Research Council, hopes to contribute more fully to the national programme and to develop space activities related to climate research generally.

Replacement of the IBM 360/195 computers at RAL

The batch processing and time-sharing services operated by the Rutherford Appleton Laboratory (RAL) have until recently relied upon two IBM 360/195s and an IBM 3032. Both the 195 machines are eleven years old: they are expensive to operate and to maintain and can no longer run modern software or interface with modern peripherals. Council has, therefore, been anxious to replace them at the earliest opportunity and decided at its May meeting to proceed with the installation of an IBM 3081D this summer (delivery took place in July).

Council also agreed that this initial purchase should be followed by the introduction of a second major new processor in May 1983. This second machine is of Fujitsu origin but marketed in the UK by ICL as part of a wider collaboration between the two companies. It has recently been publicly launched as ICL's Atlas 10 system and SERC has agreed to take delivery of the first machine. Once installed, it is intended that the existing IBM 3032 shall be withdrawn thereby completing the replacement of obsolete equipment.

Postgraduate Training

Council has now given detailed consideration to the report of the ABRC Working Party on Postgraduate Education, and its views have been conveyed to the Department of Education and Science. As the report itself says, SERC was involved in a continuing dialogue throughout the preparation of the report, and was moving in the direction of its recommendations before its appearance; there is, therefore, considerable agreement with and support for much of its contents. There were certain instances of disagreement or qualification, perhaps the most significant being in relation to the treatment given in the report to engineering interests. Here, the Engineering Board felt that the report demonstrated an inadequate appreciation of the essential educational needs and later career patterns of engineers; it is firmly convinced that its policy on advanced course training represents a positive development towards providing UK industry with properly trained graduates and, contrary to the views of the Working Party, sees a strong case for an increase in the number of such studentships provided by SERC.

Council has also been giving consideration to its own internal arrangements for dealing with studentships and their distribution amongst the various schemes and the four Boards. After consulting the Boards, it has been agreed that they should become directly responsible for the funding of studentships and the control of their numbers, within an overall postgraduate training policy approved by Council. In broad terms this means each Board will carry out on its own behalf the functions hitherto performed by the Postgraduate Training Committee, which will be stood down at the end of the present session.

Council membership

During the course of the year Dr D S Davies resigned from the Council on retiring as Chief Engineer and Scientist of the DoI and was replaced by his successor, Mr O Roith; and Dr R B Nicholson, FRS resigned on appointment as Chief Scientist of the Central Policy Review Staff. In accordance with the normal rotation of membership Dr P Clarke, Dr W H Cockcroft and Professor J C Willmott have retired from Council and four new members have been appointed by the Secretary of State for Education and Science. They are: Mr Geoffrey Hall, FEng (Director of Brighton Polytechnic); Professor Edgar Mitchell, CBE (Dr Lee's Professor of Experimental Philosophy, Oxford University); Sir Francis Tombs, FEng (Chairman of the Weir Group); and Professor James Turner (Professor of Inorganic Chemistry at Nottingham University).

THE ALONG-TRACK SCANNING RADIOMETER

UK experiment for Europe's first Remote Sensing Satellite

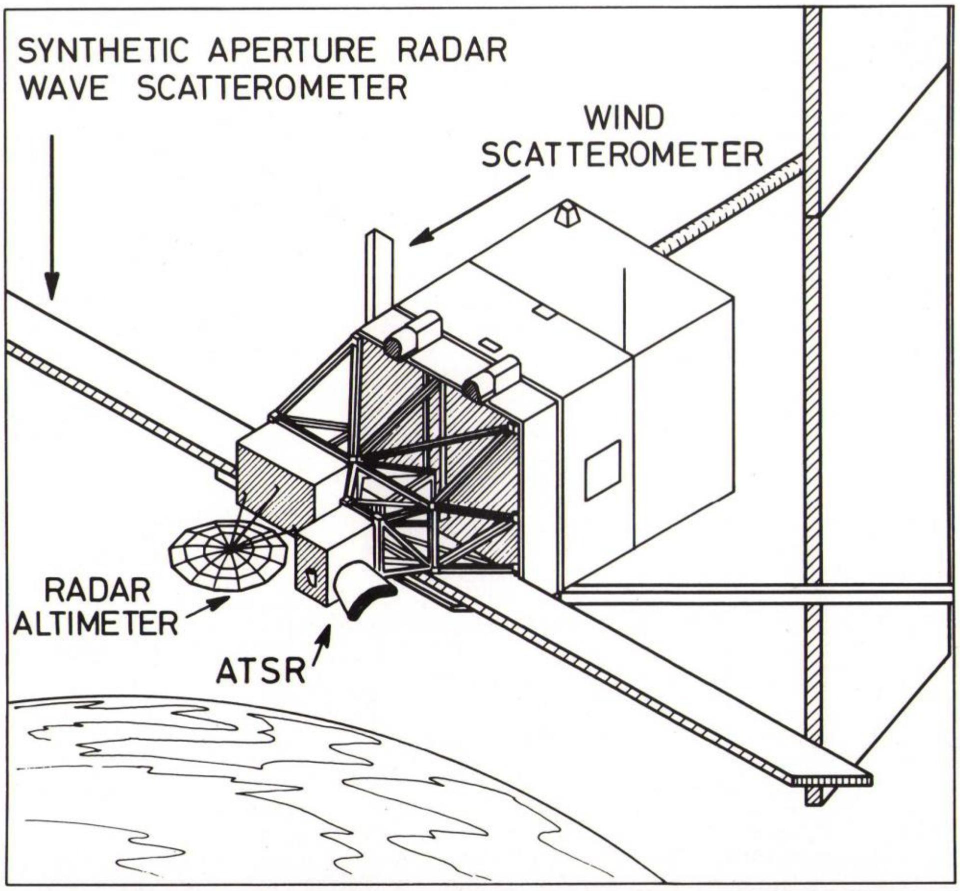
The European Space Agency is planning to launch its first satellite for remote sensing of the Earth in 1988. The satellite, ERS-1, will carry a core payload of three microwave radar instruments, plus an additional scientific experiment, and will concentrate on studies of the oceans. The additional instrument will be the UK's Along-Track Scanning Radiometer (ATSR), which was selected by ESA from 10 European proposals, and approved by the SERC in June this year.

The ATSR is a high-accuracy multi-channel infrared radiometer for studies of the radiation temperature of the sea surface, the intensity of atmospheric radiation in the infrared spectral 'window' regions, and the effect of the global oceans on the atmosphere and the world's climate.

ERS-1

The ERS-1 mission has two major aims. First, to provide a near-real-time remote sensing service to commercial ocean users (eg shipping lines, oil rig operators, fishing companies, etc), employing all-weather radar sensors to monitor ocean-state parameters such as wave height, wave direction, wind speed and so on. Second, to make a contribution to our scientific understanding of the interaction of the ocean and atmosphere, the transport of energy, heat, and momentum by the ocean and atmosphere, and the exchange of these quantities between the two. Added to the scientific aims is the existence of the additional science experiment – the ATSR.

There are three radars to be carried on the spacecraft. The first is an oblique-viewing 5.3 GHz Synthetic Aperture Radar (SAR) which provides very high spatial resolution (of about 30m) images of the ocean surface. The second radar also operates at 5.3 GHz, and makes direct radar backscatter measurements from wind-generated capillary waves at the surface. The intensity of backscatter can be related to wind speed and direction. The third radar operates at 13.5 GHz, in the nadir, and is a radar altimeter. In this case, a very short pulse is transmitted and the reflection from the ocean surface is measured; the presence of waves at the surface distorts the shape of the leading edge of the pulse and this distortion can be interpreted in terms of mean wave height. The altimeter can also be used to measure the topography of the ocean surface beneath the satellite: global measurements of dynamic topography can be used to infer geostrophic currents (ie those major ocean currents which arise from horizontal pressure gradients and the rotation of the Earth. Each of these radars yields data which are also of value to geophysical research, in the areas of ocean-atmosphere interactions and climate.



The ERS-1, Europe's first remote sensing satellite, with its operational radar instruments and the ATSR research payload

ATSR

The ATSR instrument is essentially an advanced infrared radiation thermometer. The purpose of the instrument is to make very high accuracy (less than 0.5 K absolute) measurements of sea surface temperature, and of effective atmospheric brightness temperature, on a global basis. Although our understanding of the role of the oceans in the world climate is scanty, we know that they represent a major heat store, and the exchange of energy and momentum between ocean and atmosphere (and vice versa) is a central process in the whole climate system. The device will have three infrared channels, at wavelengths of 3.7, 10.5 and 11.5 μm, selected by means of interference filters, and using cooled semiconductor photo-conductor detectors. The instrument employs a single rotating mirror to execute a conical scan, which allows the ocean surface to be scanned across the sub-satellite ground-track in both the nadir and at a forward direction of about 60°. In this way images of the ocean surface are built up at two angles (stereo viewing) as well as at the three wavelengths. The pixel size is 1 x 1 km^2, and the swath width is 500 km. The interpretation of these six pieces of information then rests on forming linear or quadratic combinations in order to extract a number of geophysical parameters including sea-surface temperature, atmospheric water vapour content and atmospheric brightness temperatures at these wavelengths. The data can also be used to study cloud properties such as cloud-top height and temperature, and global distribution. The interpretation process also involves simulations of the infrared spectroscopic properties of the atmospheric constituents such as H_2O, CO_2 and O_3, and of the various types of clouds. Indeed, as in the quantitative interpretation of any geophysical remote sensing experiment, interpretation of ATSR data will demand a very profound understanding of the electromagnetic and spectroscopic processes involved in the Earth's atmosphere and at the surface.

The ATSR as a space-borne radiometer is required to have unprecedentedly high absolute accuracy, very good long-term thermal and radiometric stability, and high sensitivity. Such requirements mean that the project is an exciting and demanding challenge to our space scientists and engineers who have proven their ability through their involvement in several earlier satellite remote sensing experiments (eg on Nimbus 4, 5, 6 and 7, and on the Dynamics Explorer B). In particular, the radiometric calibration targets will receive particular attention and the instrument utilises a novel new space-borne refrigerator (a Stirling cycle cooler) under development in Oxford University.

The ATSR project is being led by scientists at the RAL, in collaboration with researchers at Oxford University and at the Mullard Space Science Laboratory of University College London. In addition, the UK Meteorological Office is contributing to the project.

Each of these four centres has considerable expertise in building novel and advanced instruments for space, and in the interpretation of remote sensing data for geophysical research. It is anticipated that each institute will take responsibility for a major element of the programme, such as testing, ground support equipment and calibration targets. In addition to the project team made up of staff from these four centres, more than 20 UK and overseas scientists are involved in the project as guest investigators, many supported by the Natural Environment Research Council: these people have agreed to contribute in a variety of ways, such as by providing 'surface truth' measurements coincident with satellite overpasses, or by participating in data interpretation or scientific study exercises.

Once the ATSR instrument is built and tested, is operating in orbit and the data interpretation has been carried out, many research topics can be investigated. For example:

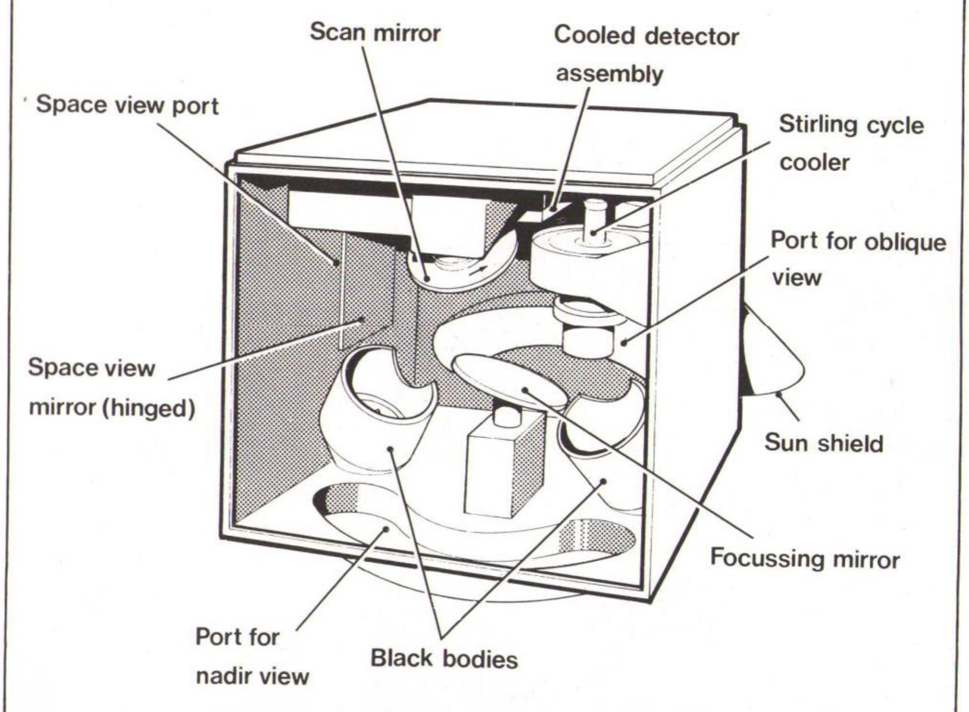
☐ *Studies of the correlation between tropical sea-surface temperature anomalies (departures from climatological averages) and changes in atmospheric circulation, and of the physical processes which cause such 'teleconnections'.*

☐ *Studies of detailed infrared radiation balance in the 10 to 12 μm atmospheric window, in particular of non-linear molecular absorption processes in tropical and polar regions which presently have no accepted theoretical explanation.*

☐ *Studies of cloud-climate feedback effects, to determine the role of clouds in establishing the balance between scattering of incoming solar radiation and emission of outgoing thermal radiation. These studies will test our understanding of the multiple scattering physics of clouds and aerosols.*

It seems clear that the ATSR project will provide data which will be of great value in testing theories of how the oceans and the atmosphere interact to produce the long-term climate. The ATSR, and the whole ERS-1 project, will thus make a major contribution to the international World Climate Research Programme which is now under way. To achieve a significant advance, however, the measurement of global ocean surface temperature must be made with startlingly high absolute accuracy, the achievement of which will require a well conceived space experiment, and a deep knowledge of atmospheric spectroscopy, and as such the ATSR presents an attractive and exciting prospect to scientists supported by SERC.

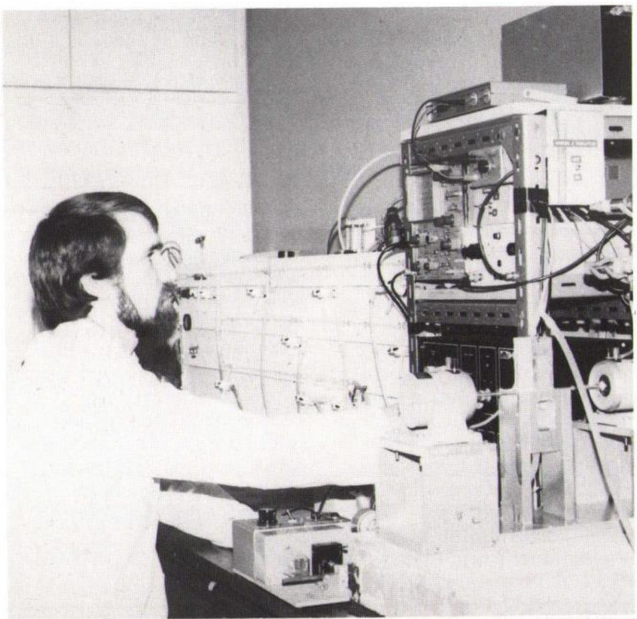
J E Harries



A cut-away view of the Along-Track Scanning Radiometer

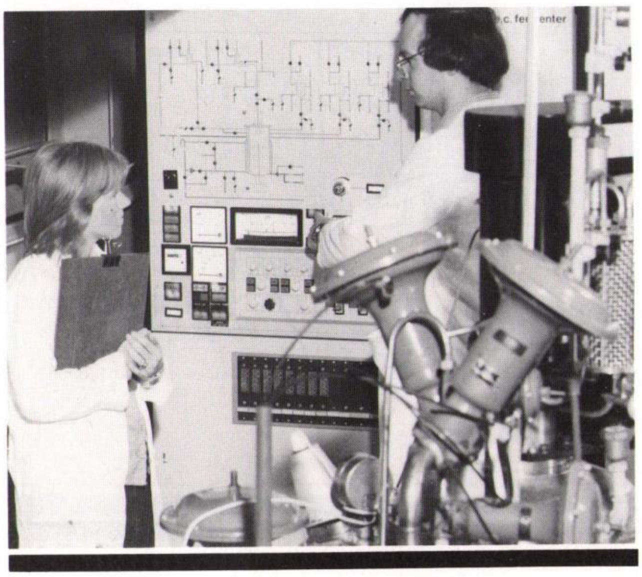
Biotechnology at UCL

Biotechnology has existed at University College London for almost thirty years. Biochemical engineering research has been pursued in the Department of Chemical and Biochemical Engineering, often in collaboration with members of the Department of Biochemistry.



Don Bell, a research student, examining the effect of acoustic waves on the properties of protein precipitates.

Dr Neville Fish, a SERC Advanced Fellow, discussing large-scale fermentation with research student, Barbara Tallboys, who has an 'instant' award from SERC.



The first joint project on the large-scale manufacture of coenzyme A, funded by the Medical Research Council, started in 1954. This was followed by work on the large-scale isolation of nucleotides from yeast funded by SERC (then DSIR). By the early 1960s there were projects on biochemical fuel cells, kinetics of continuous culture of microorganisms, bacterial growth on hydrocarbons and studies on immobilization of enzymes.

The Department of Chemical Engineering was also providing pilot-scale batches of microorganisms for research projects in the Biochemistry Department and hundreds of grammes of glutathione for student practicals in that department.

Since those early days SERC has supported a wide range of research projects either by research grants or CASE studentships; some in biochemical engineering; some in biochemistry; others in the more general area described as biotechnology.

Fermentation research has concentrated on the influence of culture conditions on the synthesis of enzymes by microorganisms growing either in batch or continuous culture. Some of the early work using regulatory mutants demonstrated the importance of catabolite repression and its interaction with induction in controlling the levels of particular enzymes. This work laid much of the foundation for the production of enzymes in the biochemical engineering pilot plant (usually at 1000 litre scale). Recent work has been examining other problems of scale-up including the effect of shear on fungal morphology and physiology and the effect of non-homogeneity in large fermentors on product formation.

Enzyme technology

Much of the work during the last two decades has been devoted to aspects of enzyme technology. It was necessary to develop techniques for the large-scale isolation of intracellular and periplasmic enzymes from microorganisms, especially penicillin acylase from *Escherichia coli* and cholesterol oxidase from *Nocardia rhodochrous*, both of which are now produced commercially.

Immobilized penicillin acylase is now used industrially for the conversion of benzylpenicillin to 6-amino-penicillanic acid, a key intermediate in the production of semi-synthetic penicillins. Cholesterol oxidase is a component in kits for clinical analysis of human sera. More recently, the problems of recovery of membrane-associated enzymes have been

Data logging and processing from fermentors in the biochemical engineering pilot-plant using microcomputers.

examined. These complexes, which catalyse many oxidation-reduction and synthetic reactions of potential industrial interest, are acutely sensitive to mechanical shear and appropriate extraction and recovery operations must be devised.

At the same time a range of techniques for immobilization of enzymes and enzymic cofactors was developed followed by detailed studies on the design and operation of immobilized enzyme reactors, particularly for the deacylation of benzyl-penicillin. In recent years the emphasis has been on reactions catalyzed either by isolated enzymes or intact microorganisms in which the reactants or products are essentially water-insoluble. Two-liquid phase reactors in which the organic phase is a major part of the total reactor volume are being operated for steroid transformations and the modification of oils and fats.

Protein precipitation

Some years ago it became clear that the experience gained on large-scale isolation and processing of enzymes was also applicable to non-enzymic proteins such as vegetable and blood proteins. These globular proteins have been shown to be much less sensitive to shear than had been supposed. This allows separation steps, such as ultrafiltration, to be applied over a wider and more useful range of operating conditions. On the other hand results have demonstrated that protein precipitation, which is a key recovery stage, entails a balance between effective reagent contacting and shear-induced breakdown of the precipitate particles. Improvements leading towards large, more dense, particles make centrifugal recovery of the protein in industrial machines more efficient. Developments in continuous-flow protein processing have been applied to the large-scale isolation of blood products.

In the Department of Chemical and Biochemical Engineering, much of the biotechnological research has been concerned with biochemical engineering studies. In the Biochemistry Department in the last few years there have been major projects in microbial genetics. Mutant strains of *Pseudomonas aeruginosa* have been obtained producing altered enzymes and high levels of enzyme activity.

Several groups are actively engaged in gene cloning experiments. Research is in progress on the stability of natural and constructed plasmids. One of the joint projects between UCL and the Polytechnic of Central London is directed to studying plasmid stability in large-scale cultures.

In parallel with the research, there has been extensive collaboration both in undergraduate and postgraduate teaching. Since its inception in 1959 the MSc course (initially a Diploma course) in Biochemical Engineering provided by the Department of Chemical and Biochemical Engineering with the assistance of the Department of Biochemistry has been eligible for Advanced Course studentships. From October 1983 the Department of Biochemistry will offer an MSc in Applied Molecular Biology and Biotechnology with the assistance of the biochemical engineers in the Department of Chemical and Biochemical Engineering.

Industrial links

Industrial links are strong, particularly through CASE studentships and research contracts. Collaboration with Beecham Pharmaceuticals and the former Whatman Biochemicals helped in the development of novel processes within these companies. For over five years, a one-week course on biochemical engineering has been run each year for industrialists. There are also many informal links with ex-UCL biochemical engineers working in industry.

Professor Patricia Clarke and Dr Rob Drew, a lecturer appointed as her replacement under SERC's Special Replacement Scheme, examine the results of genetic experiments. Under this scheme, a university or polytechnic gives a tenured appointment to a promising young scientist or engineer, thus releasing the senior worker to spend more time on research.

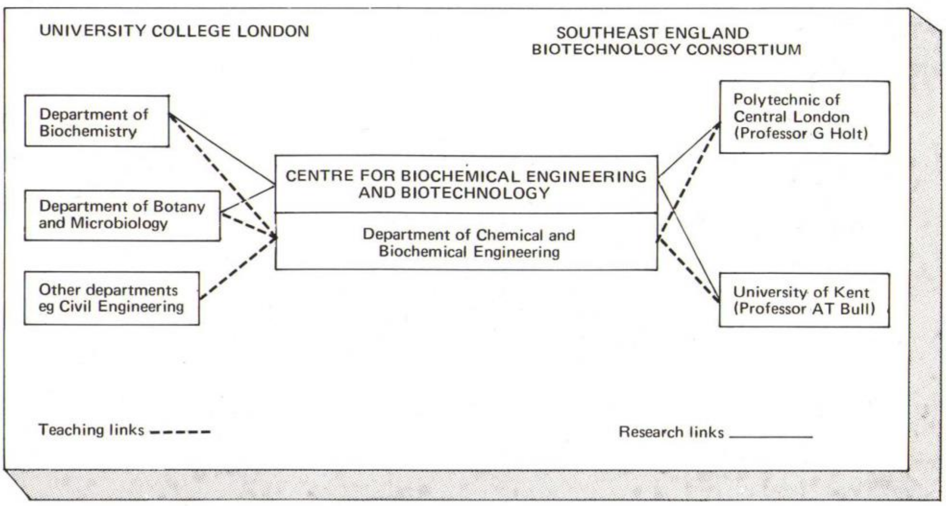
The informal collaboration which has existed between departments in UCL for three decades has been very successful. However, with the expansion of the biochemical engineering group and a wider interest in biotechnology in UCL, a Centre for Biochemical Engineering and Biotechnology has been set up to foster and coordinate these inter-departmental activities. Space has been provided for joint projects between the biochemical engineers and biochemists and members of other departments in the College. The Centre acts as the link with the Polytechnic of Central London and the University of Kent, the other members of the Southeast England Biotechnology Consortium.

Biotechnological activities within UCL have been growing for over a quarter of a century and have now reached a most exciting phase. SERC has made and is continuing to make a significant contribution to those activities.

M D Lilly

Professor Malcolm Lilly is Professor of Biochemical Engineering, University College London.

Collaborative links within UCL and with groups elsewhere



Protein crystallography, interactive graphics and drug design

Although it is over twenty years since the first successful structure analysis, protein crystallography is still a developing subject. Recent progress has occurred in the production of strongly diffracting three-dimensional crystals of membrane proteins, nucleosomes and other complex ordered systems, in the crystallographic study of repressors and hormones synthesised by recombinant DNA techniques, and in the use of synchrotron radiation for data collection and anamalous dispersion. There have also been developments in the use of vector processors such as the CRAY 1 in least-squares refinement, and interactive computer graphics for construction of molecular models. Furthermore, protein crystallographers have now determined the structures of several enzymes and polypeptide hormones of pharmaceutical interest, and this has stimulated a great interest in the use of interactive computer graphics for the study of drug design.

This article reviews progress made in the UK in these areas, and points to the major contributions made by SERC in supporting a collaborative computational project (CCP4) in protein crystallography, in making available the CRAY 1 to the academic community, and in establishing university-based workstations linked to the most modern interactive computer graphics systems.

Refinement of proteins

Improvement of a protein model involves the alternation of automatic and interactive steps until convergence.

The automatic steps involve least-squares refinement of three positional and at least one thermal parameter for each non-hydrogen atom of the protein and solvent. Even for medium-sized enzymes (molecular weight about 35,000), this will involve more than 10,000 variables. In order that these parameters are well defined and that the refinement converges, there should be more than ten times this number of x-ray data; this implies a resolution of about 1.1Å. However, this is not usually achieved and a compromise resolution of less than 1.5Å is often adopted. Instead, 'observations' concerning the geometry are included as restraints on bond lengths, bond angles and planarity of aromatic rings; the chirality of amino acids may also be preserved and intermolecular interactions optimised. Two programs are now operational on the CRAY 1 to achieve this: an American import of Dr Wayne Hendrickson and a home-grown program by Dr David Moss and his colleagues at Birkbeck. A protein of about 200 amino acids may now be refined at 1.8Å resolution at four minutes per cycle on the CRAY 1 instead of 60 minutes on an IBM 370/165.

The refinement at high resolution (about 1.5Å) will give positions with a precision of the order of 0.2Å or even better for well-defined atoms. This precision is required for defining active site residues of enzymes and their complexes with inhibitors. There are now two small proteins which have been refined at about 1.0Å resolution, and this for the first time allows anisotropic thermal parameters to be investigated – giving further clues to the dynamics and flexibility of the protein – and even hydrogen atoms may be positioned.

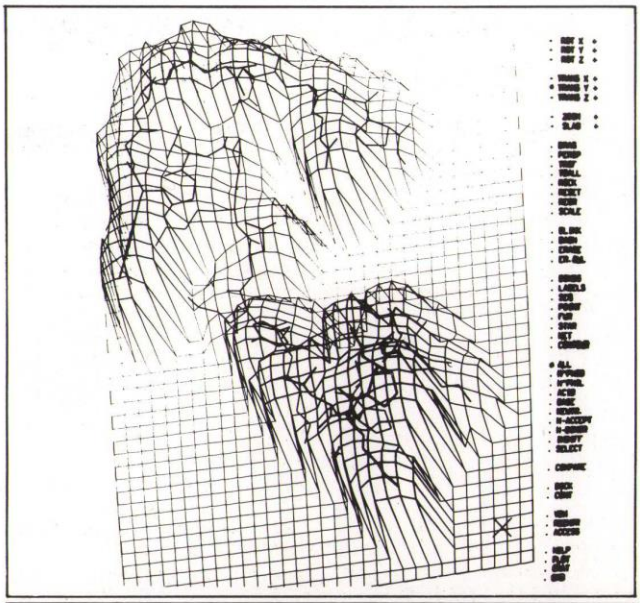


Figure 1
A complementary surface to a polypeptide growth factor generated as a net. (Program BILBO by Anne-Marie Honegger.)

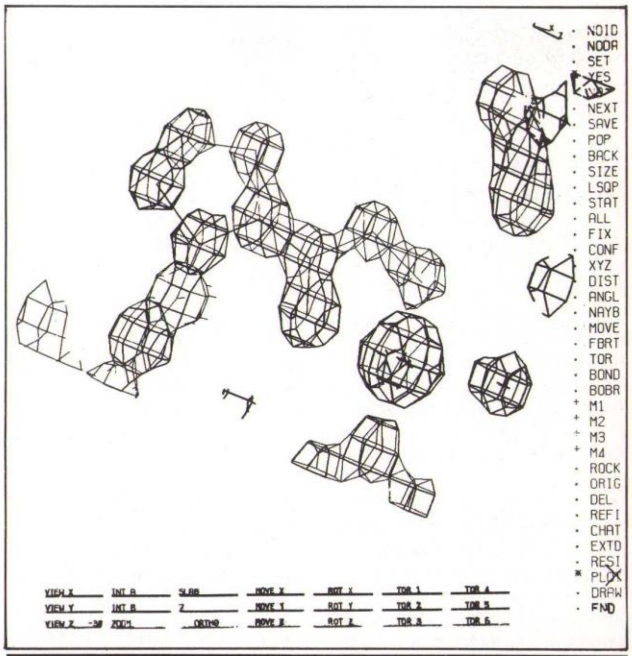


Figure 2
The electron density at about 1.0Å resolution of a pancreatic polypeptide. The bonds are shown superposed; the large atom is a zinc ion. (Program FRODO by Dr Alwyn Jones, recoded and extended by Dr Ian Tickle.)

Interactive computer graphics . . .

The interactive step in improving a protein structure has been traditionally achieved using wire models. It can now be carried out using interactive calligraphics (vector drawing) such as the Evans and Sutherland Picture System, capable of rapid transformation of three-dimensional data with combinations of rotation, translation, scaling and perspective. Real time clipping is performed not only on the top, bottom and sides of the pictures, but also in depth. The intensity of the cathode ray tube may also be controlled in proportion to the distance from the 'viewer' enhancing the perception of depth. This system is extremely efficient for the display and manipulation of complex biological molecular structures. In contrast, a raster system – of the type used in domestic television – requires a large refresh memory with several bits for each pixel on, say, a 512 x 512 grid. Although this leads to difficulties in the creation of complex dynamic systems, it is nevertheless useful for the display of non-transparent surface and static models. This kind of very high resolution raster graphics is one of the attractive aspects of the PERQ computer, which SERC is now supporting.

For molecular modelling the more expensive calligraphics systems have so far been most attractive. The electron density based on the method of isomorphous replacement or calculated on the basis of the refined atomic positions is displayed in the form of a 'chicken wire' and the model is manipulated into the density (figure 2). Such techniques were developed originally by Professor Tony North at Leeds, but have now been adopted by a number of different laboratories. The protein is manipulated by rotations around torsion angles, or by isolating fragments which can be rotated or translated before being annealed again to the rest of the protein. Our Evans and Sutherland Picture System is used night and day, and much of the time is spent in this way, improving our protein models before they are recycled into further refinement on the CRAY 1 through a line from Birkbeck to the Daresbury Laboratory.

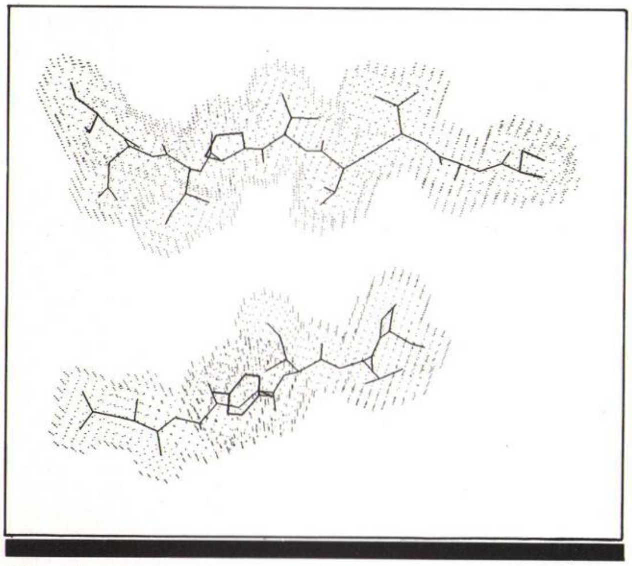


Figure 3
Two sections of polypeptide chain displayed with the van der Waals surface indicated by dots. The program MIDAS (by Dr Ian Tickle and Laurence Pearl) allows the two surfaces to be 'docked' together interactively or automatically.

. . . . and drug design

The existence of highly refined models of enzymes and polypeptide hormones, combined with our ability to manipulate these molecular structures using computer graphics, offers the attractive possibility of a rational approach to drug design. Let us suppose that we have the detailed structure of an enzyme and a complex with a substrate analogue, we can then begin to ask questions concerning the design of a good inhibitor. Structures of several enzymes which are targets for drugs are known or can be inferred from homologous structures. These include dihydrofolate reductase, inhibitors of which are used as anti-tumour agents or, with a change in their specificity, as antibacterial agents. They also include renin, whose approximate structure may be derived from homologous acid proteinases and inhibitors of which are used in the control of hypertension. The enzyme active sites can be displayed in various ways: van der Waals surfaces or accessible surfaces, highlighting hydrophobic or charged groups or specific residues. Complementary surfaces can be generated (figure 1): models of putative inhibitors can be 'docked' (figure 3) while the energy, the change of surface accessibility and other parameters are continuously updated on the screen.

The systems are also useful for designing hormone analogues, and for trying to assess the reasons for relative receptor affinities of series of homologous hormones. For example, insulin and certain somatomedins (insulin-like growth factors) can exhibit each other's activities. By combining structural, chemical and biological data, the regions important for receptor binding can be identified and the critical shapes of molecules with certain kinds of preferred activities defined. The availability of recombinant DNA techniques makes the synthesis of modified molecules a real possibility.

That this is a real development is proven by investment of pharmaceutical companies in the hardware and manpower to develop these techniques. The recent purchase of interactive calligraphic systems by SERC for Birkbeck and Oxford protein crystallography groups has been followed by the purchase of similar systems by Merck, Sharpe and Dohme in the USA and by ICI in the UK, while Wellcome, Glaxo, Hoffmann-La Roche and many others appear to be in the process of making similar purchases. Several are already negotiating for the use of the software developed by Dr Ian Tickle, Anne-Marie Honegger, Laurence Pearl and others in the Birkbeck laboratory. We are looking forward to an exciting period of application in an area which until recently has been of interest only to academics.

T L Blundell
Professor Blundell is head of the Department of Crystallography at Birkbeck College, University of London.

Amino acid sequencing facilities

A detailed understanding of the properties and activity of proteins ultimately depends on the ability to describe accurately the 3D structure of the molecule. The most successful approaches to this problem have involved the combination of x-ray diffraction data with amino acid sequence information on the whole or part of the primary sequence of the protein.

SERC, appreciating the need for this kind of information, has established two amino acid sequencing facilities in the Universities of Aberdeen and Leeds, each providing equipment for liquid-phase sequencing of proteins and peptides. While in-house research occupies some part of the time on these facilities, additional time is also available for use by UK research workers, subject to arrangement with the facility managers. Priority is given to SERC grant holders.

Scientists interested in using the facilities should in the first place contact Carol Iddon at SERC Central Office, Swindon (ext 2421) for advice on how to apply for time on either facility.

The Harwell Electron Linear Accelerator

Pulsed beams of neutrons first became available to UK university scientists on the 45 MeV Harwell Electron Linear Accelerator (Linac) in the early 1970s. This was through the rental agreement operated jointly by SERC (then SRC) and the Atomic Energy Authority. This accelerator has recently been replaced by a 136 MeV Linac (Helios) and a substantial construction programme has produced a range of new spectrometers for use by experimenters.

Techniques to use beams of neutrons from reactors as probes to study the properties of matter were first developed in the late 1940s and early 1950s. In the last decade, as higher and higher fluxes of neutrons have been sought, it has become clear that only pulsed sources are able to produce the fluxes required. Several such sources are now being operated or constructed in places as far apart as Japan, the USA and Britain: Rutherford Appleton Laboratory's Spallation Neutron Source is scheduled to start up in 1984/85 (see *Bulletin* Vol 2 No 4, Spring 1982).

In the Harwell Linac the neutrons are produced in a two-step process. Pulses of electrons are accelerated to an energy of up to 136 MeV and are then fired into a target of a heavy element. The electromagnetic fields of the target nuclei cause rapid deceleration of the electrons and the energy lost in this process is dissipated partly as heat in the target and partly by the emission of γ-rays (bremsstrahlung radiation). A small number of the γ-rays produce excitation of target nuclei which subsequently return to their normal energy state by emission of the desired neutrons.

The electron accelerator consists of a series of resonant cavities which are fed with microwave power at a frequency of 1300 MHz. The powered cavities produce a travelling wave along the axis of the accelerator with the right conditions to allow bunches of injected electrons to be trapped just ahead of the crests of the waves and to be swept through the 16 metres of the accelerator, rather like a surf-rider is carried into the shore.

The pulses of electrons are produced initially at rates of up to 300 times per second, by a sophisticated version of the hot filament triode valve, and after acceleration are transported to a target by a system of steering and focusing magnets. As figure 1 shows there are four separate target areas (cells) available on the Linac with one of the cells being designed to use electrons that have only traversed part of the accelerator. At the present time the beam of electrons can be steered into any one of the cells. A system is being developed which will allow the beam to be shared between two targets by switching alternate pulses of electrons in the appropriate directions. Only one of the cells is used in the SERC/AEA joint programme – the Condensed Matter Cell (figure 1). The other three cells are used by Harwell staff for measurements necessary for the development of the nuclear power programme. Under the joint programme arrangements for running the Condensed Matter Cell, the available operating time is divided equally between SERC and AERE. In addition to having their own programme of condensed matter research, AERE staff also undertake commercial projects on behalf of particular industries.

The target in the Condensed Matter Cell is currently a series of plates of tantalum stacked with gaps between the plates for water cooling. Later this year these plates will be replaced by suitably clad uranium plates which should double the number of neutrons produced from each electron pulse. The range of energies of the neutrons produced at the target is too high to be immediately useful in condensed matter research. The neutrons are therefore moderated and slowed to the required energies by surrounding the target with hydrogeneous materials, in this case water, at a constant temperature. Reflectors of heavy water are placed near the target to enhance the numbers of slow neutrons produced. The condensed matter target, moderator and reflector assembly is viewed by a system of beam tubes which allow the bursts of neutrons from defined areas of the moderators to move through about 3 metres of dense shielding towards the instruments used by the experimenters (figure 2).

Some parameters of the electron accelerator and the condensed matter target are given in Table 1.

The Neutron Scattering Instruments are in two experimental areas located on either side of the condensed matter target. Currently, there are twelve instruments in position; five are fully operational, two are available for test experiments as part of final commissioning programmes, four are development projects and one is a new instrument, under construction. The lay-out of both experimental halls is shown in figure 2 and brief details of each of the instruments are given in Table 2.

It will be seen from the status of the various instruments that there are two components to the programme of work being carried out. The operational instruments are scheduled regularly for use in

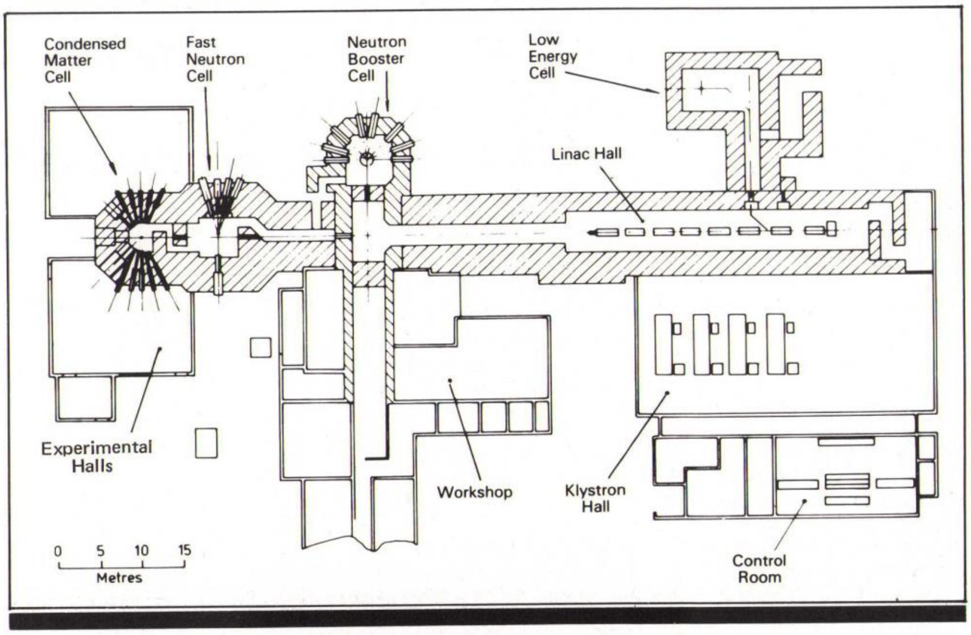


Figure 1. The 136 MeV Linear Accelerator installation

experiments by university scientists, AERE and RAL staff. The other seven instruments are in various stages of being developed into operational instruments involving novel techniques which exploit the energy spectrum of the neutrons and the pulsed nature of the neutron beam. Two of the instruments, the LAD and the HTIS (see Table 2) have been designed and built for eventual use on the Spallation Neutron Source. Two of the four development projects (the PFS and SXS) are specifically designed to test and establish techniques for later SNS instruments but it is expected that even in their present form some good science will be done on them.

The SERC-supported programme got away to a good start as soon as the Linac became available and teams from the Universities of Birmingham, Bristol, Durham, Oxford, Reading, Salford and Sheffield have used allocations of time in the last few months. The experiments covered a wide range of topics in chemistry and physics including studies of chemi- and physi-absorbed molecules, hydrogen bonding, alkali metal intercalates, hydrogen-metal systems, metallic and inorganic glasses, liquids and molten alkali salts. The data obtained in the experiments are currently being analysed but it is already clear that access to higher incident energies and the high resolution of instruments like the BSS and IRS have opened up new areas of science. For instance, measurements on the $VH_{2.0}$ system have shown two opitcal modes very close together in energy where only one had been observed before. Other measurements on $NaHF_2$ have thrown new light on the form of the Debye-Waller factor appropriate for the calculation of band insensities in inelastic neutron scattering spectra particularly in the higher energy transfer region, which will permit a major advance in the field of molecular spectroscopy.

The Harwell Linac can be seen to be an important step in the development and application of pulsed neutron scattering techniques. To obtain the higher fluxes of neutrons now required, proton rather than electron accelerators have become essential as with an uranium target the spallation process produces some 30 neutrons per proton compared with the 0.04 neutrons per electron. An additional bonus is that the power dissipated in the target, which has to be removed by cooling, falls to 55 MeV/neutron for protons from 1500 MeV/neutron for electrons.

The SNS is to come but in the meantime, the Harwell Linac is producing first class scientific results, developing new instruments and novel techniques and providing valuable experience of pulsed neutron scattering for UK university teams, Harwell and SERC staff.

D C Salter

Table 1

(a) Main accelerator parameters for operation of the Condensed Matter Cell

Energy Range	Maximum pulse duration	Maximum current during pulse	Pulse energy	Maximum pulse rate
20 – 136 MeV	5 μsec	1 A	300 J	300/sec

(b) Main parameters for the Condensed Matter Cell Target

Maximum mean electron power into target	Typical neutron pulse duration	Pulse rates	Maximum neutron yield per pulse	Maximum mean neutron output per second
50 kW	2 μsec	300	5.7×10^{11}	1.7×10^{14}
	5 μsec	150	1.2×10^{12}	1.8×10^{14}

Table 2 Details of instruments on the condensed matter target of the AERE Linac

	Instrument/status	Purpose
IRS	**Inelastic Rotor Spectrometer** -- operational	Inelastic scattering measurements in region of high energy and low momentum transfers to study atomic motions in liquids, internal vibration modes in molecular systems and high frequency magnetic excitations
HTIS	**High Throughput Inelastic Spectrometer** – under construction (SNS instrument)	High intensity time of flight analogue of conventional beryllium filter spectrometer for molecular spectroscopy
TSS	**Total Scattering Spectrometer** -- operational	Measurements of structure factors for liquids, gases and amorphous solids. Can also be used for powder diffractometry.
BSS	**Back Scattering Spectrometer** – operational	High resolution measurements of powder diffraction patterns and diffraction peak broadening
CQS	**Constant Q Spectrometer** – available for test experiments	Crystal analyser spectrometer for coherent inelastic studies using single crystal samples. Especially suitable for energy transfers > 100 meV
SAS	**Small Angle Spectrometer** – development project (joint programme)	Prototype spectrometer
ASD	**Active Sample Diffractometer** – available for test experiments	Low resolution powder or liquid diffractometer with shielded sample position to allow studies of active materials. Specially designed to permit studies of fissile materials
PFS	**Polarising Filter Spectrometer** – development project (RAL)	Double Samarium filter for inelastic polarisation analysis
TS	**Transmission Spectrometer** – operational	Measurements of removal cross sections in energy region 1 meV – 1 keV
RDS	**Resonance Detector Spectrometer** -- development project (joint programme)	Inelastic scattering measurements in the eV range
LAD	**Liquids & Amorphous Materials Diffractometer** – operational (SNS instrument)	Measurement of structure factors of liquids and amorphous solids over a wide range of momentum transfers
SXS	**Single Crystal Spectrometer** – development project (RAL)	Prototype time of flight analogue of conventional single crystal diffractometer

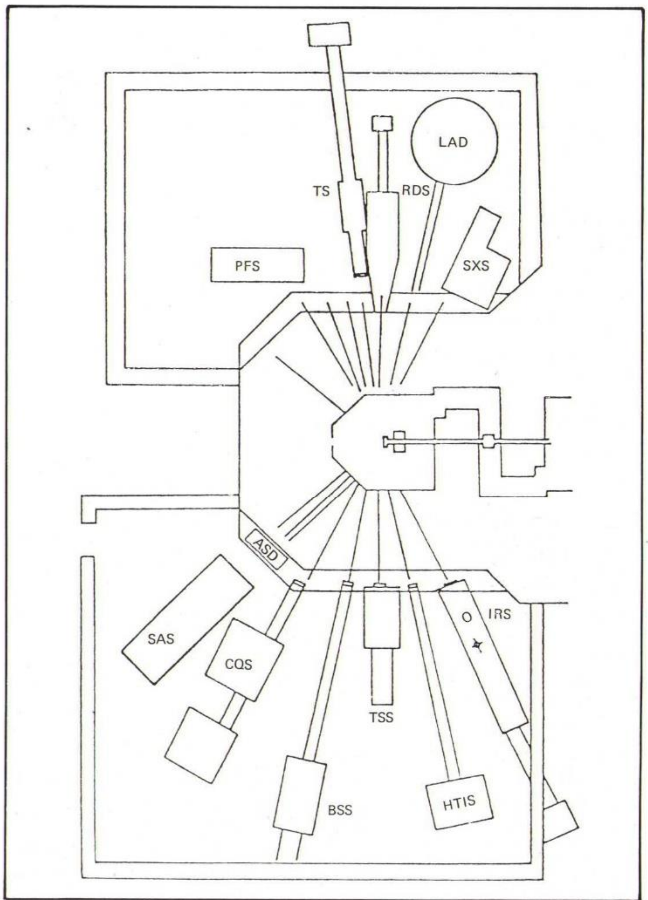


Figure 2.
Layout of instruments in the Linac Condensed Matter Cell

CERN's Proton-Antiproton Collider

At 4.55 am on 10 July 1981 in CERN, Geneva, head-on collisions were produced between very high energy beams of protons and antiprotons. The energy of the beams was 270 GeV giving a total of 540 GeV energy in the collision for possible production of particles of matter. The mass of the proton is equivalent to 1 GeV energy and so these collisions provide the opportunity of producing very massive particles in the laboratory should they exist in nature. They thus provide a possibility of testing the recent theories on the forces which hold matter together, which predict quite precisely the existence and characteristics of such particles. The accelerator producing these 540 GeV collisions is called the Proton-Antiproton Collider.

In November 1976 the Super Proton Synchrotron (SPS) was completed in CERN, Geneva. This accelerator can accelerate beams of protons up to an energy of 450 GeV. If a 450 GeV proton collides with a stationary proton in the laboratory the energy available to make new forms of matter is only 29 GeV. The remainder of the energy is required to conserve momentum and is thus unavailable.

In 1978 approval was given to a proposal to have an additional mode of operating the SPS. In this collider mode, protons and antiprotons are injected simultaneously into the accelerator ring in opposite directions. The two beams are then accelerated together up to 270 GeV, the highest storage energy, and then stored for as long a time as possible. During this storage period, collisions between the beams take place and can be investigated. The available energy for each collision can thus be raised to 540 GeV.

The protons and antiprotons in the collider take approximately 24 μsec to perform one complete orbit of the ring. The particles are not stored as a continuous filament inside the collider but rather as three equally spaced bunches each 60 cm long. This gives six locations around the ring at which the beams collide and therefore six locations where experiments may be mounted.

Once the collider has been filled with protons and antiprotons and acceleration up to 270 GeV has taken place, the particles are slowly lost from the circulating beams due to interactions with each other and with residual gas molecules in the storage vessels. Effective storage times are usually greater than 24 hours.

Colliding beam machines are clearly more efficient at providing available energy for studying new phenomena. In accelerator mode, the SPS produces 450 GeV protons which give 29 GeV available energy on a stationary proton target whereas, in collider mode, it produces 540 GeV available energy. Why then do we ever build conventional particle accelerators? The answer lies in the fact that although available energy is higher in collider mode, the probability of producing a collision is lower. This probability is proportional to a quantity called luminosity. For example, in accelerator mode, the SPS produces a beam of 10^{13} protons with energy 450 GeV every 10 seconds. If this impinges on a proton target (usually liquid hydrogen say 30 cm long) the luminosity is approximately equal to 10^{38} per cm^2 every second. In collider operation, the best luminosity could be only 10^{29}

The physics at 540 GeV

The principal reason for building the Proton-Antiproton Collider is to search for a family of massive particles which physicists call intermediate vector bosons. They have a predicted mass of about 90 GeV/c^2 and so cannot be produced by any existing accelerator.

Why are the bosons so important? They are the exchange particles for one of the fundamental interactions between particles of matter – the 'weak' interaction which causes radioactive decay. Table 1 gives a description of

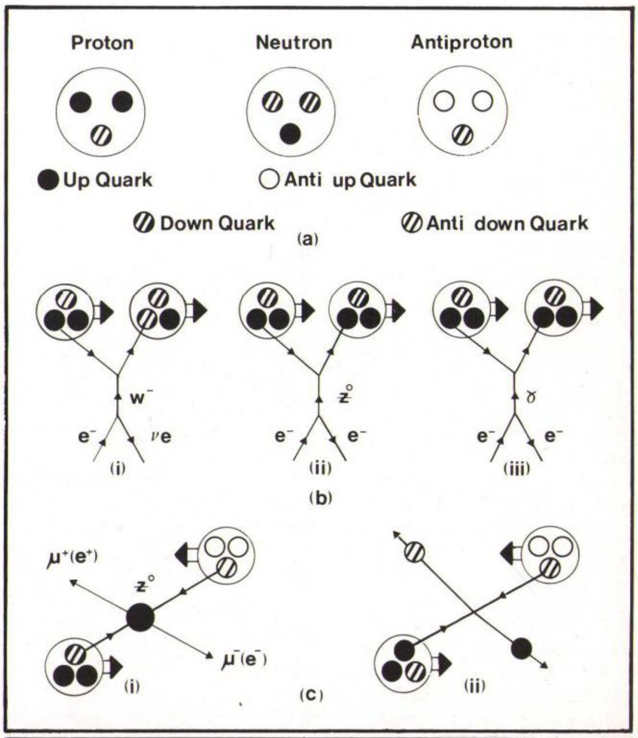


Figure 1
(a) Quark composition of a proton, neutron and antiproton.

(b) (i) Electron capture inside an atom. The arrows indicate time increasing. An orbiting atomic electron interacts weakly with an up quark in a proton of the nucleus, via exchange of a W boson. The electron becomes an electron neutrino, the up quark becomes a down quark thus changing the nuclear proton to a neutron. The subsequent nucleus decays down to a stable state by emitting radiation.

(b)(ii) Similar to (i) except the weak interaction goes via the neutral partner of the W, the Z^0 boson, thus leaving the proton unchanged in character. This may be described as elastic electron-proton scattering via the weak interaction.

(b)(iii) Elastic electron-proton scattering via the electromagnetic interaction, possible because the electron and up quark are charged. The exchanged particle in the interaction is now a photon.

(c)(i) A down quark from a proton and an antidown quark from an antiproton annihilate via the weak interaction to form a Z^0 boson. The boson immediately decays into a $\mu + \mu -$, $e + e -$ or quark antiquark pair. Decays to $\mu + \mu -$ or $e + e -$ occur about 10% of the time and should be easily observable in the laboratory. The residual quarks (two antiup quarks and two up quarks) convert into clusters of particles.

(c)(ii) A quark-antiquark elastic scatter in a proton-antiproton collision. The quarks are seen in the laboratory as clusters of particles.

the interactions known at present. For all these interactions, the binding force is produced by an exchange process. Two particles can convey information about their existence by exchanging a third particle. This interaction can only take place if the two particles are sufficiently close together. Thus the exchange requirement constitutes a 'binding' force. For example, if two people are required to exchange a ball, they are automatically bound together by the exchange force. Similarly if an electron in an atom gets sufficiently close to a proton it can exchange bosons with it, participating in a weak interaction (figure 1b(i),(ii)). This may cause electron capture (figure 1b(i)) and subsequent radioactive decay of the nucleus.

Since the electron and proton are charged they may also interact via the electromagnetic interaction by exchanging photons (figure 1b(iii)). It can be seen that diagrams 1b(ii) and 1b(iii) are very similar and in fact it was recently postulated that the weak and electromagnetic forces are both manifestations of the same force, subsequently called the 'electroweak' force. If this postulate is true, the mass of the Z^0 boson can be predicted and is approximately 90 GeV/c^2. In figure 1c(i) the diagram indicates the mechanism for producing a Z^0 at the collider. The predicted rate for producing Z^0s and observing their decay into $e+e-$ or $\mu+\mu-$ pairs is one per integrated luminosity of 10^{34} per cm^2. This represents one day's running on the collider when it achieves design luminosity.

Although boson production represents the main physics motivation for the collider project, other interactions are of very great interest in our understanding of the basic properties of matter. According to our present beliefs, the proton consists of three point-like indivisible particles called quarks (figure 1a). They interact with each other via the strong interaction, the exchanged particle being called the gluon. Similarly the antiproton consists of three antiquarks. Understanding the strong interaction, which not only holds together the proton but also the nucleus of the atom, is clearly one of our most vital aims. Ideally one would do this by, say, scattering a beam of quarks off a quark target. However we cannot make a beam of free quarks, nor can we have a target of stationary quarks and so we must learn about quark-quark interactions by bombarding composites of quarks by composites of quarks, ie proton-proton or proton-antiproton scattering (figure 1c(ii)). If a proton scatters off an antiproton at high energy the actual scatter is between the quark constituents, and it is possible to test a model for the strong interaction by comparing its predictions with what is actually observed experimentally. A test of this quark-quark scattering model represents another very important objective of the collider experiments.

The collider experiments

Of the three large collider experiments, UA1, UA2 and UA5 (UA stands for Underground Area), two, UA1 and UA5, have British involvement.

The UA1 experiment, which involves physicists from Birmingham University, Queen Mary College London and Rutherford Appleton Laboratory, is the most ambitious experiment on the collider. It is built around a large dipole magnet with a field of up to 0.7 Tesla over a free volume 4 m high x 4 m wide x 8 m long. In order to detect Z^0 bosons, any experiment must be able to identify and measure the energy of electrons and muons. And to study collisions in full and in particular allow measurement of quark-quark scattering, it is important to be able to reconstruct the tracks of charged particles and measure their energy. To this end the magnetic volume is filled with a drift-chamber tracking device and a calorimeter for identifying electrons. External to the iron of the magnet there are further tracking chambers for muon identification.

Table 1

Interaction	Relative strengths at low energies	Exchange Particles	Manifestations
Strong force	1	Gluons	Nucleus
Electromagnetic force	$\frac{1}{1000}$	Photons	Atom
Weak force	$\frac{1}{100000}$	Bosons (?)	Radioactive decay
Gravitation	10^{-38}	Gravitons (?)	Planetary systems

The UA2 experiment has set its sights firmly on detecting Z^0s by measuring the electrons produced in their decay, and thus has surrounded the proton-antiproton collision point by electron detectors.

The UA5 experiment, which includes physicists from Cambridge University, has surrounded the collision point with a streamer chamber. This device provides very good angular coverage for charged particles produced in the collision. With this detector it is possible to obtain an excellent pictorial view of what a collision looks like.

First collisions between protons and antiprotons were seen in July 1981 during a period allocated to collider machine development. During November/December 1981 the first period of operation for physics took place. During this period an integrated luminosity of 2×10^{32} per cm^2 was produced by the collider. This is not enough to produce Z^0s. However, information on up to 600,000 collisions was recorded and is being analysed.

A typical event for UA5 is shown in figure 2. As can be seen, the multiplicity of charged particles is very high (averaging 26 charged particles per interaction). The transverse momentum spectrum of single charged particles as measured by UA1 is in agreement with the prediction of quark-antiquark scattering. This indicates that our basic model for high energy proton-antiproton collisions is correct.

John Garvey

Dr Garvey is a member of the Particle Physics Group at the University of Birmingham.

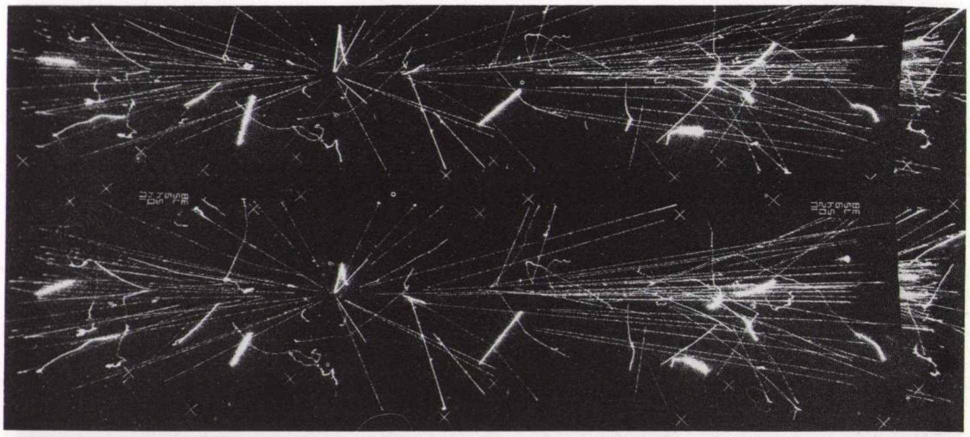
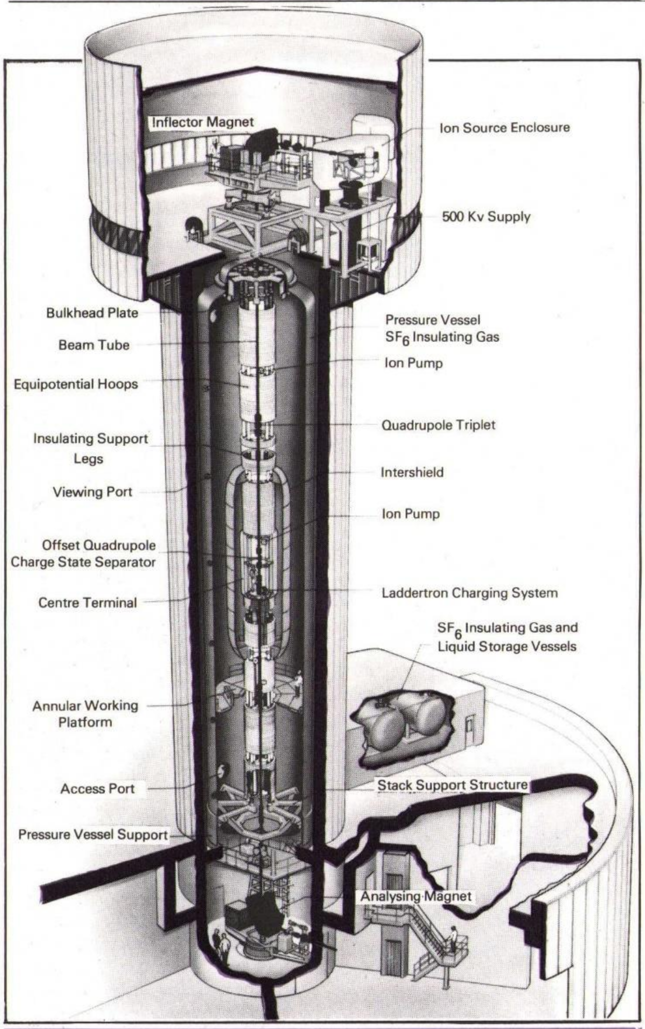


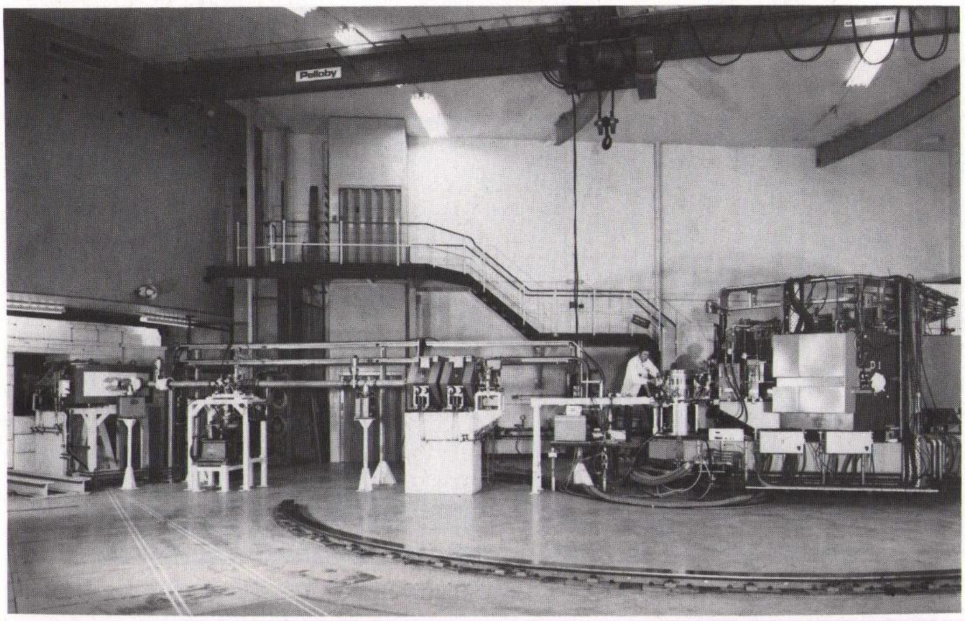
Figure 2: *A proton-antiproton collision in the streamer chamber of experiment UA5. The collision point can be seen clearly. The 540 GeV available energy in the collision produces a high multiplicity of charged particles.*

The Nuclear Stru
at Daresbury



A cut-away view showing the main components of the Nuclear Structure Facility

Large magnetic spectrometer being prepared for experiments



At long last the Nuclear Structure Facility (NSF) is on the verge of being available for the start of the experimental programme in nuclear structure physics. The NSF is a tandem electrostatic accelerator housed in a steel pressure vessel 43 m high and 8 m in diameter, in turn contained in a tower the height of a 22-storey building. After delays in the building and civil works, initial high voltage tests of the machine, without intershield or accelerating tube installed, were carried out in mid-1980. The predicted terminal potential of 23 MV was achieved and installation of the intershield followed immediately. This is designed to enable the terminal potential to be raised comfortably above the maximum design operating voltage of 30 MV.

When the next stage of voltage testing began at the end of 1980 serious difficulties were encountered. Electrical breakdown occurred along the column at voltages well below 30 MV, on two occasions leading to breaks in the laddertron charging system. Months of intensive investigation followed and the unique range of high voltage test facilities available at Daresbury was never more appreciated in trying to pin down the source of the trouble.

The problem was finally traced to the behaviour of the nylon used for the laddertron insulators and the drive shafts for power transmission. While a good deal is known about the behaviour of nylon as an insulator at various temperatures, the violent changes observed under the very high voltages in the NSF had not been suspected by Daresbury or by the experts in industry.

The question of suitable materials has not yet been solved, but by adjusting temperatures carefully in the accelerator, a terminal potential of 29.3 MV was reached. The limit was again set by the nylon; due to the delay in the programme it was decided to accept this as satisfactory. It is quite clear that the basic electrostatic limit of the machine is at a voltage well beyond this value.

One of the difficulties in sorting out problems in this accelerator is the time required to make any changes. The pressure vessel is filled with 150 tonnes of insulating gas, sulphur hexafluoride. Pumping this out and then putting it back means that access to make even a small change takes several days.

The next stage, started towards the end of 1981, was the installation of the accelerator tube and a great deal of equipment associated with it: beam focusing and diagnostic equipment, vacuum pumps, etc. This, and all the other equipment inside the

cture Facility

accelerator, is controlled by means of a high bandwidth modulated light link and a series of computers, using colour TV displays. The commissioning of this extensive system was reasonably complete by Easter of this year, and once again the air in the vessel was evacuated and the sulphur hexafluoride pumped in, in readiness for the final stages of commissioning. Each of the 36 modular lengths of accelerator tube (18 on each side of the terminal) was first conditioned individually to a voltage in the range 1 to 1.3 MV, and then the voltage of the whole machine was gradually raised. When the terminal potential reached 10 MV, a carbon beam was accelerated through the machine, and down a beam line to a scattering chamber where a simple experiment was performed.

Various parts of the accelerator have been brought into service and their operation studied and adjusted. These include the 500 kV injector which can produce beams of almost any ion species, the stripper at the high voltage terminal, the device following it which selects only one of the range of charge states of ions produced, beam focusing, beam diagnostics, the analysing magnet, and the beam lines leading to the different experiments.

The terminal potential has been gradually raised. By June this year, this had reached 18.8 MV, with beams accelerated at potentials up to 16.3 MV and achievement of the initial design aim of 20 MV is expected.

Inevitably, in such a complex machine, there are many problems still to be solved, but the nuclear structure community is waiting anxiously to start the programme of research on this world-class machine. More than 30 proposals have been approved by the Programme Panel, and much of the experimental equipment is ready or being installed.

The accelerator is designed to be the biggest of its kind in the world. Resources permitting, a programme of development will be carried out to raise the terminal potential to the ultimate design value of 30 MV.

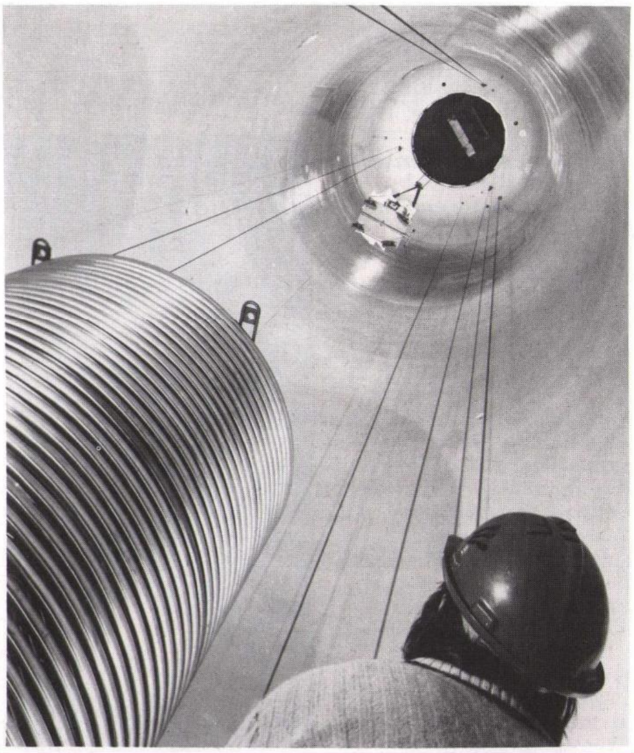
R G P Voss

The first batch of experiments that will be conducted by university research workers on Daresbury's Nuclear Structure Facility covers:

- **atomic physics investigations**
- **the study of discrete nuclear levels, involving the detection of charged particles**
- **the phenomena of heavy ion reactions**
- **gamma-decay of high angular-momentum states and of very unstable nuclei**
- **experiments to use and commission the NSF's dilution refrigerator, isotope separator, laser facility and magnetic spectrometer**
- **radiochemical investigations of deep inelastic reactions of heavy ions**

The 70 metre high tower that houses the Nuclear Structure Facility at Daresbury

Part of the column being lowered during construction



Imaging using positrons

Positron-emitting isotopes can be used to measure the shapes and functions of organs in the body. A positron-emitting (radioactive) isotope can be introduced into the body by inhalation, injection or orally. As the isotope decays, the positrons combine (or annihilate) with electrons in the surrounding tissue, releasing two gamma rays travelling in opposite directions. An electronic detector, placed around the organ, can detect the two gamma rays and so pin-point the position of the positrons' annihilation. Hence, by detecting hundreds of annihilations, a three-dimensional picture of the organ can be built up.

The electronic detector is called a 'positron camera'. It consists of two multiwire proportional chambers (of area 30 cm by 30 cm) which have been specially designed to detect gamma rays. The chambers are placed on either side of the organ under investigation (eg an arm or a leg). The readout electronics are connected to an on-line computer which presents the data as a slice image of the distribution of radioactive material within the patient. The positron camera has been developed over a four year period at the Rutherford Appleton Laboratory under the direction of Dr Eddie Bateman. The clinical evaluation of the device is being conducted in collaboration with various university groups and the Medical Research Council.

Biologically significant elements such as carbon, nitrogen and oxygen (among others) can be made into short-lived positron-emitting isotopes. These may be substituted into organic compounds, introduced into the human body and the regional tissue metabolic pathways, and traced in time and space using the positron camera. The rather short half-lives of the isotopes demand that their source (such as a cyclotron) be close to the detector and patient.

The positron camera under clinical tests at Hammersmith Hospital. Mr Terry Jones is observing a colour image display of the circulation of blood to the foot of a test subject.

An image of the major blood vessels and areas of high tissue perfusion in a healthy exercised human foot as recorded by the positron camera. The imaging isotope is ^{15}O in the form of $C^{15}O_2$, administered by inhalation.

The positron camera has been operating successfully for almost two years, including the performance of clinical trials at the Hammersmith Hospital in collaboration with the Royal Postgraduate Medical School and the MRC Cyclotron Unit. The following projects have been carried out:

- ☐ Studies of peripheral limb blood circulation problems using $^{15}O_2$ and $C^{15}O_2$.
- ☐ Studies of the blood supply to lymphoedemas in the peripheral limbs with $^{15}O_2$ and $C^{15}O_2$.
- ☐ Imaging of bone lesions associated with arthritic diseases (and others) using F^{18}.
- ☐ Imaging of blood pool in peripheral limbs and in the brain using ^{11}CO.

A large sequence of animal studies was also carried out using Rb^{82} (heart and kidneys), ^{68}Ga transferrin, ^{68}Ga labelled albumin (lungs) and F^{18} (bones).

In a second phase of clinical exploitation at the Queen Elizabeth Hospital, Birmingham, in collaboration with the Birmingham University Medical School (and also the Nuffield Cyclotron Laboratory which produced the isotopes), studies were carried out on thyroid disease using ^{124}I and a much more ambitious programme was begun in the attempt to image other organs using antibodies labelled with ^{124}I.

The clinical studies demonstrated that the positron camera is essentially complementary to the Emission Computed Axial Tomography technique (which is commercially available) since it presents images in the lateral rather than the axial plane, so making it ideal for the study of peripheral limbs. It also offers better spatial resolution, which will continue to improve during further development.

J E Bateman

Progress at the Technical Change Centre

The Technical Change Centre (TCC), set up in late 1980 (see *Bulletin* Vol 2 No 2, Spring 1981) is now developing its major programme of research on the choice, management and acceptability of technical change relevant to the advancement of the national economy. The Centre receives support from SERC, from the Social Science Research Council and from the Leverhulme Trust.

Under its Director (Professor Sir Bruce Williams) and Deputy Director (Dr A J Kennedy), the Centre set up offices in London in mid-1981 and began to build up a staff of research workers whose specialisations cover a wide band of disciplines: science, technology, economics and the behavioural sciences. The staff includes two Assistant Directors: Dr A D W Jones, a physicist from the British Steel Corporation, and Professor R Dore, an industrial sociologist with special knowledge of Japanese culture and industry, and of the developing countries.

Some of the TCC's current projects have been selected and designed with SERC interests strongly in mind, and there is close collaboration with SERC staff in the work. The first of these studies is concerned with the successful introduction of new and improved materials into profitable engineering use. The study is being set against the background of the UK's capabilities, in terms of resources and expert knowledge, with the aim of deriving an overall view of the UK position and of the more promising lines of advance. The contributions made by SERC-sponsored work are being assessed in this context, with consideration being given to those areas in which SERC influence and support could prove particularly rewarding. The project is led by Dr Kennedy, with a panel made up of university staff and industrial consultants in specialist subjects.

Another project particularly linked with SERC is that on computer-aided design and manufacture. Mr J Butler is studying the current UK scene and in particular the extent to which academic research in these fields has been, and is being, taken up by UK industry, and where future SERC work might be most fruitfully directed.

A preliminary study of the effectiveness of the higher education system in research, in postgraduate training schemes, in its links with commerce and industry, is being undertaken in relation to the timely fulfilment of technical change. The investigation will include an evaluation of the Council's industrially-orientated training schemes with particular reference to CASE awards and to the Engineering Board's policy towards the recognition of Advanced Courses. Dr D Bosworth of Loughborough University is the principal research worker on the project.

The fourth of the SERC-oriented projects concerns the Specially Promoted Programmes. An attempt is being made to assess the value of this form of identification and funding, and the effects the scheme has had in its contributions to learning on the one hand and to industrial development on the other. Particular emphasis will be given to the mechanisms of transfer. Consideration is also being given to the ways in which SERC might evaluate and select subject areas in the future. Dr Kennedy, Dr Jones, Mr J Quinn and Miss K Woolley are collaborating in the study.

The Centre is co-operating with the British Association for the Advancement of Science in developing procedures for the conduct of periodic science audits, and with the British-North American Research Association in a comparative study of factors inhibiting the successful development and exploitation of innovations in Britain and North America.

Early in 1982 the Centre organised a symposium on 'what we know and what we do not know about technical change', and there are plans for further regular symposia to bring together research workers in particular areas.

For further information contact:
The Technical Change Centre
114 Cromwell Road
London SW7
Telephone 01-370 5770

The other current projects at TCC cover a wide variety of studies. They include:

- A study of the impact of the recession on the extent and nature of R & D in large companies (Dr N Swords-Isherwood);
- R & D in British Rail, directed on the one hand to a major technical step and on the other to incremental change, as the beginning of a broader study of whether the UK gives sufficient emphasis to incremental technical changes (Sir Bruce Williams and Miss J Bryan-Brown);
- the balance between the influences of R & D and learning curve phenomena in incremental cost reductions (Mr M Bell);
- relationships between technical change and the demand for skilled labour in industries where there is no provision for training them (Dr M Cross);
- the effective exploitation of technologies in mature industries (Dr Jones, Miss Woolley, and Dr S Cunningham);
- how and why firms differ in the adoption of microelectronics (Dr E Sciberras and Mr B Payne);
- the extent and effectiveness of the monitoring of the technological environment by UK firms (Mr J Quinn);
- the effects of types of workers' motivation on innovation (Professor Dore and Mrs A Sieve);
- the impact of technical change on regional employment (Mr D Gleave);
- the effects of developments in information technology on the amount and nature of employment in the service sector (Mr R Barras and Mrs J Swann);
- past and prospective changes in life hours in the labour force and their policy implications (Sir Bruce Williams and Dr P Armstrong);
- a statistical analysis of the changing patterns of international trade and their influence on, for example, the structure of the economy – import penetration (Dr K Parker);
- the feasibility of elaborating models of firms in mechanical engineering, in the UK, France and Germany, to test the impact of Government measures to stimulate innovation (Mrs J Cox);
- the industrial infrastructure required for the diffusion of information technology (Professor M Gibbons, Professor S Metcalfe and Professor R Williams at Manchester University).

Specially promoted programmes — newsround

Electroactive polymers

The Engineering Board approved in January this year a specially promoted programme to encourage research into polymeric materials with novel optical and electrical properties. The programme is expected to add about £1 million to the Materials Committee's budget from 1982/3 to 1986/7. The purpose of the SPP is to stimulate a coherent and timely UK activity in the science and technology of electro- and photo-active polymer systems for applications in new photoelectric, reprographic and microelectronic devices. The programme will have to link basic synthetic and characterisation research to the materials requirements of high technology uses.

Needs have been identified for materials research into thin film micro-batteries for microprocessor and display applications, new resist coatings for electron and x-ray beam lithography, reversibly photochromic and particularly photorefractive systems for holographic information storage, photoelectric systems for use in image intensifiers, conduction devices characterised by anisotropic conductance and device dimensions of molecular sizes, and very thin film conductance and switching devices.

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

A programme coordinator will shortly be appointed, to promote interdisciplinary research grant applications, arrange workshops, coordinate the constituent research projects within the SPP, and liaise with interested government departments (such as the Department of Industry and Ministry of Defence), other SERC bodies (particularly the Solid State Devices Subcommittee of the Information Engineering Committee), and UK 'end user' industries which might exploit the technology for the national good.

In launching this initiative, the Committee is keen not only to encourage currently supported research groups to expand their activities in the required direction but also to attract the skills of synthetic organic chemists, physicists and electrical engineers who may not previously have worked in the field.

Further information can be obtained from Dr Steve Milsom, Secretary of the Non-Metallics Subcommittee, SERC Central Office, Swindon (ext 2338)

Coordinators for Radio Communications ...

To help promote the Council's newly established SPP in Radio Communications Systems (*SERC Bulletin* Vol 2 No 5, Summer 1982), two part-time coordinators have been appointed. Their task will be to coordinate existing work, to encourage more applications from academic departments with an interest in radio engineering, and to encourage industrial participation in the programme.

Mr Stephen Barton is responsible for satellite communications. He is employed as a communications consultant in the Space and Astrophysics Division at Rutherford Appleton Laboratory (RAL). He has been associated with high bit rate modem design and microwave propagation at Marconi Research Laboratories and has done work on military communications systems at the Government communications centre at Hanslope Park. He can be contacted at RAL, Chilton; telephone Abingdon (0235) 21900 (ext 6556).

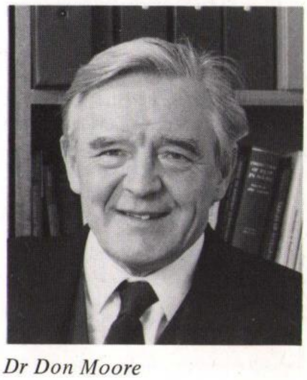
Mr Frank Grimm has been appointed coordinator for terrestrial radio systems. He has spent most of his professional career working on mobile radio communications. From 1977 until his retirement in May of this year he was the technical coordinator of Philips Mobile Radio Management Group and has served on a number of international committees advising on research and development. He is keen to forge closer links between academics and industrialists and can be contacted at: 85 Beaumont Road, Cambridge CB1 4PX; telephone Cambridge (0223) 246202.

... and for Materials and Energy Conservation

The Council has appointed Dr Don Moore as coordinator of its specially promoted programme in Materials and Energy Conservation, in succession to the late Dr Jack Butterworth. The programme was set up in 1979 to support multidisciplinary research into materials and energy conservation in the materials processing industries. SERC has since awarded a total of £1.1 million for the support of 28 research projects, several projects being carried out with the involvement of industry. The current priorities of the programme were outlined in 'Priorities for Materials Research' (*SERC Bulletin* Vol 2 No 5, Summer 1982).

Dr Moore's career has been spent mainly in the metallurgical and engineering industries and has embraced a wide range of materials, products and processes.

In 1951 he joined ICI Metals Division (now IMI), was appointed Research Manager in 1964 and later Manager of the New Ventures R & D Department. He transferred to the ICI Corporate Research and Technology Department in 1974 where he has been responsible for corporate academic relations until his retirement this March. He can be contacted at Little Birches, Church Lane, Sheriffhales, Shifnal, Shropshire TF11 8RD; telephone Telford (0952) 461022.



Dr Don Moore

SERC and ZWO collaboration

The Mutual Statement on Scientific Collaboration is signed by Professor W F de Gaay Fortman, Chairman of ZWO (left), and Professor J F C Kingman, FRS, Chairman of SERC.

The British and Dutch research communities, represented by SERC and the Netherlands Organisation for the Advancement of Pure Science (ZWO*), in June signed an agreement to encourage collaboration in scientific research. The two Research Councils entered a partnership in 1981 to build and use new astronomical telescopes (see *Bulletin* Vol 2 No 3, Autumn 1981). The Mutual Statement will extend the possibility of collaboration into wider areas of scientific research where the two nations have complementary interests. It will encourage collaboration between Dutch and British scientists, secure access for scientists of both nations to world-class research facilities and encourage collaboration in the fields of instrumentation, data processing and data analysis.

The Mutual Statement recognises the need for scientists to work in partnership in programmes of world-class research. The two Research Councils can now work within the framework of the agreement to achieve scientific collaboration in areas of common interest and will be prepared to balance the costs and benefits over more than one area.

The Mutual Statement on Scientific Collaboration was signed in London by Professor W F de Gaay Fortman (Chairman of the ZWO) and Professor J F C Kingman, FRS (Chairman of SERC). In attendance were Professor R van Lieshout (Director) and Dr H Weijma, representing ZWO, and Mr B W Oakley, CBE (Secretary), Dr H H Atkinson (Director of Astronomy, Space and Radio and Nuclear Physics) and Dr L C W Hobbis (Head of Science Division) representing SERC.

*Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek

New VAX computer for STARLINK

A new node has been added to the STARLINK network. Installed at the University of Durham in March this year, this brings the total number of STARLINK computers to seven.

The STARLINK network was set up by SERC in 1980 to provide interactive data processing facilities for astronomers in universities and in SERC establishments. Originally the network comprised six DEC VAX-11/780 minicomputers, located at RAL, RGO, ROE, Cambridge, Manchester and London. Apart from substantial memory resources plus disks and other peripheral devices, each of these machines is equipped with two powerful Sigma ARGS colour display systems used in interactive image processing. The six computers are connected to each other by communication lines in a star pattern (hence the name STARLINK) and astronomers use these links to exchange software, documentation, messages and sometimes data.

The computer at Durham is a VAX-11/750. With 2 megabytes of memory, several hundred megabytes of disk and a 125 ips tape drive, it is a machine of considerable power. The astronomers at Durham will use the new computer for a wide variety of work, including the reduction of spectral data from the 3.9 metre Anglo-Australian Telescope and the analysis of galaxy images on plates taken with the UK Schmidt Telescope. Work is in progress to link this computer with the other six, through SERC's X25 computer communications network, SERCnet.

High-lift wing research

Improvements in the high-lift performance of aircraft can have a dramatic effect on aircraft design and competitiveness. They can lead directly to increased payload, reduced airframe size, smaller engines, lower fuel consumption and lower noise. In addition to the direct performance benefits, a more soundly based high-lift technology will reduce development risks and improve the optimisation and response time in the design process.

In view of the importance of the topic, a coordinated programme of research has been identified by UK industry and government establishments, principally British Aerospace and the Royal Aircraft Establishment. It has recently been agreed that SERC-supported university research should also be integrated into the programme.

Improvements in lift are achieved by the use of efficient multiple aerofoils which also reduce drag, particularly at take-off. The programme is primarily concerned with the flow over these aerofoils and to some extent compressibility effects. It is aimed at civil aircraft at low speed rather than high subsonic speeds and high lift of slender wings.

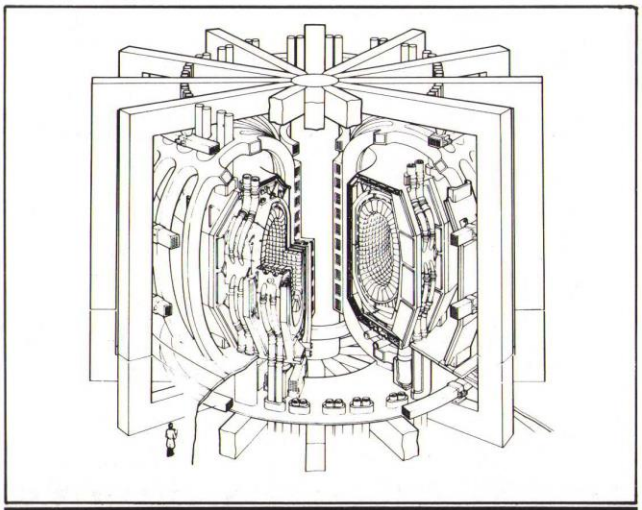
The university research is expected to concentrate on the theoretical methods, the understanding of flows and some aspects of design guidance. Initially these studies will be two-dimensional but it is intended to extend to three dimensions and to experimental comparisons later in the programme. Topics to be included are modelling of separated flows in slat coves, boundary layer and wake interactions and boundary layer development in severe adverse pressure gradients. This modelling will be integrated into predictive methods which are being developed by industry. In later stages, university involvement in experimental work could be extended to include the use of large wind tunnel facilities which now play an important part in industrial research and development.

University/industry collaboration is well under way. Further university involvement is being encouraged and applications in this area are invited. Those interested in being involved in the programme should discuss proposals with the coordinator Mr J Arnall, the Group Coordinating Engineer-Aerodynamics, British Aerospace, Richmond Road, Kingston-upon-Thames, Surrey KT2 5QS; telephone 01-546 7741.

Fusion technology

Controlled thermonuclear fusion is arguably the world's most important long-term source of energy. So far, most research work on fusion has been in the area of basic plasma physics but in recent years it has become apparent that substantial developments in engineering and technology will also be required if nuclear fusion reactors are ever to become a practical everyday source of electric power.

The Energy Committee has over the past three years supported a programme of research in fusion technology. This programme has until now concentrated almost entirely on the materials aspects, in which the problems are extremely severe, particularly in the first wall of the reaction vessel, which will see a very heavy neutron load from the reacting plasma. Particular emphasis has therefore been given to problems of radiation damage in structural materials and also in the superconducting materials for the magnetic coils which surround and confine the plasma. In addition, research work has been supported on problems of chemical compatability between the lithium breeder and its containing materials, the strength of structural materials, thermoelectric magnetohydrodynamic effects in flowing molten lithium and separating the isotopes hydrogen, deuterium and tritium. To date, 13 grants to a total value of £512,000 have been awarded.



Conceptual design for a future Tokamak power reactor (Photo: UK Atomic Energy Authority)

The Energy Committee now wishes to broaden the scope of this programme and has chosen to emphasise the areas of heavy electrical and mechanical engineering. It is perhaps no exaggeration to say that the coming generation of fusion devices and the subsequent prototype reactors will pose the next major challenge to heavy electrical engineering. Because of the large scale and expense of the equipment involved, it may be difficult for university groups to make an effective contribution in terms of practical experimentation, but there is great scope for universities in the areas of conceptual design studies, systems modelling, etc, using computer simulation techniques. Many university groups overseas, particularly in the USA, have gained excellent reputations for their conceptual design work on future reactor systems. UK universities are rather well placed in this area because of the existence, on SERC's Interactive Computing Facility, of many computer programs relevant to the design of fusion reactors. Indeed several of these programs have already been purchased by the American Magnetic Fusion Energy Computing Network.

During the coming months SERC's Energy Unit Coordinator Mr M N Wilson would like to make contact with university groups interested in starting new work in this area. Possible topics for investigation include:

Design and stressing of novel structures
Thermal problems
Optimisation of the operating cycle
Control strategies
Failure analysis
Design of novel electrical energy transfer systems
High power radio frequency systems
Neutral beam accelerators

For further information please contact:
Mr M N Wilson, Rutherford Appleton Laboratory (ext 275).

Meteorological data now available

Users of meteorological data will know that the Meteorological Office now have to make a charge for copies of their data on magnetic tape. Negotiations on behalf of the Building Subcommittee have resulted in SERC being able to make a substantial part of the available data accessible via the SERC's Interactive Computing Facility. The Meteorological Office have about 300 station-years of data in computer-readable form and about 60 station-years will be accessible via the network. However it should be noted that the data may only be used for research purposes; non-research users will still have to make their own arrangements with the Meteorological Office. Prospective users will have to sign an undertaking that they will only use the data for specified research projects.

The data base is provided with research into energy use in buildings in mind, but there is no reason to restrict its use solely to that field. Researchers on any programme that can make use of the data will be eligible to apply for access.

For the purposes of energy in buildings research, it is usually necessary to have all the major meteorological parameters measured at the same site and so the data base will only contain data from sites such as Kew, Aberporth and Eskdalemuir.

The variables measured consist of dry and wet bulb temperatures, wind speed, wind direction, rainfall and solar radiation and have been measured at hourly intervals.

In the first instance, a user will be able to select which site, which variables, and over what period data are required, and have them transmitted from the central computers at the Rutherford Appleton Laboratory to any of the computers on the network. Later it is hoped to have a more sophisticated selection system which will be able to advise on what station and dates will best suit a particular purpose (for example, what station and what periods contain cold spells with little wind).

Prospective users of the data base are asked to get in touch with:

Dr W A Smith, Rutherford Appleton Laboratory (ext 6600).

POLYMER ENGINEERING DIRECTORATE

Future strategy

The Polymer Engineering Directorate (PED) has been in existence for six years and many of its original objectives have now been met. Industry and the academic community are now more aware of each other's needs and capabilities and the Directorate has built up a coherent portfolio of polymer engineering projects.

Council has decided that, in keeping with its policy for the special Directorates, PED will cease to function as part of SERC after September 1984. Discussions are currently taking place on its future organisation. Nevertheless the Directorate is anxious that during the next two years its work is focused on a forward-looking set of research projects, geared to the needs of industry, which will continue to attract SERC research grant funding.

Funds have in the past been distributed widely, but it is now essential to concentrate effort and resources and be more selective in funding. It is therefore unlikely that PED will be able to support so many 'isolated' activities in future. The time is, however, right to embark on some more ambitious and innovative programmes. The Directorate's scope for seeing programmes through from research to the development phase has been widened by its recent stronger links with the Department of Industry's Materials and Chemicals Requirements Board. In addition, SERC's Teaching Company Scheme lends itself to applications in the polymer processing industry where new technology is being introduced, and joint projects are being discussed.

Looking at existing activities, it is clear that the most successful programmes are industrially led, and this lead more usually comes from the 'user' industries since they are best placed to identify market requirements. Increasing emphasis will be put on stimulating such programmes.

Significant resources are being devoted to education and training, but here PED's role is limited. The responsibility for positive action lies with the universities and polytechnics in providing the sort of trained manpower required by the industry. The Directorate will, however, be looking at research and training in a more integrated way since academics who are supported by PED have a responsibility to extend this into their teaching activities.

Criteria for future support

The aims of PED have now been redefined:

- ☐ to promote university/industry liaison with the objective of increasing the level of technology in the polymer industry
- ☐ to carry out research programmes in universities and polytechnics in collaboration with industry and to meet specific needs of industry
- ☐ to promote and encourage new initiatives in education and training to universities and polytechnics to meet the current and future needs of industry.
- ☐ to support novel and forward-looking ideas in universities and polytechnics which would ultimately be of value to industry, and which will maintain the academic strength of polymer engineering groups

This redefinition of objectives may mean that some future proposals submitted to PED will not now meet the Directorate's special criteria for support (although this would not imply criticism of the proposals) and these applications will be referred to the relevant subject committees within SERC for consideration in the normal way.

Areas of future interest

Some areas where more emphasis should be given are:

Integrated processing
Relative processing
Design
Novel composites
Non-destructive testing

The Directorate would urge prospective applicants from universities and polytechnics to continue to make an informal approach before submitting a finalised application so that their outline proposals may be discussed. Similarly, industrialists with ideas for research or development programmes should get in touch with the Directorate at an early stage at:

Polymer Engineering Directorate
3-5 Charing Cross Road
London WC2H 0HW
Telephone 01-930 9162

MARINE TECHNOLOGY DIRECTORATE

Measurement of potential and pH within fatigue cracks

In the past, studies of the electrochemical conditions within corrosion-fatigue cracks have been limited mainly to indirect measurements and mathematical modelling. Recent work at Glasgow University, with support from the Marine Technology Directorate, has led to the development of methods for the direct measurement of electrochemical potential and pH within fatigue cracks.

The methods involve placing small electrodes in holes (2.0 mm and 1.2 mm in diameter for the pH and potential electrodes respectively) drilled to terminate slightly ahead of the crack tip. After further air-fatigue cycling until the crack just intersects the holes, the electrodes are carefully positioned in the holes. The potential measurement is by means of a calomel electrode/agar capillary and a glass electrode is used for pH measurement.

The initial application of the techniques to BS 4360: Grade 50D steel in sea water have indicated consistent trends in the measurements. Under the conditions of the experiments, the electrode potential within the crack was more noble than that of the bulk solution, and under both static and fatigue loading, pH values were appreciably lower in the crack than in the surrounding sea water. Moreover, it appeared that the crack micro-environment can be significantly affected by the previous loading/chemical history of the component. There were also indications that, under some circumstances, the crack interior can act independently of the exterior.

The evidence from these experiments suggests that, under free corrosion conditions, hydrogen evolution may occur within the crack. This, in turn, might increase the rate of crack growth through hydrogen embrittlement.

Thus it is clearly seen that the techniques can provide detailed information relevant both to corrosion-fatigue mechanisms and to operational matters, such as the effect of cathodic protection on crack-tip conditions. Experimental data provided in this way will assist in evaluating predictions from theoretical models of fatigue.

Contact: Dr Paul Mayo
University of Glasgow Marine Technology Centre
James Watt Building
Glasgow G12 8QQ
Tel: 041-339 8855 ext 361.

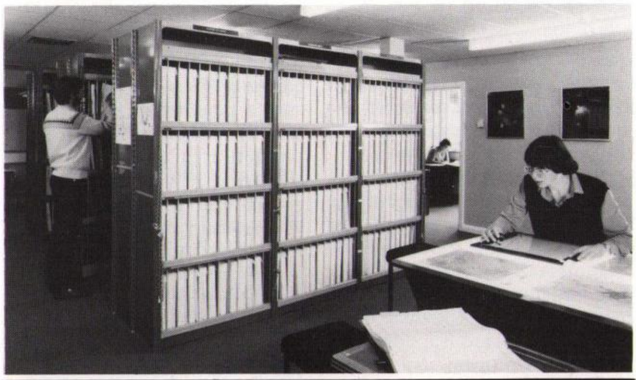
New plate library for Edinburgh

Astronomers have been using photography as a research tool for over a century and many observatories have built up considerable stocks of valuable photographs over the years. Recent advances in photographic technology and in telescope design as well as in the development of computer-controlled measuring machines have led to a sudden dramatic increase in the use of photography in astronomy. In particular, several of the world's largest Schmidt-type telescopes have been used to produce complete sky atlases. SERC's UK Schmidt Telescope (operated in Australia by a team of Royal Observatory, Edinburgh, staff) is at the forefront of this research.

A high proportion of the large glass plate negatives which form the output of the UKST are sent by air freight to Edinburgh, and the Royal Observatory on Blackford Hill, which was built ninety years ago for observational work, has rather suddenly become the centre for a new type of astronomy. Astronomers come from all over Britain, and from other countries, to make use of the large and growing collection of astronomical photographs taken overseas.

These people come to Edinburgh partly because many of the photographs are too valuable and fragile to be readily transported from one laboratory or observatory to another, and partly because the ROE has specialised in setting up a range of unique machines for measuring and inspecting the photographs. This is a good example of how SERC fulfils its aim of supporting research in the universities by providing centrally those facilities which are too costly or specialised to be available at individual universities.

The new Plate Library, which was officially opened on 20 May 1982, grew out of earlier facilities. When the first photographs came back from the UKST in Australia in 1973 they were stored in a cardboard box, and then in one specially-modified filing cabinet. The collection grew, as did the suite of associated light tables, microscopes and measuring machines, until the stage was reached when there was a real risk that the floor would collapse (glass is heavy stuff) in the ordinary office then being used as the Plate Library. In parallel with this the ROE Mechanical Workshop was also outgrowing its original home and a new workshop was built in 1979-80. The UKST Unit was able to take over the old workshop and to arrange for it to be suitably modified by the Works Unit of SERC to meet the requirements of a modern Plate Library. Not the least of the advantages of this area is that it has a very strong concrete floor, with solid Blackford Hill basalt just beneath it.



A general view of the plate library at ROE

The UKST takes some 800 photographic plates per year, and the Plate Library also houses collections of original plates and copies from several other telescopes around the world. The current collection comprises some 5,000 original plates taken by UKST, 2,500 glass copies of various sky atlases and 4,000 copies on film or paper together with several thousand older plates taken using other Edinburgh telescopes.

The opportunity was taken to store the plates in an air-conditioned environment, since astronomers like to keep their photographs for a very long time and indeed still sometimes use some of the earliest astronomical plates, taken towards the end of the last century. Thus archival-quality storage was deemed essential.

Another advantage of the move was that space was available for the many specialised measuring machines, formerly housed in odd corners in attics and basements of the Observatory, to be put in rooms next to the plate collection.

One such machine is a heavily modified Zeiss plate comparator. It has been fitted with a closed-circuit TV viewing system and stepping-motor drives. The whole machine is under the control of a microprocessor, and has digitised position output.

The comparator allows the astronomer to inspect two photographs of the same region of sky simultaneously. Images from each plate are directed to TV cameras and can be displayed, together or separately, on TV monitors. The original machine was designed to compare photographs taken at different times, to search for stars which vary in brightness, or to compare photographs taken through different coloured filters to find stars with extreme colours.

The ROE modification has recently been used very effectively in a different way, comparing a prism plate with a direct plate. The astronomer first examines an objective prism plate, looking for unusual spectra. When an interesting object is found, the prism photograph is compared with a direct photograph of the same area in order to eliminate the effects of overlapping spectra, to identify the object as a star or a galaxy, and to record its position. This has proved to be a very powerful tool in the search for quasars, the enigmatic objects which at first sight seem to be simple stars but which are in reality the brightest and most distant galaxies that we can observe in the universe. These objects have peculiar spectra, dominated by intense ultraviolet radiation and by emission lines of very hot gaseous carbon, oxygen, nitrogen, hydrogen and other elements. On a typical UKST photograph covering 40 square degrees of sky, astronomers can easily find several hundred quasars.

Finally, but by no means least, there were people to consider. A set of offices along one side of the new Plate Library provides accommodation for the team of 'Plate Librarians' whose job it is to find the photographs that customers want, to liaise with the telescope operating team in Australia when new photographs are required, to deal with the worldwide marketing of the film Atlases, to maintain the computer database which holds details of all existing photographs and research programmes, and to assist visitors using the plate inspection and photographic equipment.

Split comet photographed

Comet du Toit was first observed in 1945. Its next six orbits round the Sun were not observed but it was fortuitously picked up again in February this year on a photograph taken with the UK Schmidt Telescope in Australia. The astronomer concerned, Mr Malcolm Hartley of the Royal Observatory, Edinburgh, discovered that this formerly single comet was now double.

A second photograph, taken a month later when the pair of comets had moved to a different part of the sky, showed that one fragment, known as Comet du Toit-Hartley 1, which was very much the brighter of the two in February, had diminished considerably in brightness over the month. This provides a graphic demonstration of the difficulties of predicting comet magnitudes.

Most distant object

In March this year a long established astronomical record was broken. For ten years the most distant known object in the Universe had been a quasar with a redshift of 3.53. (The redshift of an astronomical object is a measure of the velocity with which it is moving away from us. Since the whole Universe seems to be expanding away from some initial 'Big Bang', the objects with the highest velocities are those which are now most distant. Hence a very large redshift corresponds to an enormous distance.)

Dr Ann Savage is an astronomer on the staff of the Royal Observatory, Edinburgh, who is at present working in Australia as a member of the operating team of SERC's UK Schmidt Telescope (UKST). Using a recent very accurate radio position of the intense radio source PKS 2000-330 obtained by Dr David Jauncey and Dr Alan Wright (who are radio astronomers working in Australia) Dr Savage identified, on a photograph taken with the UKST, a faint star-like object associated with that radio source. Then on 25 March Dr Savage and her colleague Dr Bruce Peterson (who is on the staff of the Mount Stromlo Observatory of the Australian National University) used the 3.9 m Anglo-Australian Telescope to obtain a spectrum of this object; it turned out to be a quasar with a redshift of 3.78, which means that it is the most distant quasar identified so far. The redshift of 3.78 corresponds to a recession velocity of more than 90% of the speed of light, which is excitingly close to the 'edge' of the observable Universe.

Because the distance record had remained unbroken for so long, it had begun to look as if there might be a rather sharp cut-off to the distribution of quasars in space, and hence to their time of formation. The discovery of this new large redshift suggests that perhaps the cut-off is not sharp.

Furthermore, since PKS 2000-330 is relatively bright, it seems likely that many more quasars at such enormous distances will be found when astronomers learn to recognise them.

Telescope high and dry

The UK Millimetre Telescope, a radio telescope currently being designed at RAL, will be used for observations at wavelengths of around 1 mm. Such observations are strongly affected by water vapour in the atmosphere and it is important to have a site where there is a minimum of precipitable water in the beam.

An examination of the properties of different possible sites and of the costs of operation of the facility in the countries concerned has led to a Council proposal that the UKMT should be located on Mauna Kea, the 4200 m mountain in Hawaii where ROE already has a team operating the UK Infrared Telescope.

Museum of the year

The Visitor Centre at the Royal Observatory, Edinburgh, has been awarded joint first prize as 1982 Museum of the Year for Scotland. The award was made by the Scottish Group of National Heritage, chaired by the Countess of Perth. It was presented in June by the Rt Hon Paul Channon, MP, Minister of State for the Arts, to ROE project officer Dr Jim Campbell, with a cheque for £500 from the sponsors, Scottish and Newcastle Breweries Ltd. The centre, which was opened in April 1981 (see *Bulletin* Vol 2 No 3, Autumn 1981), shared the joint first prize with the Wick Heritage Centre.

Interstellar comets?

The comets that occasionally appear in our skies have been orbiting the Sun for a long time. But for how long? Have they been with us since the solar system was formed or have they been swept up from interstellar space much more recently? Is there any relation between geological catastrophes (such as the change in living conditions on Earth that marked the end of the dinosaur era) and the passage of the solar system through giant molecular clouds in interstellar space?

A small Workshop held in April this year at the Royal Observatory, Edinburgh, spent two days exploring such questions. It was notable for the variety of disciplines represented – mineralogists, nuclear physicists and space scientists as well as astronomers. A report of the proceedings is being produced by the ROE.

RGO and the HIPPARCOS astrometric satellite

Since the original HIPPARCOS proposal, for an astrometric satellite to be launched by the European Space Agency (ESA) towards the end of 1986 (see *Bulletin* Vol 2 No 1, November 1980), the project has been enhanced by a minor modification to hardware and an increase in data handling. It will now include project TYCHO which will provide a complete survey of positions, albeit to rather lower accuracy than the main programme, and also magnitudes and colours of some 400,000 stars.

In March of this year ESA accepted proposals from two independent consortia to perform the data analysis, which will lead to a final HIPPARCOS catalogue. From the UK, the Royal Greenwich Observatory and the Mullard Space Science Laboratory will collaborate with Scandinavian astronomers and geodesists at Lund and Copenhagen in the Northern Data Analysis Consortium (NDAC). The other consortium includes institutes in France, West Germany, Italy, Netherlands and the USA.

The selection of stars, up to a maximum of 100,000, will be made from the proposals submitted by the world-wide astronomical community. Preliminary positions and magnitudes (brightness) of all selected stars must be obtained and collated to form the Input Catalogue. This is a major task which will be shared within a consortium of some 30 institutes from 10 countries, including RGO.

Astrometry is the measurement of positions of stars in the sky and, in particular, the changes of position ('proper motion') arising from the relative motion of the stars and the Solar System and the parallactic shift of nearby stars due to the annual orbital motion of the Earth. This branch of astronomy has been actively pursued at RGO since the foundation of the Royal Observatory at Greenwich in 1675.

The reference frame for the identification of all celestial objects – stars, galaxies, radio sources, x-ray sources – and for studying motions in the Galaxy and the Solar System, is provided by catalogues of stars in which each position is defined by coordinates, known as right ascension and declination, which are analogous to terrestrial longitude and latitude. Up to the present time such catalogues have been based on the observation of the time and altitudes above the horizon of stars as they cross the local meridian. At RGO these observations are made with the Cooke Transit Circle.

Trigonometric parallaxes are now measured exclusively by photographic techniques in which the parallactic shift of a nearby star is measured in relation to those of supposedly more distant stars. The Thompson 26 inch refractor was used at Greenwich from 1897 to measure parallaxes and is still in use for this purpose at Herstmonceux.

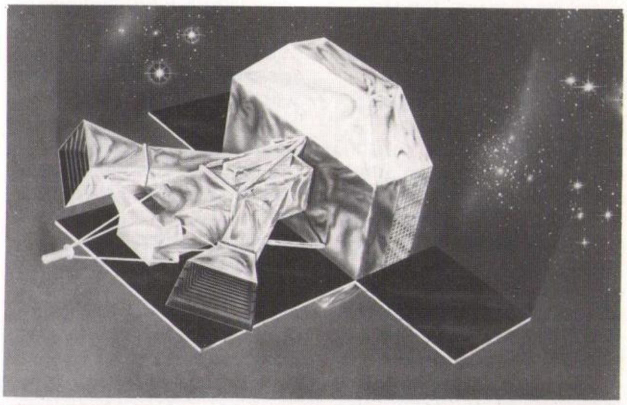
A major limitation to the accuracy of all astrometric observations is set by the Earth's atmosphere. In order to avoid this and to overcome other, instrumental, problems the French astronomer Pierre Lacroute proposed more than 15 years ago that astrometric observations should be made from space. The outcome of many years of discussion and study is the HIPPARCOS satellite.

The basic principle of HIPPARCOS is a global triangulation of the whole sky by means of the optical superposition of two fields of view which are inclined at a fixed angle of about 60°. The whole sky is to be scanned many times during a 2½ year mission, in a series of great circles containing the two fields of view. The construction of a catalogue from the complete set of data will be an enormous computational task. The estimated accuracy will be, on the average, 0.002 arc second for each coordinate of position and annual proper motion, and for trigonometric parallax. For the latter in particular this will mean a fivefold improvement over what has generally been obtained from ground-based observations, with a consequent increase of more than two orders of magnitude in the volume of space for which tolerably accurate distances to individual stars can be measured. This will have far-reaching consequences for astrophysics and for studies of galactic dynamics.

Another interesting application of the HIPPARCOS data will be to measure the relativistic deflection of light at large angular distances from the Sun. This has so far only been measured, both optically and at radio wavelengths, in the extreme case of sight lines passing very close to the Sun where the deflection has its maximum effect.

According to current schedules, the final catalogue should be available about five years from the date of the launch. This may seem rather a long time to wait for the results from proposals submitted now, but it should be emphasised that the HIPPARCOS data will supersede most of the astrometric data which have accumulated during more than two centuries and will provide the present and future generations of astronomers with an unparalleled source of fundamental data for studies of stars and the Galaxy.

C A Murray



An artist's impression of the HIPPARCOS satellite showing the two apertures 60° apart bracketing the 30 cm telescope with the detection system and antenna on the left.

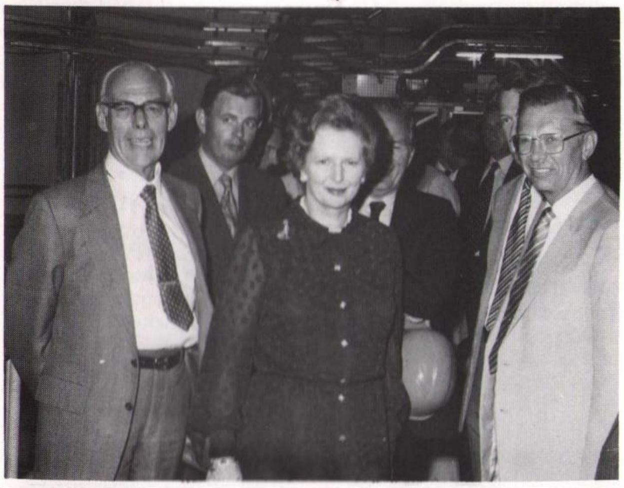
Planet named 'Taylor'

The Royal Greenwich Observatory's Mr Gordon Taylor has had a minor planet named after him. One of tens of thousands of asteroids in the belt between the orbits of Mars and Jupiter, 'Taylor' was discovered in January this year by Dr Edward Bowell of the Lowell Observatory in Arizona. The discoverer nominated Mr Taylor in recognition of his work over many years in developing a technique to determine the sizes of minor planets, by waiting for them to pass a star.

"It is great honour both for the Observatory and for myself." said Mr Taylor. "Of the 2,600 asteroids named so far, I believe less than a dozen have been named after British astronomers."

Mr Taylor is Chairman of the Working Group on the Predictions of Occultations by Satellites and Minor Planets (International Astronomical Union Commission 20) and a Past President of the British Astronomical Association.

Prime Minister visits CERN



The Prime Minister, the Rt Hon Mrs Margaret Thatcher, MP, paid a private visit to the Meyrin facilities of CERN (the European Organisation for Nuclear Research) in Geneva in August, while on holiday with her husband. Seen left, visiting one of the proton-antiproton collider experiments are (left to right): Mr Denis Thatcher; Professor John Kingman, FRS, Chairman of SERC; the Prime Minister; (partly hidden) Sir Alec Merrison, FRS, President of CERN Council: and Professor Herwig Schopper, Director General of CERN. Above: The Prime Minister talks to visiting scientists and students and British staff. *Photos: CERN*

The European Science Foundation

The European Science Foundation, which was set up in 1974, is an international non-governmental organisation composed of 47 academies and research councils from 18 countries. SERC is one of the seven UK member organisations of the ESF, the others being the other four research councils (namely ARC, MRC, NERC and SSRC), the Royal Society and the British Academy. The Chairman of NERC, Sir Hermann Bondi, KCB, FRS, and Mr Michael Posner, Chairman of SSRC, currently represent the UK on the ESF Executive Council.

The main objectives of the ESF are 'to advance co-operation in basic research, to promote the mobility of research workers, to assist the free flow of information and ideas and to facilitate the harmonisation of the basic research activities supported by its member organisations'. It provides a forum where member organisations are able to discuss common policies and joint activities. The interests of the ESF cover all the sciences including the social sciences, and the humanities. Its member organisations are all represented in the ESF's Assembly which meets once a year and is its main decision-making body. At present the ESF has five standing committees covering the humanities, social sciences, medical research, natural sciences, and space science. These Committees monitor the ESF's activities in their respective fields; make recommendations on how to improve European co-operation and act as sounding boards for new ideas.

All member organisations contribute to the general budget of the ESF, which meets the basic running costs of the central secretariat in Strasbourg. Special budgets support 'Additional Activities' – specific scientific programmes or projects to which only those member organisations who want to participate make a contribution. The total general budget for the calendar year 1982 is 6,812,000 French francs to which the UK members' contribution is 11.83%, or £68,400.

ESF 'Additional Activities' and SERC

SERC's involvement in 'Additional Activities' is funded from the budget of the appropriate Council Committee or Board, with financial approvals being made through the standard Committee and Board procedures. Current involvement includes:

Taxonomy: SERC contributes to one of the three projects of this activity: 'European Floristic, Taxonomic and Biosystematic Documentation System'. This project, when implemented, will involve the continuous updating and revision of existing Floras.

Institut des Hautes Etudes Scientifiques (IHES): the institute was adopted as an Additional Activity in 1976. It was founded in 1958 and is located outside Paris. It exists to support and stimulate research in pure mathematics and theoretical physics. It supports a Director and six permanent professors, and a large number of visiting scientists who come for periods between one month and two years to undertake research and participate in seminars and conferences.

Synchrotron radiation: until 1981, the ESF supported an Additional Activity in this field, for: the improvement of relations between existing centres of research using synchrotron radiation; studies of the x-ray machine proposed for a European Synchrotron Radiation Facility; and preliminary studies of a small machine emitting in the soft x-ray and vacuum ultra-violet.

The Council's current contributions to the Additional Activity programmes are:

Calendar year	1981 £	1982 £
Taxonomy	8,600	7,900
IHES	65,000	75,000
Synchrotron Radiation	3,100	–

UK representatives have also participated in a programme of workshops on polymer science and on European collaboration on instrumentation for neutron scattering facilities and on facilities for nuclear structure research.

Funding by SERC of any ESF Additional and other Activities comes from SERC's normal annual allocation. No extra funds are available to SERC for participation in ESF programmes.

ESF communications

The Foundation now publishes a pamphlet called *ESF Communications,* aimed at making its work more widely known within the scientific community in Europe. Copies can be obtained from: ESF, 1 quai Lezay-Marnesia, F-67000 Strasbourg, France, telephone: (88) 35 30 63, or from Mrs E Irish, SERC International Section, Central Office, Swindon (ext 2404).

International collaboration through the Royal Society

As a follow-up to the article describing the Royal Society's visiting fellowships for Australasia and Japan (*Bulletin* Vol 2 No 4, Spring 1982), we give here a broad outline of other Royal Society programmes for fostering international collaboration.

Each year about two thousand scientists travel to and from Britain under various schemes sponsored by the Royal Society. About a quarter of the Society's total income is allocated to this overseas travel, amounting to some £1.2 million from the Parliamentary Grant-in-aid and additional amounts from private funds. A third of the overseas allocation in 1980-81 was used for travel grants for short-term visits by British scientists, usually for meetings overseas (in practice about a third is used for travel to the USA) but the major part of the allocation is used for longer visits to promote joint research programmes with laboratories in specific countries or regions, usually through bilateral agreements with academic or scientific institutions. These schemes aim to provide support for research workers at all levels in pure and applied science who wish to visit another country to the benefit of their research.

European Science Exchange Programme

The largest and most important collaboration is covered by the network of bilateral agreements with 15 West European academic bodies and research councils, the countries involved being Austria, Belgium, Denmark, Finland, France, Federal Republic of Germany, Greece, Republic of Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland.

The scheme is intended to further collaborative research between scientists in university laboratories and other scientific institutions of Western Europe and provides both for short-term (three weeks to three months) study visits and longer-term (six months to two years) fellowships. Applicants must be of PhD status and awards cover contributions both for personal maintenance and for travel to and from the research centre.

The selection procedure is undertaken jointly with SERC and extends to longer-term fellowships tenable in Western Europe funded through the SERC and NATO fellowship schemes.

Scientific collaboration outside Western Europe

Agreements to provide exchange visits by scientists have been concluded with the academic bodies or research councils of many countries outside Western Europe. In general these provide travel costs and subsistence for both short-term study visits and longer periods for collaborative research, but the details of each agreement vary and anyone interested is advised to contact the Royal Society to discuss the specific way in which assistance can be given. Exchange agreements of this nature are held in Eastern Europe with Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania, USSR, Yugoslavia; in the Middle East with Egypt, Iran, Israel; further eastward with India, China, Japan, Philippines; and in South America (comprising the Latin America Programme) with Argentina, Brazil, Chile, Mexico, Peru, Venezuela. Most recently an agreement has been concluded with Pakistan. Preliminary approaches for scientific contacts have been made with other countries, and the absence of a particular country from those named above should not deter applicants from approaching the Society.

Japan

The Society is currently in negotiation with the Japan Society for the Promotion of Science (JSPS). A JSPS scheme at present provides fellowships covering all fields of the natural sciences, including engineering, open to postdoctoral scientists working in scientific institutions in the UK through which there are already links with senior Japanese scientists and their departments.

The Commonwealth

Scientific collaboration between Commonwealth countries is promoted by the Commonwealth Bursaries Scheme, set up 28 years ago. Various types of award are available for study or research by Commonwealth scientists in countries other than their own; potential applicants are advised to discuss this with the Society. The scheme cannot, however, provide sufficient opportunities for exchange with the scientifically advanced Commonwealth countries – Australia, New Zealand, Canada, for example – as it is assumed that these, like the USA, enjoy plenty of contact with the UK. But the situation is changing and in July last year a new scheme was initiated to enhance scientific collaboration between the UK and Australia and New Zealand.

Other schemes to support international collaboration have been described in previous issues of the *Bulletin:* 'Schemes to support international collaboration (Vol 1, June 1980) and 'Opportunities for research training funded by the European Community' (Vol 2 No 4, Spring 1982).

Further information on these schemes may be obtained from the relevant SERC Subject Committee Secretariat or International Section, SERC Central Office, Swindon (extensions 2404, 2308 or 2121).

Mathematical modelling in biology

The modelling of biological systems can present interesting and challenging problems in mathematics, as well as giving insight into the underlying mechanisms of biological and medical processes. There is a long tradition of interaction between mathematicians and biologists in some fields, such as population biology, but in many areas, mathematical activity is just beginning to develop. The Mathematics Committee of SERC is anxious to encourage the growth of Mathematical Biology in the UK, and in particular to foster the inter-disciplinary contact necessary to promote it.

Mathematical Biology covers a wide range of activities, and recently SERC has supported research in such diverse areas as biomechanics (at Cambridge and Strathclyde Universities), the applications of algebra in genetics (at Birkbeck College) and reaction-diffusion systems (at Dundee and Oxford Universities). The Committee is anxious to receive more grant applications for research in mathematical biology, particularly in novel areas and involving direct collaboration with biologists.

In the development of a new and interdisciplinary subject, an important part of the process is the dissemination of ideas and the forging of collaborative contacts, and in this context the Visiting Fellowship scheme offers the opportunity to invite leading workers from overseas to the UK. Recent visits by leading mathematical biologists A T Winfree (Purdue) and G F Oster (Berkeley) to Oxford, for example, were very successful. Exceptionally, the Committee may also be prepared to consider the funding of research meetings, symposia or workshops aimed at developing interest in areas of mathematical biology, or the forging of collaboration between mathematicians and biologists.

Anyone wishing to make an application to SERC for support in an area of Mathematical Biology should contact the Mathematics Committee Secretary, Mr R F Hemmings, at SERC Central Office (extension 2312) who will be pleased to give advice.

Major new grants

April - July

ASTRONOMY SPACE AND RADIO BOARD

Professor R L F Boyd and Professor J L Culhane (University College London): £684,000 over one year for space research at Mullard Space Science Laboratory

Professor F G Smith (Manchester University): £507,000 over one year for radio astronomy research at Jodrell Bank

Professor K A Pounds (Leicester University): £462,300 for x-ray astronomy, astrophysics and solar physics for the calendar year 1983

Professor A Hewish (Cambridge University): £407,400 as SERC's contribution to the budget of the Mullard Radio Astronomy Observatory for the calendar year 1983

ENGINEERING BOARD

Dr J M Robertson, Dr A R Dinnis, Dr J R Jordan and Professor J H Collins (Edinburgh University): £1,779,294 over four years as a Special Rolling Grant for a VLSI Microfabrication Facility

Professor F J Bayley and Dr J M Owen (Sussex University) in collaboration with Rolls-Royce and GEC: a grant of £300,000 plus use of SERC Cray computing facilities over three years for 'Heat Transfer and Fluid Dynamics of Gas Turbines'

Dr F C Lockwood (Imperial College): £261,000 plus use of computing facilities at a notional cost of £75,600 for 'Measurement in and Prediction of Pulverized Coal Fired Furnaces'

Professor K W Sykes (Queen Mary College, London): £476,910 for Distributed Array Processor Support Unit

Professor E D R Shearman (Birmingham University): £326,334 plus associated computer facilities and RAL staff effort for 'High Frequency Ground-wave Radar Remote Sensing of Sea-State, Sea-Surface, Wind and Currents'

Dr M J B Duff (University College London): £355,200 for 'Image Processing'

SCIENCE BOARD

Professor Sir Rex Richards (Oxford University): £334,300 for 'NMR studies of proteins'

Professor Sir George Porter (The Royal Institution): £479,400 for 'Primary photoprocesses and photosynthesis'

Professor J M Reid (Glasgow University) in collaboration with Professor S D Smith and Dr C R Pidgeon (Heriot-Watt University): £309,300 and £208,700 respectively, plus Daresbury Laboratory contribution to the value of £94,000 for 'UK Free Electron Laser Proposal'

Professor E T Hall, Dr R E M Hedges and Professor K W Allen (Oxford University): £386,200 for 'Radiocarbon Accelerator Laboratory: years 5-8'

NUCLEAR PHYSICS BOARD

Grants at the following levels to support particle physics experimental groups at:

Birmingham	£572,966
Cambridge	£376,845
Glasgow	£664,368
Imperial College	£914,008
Liverpool	£526,759
Manchester	£417,429
Oxford	£792,963
University College London	£407,440

each over three years.

Research grants: attendance at conferences

SERC is to make a limited relaxation in its research grant rules about attendance at conferences. From 1 October 1982, SERC's research grants will now contain a revised grant condition which will allow attendance at conferences not previously specified. The revised condition will be subject to certain provisos, including the requirement to send SERC a statement showing how attendance at the conference has furthered the research project.

Some new publications from SERC

Daresbury Laboratory
Daresbury Laboratory has introduced a new style of Annual Report. The report is now split into a main volume, *Daresbury 1981/82,* designed to be informative to both the layman and the specialist, and three separate appendices covering the detailed aspects of the Laboratory's work. These are: *Nuclear Structure Synchrotron Radiation Theory and Computational Science.*
Copies are available from the Librarian, Daresbury Laboratory; telephone Warrington (0925) 65000 (ext 519).

RAL 1981
Rutherford Appleton Laboratory 1981 describes the year's progress in a wide-ranging programme of work funded by all Boards of the SERC. Copies are available from the Librarian, RAL; telephone Abingdon (0235) 21900 (ext 5384).

Nuclear structure review
The Nuclear Structure Committee Annual Review 1981-82 is intended to provide the UK academic nuclear structure physics community and others interested in the subject, with general information about the Committee's current policies and activities and the physics research achieved during the year. Copies can be obtained from the Nuclear Structure Secretariat, SERC Central Office, Swindon (ext 2223).

Particle physics report
The Particle Physics Committee Annual Report 1981-82 presents an introduction to the subject and the aims of the research programme. It analyses the use made by the British community of international facilities, and presents a summary of results obtained during the year, with a brief look forward at future developments. The report also includes details of research grants, fellowships and studentships funded during the year.
Copies can be obtained from the Particle Physics Committee Secretariat, SERC Central Office, Swindon (ext 2325).

Energy Committee report
Research activities supported by the Council's Energy Committee, and the work of the Energy Research Support Unit, are described in the Committee's *Annual Report 1980/81,* copies of which are available from the Energy Committee Secretary, Rutherford Appleton Laboratory (ext 5440).

Polymer courses
Copies of a new booklet, *Short Courses in Polymer Engineering 1982-83* may be obtained from the Polymer Engineering Directorate in London, telephone 01-930 9162.

Astronomy I report
Annual Report of the Astronomy I Committee, 1 October 1980 to 30 September 1981 covers radio, x-ray, gamma-ray cosmic ray, heavy particle and theoretical astronomy. Copies are available from the Astronomy I Committee Secretariat, SERC Central Office, Swindon (ext 2239).

Joint SERC-SSRC Committee
The Joint SERC-SSRC Committee has produced its *Annual Report 1980-81,* copies of which are available from the Committee Secretariat, SERC Central Office, Swindon (ext 2429).

Machines and power
Copies of the *Machines and Power Committee Annual Report 1980-81* are available from the Committee Secretariat, SERC Central Office, Swindon (ext 2202).

HALLEY'S COMET IN THE LABORATORY:

A new use for a pulsed laser

The high power, pulsed laser VULCAN operated by the Central Laser Facility at the Rutherford Appleton Laboratory is used for many different research programmes, most of which exploit its ability to produce hot dense plasma by compressing microscopic glass balloons filled with various gases. Recently, this laser and a smaller laser operated by the RAL Space and Astrophysics Division have been used for experiments which are designed to develop a technique for simulating the impact of small, high velocity particles on solid targets. This technique will be used to mimic the impacts expected, when a space-probe collides with the dust particles of Halley's Comet.

A comet is observed as a bright point-like object with a faint, diffuse tail which points away from the Sun as the comet slowly moves across the sky. Because their orbits are highly elongated, comets remain near to the Sun for a relatively short time before returning to the cold remote regions of the outer solar system to wait for many years for their next return to the Sun. The comet probably resembles a large dirty snowball, typically 4 km in diameter, comparable in size with Mount Everest. The ice is heated and evaporates as the comet passes close to the Sun, releasing large quantities of gas and solid dust particles which are repelled by radiation pressure and the solar plasma wind to form the extended tail of the comet.

An important opportunity to study a comet at close range will occur in 1986, when Halley's Comet is expected to return to the central part of the solar system once again, according to the orbital predictions made by Halley which forecast the 1758 sighting of the comet. To exploit this opportunity, the European Space Agency is preparing a space probe (GIOTTO) which will fly close to the nucleus of the comet and study the composition and structure of the gas and dust in the comet (see *Bulletin* Vol 2 No 1, November 1980). The University of Kent at Canterbury, together with several collaborating groups, were selected by ESA to provide an experiment to study the dust particles in Halley's Comet by recording the impacts on the spacecraft during the encounter. The Rutherford Appleton Laboratory is responsible for providing project management and technical support for this experiment which is named the Dust Impact Detection System (DIDSY).

A model of the Giotto spacecraft

An important problem in carrying out the experiment is the high relative velocity between the cometary dust particles and the spacecraft which is moving at 68 km/sec towards the comet. To simulate particle impacts at this velocity is difficult because there is no laboratory technique for accelerating particles of the required mass (10^{-10} g to 10^{-5} g) to a velocity of 68 km/sec, but some means of simulating impacts is needed for confirming the DIDSY sensor performance. In an attempt to resolve this problem, the use of lasers is now being studied as an alternative way of simulating the momentum impulse produced by a particle impact. Although there are obvious differences between a focused laser pulse and a fast particle impact, there are several important similarities. The two types of event can have the same time duration (about 10^{-9} sec) and the same energy release (about 2J) in the same target area (about 0.1 mm diameter), so that the two processes are energetically quite similar. Particle impacts and lasers produce similar craters in target materials and the momentum impulse for the two processes is comparable. The work is still in progress but it seems probable that yet another problem has been found for the laser to solve.

W M Burton

The GIOTTO spacecraft trajectory through Halley's Comet. The spacecraft is targeted at a point 500 km sunward of the comet. *(Design courtesy of ESA bulletin No 29)*