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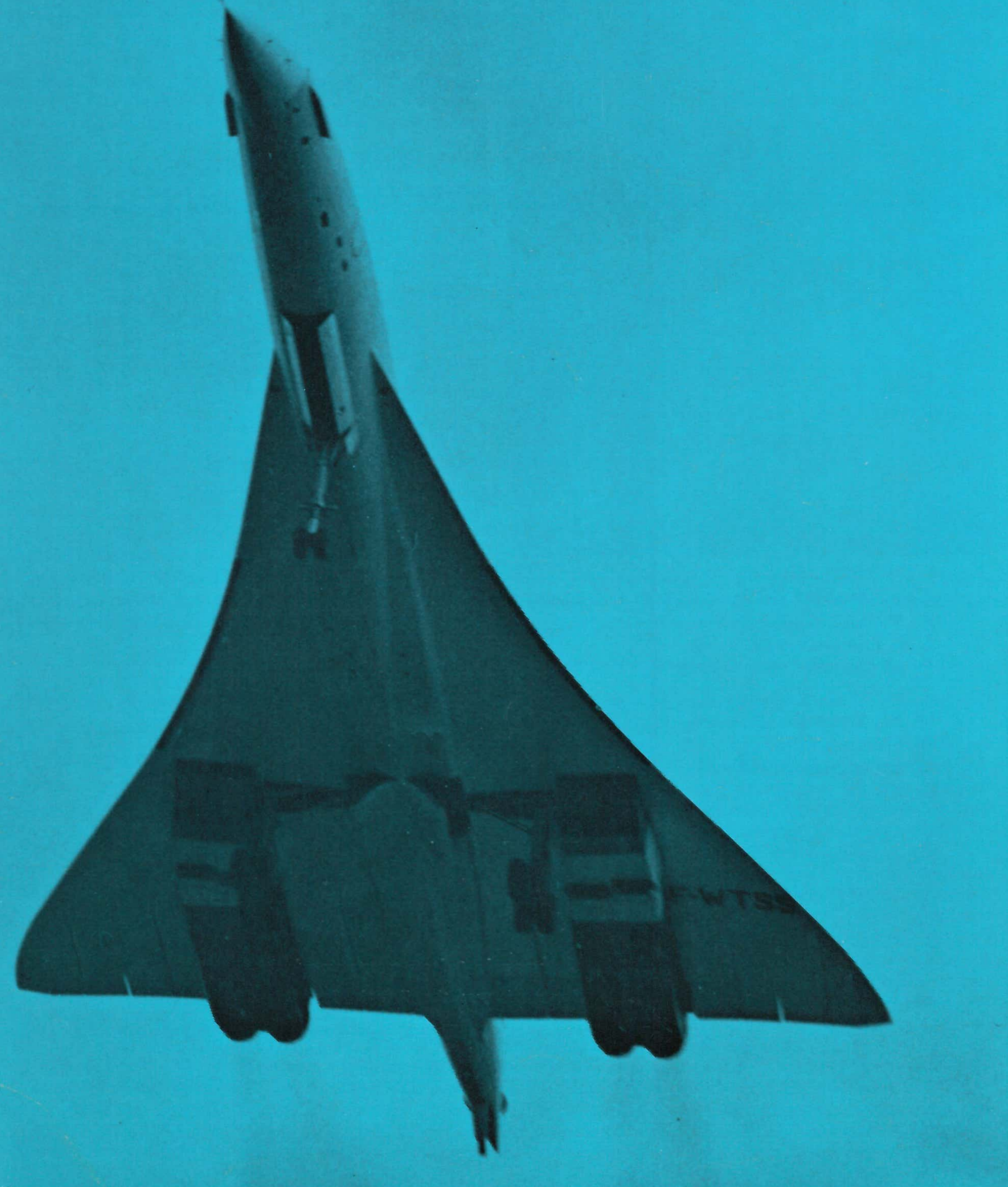

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QUEST

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contents

Concorde takes a moon shot

Cover picture: the French Concorde 001 that will carry scientific experiments to record the sun's eclipse by the moon on June 30 – *see page 13.* *Photo by kind permission of the British Aircraft Corporation.*

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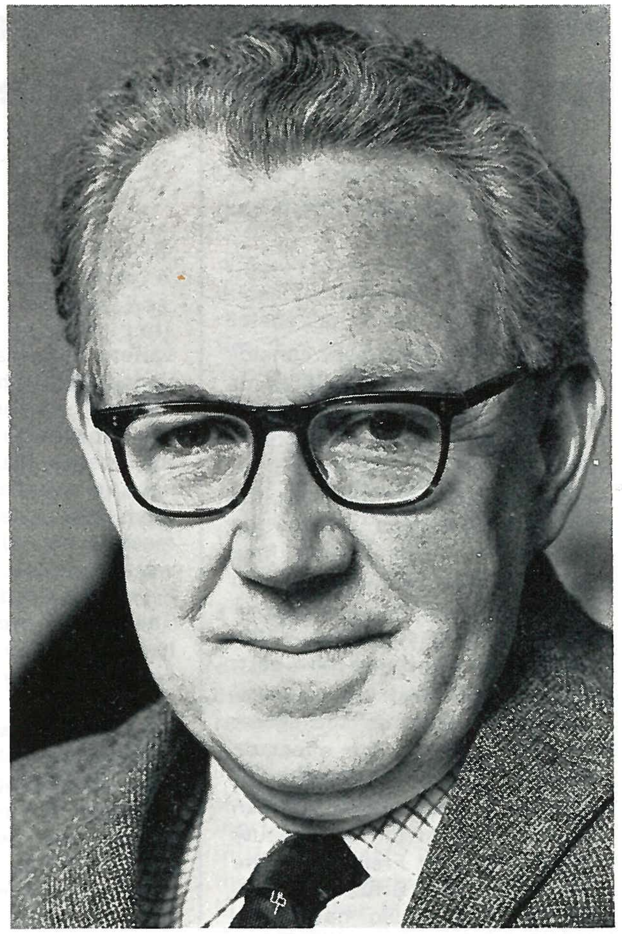
Chairman designate



seen right

Professor Samuel Frederick Edwards FRS who is to become Chairman of the Science Research Council when Sir Brian Flowers FRS leaves on October 1, 1973.

Professor Edwards is John Humphrey Plummer Professor of Physics at Cambridge University. He was educated at Swansea Grammar School, Gonville and Caius College, Cambridge, and Harvard. Before being appointed to his present position he held posts at Birmingham and Manchester Universities. He was elected a Fellow of the Royal Society in 1966 and has been a Vice-President of the Institute of Physics since 1970. He served as a member of the Council of the European Physical Society from 1969–71. He has been a member of various committees of the Science Research Council since 1968 and of the Council's Science Board since 1970. In 1971 he was appointed a member of the University Grants Committee.

Professor Edwards' interests lie mainly in chemical physics where he studies the properties of rubbers and plastics, basing their properties on their molecular architecture. He also has an interest in the application of modern theoretical physics to industrial problems, and has collaborated in the study of problems arising from reactor design and plasma physics.

Professor Edwards is 45 years of age, married with three daughters and a son, all teenagers. He lives in Newnham in West Cambridge. His relaxations are found in gardening and chamber music.

Is the next epoch 'EPIC' for Rutherford and Daresbury

Joint studies are now being undertaken by the Rutherford and Daresbury Laboratories on the design of a very large particle accelerator complex for future use in this country. At the same time, the high energy physics potential is being analysed in detail by various working groups involving both university and SRC staff.

The name EPIC stands for ELECTRON PROTON INTERSECTING COMPLEX. The basic difference between EPIC and the existing accelerators at RHEL and DNPL is that EPIC could have collisions between high energy particles that are moving in opposite directions, whereas in both Nimrod and NINA the high energy particles are fired into stationary targets. A much greater energy becomes available in the centre of mass of the system, leading to a new range of physics.

Such colliding beam devices are commonly known as Storage Rings and many are operating successfully around the world. At CERN there is the ISR which provides for proton-proton collisions, with incident protons of energies up to 30 GeV.

The EPIC design considers a system that first accelerates and then stores the particles. The types of particles to be stored are electrons, positrons, protons, and possibly deuterons. The complex will have a long-term development potential.

Two distinct possibilities are under study for a first development stage. In the one there is provision for collisions between electrons and positrons, both with incident energies up to 14 GeV. In the second there is provision for collisions between electrons and protons, with incident electron energies up to 14 GeV and incident proton energies up to 100 GeV. A single main magnet ring is adequate for the first possibility, but a dual ring is required for the second.

The feasibility study of EPIC will continue through 1973, and if the conclusions reached are favourable, a detailed design study will be proposed.

We join France and Germany for intense neutron beam research

This article is based on the one by Harry Norris published in the Rutherford Laboratory Bulletin 3/73.

Last year the Government considered the various possibilities of new high flux neutron facilities and decided that the interests of British scientists could best be served by collaborating with the French and Germans in using the new reactor at the Institut Max Von Laue, Paul Langevin (ILL) in Grenoble. In December an agreement was reached whereby the SRC became a full one-third partner in the Institute.

Under the terms of the agreement, which came into effect on January 1 1973, the Director of the ILL will be alternately German or British, one of the two Deputy Directors will be French and the other alternately British or German. SRC will also have one-third representation on the Steering Committee whose chairmanship and vice-chairmanship will rotate between France, Germany and the United Kingdom. In addition, a fair share of other posts will be available for British people, preference will be given to the placing of some contracts in the UK and it is agreed that any new source of intense neutron beams which the partners may decide to provide for the purpose of their collaboration will be built in the UK.

SRC will be responsible for one-third of the running costs of the ILL. This will be rather under £2,000,000 a year at current prices and exchange rates. We will also contribute about £1,000,000 a year (in real terms) for ten years towards the capital cost of the ILL reactor.

Interest in neutron physics is not new but until now the lack of suitable high flux facilities has greatly curtailed the amount and variety of research that could be undertaken. The flood of good research proposals that followed the decision to negotiate showed the interest that British scientists have in this field. Forty-seven of them were considered at a special meeting in October, thirty-five were accepted, and the rest can be resubmitted in later rounds. The first of them, from Reading, had a short run before the reactor was shut down for four weeks in mid-December, and several others are now under way.

This has all meant intensive and interesting work for the Neutron Beam Research Unit (NBRU) at the Rutherford Laboratory, led by Dr L C W Hobbis. NBRU has overall responsibility for the SRC/UK end and has concentrated hard on coping with subjects such as instrumentation, computing, experiment proposals, technical liaison and the transporting of samples and apparatus to and from Grenoble. They spared no effort to get things started and achieved a large amount of work in a very short time.

Apart from research on the neutron itself, a neutron source of high intensity like the ILL reactor provides a research tool that has applications in many fields: like solid and liquid state physics, chemistry, biology and materials science. The unique properties of the neutron – no electric charge (which enables it to penetrate matter very easily), and a magnetic moment (which enables interaction with magnetic structures) and, in the case of very slow-moving thermal neutrons, a wave-length roughly equal to the distances between atoms in liquids and solids – are all extremely useful in the study of the structure and dynamics of all kinds of materials.

The Grenoble reactor, similar in design to the Brookhaven High Flux Reactor is of the steady state type and apart, possibly, from the new Dubna pulsed reactor, which may be operating by this time, has the strongest thermal neutron source in the world. The fuel is concentrated in a small core from which fast neutrons can escape with relatively high energies of approximately 1 MeV. The core is surrounded by a heavy water reflector tank, 2.5m in diameter, in which the neutrons are slowed right down to thermal energies (of about 0.25 eV). Some of the neutrons return to the core to produce further fissions there and the rest are used for the experimental programme.

The core itself is constructed of thin plates of aluminium uranium alloy, highly enriched with U235, contained between aluminium plates; the whole system being removable as a single unit when approximately 30% of the uranium has been used up (or after about 36 days of operation at full power). The core/reflector assembly is surrounded by a tank of ordinary water, 6m in diameter and 15m high, supplemented laterally by 1.2m of heavy concrete. The intense thermal neutron flux reaches its maximum (1.5 x 10^{15} neutrons per square centimetre per second) in the heavy water outside the core at a distance of approximately 15cm from it: it is here that the channels used for extracting neutron beams are arranged. (For further information on the Grenoble reactor see *Endeavour* vol XXXI May 1972, Page 67).

Concrete jackets suit the magnet men

Radiation damage to the insulation of electromagnets is one of the problems encountered in high energy physics experiments. But the Rutherford Laboratory has now come up with a solution.

The electromagnets are essential components in particle accelerators and the ones most exposed to radiation damage. One way to protect them is to use insulation made of mineral materials instead of resins or plastic. So someone suggested cast concrete and although it seemed an unlikely candidate at the time, it was tried.

As a result of the tests they found that insulation systems made of selected cement and aggregate, if adequately dried, could have the required resistance. So they went ahead and eventually produced two prototype electromagents with the new type insulation. One of them, a dipole bending magnet, was built at the Laboratory and the other, a quadrupole focusing magnet, was built by Lintott Engineering Ltd, Horsham, Sussex.

The dipole is now in use at the Daresbury Nuclear Physics Laboratory and the quadrupole is installed at the Deutches Elecktronen-Synchrotron High Energy Laboratory at Hamburg. Both are performing well without radiation trouble. The quadrupole in fact replaced a conventially insulated magnet that had been destroyed by radiation after 5,000 hours, and it has already sustained a greater exposure without any noticeable effects. As accelerators are developed to produce beams of higher intensities, the demand for radiation resistant components will grow. Beams now being planned for the Rutherford Laboratory's own accelerator are going to need the new magnets.

IMPORTANT NOTICE

Do you know all about annual confidential reports?

A new report form is to be introduced for general use in SRC to replace the several different varieties that have been used to date. The new form which has been agreed with staff side will assist in achieving a uniform standard of reporting throughout SRC.

As well as retaining the best features of the old forms, the new form incorporates some completely new concepts.

Don't panic; we are arranging a programme of training courses which will give you a chance to discuss the form and check your standards against those of other reporting officers in the same group.

The form will be first used for the P & TO review and the training for this group will take place in June & July. The training for the Administrative Group will be in September & October and for the Scientific Group in November & December.

● **If you are a reporting officer make sure you attend a course.**

Nimrod will get 8 million million more ppp

In November the Council agreed that a new Injector should be built for the Rutherford Laboratory accelerator Nimrod which, it was also agreed, would be kept in operation until 1978 and beyond (see Council Commentary on page 5).

Why a new injector? The present beam intensities extracted from Nimrod are 1.2 x 10^{12} ppp (protons per pulse) and various improvements are raising this to 2 x 10^{12} ppp, still using the present 15 MeV injector. However, the range of physics using Nimrod as the secondary particle source could be much extended if the intensity was increased by a factor of 5, up to 10^{13} ppp, or in other words 8 million million more ppp. To achieve this increase, the energy of the injector has to be raised (because of transverse incoherent space charge effects) to 70 MeV.

The new injector should be ready early in 1975 and, for a time, both injectors will be available.

Last year Nimrod's total of good beam time for experimental teams was the highest yet – 5,398 hours – with an efficiency record of 90.5% of scheduled operating time. A record number of protons was accelerated – more than 22 x 10^{18}–which was twice as much as in 1970 and three times the number achieved in 1968. This is because of the many improvements made to the machine since it was first built – and is also due to the efficiency of the people who run and maintain it.

The new injector will be an Alvarez type of linear accelerator consisting of 4 RF cavities. The design of the 1st and 4th of these tanks is based on corresponding parts of the injector in use on the 200 GeV accelerator at the National Accelerator Laboratory, Chicago. The 2nd and 3rd will be tanks 2 and 3 from the Rutherford proton linear accelerator (the PLA, now closed down), only slightly modified, and where possible PLA quadrupoles will be used and its de-buncher ramper cavity.

More power might cost less

An SRC Working party, led by Mr D Harcombe of the Central Electricity Generating Board, has been looking at university research into Superconducting ac Generators. The use of zero-resistance superconductors, at least in the winding of the rotor, hold a promise of savings in cost, size and weight in the high-power generators of the future.

The working party have published their findings and their suggestions for future research in a report.* They say that while the eventual justification for such generators will depend on numerous economic and development factors, not yet assessable, nevertheless their potential is such that research should be undertaken now into several aspects. They consider that universities are well equipped to do it and that the work offers good opportunities for collaboration with industry and a promising focus for future university research and training. By these means the present UK lead should be maintained and built up.

***'SRC Report on Superconducting ac Generators'.** *Copies available from the Electrical and Systems Committee, Engineering Division at London Office.*

Calling Mr. Chairman . . .

How far off is the day when we can participate in a meeting taking place the other side of the world and yet not leave the office? Is it mere fantasy or will the time really come when we have no need to travel even to the office?

Professor Sir Hermann Bondi, FRS, Chief Scientific Adviser to the Ministry of Defence put these questions in his opening address to the Conference on "Satellite Systems for Mobile Communications and Surveillance" held at the Institution of Electrical Engineers (IEE) in March.

Telecommunications was a growth industry and the prospects were almost limitless, he said. But he considered that the greatest handicap to full communications might be our lack of understanding of ourselves, particularly of our reactions to each other. The extension of satellite communication to ships and aircraft was going to emphasise the global character of telecommunications; there was an evident need to introduce world-wide discipline into such operations.

From the discussion that followed a paper presented by D O Fraser of BAC it appeared that airlines were unhappy about the development of satellite systems partly because they felt they had not been sufficiently consulted and partly because they were concerned about the costs that they would have to bear.

On the subject of suitable frequency bands, one speaker said that the choice of L band had been made 2 years ago at the World Administrative Conference. A delegate from the Ministry of Posts & Telecommunications said that 11-14 GHz bands were likely to be recommended for earth station/satellite links.

E J Martin from the US Communications Satellite Corporation (COMSAT) said that a satellite service for the US Navy would open in September 1974. There would be two satellites, one for the Atlantic and one for the Pacific and it might perhaps be possible for the merchant service to use the facilities in the L band.

The 3-day conference was organised by the Electronics Division of IEE, in association with ESRO, IERE, RAS and the Royal Institute of Navigation. The papers are published as IEE Conference Publication 95 at £7.60 (or £5 to members of a sponsoring body).

MSSL senses the ionosphere

The Mullard Space Science Laboratory (MSSL), whose geographical and astronomical research in space is supported by the SRC, currently has an experiment running in the ESRO-4 spacecraft, launched last November.

The spacecraft is carrying five different experiments to study particles in the vicinity of the Earth. The other four belong to the Psysikalisches Institut, University of Bonn, the Kiruna Geophysical Observatory, the Space Research Laboratory Utrecht and the Max Planck Institut, Garching-München.

The MSSL experiment is measuring the density, temperature and composition of ions in the F-region of the ionosphere using three sensors. The main sensor is a gridded, spherical ion-collecting probe (200 mm dia) mounted on a 1.3 metre boom to keep it outside the charge cloud surrounding the spacecraft. Its potential is swept repeatedly from negative to positive voltages so that it acts as an ion mass spectrometer. A smaller probe (10 mm dia) on the same boom, collects electrons as its potential is swept above and below the spacecraft's potential, and variations in the electron current show when the probe is at space potential, thus indicating the spacecraft's potential relative to space – information needed to interpret the mass spectrometer's measurements.

The third probe (100 mm dia) is mounted on a 0.35 metre axial boom and carries a constant negative potential with respect to the spacecraft so that a total ion current can be measured as a check on the constancy of the ion density during each mass sweep of the spectrometer. The measuring circuits have a new feature whereby the output is set at mid-scale at the beginning of each mass sweep so that short period fluctuations of ion current as low as 2% can be detected whatever the ion density.

£1M A YEAR FOR ATOMS MOLECULES AND PLASMAS ++ BEST DATA YET FROM SKYLARK SPACE PROBE IN SOLAR ULTRA-VIOLET SPECTRUM ++ SYMPOSIUM ON ELECTRON AND PHOTO INTERACT ++ £59,000 HARDWARE FOR MULTI ACCESS COMPUTER SYSTEM ++ BRITISH EXPERIMENT IN ORB ING SOLAR OBSERVATORY ... -G ++ FIRST LUNAR SAMPLES FOR BRITAIN ARRIVE AT SRC ++ ... FOR CONTROL ENGINEERING RESEARCH ++ ANGLO-AUSTRALIAN TELESCOPE CONSIDERABLE CONTRI BUTION TOWARDS SCIENTIFIC DISCOVERY ++ RSRS PARTICIPATES IN UK4 SATELLITE TO MEA INTENSITIES OF ELECTROMAGNETIC RADIATION ++ DEVELOPMENT IN ANALYSIS OF BUBBLE CHA BER PHOTOGRAPHS BY SWEEPNIK AIDED BY SRC GRANT OF £40,473 ++ SUCCESSFUL LAUNCH O

council commentary

September 1972 to February 1973

Because of Council business that continued over several meetings, the autumn Council Commentary was held over from the last issue of *Quest*. It appears below combined with the commentary for the winter quarter.

Visit to Swansea

The annual weekend meeting of Council members, Board representatives and senior staff was held in September at the University College of Swansea. The meeting reviewed two areas of wide and current interest – Materials Science and Technology and the field of Artificial Intelligence. It went on to discuss international collaboration, particularly in Europe.

Welcome to new Members

In October, the Chairman welcomed Professor H G Callan, Mr J M Ferguson (new Chairman of the Engineering Board), Dr R W Pringle and Professor D W N Stibbs, who were attending for the first time as Council members. He also welcomed Professor Mason and Professor Matthews in their new roles as Chairman of the Science Board and the Nuclear Physics Board, respectively.

Chilton visit

The Council decided to hold the May 1973 meeting at the Rutherford Laboratory and to visit the Atlas Laboratory.

Assessor from DOE

The Council agreed to invite Mr D J Lyons, Director General of Research and Development at the Department of the Environment, to join the Council as an assessor.

Estimates 1973/74

The Council agreed the 1973/74 estimates within a net total of £69.0M. These estimates were based on the forward look approved by Council in April 1972, but took subsequent developments into account. The two major uncertainties in the preparation of figures were the exchange rates to be used for international subscriptions and other major items that involved foreign currency, following the floating of the £, and the effect of increased costs that would arise from the introduction of Value Added Tax.

Forward Look 1974/5–1978/9

In November the Council agreed the financial guidelines which have now been given to the four Boards for the preparation of the 1974-79 Forward Look. Boards are required to make their submissions to Council in April so that the Council-wide Forward Look can be submitted to the Department of Education and Science at the end of April. The guidelines given to the Boards, which vary according to present policies and priorities, are based on the provisional allocation for the Council for 1974/5 and assume a 3% per annum growth rate thereafter.

The Council took note of a submission from the SRC Staff Side concerning the future nuclear physics programme. The submission was relevant to the Council's consideration of the Forward Look guidelines and of some individual projects in nuclear physics.

Postgraduate Education

The Council was informed that the Education and Arts Sub-committee of the House of Commons Expenditure Committee intended to examine official spending on postgraduate education. The Research Councils and DES had been invited to submit evidence and, later, to provide witnesses for examination. There would be a joint memorandum by the ARC, MRC, NERC, SRC and SSRC covering items of common interest and in addition each Council would submit separate memoranda setting out their individual policies and procedures. An SRC team would give evidence to the Sub-committee in April.

Postgraduate Awards

In November the Council confirmed the Forward Look assumption that the number of awards for 1973 should be 3950, an increase of 3% over 1972, and then decided on the allocations to the special schemes and the studentships quotas to Boards.

In December SRC postgraduate awards policy was discussed in the light of the UGC quinquennial settlement, which provided for an extra 7000 postgraduate places in universities by 1977. The UGC had advised the universities of their views on the relative priorities of subjects and the extra provision which should be made for postgraduates at each university. With the exception of applicable mathematics and computing science, the UGC considered that expansion should be less rapid in science and engineering than in, for example, the social and medical sciences. The priorities they proposed in science and engineering accorded reasonably closely with SRC planning.

The Council asked Boards and Committees to consider SRC policy in the light of the UGC guidance to universities and to advise the Council on any points of difficulty or apparent conflict.

The Council confirmed that 3950 awards should be allocated in 1973 and agreed that planning for the Forward Look should be based on an increase of about 1.5% per annum in the number of post-graduate awards at universities, the increase in the polytechnics to be considered later in the light of the Polytechnics Working Group's report.

New Buildings at Rutherford and Atlas

During 1972 the Council approved proposals for an extension at the Atlas Computer Laboratory, a library for the Rutherford Laboratory and a 70 MeV injector for Nimrod, including the necessary building work. When tenders were obtained, it was clear that building costs had risen greatly since the first estimates of costs had been prepared and that reference back to Council was required on all three schemes. In addition, revised estimates had been made for the Nimrod injector equipment. The Atlas Laboratory extension design had been simplified following Council approval in July 1972, but even so the total cost had risen slightly. The building and civil engineering works on all three schemes had been combined into a single invitation to tender and work was scheduled to begin on March 19 – the date required to fit work on the injector building into the Nimrod operating and closure schedule.

In February, subject to confirmation being obtained from DES and the Treasury that the unit building cost for each of the three schemes was reasonable, the Council approved the simplified Atlas Laboratory extension at a cost of £87,000 and agreed to seek DES approval for the construction of a new library at the Rutherford Laboratory, at a cost of £158,000, and for extra-mural capital expenditure on the Nimrod injector project of £1,171,000 (£221,000 building costs and £947,000 equipment costs).

Location of SRC Facilities

In January the Council agreed that the Nuclear Structure Facility, which they had approved in November, should be sited at Daresbury, subject to planning permission. They also agreed that a northern laboratory need not be confined to nuclear physics. In addition the Council initiated a general study of the regrouping of SRC's various intramural activities.

ASTRONOMY, SPACE AND RADIO

Skylark Rocket

The Council approved an increase in expenditure on Stage 5 of the above project which was for the development of a three-axis star-stabilised platform suitable for astrophysics experiments. The increase, which was caused by re-design and modification of sub-units and some extra work not covered by the original estimates, brought the total approved to £767,000. The star-pointed stabilisation had been developed through sun-pointing and moon-pointing stages.

The work had been commissioned through the Procurement Executive of the Ministry of Defence by the Department of Trade and Industry. High priority had been accorded to the work by the ASR Board because of the exciting opportunities in stellar physics that this project now offered.

Astrophysics Research Unit

After careful consideration, the Council decided that responsibility for the ARU should pass to the Director, RSRS, on January 1, 1973.

Northern Hemisphere Review Report

In October the Council noted that the ASR Board's assessment of the requirements for optical astronomy in the northern hemisphere would be reported to the Council as soon as possible. In December the ASR Board considered the recommendations of the NHR Report and decided that the management issues in the report posed fudamental questions about the role of the Observatories that ought to be considered at Council level. In January the Council agreed to set up a Panel, under the Chairman, to review the whole area of the ASR Board's activities including both the executive and the complementary committee structures.

RGO Computer

The Council agreed to ask DES to approve the purchase of an ICL 1903T computer for the Royal Greenwich Observatory at a cost of £252,000, and noted the SRC Computer Review Panel's proposal to set up a link-line between RGO and ACL to allow access to a larger machine.

Radio Astronomy at Cambridge

The Council also agreed to seek DES approval for a consolidated grant to Professor Sir Martin Ryle at Cambridge University of up to £105,000 for 1973 to support a wide range of investigations at the Mullard Radio Astronomy Observatory.

Satellite UK-6

The satellite would contain three experiments with equipment for studying ultra-heavy cosmic ray primaries and x-ray astronomy. Council agreed to ask DES to approve the project at a cost not exceeding £3.4M, plus grants for payloads and data processing. RSRS would be responsible for the management and financial control of the project.

ENGINEERING

Total Technology

The Engineering Board has been developing a concept of wider training for postgraduate engineers which has been summarised under the term "Total Technology". Approval was given by Council in November to the introduction of a pilot scheme for postgraduate education in 'Total Technology', which is defined as:–

> 'the practice of engineering broadly comprising research, development, design, production, marketing and operation of plant; in addition the service and construction industries require a special emphasis to be placed on planning and operational management. The functions of this continuum of activities are not distinct and separate but merge into each other with ill-defined boundaries and any one function has a marked influence and interrelationship with the others. Success can only be achieved with a well-balanced synthesis of all these functions. Total Technology is the name given to cover this wide spectrum of functions in the practice of engineering, coupled with the skills and experience required for welding them together.'

Some financial support was being sought from the University Grants Committee and the scheme was strongly supported by the Department of Trade and Industry.

High Voltage Electron Microscopes

The Council approved in principle support for the continued operation of three HVEM's at the Universities of Oxford and Birmingham and at the Imperial College of Science and Technology until 1977, within a total estimated cost of £415,000. Commitments within this total would depend on approval of individual applications. Experience had fully confirmed the expected advantages of HVEM, in particular their ability to probe thicker specimens owing to the higher penetrating power of the electron beam, the possibility of carrying out in-situ dynamic experiments and the direct observation of radiation damage produced by the electron beam itself. Both physicists and biologists were interested in using this new technique.

The Council also approved the first individual case in the above programme – a grant of up to £122,650 to the Imperial College of Science and Technology for the cost of operating the HVEM facility until 1977.

A fourth HVEM had been installed at Rotherham, and was owned jointly by the British Steel Corporation and the SRC. The half-time use of this instrument, available through SRC support, was mainly being used by northern universities. The arrangement was due for review in about two years' time.

Polymer Science

Pending the outcome of the review for materials science and technology, undertaken as a result of the Swansea weekend conference, the Council approved the Engineering Board's interim recommendations for support for the five Polymer Science Research Centres – Queen Mary College, Imperial College, Liverpool, Glasgow/Strathclyde and Manchester Universities – until mid 1974, within an overall total of £213,000.

NUCLEAR PHYSICS

The Future of Nimrod and NINA

In March 1972 the Chairman had agreed to make a personal assessment of the situation in order to help the Council take a decision in the following November on the future of NINA and Nimrod and in preparing his paper he discussed the problem with many senior physicists in the UK and abroad. In July Council had considered the proposal to build a 70 MeV injector for Nimrod and had agreed to it in principle, subject to the further decision that Nimrod should continue in operation beyond 1978.

In November it was agreed that Nimrod, with its new injector, should continue to operate beyond the immediate 5-year period and that DES approval should be sought for construction of the new injector at a total cost of £2.18 million.

As much effort as could be spared should be devoted to the NINA experimental programme for the next few years, but NINA should gradually be phased out as a national high energy physics facility; the exact time scale being a matter for the NP Board to propose in the light of its total programme. The Council also noted that the Science Board was examining ways of meeting its future requirements for radiation facilities.

Nuclear Structure Facility

In April 1970 the NP Board had reported to Council the need for a powerful new electrostatic accelerator for nuclear structure research and in June 1970 the Council had approved the preparation of a design study for the construction of a Nuclear Structure Facility (NSF). The completed design was presented to Council for approval at the November 1972 meeting and Chairman, on behalf of Council, congratulated Professor Ashmore

and his staff on the quality of the work done at Daresbury on the design study.

The proposal under discussion was that the NSF should be sited at Daresbury but a decision was deferred – and made subject to the outcome of planning permission – until January, when a paper dealing with the manpower implications of the Nuclear Physics programme, with particular reference to the siting of the NSF, would be submitted to Council.

The Council approved the design study and agreed to seek DES approval for the construction of the NSF as a national facility at an estimated total cost not exceeding £7.2 million. The siting was agreed in January – see 'location of SRC facilities' on p 6.

Computers for film analysis

Purchase of two IBM 370/145 computers, with associated peripherals, was approved at a cost of just over £500,000 each for the film analysis groups at Birmingham and Glasgow Universities. These will replace their rented IBM 360/44 machines.

High Flux Neutron Beam Research

In January the Council welcomed the successful completion of the negotiations with the French and Germans which had begun in September 1972 on the terms of UK membership of the Institut Laue Langevin at Grenoble and had resulted in the UK becoming a full member of ILL on 1 January 1973. Appreciation was expressed of the efforts which Professor E W J Mitchell and the officers concerned had made to bring this about. Thanks to the goodwill of ILL, some British experiments on the reactor had already been fitted into the current programme. The UK had already been asked to submit names for appointment to various ILL committees and the SRC Neutron Beam Research Unit and ILL were discussing future instrumentation.

The first formal meeting of the expanding ILL Steering Committee was due to take place in April; the UK delegation would be Mr M O Robins, Professor Mitchell, Dr L C W Hobbis and Mrs J O Paton.

Flash Photolysis

Amongst the grants approved by Council was a supplement of up to £12,500 to the Royal Institution (Professor Sir George Porter) for work on nanosecond and picosecond flash Photolysis.

Graphics Display of Molecular Models

A supplementary grant of up to £27,500, for a graphics display system based on a Digital Corporation PDP 11/45 computer was awarded to Dr H C Watson and Dr H Muirhead at Bristol University. They will use the system to simulate molecular model building for the x-ray diffraction studies of enzyme structure and function, for which they already have a 7-year grant of £88,220.

New generation accelerator discussed at DNPL

See picture left:

Dr R G P Voss (second from l.) talks about plans to build the world's largest electrostatic accelerator at the Daresbury Nuclear Physics Laboratory (where he is Deputy Director).

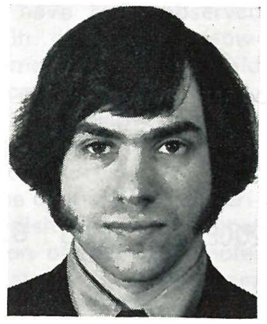
With him are visitors to the Conference on the Technology of Electrostatic Accelerators (held at the laboratory in May).

L to r: Professor K Purser, General Ionics Corporation USA; Dr Voss; Professor A Gallman, Centre de Recherches Nucleaire, Strasbourg; Professor A Ashmore, Director of the Daresbury Laboratory; Professor P A Assimakopoulos, Greek Atomic Energy Commission; and Professor O Sala, University of Sao Paulo.

In front of them is a prototype tube module designed and built at the Laboratory as part of the design study for the proposed accelerator (see 'Nuclear Structure Facility' on p6 and p7).

Electrostatic accelerators are large and complex machines that generate very high voltages. Although they have been in use for many years, not all the problems that arise in their design and operation are fully understood. A strong team of scientists and engineers at Daresbury, with help from several universities and the UK Atomic Energy Authority, are studying all the fundamental aspects.

By using such an accelerator British scientists will be able to keep their place in the front line of nuclear structure research.



Dr Terry Lee (left) is a Senior Scientific Officer at the Royal Observatory Edinburgh.

How ROE created a cold cold space at Culham

Cryogenics reveal the secrets of the stars

T J Lee

At the UKAEA's Culham Laboratory in March 1969 five physicists and astrophysicists talked about using the low temperature equipment available at Culham to simulate cold interstellar space where the background temperature is just 2.7 Kelvins (degrees) above absolute zero.

They believed that simulation could help understand the processes by which stars are formed from hydrogen gas clouds in interstellar space. The theory is that something causes the large uniform clouds to break up into local dense regions known as 'protostars'. These masses have become so dense that their own gravitational forces cause them to shrink extremely rapidly, which sends up the temperature until the star 'turns on'. Which means the nuclear fusion processes that convert hydrogen into helium and release the light and another energy, by which stars are seen, have started.

Did Reddish know the answer ?

Vincent Reddish of ROE had shown that under the right conditions the fragmentation could be caused by the freezing of hydrogen molecules onto dust grains. Freezing out of molecules in slightly colder areas of a cloud causes the gas from warmer regions to be sucked into the colder ones to increase the density and form the 'protostars' mentioned earlier. This fragmentation process induced by cooling of grains could be part of a feedback loop which acts as a cosmic thermostat and controls the evolution of stars and galaxies. Such an idea is attractive because it shows that the things we observe are a result of the competition between physical processes.

At that time it was not possible to test the theory by comparing conditions in space with the conditions within which hydrogen freezes. The latter are controlled by the vapour pressure curve, this was known from experiments at temperatures greater than 10K, and though sound theoretical predictions down to the temperatures of interest (about 3K) had been made no experiment gave results which agreed with them. Indeed the experiments didn't agree with each other. So the answer seemed to be to go to the laboratory and make the measurements with the best possible simulation of interstellar space conditions.

The talks at Culham ended with a rough outline programme based on the cryopump developed by John Chubb at Culham to reduce hydrogen gas to very low densities (pressures) in plasma physics experiments. The link between ROE and UKAEA Culham was made formal with a contract approved by SRC's Astronomy Policy and Grants Committee, whereby SRC paid for the use of Culham's resources. Then they began to look for a Research Fellow to carry out the programme.

On the other side of the Atlantic where I was studying the way in which ions, atoms and molecules 'stick to' and are 'boiled off' from surfaces at temperatures greater than 1000K, not below 4K, an advert in the back pages

How RDE created . . . continued

of *Nature* caught my eye. Three months later I arrived at Culham and 'low temperature laboratory astrophysics' was born.

My first meeting with the hissing, clicking, clattering mass of pipes, wires and meters shown in the photograph was somewhat alarming, but helped by Len Gowland (in the picture) and John Chubb I was soon able to drive the machine with great panache.

The first few months were given to overhauling the equipment and modifying it to astrophysical rather than technological needs. Our volume of interstellar space was contained in the cylindrical vessel in the top right-hand corner of the photograph. Very low gas densities (pressures) were maintained by the plumbing below, and the experiments were controlled and data recorded with the equipment seen left. Automatic control and recording meant less work for us and fewer chances of mistakes; it also enabled us to make very many measurements and thus increase the detail and accuracy of the observations.

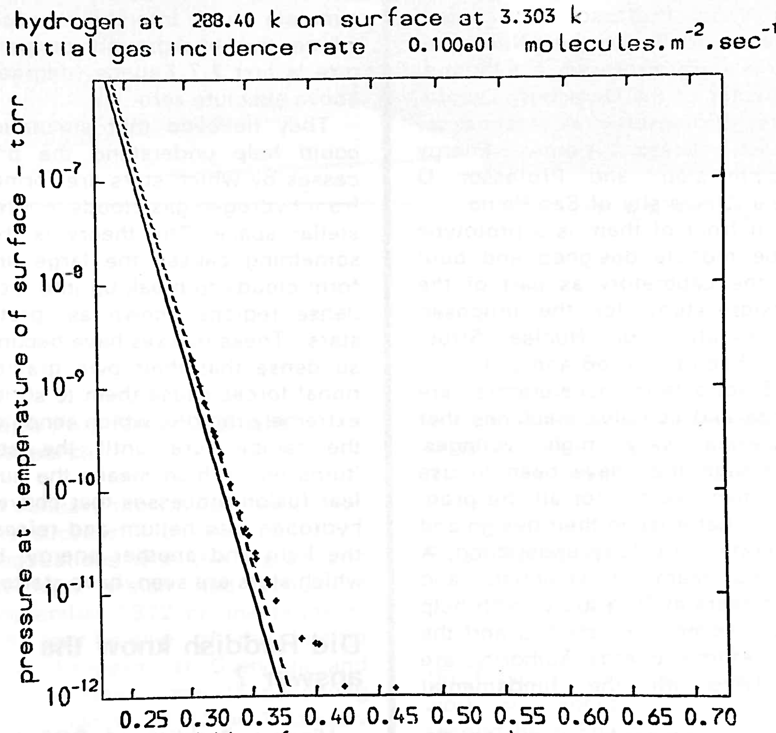
. . . the unexpected had to be explained . . .

We used Culham's brand new ICL 470 computer for data reduction and unfortunately had to contend with the growing pains of the new system. Sometimes we were completely held up. But at last it began to run smoothly and to keep up easily with our rate of production. One of the ten kinds of graph produced from our readings with the Culham GHOST computer graphic system is shown right.

To go back a little. The theoretical prediction of the hydrogen vapour pressure had indicated that hydrogen molecules would freeze on dust that had a temperature of 2.7K if the number of molecules was more than 1,000,000 per cc (this corresponds to a pressure of about 10^{-16} atmospheres or 10^{-15} pounds per square inch). Experiments concerned with high speed cryopumping of hydrogen failed to freeze out hydrogen molecules in conditions where there were 100 times this number. This suggested that the vapour pressure (density) did not follow the expected temperature dependence at temperatures below 3.5K and that an anomally existed.

Our experiments were set up to make reliable measurements of the vapour pressures at temperatures below 4K. We needed to explain the unexpected behaviour so as to find out what effect it might have in an interstellar environment. To this end we considered the effects of radiation, the presence of gases other than hydrogen and different grain surfaces. In our experiment the grain was the copper bottom of the liquid helium cryostat which could be cooled with different materials (eg argon, water, CO_2).

At the start of each experiment, the density of gas was reduced to below 10,000 molecules per cubic centimeter. Then layers of solid hydrogen were built up in a slow and controlled way. The temperature of the liquid helium cryostat was varied between 1.6K and 4K and vapour densities (pressures) of molecular hydrogen in equilibrium with the solid were measured every few hundredths of a degree. In this way vapour pressure data was obtained for different thicknesses of layer under different conditions. All measurements were recorded automatically on punched paper tape.



VARIATION OF SATURATED VAPOUR PRESSURE WITH 1/(SURFACE TEMPERATURE) - RUN 3. 2. 71

∇ ion gauge g2 + ms10 ⊙ etl gauge

POINTS 139 TO 178

TEMPERATURE DECREASING

SIGNAL MULTIPLIERS

BBG 0.000 MS10 1.000 MODG 0.000

ZERO OFFSETS IN M-3

BBG 0.0000E00 MS10 0.2200E13 MODG 0.0000E00

COVERAGE OFFSET 0.1380E21 M-2

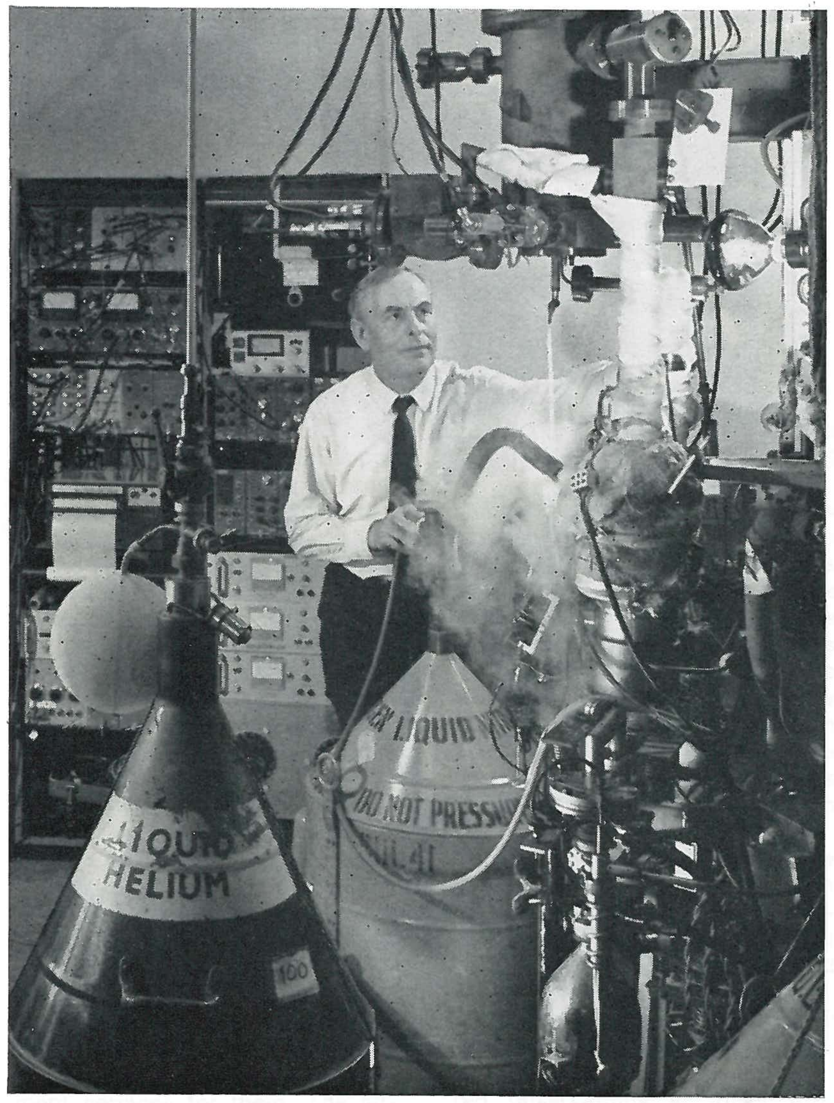
The computer produced graphs of these measurements. Those that were of most interest showed the variation of molecular hydrogen density with temperature, which is the basic information we needed, and the log (vapour pressure) – reciprocal temperature relationship which should, in theory, be a straight line. Deviations from this line were always observed, sometimes they were very small and at other times large. A systematic analysis of the way in which these depended on controlled conditions gave me a clue to their origin. They could all be explained in terms of a temperature "step" at the solid hydrogen/substrate boundary. I was able to deduce that there would be no deviation for solid hydrogen in the conditions prevailing in interstellar space and that solid hydrogen has normal vapour pressure properties. The real vapour density at 2.7K is a little larger than predicted theoretically and a density greater than 8 million molecules per cubic centimetre is required at this microwave background temperature for solid hydrogen to freeze on to grains.

Molecule formation could well be the mechanism . . .

Can such conditions exist in space? Densities a hundred times greater and temperatures of about 5 Kelvin's have been observed separately in our galaxy. However, it seems unlikely that solid hydrogen can exist in clouds which are not already breaking, up, it could well accelerate the fragmentation process.

During the course of the experiments Reddish discovered that the formation of hydrogen molecules from atoms (two atoms per molecule) could also trigger star formation and control the evolution of stars and galaxies in the same way as solid hydrogen formation (though not as efficiently). Here again there was a problem, practically no experimental data existed which theoreticians could use to test the feasibility of the idea. The estimates which theoreticians were able to make indicated that very stringent conditions were required for molecule formation.

So again, we modified the apparatus to start a second series of experiments. This time the aim was to measure some of the physical parameters which govern the rate at which two atoms can form a molecule when they collide with a cold object. The result of these experiments is that we found conditions for molecule formation to be in fact much less severe than had been thought. Molecule formation could well be the mechanism that is the cosmic thermostat and controls star formation.



Len Gowland, UKAEA Culham, gets to grips with the 'hissing, clicking and clattering mass of pipes, wires and meters' that refrigerate and reduce gas density at temperatures down to absolute zero (–273°C). As described in the article (begin on p. 9), it was used recently by Dr Terry Lee and a team from ROE to simulate interstellar space.

continued on p. 12

What goes up . . . must come down safely

The picture shows technician Tom Hawkins working on a rocket payload at Culham. This payload will be launched from Mauritania on June 30 into the path of the total solar eclipse over North Africa to record ultraviolet spectra of the solar chromosphere and corona and in this way study the structure of these regions of the Sun, as described in the *Sky at Night* programme on BBC 1, April 2. It will be recovered afterwards from the Sahara Desert.

The payload is being prepared by the Astrophysics Research Division of RSRS at Culham Laboratory in collaboration with Imperial College London, Harvard College Observatory and York University, Toronto. The rocket, an Aerobee 170, will be provided by Kitt Peak National Observatory, USA, who are also responsible for the launch and site operations.

The experiments will complement and extend the measurements made by the same groups during the 1970 eclipse. (*Quest* 3, 2 p. 25).

Picture by courtesy of *Oxford Mail.*

We're off to Africa to catch an Eclipse

This year a total solar eclipse will be visible from North Africa. SRC are supporting experiments from three research groups, one from ARD/RSRS to be launched in a rocket and another two from universities to be flown in the latest and, as some might think, the least likely vehicle to be pressed into the space research service: ***see pictures, left and on p. 14 and article right.***

There will be ground-based observing stations in Mauritania at Atar, on an old French airbase – four French experiments, and at Nouadhibou – the ARD rocket launching site; also at Chad – a joint experiment from the Paris Astrophysics Institute and the University of Kiev (it continues some observations made during the 1968 eclipse over Siberia).

Although eclipses can be predicted, the fact that at certain times the moon stands before the sun and appears to be the same size is an extraordinary accident. If it appeared to be smaller, a total solar eclipse would never occur, if it appeared much larger eclipses would last for hours instead of minutes – and just think what that would have meant to the superstitious!

Since the moon is relatively close to the earth and since its apparent diameter cannot be more than very slightly greater (sometimes smaller) than the sun's, it can only be seen to completely obscure the sun from a fairly limited zone known as the "totality zone". The maximum duration of an eclipse, slightly over 7 minutes, occurs when the moon has the largest apparent diameter (when it is closest to earth) and the sun is at its furthest point from earth (in summer in the Northern Hemisphere). Most eclipses are much shorter and some are not total but "annular" (when the moon's disc is not big enough to entirely cover the sun).

As eclipses are rare (about 3 a year) and the belt of the totality zone is narrow, the probability of seeing one in a given region is so small that observers have to be prepared to move their instruments to the path of the eclipse. Sometimes this is impossible, as in 1965 when a total eclipse lasting 4 minutes crossed the Pacific and two almost inaccessible atolls. But even from an accessible place bad weather often spoils the viewing.

In 1973 the eclipse is not only the longest sort but it can also be seen from the Southern Sahara where the weather should be fine and the skies clear. So several research teams are looking forward to June 30 very hopefully.

How ROE created . . . continued from p. 11

We had answers to all the questions that could reasonably be asked of the apparatus by mid '72 and found we had finished the programme nearly three months ahead of schedule. We found the interest shown in the project by the people at Culham made working there particularly enjoyable. Many made small contributions and the computer staff co-operated wonderfully.

Our high rate of production was possible only through the skill, enthusiasm and self-discipline of Len Gowland, the UKAEA member of the team. So we decided that the customer/contractor principle worked well for us. No account of working at Culham would be complete without mention of Jerry Janes of ARU and his staff who were an admin department really worth having around.

. . . the jet-age way is supersonic

Aero-technicians who watched a recent "Sky at Night" programme on BBC 1, will have been considerably shaken to hear that "four small holes will be drilled in the skin of the aircraft" before Concorde is flown across 1,900 miles of desert. But all is well, we found out later that the "holes" are in fact special observation windows that have been fitted for the first ever eclipse-watching experiments to be flown at supersonic speed.

One of the windows will be used by Dr J E Beckman of Queen Mary College (who appeared on the programme). His is one of two SRC-supported experiments that will be looking at the solar eclipse over North Africa on June 30, the other is Dr M Gadsen's of Aberdeen University. The Radio and Space Research Station is providing general support and management services for them. The aircraft will also be carrying two (or three) French experiments and one from the USA, all studying different eclipse phenomena.

Why Concorde ?

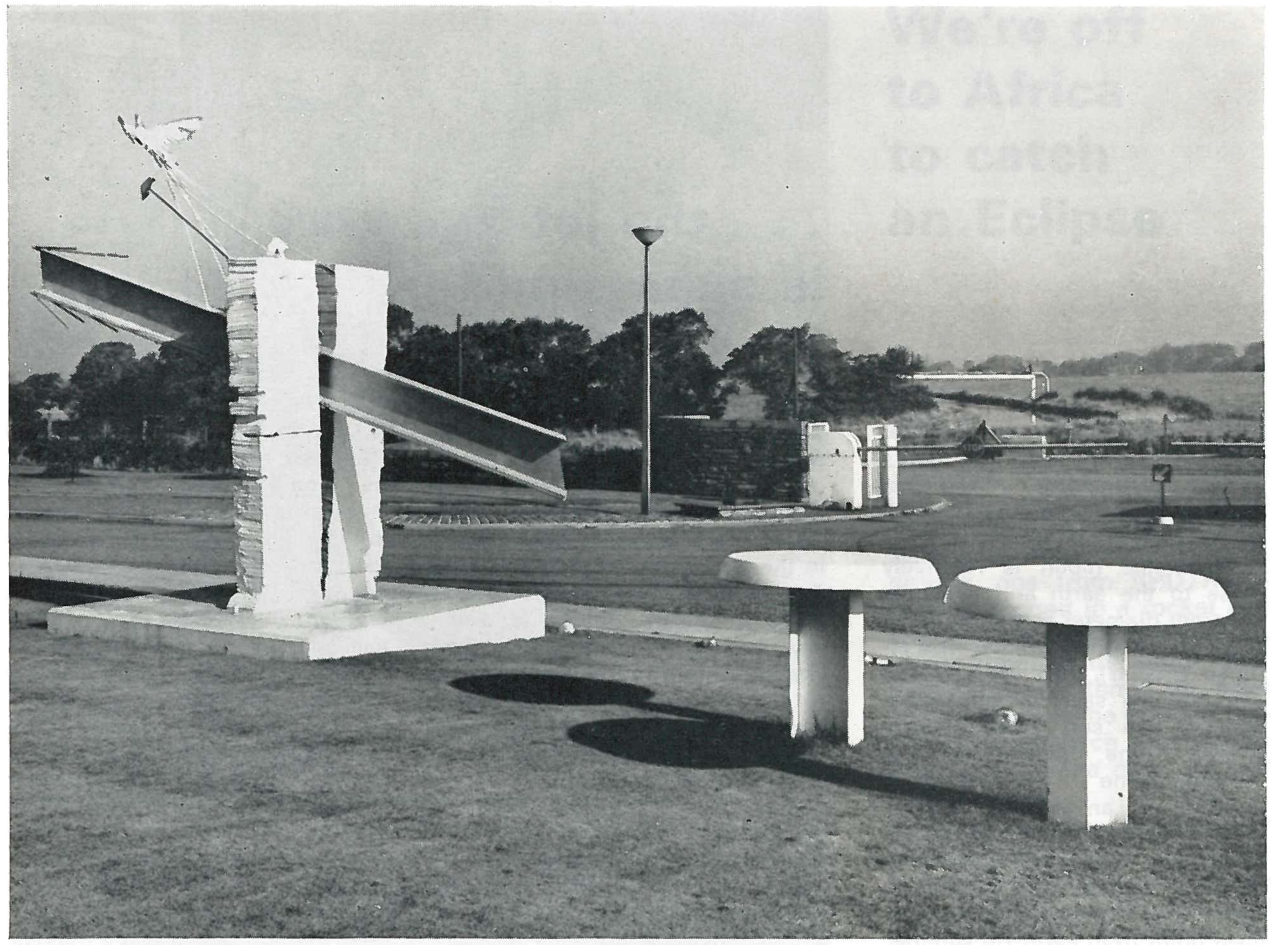
How did we get hold of a Concorde? The story begins in 1952 when aircraft were first used to prolong observations of eclipses. These are never seen for much longer than seven minutes – often less – from a fixed point on the ground and are often only visible over almost inaccessible areas like oceans (1965) and deserts (1973). By flying in the direction of the lunar shadow a subsonic aircraft can watch an eclipse for five minutes longer and this year an American crew will be doing this in a KC135.

But a supersonic aircraft is another thing altogether and both French and British astronomers asked for the Concorde prototypes 001 and 002, respectively, to be used during the 1973 eclipse. As a result they have the use of the French Concorde 001 shortly before it will be withdrawn from service. The French invited the UK to provide two experiments and these were chosen from seven proposed.

Concorde will establish a 'world record' for eclipses with an observation time of 80 minutes. Flying right over the difficult terrain and well above bad weather conditions, it will also, at a height of 17,000m (55,000 feet, be above most of the atmospheric effects that prevent infrared observations at lower altitudes.

Before the flight, there will be several ground tests and three test flights so that this first ever opportunity is used to its fullest possibilities. In the last fifty years the total duration of every solar eclipse put together amounted to only 129 minutes; none of them so fully observed as on this occasion.

From the UK, Dr Gadsen (Aberdeen) will observe the emission of molecular oxygen in the earth's stratosphere, when it suddenly stops being irradiated by solar radiation. Dr Beckman (QMC) will observe distant infrared radiation of the solar chromosphere in order to determine its temperature, structure and, generally speaking,



The jet-age way continued

prevailing physical conditions.

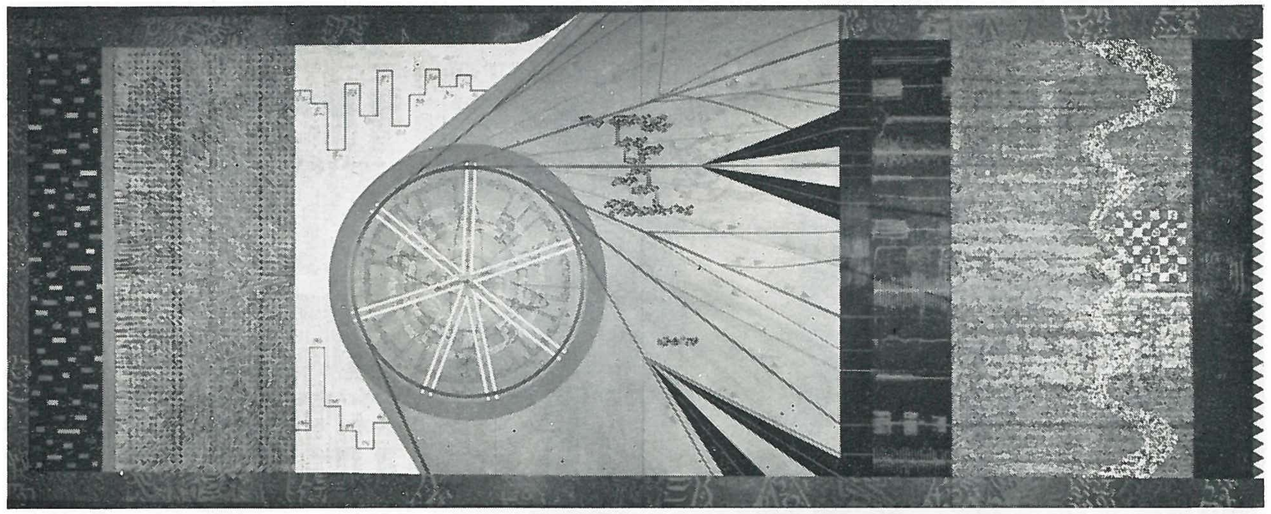
A French experiment from the Paris Observatory, Meudon, will study the thermal corona – the accumulation of dust round the sun that is called 'zodiacal light' when it diffuses the sun's light. Two spectral analysis systems coupled to two highly sensitive infra red detectors will be used to determine the spatial distribution of the dust between 2.5 and 10 solar radii and to analyse their spectrum to show the composition of the particles and to find out if silicates occur very close to the sun. The same experiment tried in 1970 from the ground by an American team was unsuccessful.

The Paris Astrophysics Institute will photograph the internal white corona (free electrons diffusing sunlight) for about an hour, using a telescope with a 10cm aperture with an equivalent focus of about 3m. This should show dust movement in the corona and the lifetimes of certain structures linked to the evolution of the coronal magnetic field, such as 'polar feathers'.

The reduction in the observed relative speed of the sun and the moon will also increase the time of the so-called 2nd and 3rd contacts, in which the solar chromosphere is eclipsed. These intervals were previously used to make 'flash spectra' lasting only a few seconds, but flying in Concorde at a speed only slightly less than that of the lunar shadow, several minutes will be available to make such studies just before and after the total eclipse phase.

An experiment from Los Alamos Scientific Laboratory, USA, will observe the emission lines of the solar corona at the chromoshere-corona transition level during the second and third contacts, followed by a determination of the oscillations of the lower corona in order to study the energy transfer in this medium. During totality the emission lines will permit a study of the behaviour of the corona further away from the sun. Their second experiment will test the propagation of coronal disturbances. These are believed to be caused by waves that heat it then dissipate in perhaps 300 seconds, but they have not yet been detected.

Recommended reading, if you want general (not too technical) information on eclipses and aircraft observations and more details of the experiments, is the SRC press notice 9A/73 and its several enclosures on which these articles are based. (Ask your local Librarian or the Press Office LO extn 114 for copies).



Daresbury's visible assets

M J Moore

Although the Daresbury Laboratory is dedicated to Nuclear Physics, this does not imply that other disciplines are neglected, and not the least the arts.

Our contributions, encouraged by the Chairman of NIRNS the late Lord Bridges, are modest perhaps in the artistic sense – posterity will judge – and take the form of a mural by John Hart and a massive work by the well-known Liverpool sculptor, Arthur Dooley. Both men spent several days at the Laboratory, at different periods, acquiring "atmosphere".

John Hart's mural *(seen above)* covers one wall of the entrance hall. It is based on the construction principle and uses of NINA (National Institute Northern Accelerator), mingled with quotations from Lewis Carroll, born locally, and James Joyce. (Carroll's 'Tale of a Mouse' shape and a chessboard can be seen right).

Arthur Dooley was given ten tons of scrap steel from accelerator magnets and two pole tips (designed by John Cockcroft in 1937) from the Liverpool 37 inch Cyclotron. After much heart searching he made a symbolic 'beam' splitting the uranium nucleus *(see picture left)* with various fission products and emitted neutrons. The pole tips (right) represent the mushroom clouds of Hiroshima and Nagasaki. On the left the dove of peace is seen emerging from the disintegrations of the heavy nucleus. The sculpture stands in front of the Laboratory beside the entrance gate.

To add a personal note, the 37 inch cyclotron was built by Sir James Chadwick at Liverpool before the last war. Gerry Pickavance, 'George' Holt and I sweated some of the best years of our life in keeping it working during the years 1939-1942, before we joined the Bomb Project in other places, but that is another story.

The ties between Liverpool and Daresbury are strong indeed.

M J Moore OBE, joined the Daresbury Laboratory in 1963 as Head of Engineering Division. Previously he was a Senior Lecturer in physics at Liverpool University and a Research Assistant to Sir James Chadwick.

nutcracker 12: uneasy bedfellows

The King of Concilia has six ministers, whose offices are ranged along a single corridor in the following order: Foreign Affairs, Education, Disinformation, Counter-Insurgency, Budget, and Agriculture. In order to inject new dynamism into his government, the King proposes to reverse the order of these ministries. However while offices are being exchanged, the two ministers concerned will have to work in the King's Stately Pleasure Dome (currently also housing a large telescope). This creates difficulties, since most of the ministers cannot stand the sight of each other. Thus the Minister of Foreign Affairs refuses to share the Dome with any of his colleagues from Education, Budget or Agriculture. The Minister of Agriculture refuses to share with the Ministers of Education, Counter-Insurgency and Disinformation. Neither the Minister of Education or the Minister of Disinformation will share with the Ministers of Counter-Insurgency and Budget. All of which makes the moves rather difficult. Can you find the shortest sequence of exchanges which puts everyone in the right place?

Answer on p. 27. If you can solve the problem with less than 11 moves, there is a prize too.