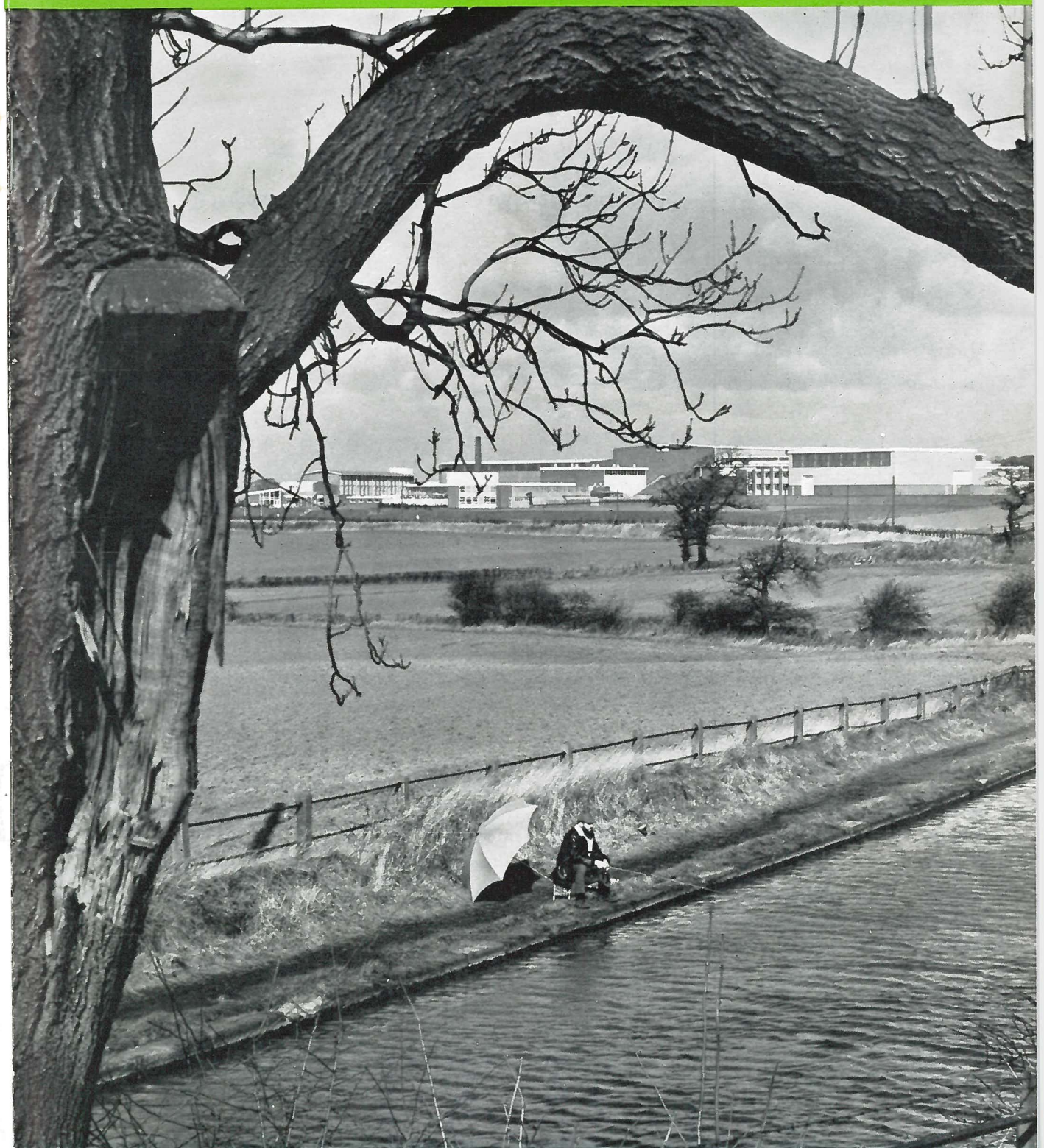
QUEST



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QUEST

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contents

cover picture: research at Daresbury – Peter Tickle of the vacuum section of the Machine Group hoping for a positive result from the canal that runs close enough to the Laboratory (seen in the background) to allow lunch time fishing. A member of the Warrington Anglers' Association, Peter's local club is the Red Lion Angling Club, where he has carried off 3 club trophies in the last 2 years. He enters most local matches and travels to Wales, Scotland and Ireland on fishing expeditions. For more about spare time activities, see page 22.

The photograph was taken for 'Quest' by Arthur Pickett, DNPL photographer, whose work has also appeared in 'Cheshire Life'.

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profile

Dr. William Francis CBE

Dr. Francis was frustrated from the word go in planning his career. At the age of 13 when he had to start specialising at the Latymer Upper School, Hammersmith he decided to become a historian. But his mother said 'your father has filled this house with books on science and I will not have *you* filling it with history books – you will be a scientist like your father.' So he did as he was told and in due course won an Exhibition in Natural Sciences to King's College Cambridge, having been Foundation Scholar, Senior Prefect and Captain of Football at school. He had given up cricket, with regret, (when 14) because it 'interfered with the passing of examinations in the summer.'

At King's he enjoyed life, captained the soccer team, got his athletics colours and did less work than he should. He stayed on to take a Ph.D. in physical chemistry in 1931, studying the electrical properties of protein membranes and was invited to join the Zoology Department by Sir James Gray where he worked on the electrical properties of frog skin with the help of a DSIR Senior Research Award. In 1933 he gained a Rockefeller Fellowship in Experimental Zoology and went to the Rockefeller Institute in New York to work on the permeability of frog muscle. When asked about life in New York and California in 1933–4 he says it was well described by Eric Linklater in the novel 'Don Juan in America'!

By this time he was in danger of becoming a 'perpetual student' but, although disappointed in his ambition to become a don at Cambridge, in 1935 he was offered the choice of lecturing in a civic university in the north or teaching at Repton, which he preferred – following a family tradition.

He enjoyed 'being a beak' and also fitted in WEA lectures to industrial workers in Derby and to farm workers in the countryside around and later became an O- and A-level examiner for Cambridge exams.

During this time he married Ursula Matthew, a Cambridge geographer, and they both grew very fond of country and village life. She died in 1966.

Over the years 1931–37 he published a number of papers in scientific journals on the permeability and other properties of membranes, both living and artificial – 'not very outstanding' he says but he is still interested in what is being achieved in this field today, with modern techniques.

When the war came he was mobilised by C. P. Snow from the Royal Society list of research scientists for war work on radar. In his own words – they had recruited all the physicists before the war so by 1940 they were 'scraping the barrel' for chemists and biologists. The early days of radar were great fun. Jack Ratcliffe (afterwards Director of RSRS) was his boss – first at Anti-Aircraft Command and later at TRE in Swanage then Malvern, where it was moved in case of a south-coast invasion. Working on the

introduction of centimetre radar into night fighters and bombers and submarine chasers, he now regards as one of the most amusing and exciting parts of his professional life because 'we were given all the staff and money we asked for and could translate the results of fundamental research into effective hardware within a matter of months.' Two of the 'promising younger men' at TRE in those days, Bernard Lovell and Martin Ryle, have since led the world in extending the principles of radar to radio astronomy.

Towards the end of the war Ratcliffe sent him to see Sir Edward Appleton, the Secretary of DSIR, who offred him a job as a peacetime PSO. He thinks he was very naive at first in expecting things to go as fast in peace as in war – progress was slow for a number of good reasons. Two of the causes he began to advocate in 1945 are now widespread under the aegis of Min Tech: namely, development contracts arising from research in civil science and regional technical information services for industry. Later on he had an interesting five years (1953–8) in charge of administering the Government grant to the co-operative industrial research associations, which gave him an insight into the problems of applying science to traditional industries.

In 1959 he found himself 'quite undeservedly in charge of the Grants and the Information Divisions of DSIR but fortunately Christopher Jolliffe, John Beckelt and later Harry Hookway were there to do the work, earn me a CBE in 1961 and propel me gently into my present post when SRC was started in 1965.'

When he isn't working he enjoys music, travel, gardening, his cottage in Cornwall and his children's activities. His eldest daughter Sarah, who went to St. Paul's Girls' School, is also a Cambridge Ph.D. At present she has a research fellowship from the Australian National University and is studying childhood morbidity among aboriginals near Alice Springs. This involves getting to know and understand the parents, if you can identify them, to find out what they do when their children are ill or hungry. 'They have some very odd ideas' she says.

His son Julian was so horrified by how hard his elder sister had to work at school that he gave up academic ambitions at the age of 14, at Westminster School, and opted for farming. For the last two years he has been in charge of an irrigation-agriculture-dairy farm project for Oxfam in India which has become a successful show piece and was recently visited by Mrs. Judith Hart, but much to Julian's chagrin the event was neglected by the British Press. Brigid who is younger went to the Royal Ballet School until, at the age of 16, her knee gave out. So she switched to Putney High School, scrambled some A-levels and is now in her third year at York University doing Music and English with great enjoyment.

The youngest, Emily, is at Dartington Hall where she is said to work hard. She saw the text of this article in preparation and forbade her father to reveal any secrets of her, so far, innocent life to the readers of *Quest*. Two years ago Dr. Francis married Margaret Morris, formerly of Geological Survey and Museum, who was then an SPSO in ASR Division, London Office and is now working part time in the Cabinet Office.

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force of conflict

Time goes on indifferent without the spark
Of nuclear force and pull of gravity.
The cell defends itself from enemies
And sperm and egg do battle and then join.
The mother labours to produce her child
With father striving to achieve success.
The students quarrel with authority
And parents find their toleration thin.
Man fights for his ideals, and always will,
The creatures for their territory and mate.
The sea assaults the land and swallows it
And cold and tempest thwart the farmer's hope.
Perfection – and our world would atrophy.
Conflict exists with reason and without:
So will it be to energise and make
The cutting edge for purpose and achievement.

Nona

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morning train

Faces in rows – people standing between
Hide behind newspapers, solemn restrained,
All silent: in company and yet alone.
Man of the city, upright and well fed,
Support of his country and strength of his class,
Overalled workman – his life in his hands.
Lovers, remote, with their bliss on their faces,
Women who lost it, or it never knew,
But some full of comfort and ever benign.
Heavy eyed student with long flowing hair,
Girl in her teens – all make up and sex,
Unaware schoolboy studies his book.
The morning is golden – the river is grey
But they do not notice they only endure,
Yesterday, today and tomorrow.

Nona

council commentary

£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 OR ING SOLAR OBSERVATORY ++ FIRST LUNAR SAMPLES FOR BRITAIN ARRIVE AT SRC ++ FOR CONTROL ENGINEERING RESEARCH ++ ANGLO-AUSTRALIAN TELESCOPE CONSIDERABLE CONTI BUTION TOWARDS SCIENTIFIC DISCOVERY ++ RSRS PARTICIPATES IN UK4 SATELLITE TO MEA INTENSITIES OF ELECTROMAGNETIC RADIATION ++ DEVELOPMENT IN ANALYSIS OF BUBBLE CH BER PHOTOGRAPHS BY SWEEPNIK AIDED BY SRC GRANT OF £40,473 ++ SUCCESSFUL LAUNCH O

At the December meeting the Council discussed the draft of a public statement of its policies on selectivity and concentration of research support. The Council also received a report on the progress of development of a possible productivity agreement with its industrial staff. The greater part of the rest of the business at this meeting was the consideration of recommendations from all four Boards of grants and projects over £50K.

The continuation of the Edinburgh/Liège infra-red astronomy experiment in ESRO's TD–1 satellite was approved at a cost of £900K; five grants for nuclear physics research in major centres in 1970 were approved at a total cost of £500K as were five engineering grants totalling £210K, most of them supplementing earlier large grants, and two Science Board grants totalling £160K. As one example, a grant of £82,000 was awarded to Dr. F. W. Randall, Queen Mary College, London, to provide a NMR spectrometer of a new type for work on the theory of C–13 and N–15 resonances and also as a general facility for other users. One other item of which the Council learned with pleasure was the decision to arrange for a study at Manchester University to assist the development of SRC and SSRC policy on problems of pollution.

January. One of the Council's major annual tasks is to decide on the policy and arrangements for post-graduate student awards. Formerly, a great deal of the work was done by the UST Board, but the Council now undertakes it directly. With the help of much detailed information submitted to the January meeting, the Council made its decisions on the quotas for various special kinds of award and for the four Boards. It also laid down that at the appeals stage priority should be given to fully qualified applicants in the Engineering Board's field, and to applicants with first-class honours.

Three items in the ASR field then followed. The Council approved the building of a 48 inch Schmidt telescope at a cost of £750K at Siding Spring beside the Anglo-Australian telescope, to be used first to complete the famous Palomar sky survey. The proposal for a Mk V large steerable radio-telescope was next considered, the scientific case being presented in very full detail. The telescope would be 400 feet in diameter compared with the 200 feet of the Mk I at Jodrell Bank, and would be suitable for use down to the shortest wavelengths practicable except on high, dry mountain sites. The Council approved the proposal within a cost of £6M. Although it will be directed and managed by the University, it will remain SRC property. Finally, the replacement of the Central Processing Unit of the computer at the RSRS was approved at a cost of £250K.

In February, there was a discussion of the basis upon which the next five-year forward look is to be prepared for full consideration in April, and of the preliminary indication of its probable lines, which has to be given to the Government beforehand. One considerable problem is the lack of definite information about the rate of the large university expansion which is certain to take place. As one important aspect of the forward look, the Engineering Board submitted a paper on its early progress with some of the questions that had led to its formation. Following the Council's expressed wish to give priority to its work, the Board has been studying the prospects for expansion, and has made plans for a 12% p.a. increase in expenditure, with about one-third being concentrated in selected centres.

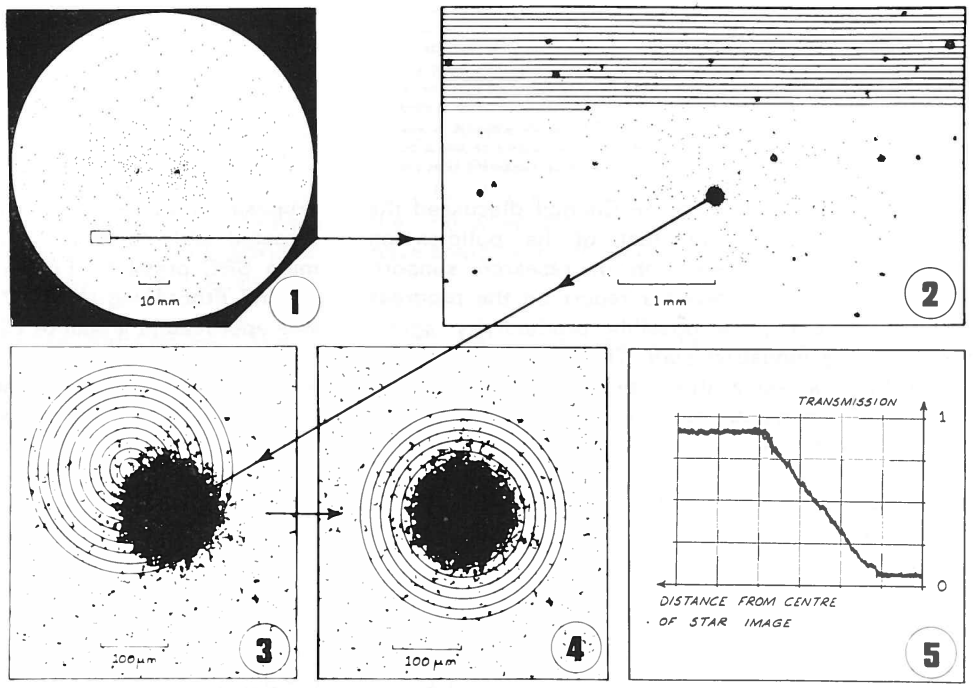
Some further large grants recommended by the Engineering Board were approved by the Council: five grants totalling £375K for collaborative programmes in polymer science and technology, two totalling £320K for control engineering, one of £138K for microwave research at University College London, and one of £237K for work at Liverpool on phenomena in arc devices. The remaining items in February included a further report on the progress of development of a possible industrial productivity agreement, and the news that the new scheme of SRC fellowships, approved by the Council a year ago, had now been accepted by the Government and was being announced. The new fellowships are of higher value than the present ones, but fewer in number.

"Plus ça change, plus c'est la même chose."

We seek and explain and what do we find
Yet more to explain still leading us on
For ever and ever – or is it complete
At this moment of time. Consider and see,
Shapes are recurring, patterns repeat
Is it so simple – a life or a wheel
Showing us now what always will be?
We cannot tell – so still do we seek.
The answers elude us but maybe we know.

Nona

machine to match a telescope



The pictures illustrate the operation of the GALAXY Measuring Machine at the Royal Observatory, Edinburgh.

1 is a photograph taken with the Schmidt Telescope, showing the stars as black images on the negative: a typical photograph contains 40,000 images. An area of the negative is selected for measurement.
2 shows the selected area enlarged. GALAXY searches for star images, using linear scanning.
3 shows a single star image greatly enlarged and the GALAXY scan of the image, using concentric circle scanning.
4 is the same star image which GALAXY has centred to measure its position to 1 micron.
5 is a drawing of the oscilloscope display on GALAXY, which measures the profile of the star image to a quarter of a micron.

N. M. Pratt

In the early 1930s, Bernard Schmidt, an Estonian optician designed the wide-field photographic telescope which bears his name. The instrument can photograph large areas of sky with nearly perfect definition of stellar images.

At the Royal Observatory Edinburgh there is a relatively small Schmidt telescope which can photograph, on a single glass plate, an area of sky four degrees or eight moon diameters across; a two minute exposure can record the relative positions and brightnesses of tens of thousands of stars. A second Schmidt camera is at the Observatory's Monte Porzio outstation (see R. J. Dodd's article on page 16).

The light from each star is focussed by the telescope to a spot with a diameter of about fifteen microns or half a thousandth of an inch and is then scattered and absorbed by the photographic emulsion. The brighter the star the further the light is spread out, so that when the plate is developed images of bright stars are larger clumps of photographic grains than those of fainter ones. Measuring the relative sizes of star images therefore gives a measure of relative brightnesses.

By comparing the brightnesses of the stars on plates taken through different colour-filters – ultraviolet, blue, yellow, red – temperatures of the stars can be deduced and at the same time effects of the obscuration caused by interstellar dust can be examined. By taking plates at different times, small changes in the positions of the stars on the sky can be detected and from these distances and motions of the stars in the galaxy can be derived. Combining measures of brightness and position, astronomers can study the history of the gas, dust and stars in space and time, in other words the evolution of the galaxy.

The invention of the Schmidt telescope presented astronomers with a particular challenge. The telescope could record the stars and nebulae in vast volumes of our galaxy in a few minutes, but how could the information be derived from the photographs? Manual measuring engines could cope with only a few thousand stars each day. A whole new concept in measuring engines was required – a machine which could measure completely automatically say, a thousand stars an hour with an accuracy of a micron in position and a quarter of a micron in size.

GALAXY

The fundamental concept of the 'General Automatic Luminosity And X Y measuring engine' – GALAXY – was due to Dr. P. B. Fellgett, now Professor of Cybernetics and Instrument Physics at Reading University. Four basic features were: a cathode ray tube to scan the photographic plate with a small spot of light; a precise mechanical carriage to hold and position the plate to better than a micron; a system developed by Ferranti Limited to measure the carriage position; and an electronic system, similar to a computer, to control the operations.

Dr. Neil Pratt,

who wrote this article, is an Experimental Officer at ROE concerned with writing programmes for GALAXY.

The design and construction of the whole system was entrusted to the Scientific Instrument Control Department of Ferranti Limited, now Faul-Coradi Scotland Limited. In September 1965 a detailed design study was begun by the manufacturer working with Dr. V. C. Reddish of the Royal Observatory, Edinburgh. Based on the study, a contract was signed in August 1966 to construct the measuring machine – GALAXY – over three years. The mechanical system was constructed by Sogenique Limited and delivered in April 1967.

When GALAXY was first used to examine photographic plates, the operations of the machine were monitored on an oscilloscope display and the excitement was considerable when the first sequence of stars, from bright to faint, were seen to be detected and automatically measured. This was in March 1969.

As the weeks went by, the exact performance of the machine was assessed and improved, the output data being processed on the Elliott 4130 computer at the Royal Observatory Edinburgh.

The first major test was the accuracy of the XY carriage in measurement phase. The Edinburgh Schmidt plates are circular and so can be placed in the plateholder at any orientation. A set of about one hundred stars was measured at orientations of the plate separated by 30° through a complete revolution. The computer analysis on June 30 revealed that the accuracy in both X and Y was better than half a micron, two times better than the specifications.

The second test, in late August, was largely concerned with the search phase. A small area of one plate was searched and the search output measured as often as possible for one week. The performance was again satisfactory, and the machine was formally accepted in October. It was the first of its kind anywhere to bring complete automation to processes of optical astronomy.

Then GALAXY began to be used to measure sets of plates of parts of the galaxy in a search for newly formed and very young stars – stars less than about 30 million years old, newcomers on the galactic time scale of 10,000 million years.

discoveries in Perseus

For a Press Conference on January 20, when GALAXY was introduced, the measures and reductions of one plate through each of three colour filters had been completed. From these provisional completely automatic measures, 1103 stars younger than 28 million years were found in part of the constellation of Perseus where only about *15* were previously known. This is a striking example of the increase in astronomical knowledge made possible through the development of GALAXY, which gained front page headlines in the National Press.

GALAXY will soon be operating twenty-four hours a day, seven days a week on a growing series of varied astronomical programmes. Computer programmes to examine the GALAXY output of tens of thousands of stars on each Schmidt plate and to combine the measures of one star from several plates are being developed.

The machine, which weighs 3.6 tons, is mounted in a light-proof cabinet 8 ft. x 6 ft. x 7 ft. high. The heavy base casting supports a very accurate two-dimensional table on to which is clamped the plateholder containing the Schmidt plate. A bridge casting over the carriage supports two parallel optical systems each with a micro-spot cathode ray tube as light source. The electronic circuitry and operating controls are contained in two racks, each 6ft. high.

One of the two optical systems, the Search Phase, projects a small spot of light, say 16 microns in diameter, along a linear scan in a raster pattern over specified areas of the plate. A photo-electric cell monitors the light transmitted through the plate and detects the reduction in brightness when the light spot falls on a star image. With the above resolution, 30 square millimetres are searched every minute, and up to ten thousand stars are found per hour and their approximate coordinates recorded on paper tape.

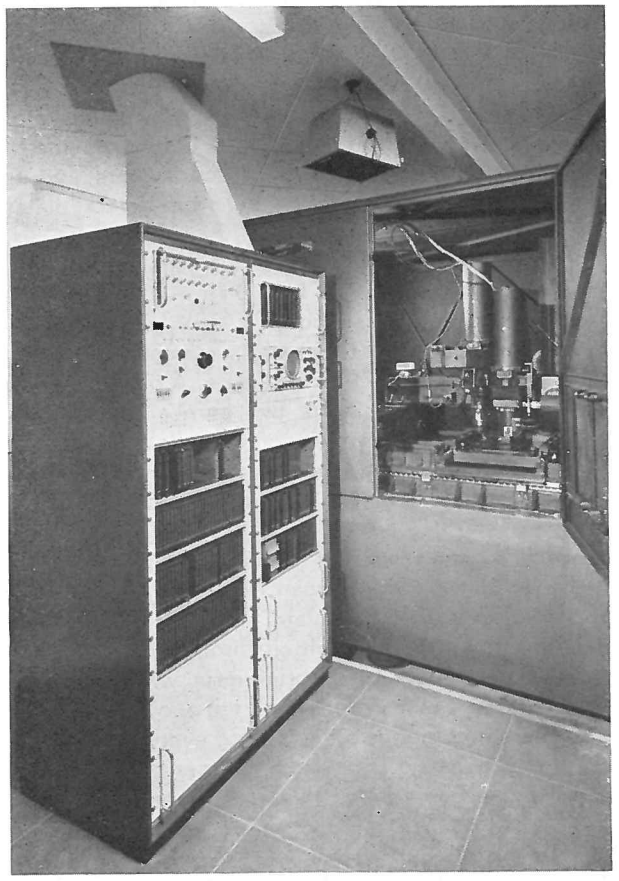
This paper tape is used as the control input for the second optical system, the Measurement Phase. The machine drives to the approximate coordinates of each star and scans the plate with a spot only

machine to match a telescope continued

one micron in diameter in a spiral pattern. If the star is not centred, a photo-electric cell monitoring the transmitted light detects more light coming through one side of the spiral than the other and generates signals to servos which move the carriage to centre the star in the spiral scan. The position is determined in units of a micron. At the same time the size of the image is being determined with the spiral scan, and the position and size of the star image are put on to paper tape. The next set of approximate coordinates are then read from the search tape and the carriage moves so that the next star image can be examined. This process is carried out on 900 stars an hour.

In addition to the programmes from Edinburgh, astronomers from the Royal Greenwich Observatory have used GALAXY, and there is an increasing number of enquiries from astronomers in both hemispheres. Investigators in other sciences have also shown great interest in the general system.

Soon, we hope, GALAXY will be providing answers to many astronomical problems which could never be tackled previously – and, no doubt, it will pose many more.



Photograph of GALAXY Measuring Machine at ROE constructed by Faul-Coradi Scotland Ltd.

physicist talks to engineers – about engineering

The Chairman delivered a lecture to the Institution of Electrical Engineers on February 5, 1970. Here is a summary of the things Sir Brian had to say about 'Engineering and the SRC'.

Engineering must engage the most serious attention as an element of any advanced society. Its practice is technical and inventive, but it is not just these; it is an art embodying the deepest consideration of human, aesthetic, environmental, economic and social factors . . . Together with the UGC and the other Research Councils, the SRC is responsible for encouraging, and in a broad sense guiding, the research and postgraduate activities in science and technology in the universities, which in one way and another absorb most of our annual budget of over £40 million.

In 1962, concerned by the decline in Britain's share of international trade in engineering goods, and recognising that design 'is the very heart and origin of all engineering activity',[1] DSIR appointed the Feilden Committee to consider the present standing of mechanical engineering design and to recommend any changes which were likely to result in improved design of British products, including changes in education and training.

The Committee found evidence that the engineering industry largely failed to accommodate itself to the post-war development of the educational system, the shop floor remaining the main point of entry. On top of this, it attracted a lower proportion of the ablest school leavers than science because it had a lower social and economic status in Britain than in other highly industrialised countries. Research was the prestige activity, attracting the best scientific and technological brains.

Since 1960 there has been a steady rise of activity in engineering and the applied sciences under DSIR and, later, the SRC. In terms of research grants to Universities and technical colleges the current value of engineering grants first exceeded that of science grants (excluding 'big science') in 1966; it reached £11 million last year and continues to rise. By the creation of the Engineering Board in 1969 with its own indicative budget, considerable delegated powers, and wide terms of reference, we have for the first time in SRC set engineering on manifestly equal terms with science.

In the engineering field, subject reviews in depth have been made of electrical machinery, control engineering, electrochemistry and polymer science and others are in progress dealing with desalination, high temperature processing, transport and building science. Our reviews will normally be published so that there is an opportunity for public discussion before their recommendations are put into effect.

education for industry

Applied science in the abstract is all too often dull and unattractive; it is from the application that it derives its inspiration and excitement, and the applications are usually to be found in industry. The Board believes that increased collaboration on research projects between industry and the universities is necessary not only for the execution of the projects but also for the effect such collaboration has upon training of scientists and engineers.

Several new schemes for the awarding of postgraduate research and advanced course studentships have been introduced, designed to meet the needs of industry. Co-operative Awards in Pure Science (CAPS for short), operated by the Science Board, enable graduates working in pure science departments to undertake, in direct collaboration with industry, research of joint interest. Another scheme is the Award Scheme for Science in Industry and Schoolteaching (ASSIST for short), under which new graduates are given promises of SRC studentships to be taken up after one to five years spent in industry or schoolteaching.

some investments

Public attention was focussed on the social problem of noise in 1963 with publication of the 'Wilson Report'.[2] At that time the DSIR was giving increasing help to technology and awarded a major grant to Southampton University for work in the field of acoustics which helped to establish the newly-formed Institute of Sound and Vibration Research upon a firm footing. The Institute has grown rapidly and now commands considerable support from industry and the SRC for research into human problems of noise in vehicles and buildings, and the effects of noise and vibration on machinery and structures.

The SRC has invested over £½ million in the Cambridge control group which has enabled them to develop experiments based on real operating data from real industrial plants. The group has contributed to the control of a paper-mill during grade changes; it has completed a model of a hot steel strip rolling mill which is now being extended to include all operations from the output of the reheat furnace to the input of the coilers of an actual mill in order to get much improved temperature control urgently required to keep the metallurgical properties of the product within specification. It is also being consulted by industry on the control of once-through boilers required in the nuclear power field, and on the control of distillation columns in cascade.

High energy nuclear physics has had a direct impact on engineering through the problems of designing, operating and developing the great accelerators and associated experimental equipment. Engineers and physicists at the Rutherford and Daresbury Nuclear Physics Laboratories, and industrial firms which have provided the equipment, have played their part in this.

Anglo-French link

Following failures of large pulsed motor-alternator sets at the Rutherford Laboratory and at other high energy laboratories overseas (and these failures provided new information on fretting and fatigue in such structures) Rutherford Laboratory engineers studied a static power supply system which would dispense with rotating machinery altogether. As part of this programme, 160 MW pulse tests were conducted between CEGB and Electricité de France using the submarine DC link between the two national systems and the results were analysed at the Atlas Computer Laboratory. Not only did these tests demonstrate the feasibility of the static power supply when coupled to a suitably massive public network, but they provided valuable information about the dynamic behaviour of the two national electricity systems.

Perhaps the most interesting interaction with industry in radio astronomy is in respect of the large steerable dishes. Initially dishes were developed for radar and then used for radio astronomy. The development of the Mark I radio telescope at Jodrell Bank and the design of further large steerable paraboloids, led to one of the designs being adopted for satellite communication at the Goonhilly station. The story continues by the adoption for Sir Martin Ryle's new 5 Km telescope at Cambridge of eight of the dishes developed for satellite communication work.

We are anxious that more collaborative projects should be proposed and we are willing, even more than in the past, to support those aspects undertaken by the universities even if the work itself takes place in industrial laboratories . . . However, I am not sure that industry is yet sufficiently aware of the possibilities open to them for such collaboration. I therefore draw your attention to it today.

[1] Wallace, P. J. *The Engineer*, 19 April 1963.
[2] Cmnd 2056

enzymes

J. A. Feather

Man has been putting enzymes to work on his behalf since he first brewed beer, fermented grape juice to make wine, or converted milk according to local taste into cheese or yoghurt. These processes have, of course, been known for a very long time but it is only in the last hundred years that the part which enzymes play in them has been understood. The fermenting agents used were simple organisms such as yeasts and bacteria in which they occurred naturally. The word 'enzyme' comes from Greek roots meaning simply 'in yeast'.

Enzymes of one kind or another are in fact found in all forms of living matter. They are essentially proteins and their function is to control the complex sequences of chemical reactions on which life depends. They act as catalysts causing the biochemical processes to occur rapidly and efficiently but remaining unchanged themselves at the end of the reaction.

The ease with which enzymes can bring about chemical reactions is one of the main reasons for the current interest in them. Not only do enzyme-catalysed reactions take place rapidly and under very mild conditions (in contrast to the high temperatures, pressures and extremes of acidity or alkalinity often used for industrial chemical processes) but they are highly specific. That is to say, a particular enzyme often acts as a catalyst for a single reaction of just one chemical compound. The result can be a complete absence of the by-products produced, almost inevitably, when a reaction is made to occur by ordinary chemical means.

One of the long-term aims of enzyme research is to gain understanding of how these molecules behave as catalysts to a level sufficient to enable synthetic substances, with similar properties, to be tailor-made to catalyse specific reactions of industrial importance. A major short term aim is to find ways of using naturally occurring enzymes industrially. Since pure enzymes are expensive it is uneconomic to use them once and throw them away. This is likely to be the result if they are used to bring about a reaction by simply dissolving them in the solution containing the materials due to react, because the very small amounts of enzyme required cannot be extracted from the solution at the end and will be lost. The answer is to attach the enzyme to some insoluble material such as a natural or synthetic polymer. An additional advantage is that the 'insolubilised' enzyme is often found to be more stable than the free substance in solution. It is therefore less likely to have its catalytic activity destroyed by heating, for example, and is usable for longer periods and at higher temperatures.

These are only a few aspects of enzyme chemistry. It is a subject of great potential importance and in 1969 it was selected by the Council as an area of science worthy of special encouragement. The Enzyme Chemistry and Technology Committee (now a committee of the Science Board), which was subsequently established to further research in this field, has already made a number of substantial awards.

One of the first awards was a grant of £200,000 over five years to Dr. M. D. Lilly and Dr. P. Dunnill of the Chemical Engineering Department at University College, London, for a programme of research on enzyme technology. They describe this project in the following article.
[*Dr. John Feather (SSO) is Secretary of the enzyme chemistry and technology committee at London office.*]

enzyme technology

Enzyme technology has two immediate aims. The first is to improve methods of preparation so that relatively large amounts of a wide range of enzymic proteins can be made available for detailed studies. These will lead to a better understanding of enzymes and their role as catalysts in living systems, which will have important implications for biochemistry and, in the long term, for medicine.

They will also open up the possibility of preparing more enzymes synthetically, and should lead to a sufficient understanding of the mechanism of enzyme action to permit the construction of artificial enzymes.

The second aim is directed to the more immediate application of enzymes as catalysts. If natural enzymes can be prepared economically on a large scale and can be converted into a form suitable for incorporation in a chemical reactor, they can play a much greater rôle than they do at present as industrial catalysts. Previous processes employing enzymes used whole organisms, cell extracts or enzymes secreted by cells in free solution. The new technology seeks to use purified intra-cellular enzymes catalysing a wide range of reactions and aims to justify the higher isolation costs by retaining active enzymes in the reactor system for much longer periods.

When the enzyme technology programme at University College London began, six years ago, it had two goals. The first was to enlarge the scale and scope of insolubilised enzyme reactors then under examination and the second to make available several trace enzymes for x-ray crystallographic study. Since then requests for help in isolating enzymes from various sources, industrial interest, and a realisation of the lack of basic data in this area of biochemical

engineering have all helped to stimulate the growth of an inter-disciplinary team of chemical engineers, biochemists, microbiologists and chemists, with a broad range of interests. The part of the current research programme supported by the Council centres on three main themes – continuous enzyme isolation, simultaneous enzyme isolation, and insolubilised-enzyme reactors.

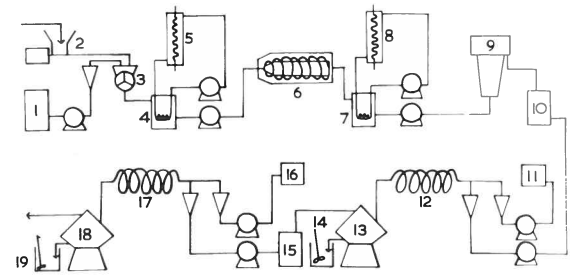
large-scale isolation

Experience in the first few years of the enzyme project indicated that the scaling up of a batchwise isolation procedure often involved losses in enzyme yield and activity. Many enzymes are particularly susceptible to damage and degradation in the early stages of fractionation and the losses were found to be due to the longer process times required on the larger scale. Moreover it became clear that the extension of batchwise procedures towards an industrial scale of operation would involve the use of increasingly massive and clumsy apparatus. A solution to similar problems in the chemical industry is to convert individual stages or, better still, the whole process to continuous operation. To find out if this approach would work with enzymes we chose two enzyme isolations, one from plant tissue, and one from microbial cells, for preliminary study.

The layout of equipment used for these two continuous isolation processes is illustrated in *figures one and two*. The isolation from plant tissue required the extraction of the enzyme from the tissue, the removal of cell debris, and two stages of acid precipitation; each of these was carried through continuously in the system illustrated. The yield and specific activity of enzyme produced were increased 50-fold and 16-fold respectively, compared with batch operation at the same scale. The isolation from microbial cells required continuous disruption of cells, streptomycin precipitation of nucleic acids and two stages of polyethylene glycol precipitation.

Of importance in relation to the continuous isolation of microbial enzymes is the fact that considerably elevated levels of some enzymes can be obtained by continuous culture. The test system was one which showed this phenomenon. In such instances the coupling of large scale continuous fermentation and continuous isolation is especially profitable. Each of the products of these processes required more purification and while the microbial amidase was purified further at the time by continuous electrophoresis, a continuous chromatographic operation was desirable. No commercial machine suitable for the purpose existed and a new machine is now being constructed with the support of the NRDC.

These preliminary experiments showed that the approach was promising but equally that the knowledge of individual operations was inadequate in



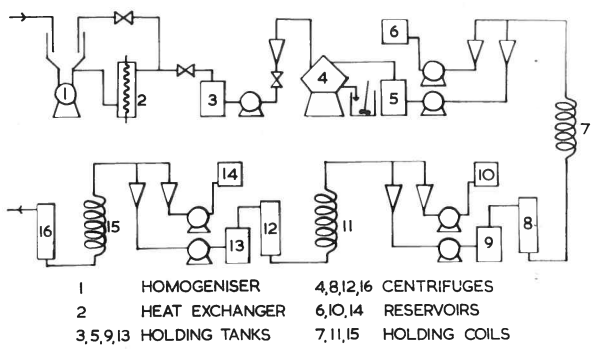


figure 1 (top) **Isolation of Prolyl tRNA Synthesase enzyme from Phaseolus Aureus (Mung Bean)**
The beans are fed continuously to a grinder (3) *with extraction liquor. Cell debris is removed continuously in a centrifuge* (6) *and after final traces of solid have been removed in a second centrifuge* (9) *the liquor is pumped to meet a stream of acid from reservoir* (11). *The first acid precipitate is removed continuously in a centrifuge* (13) *and the acid precipitation is repeated.*

figure 2 **Isolation of an Aliphatic Amidase from Pseudomonas Aeruginosa**
Continuously harvested cells from a fermenter (not shown) are pumped to a homogeniser (1) *where they are disrupted. Cell debris is continuously removed in a centrifuge* (4). *In three identical continuous stages the liquor is then subjected to the action of streptomycin* (6) *and polyethylene glycol* (10) & (14). *The precipitates are removed in centrifuges* (8), (12), (16).

chemical engineering terms. We therefore began detailed studies of operations such as continuous cell disruption and continuous precipitation with a view to providing fundamental data. The study on cell disruption is well advanced and suggests that it will be possible to define the operation in precise mathematical terms.

Another reason for making a detailed study of such operations is that a number of them are widely applicable in the biological industries. A study of the disruption of micro-organisms to release enzymes is also relevant to the release of protein from cells and hence to the economic feasibility of obtaining food proteins from single cell material grown on

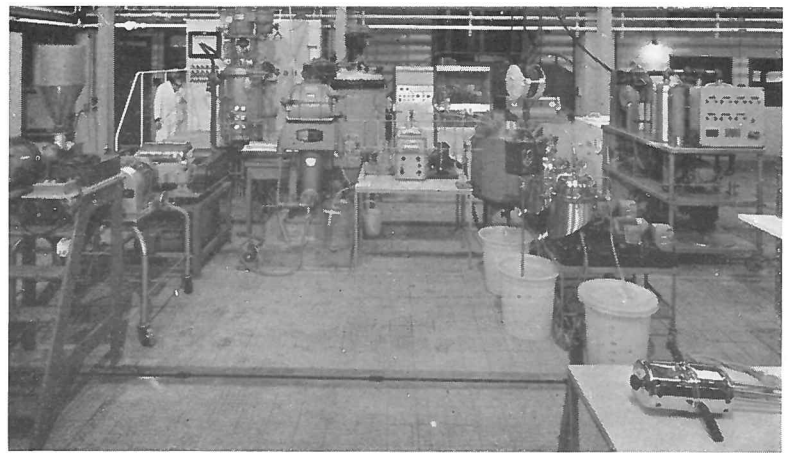


figure 3 **Enzyme Isolation Pilot Plant at University College London**

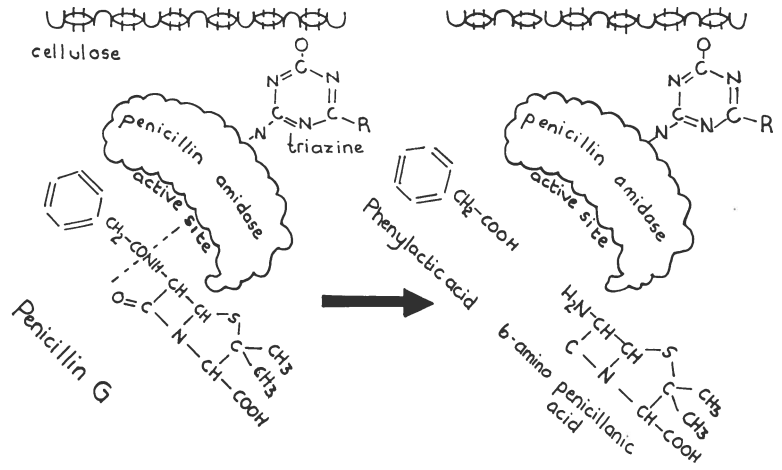


figure 4 **Action of Penicillin Amidase enzyme on Penicillin G**
Diagramatic representation of the enzyme deletion of the original side-chain of penicillin G in an immobilised enzyme reactor.

hydrocarbon (petroleum or natural gas) or carbohydrate. The special problems of continuous large scale solid/liquid separation of protein precipitates have very close analogies in the food industries and the mechanism of precipitation of proteins especially in relation to continuous operation is being followed with interest since few detailed studies have been made in these industries. It is important to us that there should be close interactions of this kind with other aspects of biochemical engineering because our research goes hand in hand with a teaching programme on all aspects of Biochemical Engineering and it would be unfortunate if it became too biased towards one area. Also, there is a danger that in an effort to give enzyme technology the emphasis the SRC believes it needs, other areas of biochemical technology and engineering could be down-graded.

The second principal theme in our fundamental studies concerns the simultaneous isolation of a number of different enzymes from a single mass of tissue. In the laboratory it is usual to isolate at one time only one, or at the very most a very few, of the thousand or so intracellular enzymes (that is, enzymes found inside cells) and to discard the remainder as purification proceeds. The same thing happens when enzymes are manufactured on an industrial scale. The protein-dissolving enzymes used in detergents are separated from the cells which produce them and the cells are discarded. (The separation is relatively simple in this case because the enzymes are secreted by the cells which do not, therefore, have to be broken up to release them.) When intracellular enzymes are made industrially – invertase, for example, which is used to convert cane-sugar (sucrose) into invert sugar (a mixture of equal amounts of glucose and fructose) – the process is controlled so as to optimise the yield of a single product.

In some instances this policy will remain the best, such as when a particular enzyme can be stimulated to a high level within the cell. However, this is not often possible, and even when it is there may be economic advantages in using the waste tissue as a source of other enzymes. Their recovery may be more attractive commercially if a number can be isolated simultaneously. The costs will certainly not decline in direct proportion to the number of enzymes simultaneously isolated, but the approach may be valuable in some circumstances, just as continuous isolation coupled to continuous culture may be in others.

As with continuous isolation we have chosen several systems on which to test the concept of simultaneous isolation. With Bakers' Yeast we are beginning to examine the isolation of a number of enzymes of possible economic importance. Another system, *Escherichia coli*, is perhaps the micro-organism which has been studied in most detail, biochemically and genetically. The enzymes from this bacterium are therefore in great demand for detailed physico-chemical study.

For our work, we have chosen a group of enzymes, the aminoacyl-tRNA synthetases, which are of particular interest to molecular biologists, in view of their central involvement in protein biosynthesis. The project will have the useful second aim of providing material for study by the team at the Cambridge MRC laboratory with whom we are collaborating. This group of enzymes is also a logical choice for purely operational reasons in that the assays for the 20 enzymes of the group are closely related and therefore particularly amenable to automation. Automatic assaying will be essential for any process which must keep track of a large number of different products.

handling problems

The last material we plan to employ as a test material for simultaneous isolation is human tissue. A joint project with the Department of Human Genetics at University College, on the isolation of enzymes from red blood cells, made us aware of the difficulty of obtaining human enzymes for detailed study and it seemed probable that, in view of the scarcity of human tissue, simultaneous isolation would be of interest here. Feasibility studies are now in progress with placentae, but a major obstacle in the large scale processing of any human tissue is the occasional presence of viruses.

This is an acute example of one feature of large-scale isolation of enzymes – the need to take bio-safety very seriously. We are fortunate in having the collaboration of the staff of the London School of Hygiene and Tropical Medicine in establishing a programme of environmental hygiene and personnel screening for our laboratory.

The third, and in many ways the culminative theme, of the study concerns insolubilised enzyme reactors. As already indicated, to be really useful and industrially economic, enzymes should be retained in some manner and if possible stabilised. Laboratory studies of the immobilisation of enzymes have been proceeding for over fifty years but only in the last decade have reasonably well defined systems been prepared. Three from among those prepared at University College will serve as examples of the state of knowledge and the potential interest of insolubilised enzymes. **Penicillin amidase** is crucial in the synthesis of the newer semi-synthetic penicillins. It removes the benzyl side-chain of the old penicillin to permit the addition of a new synthetic side-chain *(see figure four)*. At present a whole organism containing the enzyme is used but more effective control and continuous operation would be possible with an insolubilised enzyme reactor. The insolubilised enzyme retains full activity at 37°C for 11 weeks compared with a loss of activity by the free enzyme of 65% in 3 days. **Amyloglucosidase,** is employed industrially in the soluble form to convert starch to a syrup containing a high proportion of glucose. The insolubilised enzyme acts effectively on viscous solutions and retains full activity for 100 hours at 55°C. Again closer control and continuous operation would be possible using a fixed enzyme reactor. Finally, insolubilised **β-galactosidase** has been used to bring about the continuous conversion of lactose to glucose and galactose. The process may become industrially important as a means of producing, from the large amounts of lactose obtained as a by-product in butter and cheese manufacture the more useful sugar glucose.

In each of these studies laboratory or small pilot-scale projects have been completed. The next phase with single enzyme reactors is concerned with establishing their effectiveness in industrial pilot-scale operation and where necessary modifying the support material and associated systems to take account of practical problems such as blockage by suspended solids, microbial spoilage and poisoning by metals. As in the case of large-scale enzyme isolation, there is a dearth of basic biochemical engineering data on these aspects which must be patiently remedied. This part of the programme is also supported by industry and by the NRDC.

The next phase of fundamental research will concern reactors employing more than one insolubilised enzyme. There is no reason why some of Nature's bio-synthetic pathways should not be emulated but perhaps more interesting is the possibility of combining enzymes in new ways. A start has been made on multi-enzyme systems with a reactor containing two enzymes (pyruvate kinase and lactate dehydrogenase) each enzyme being attached for convenience to a separate sheet of cellulose.

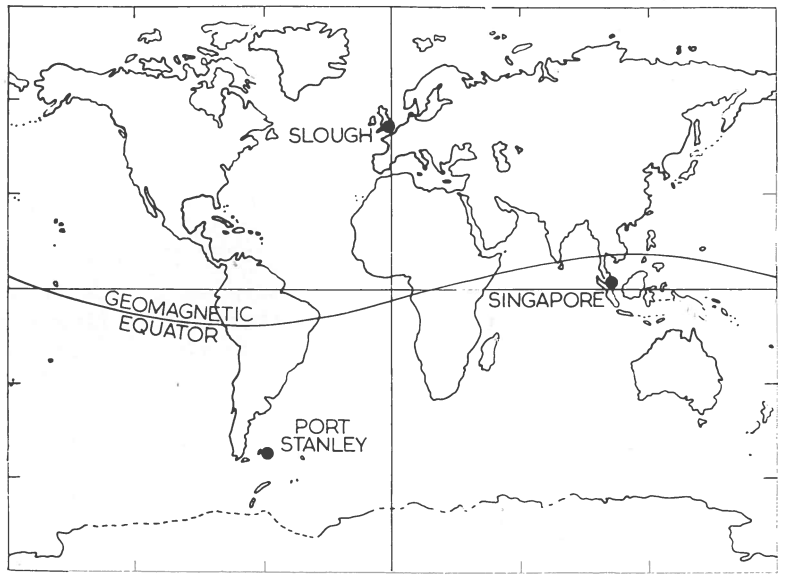
Some processes involving insolubilised enzymes have already gone beyond the laboratory stage. A Japanese company is using a insolubilised enzyme reactor to produce twenty tons a month of L-amino acids, which are added to cereals to improve the quality of their protein. In the US drug industry antibiotic and steroid conversions are being undertaken with similar reactors.

So the age of enzyme reactor technology has begun. Against this background, the development of British enzyme technology is a matter of some urgency.

quest abroad

Since the work of the Science Research Council is by no means confined to the United Kingdom, news and pictures from overseas have been collected for the following pages.

To begin – the pictures on this page show RSRS stations around the World which also, of course, have connections beyond the World – into outer space.



far east

the Ionospheric Observatory at the Singapore outstation of RSRS, which also includes a satellite data acquisition station.

far west

the satellite telemetry receiving station operated by RSRS on behalf of the European Space Research Organisation which is one of the RSRS installations at Stanley, Falkland Islands.

guest column

Mr. S. F. Bailey who is Secretary to the University Grants Committee of Hong Kong was formerly a member of SRC finance division. In this report from Hong Kong it appears that he is not the only SRC contribution to a research grants programme that is, as yet, barely under way.

beyond chinese

There are two universities in Hong Kong: the older one is the University of Hong Kong, which was established in 1911 on the foundation of the Hong Kong College of Medicine, which goes back to 1887: and the other is the Chinese University of Hong Kong which was established in 1963 on the basis of three existing colleges – Chung Chi College, New Asia College and United College. Both universities are still very small: in 1969/70 the University of Hong Kong had 2,816 students and the Chinese University of Hong Kong 2,215. By 1973/74 these figures are expected to rise to 3,130 for the University of Hong Kong and to 2,870 at the Chinese University of Hong Kong.

The total population of Hong Kong is now about four million of whom approximately 56% are under 25 years old: and the university population is therefore indeed a small one – admissions are about 12% of secondary school leavers and only about 0.5% of the age group 18 to 21.

In theory the two universities serve slightly different purposes which, again in theory, arise from a doubled secondary school system. On the one hand there is the Chinese Middle School system, adopted from the mainland system in which, naturally, Chinese is the language of instruction (and in which, incidentally, there is only one year of Form VI). A large majority of all students is Cantonese-speaking: and not all understand Mandarin well enough, in which, at least at the Chinese University, much of the instruction actually given in Chinese is likely to be. Moreover the supply of University standard teachers who speak Mandarin or Cantonese is limited: and in practice a great deal – probably more than half – of the CUHK teaching is in English. At the same time in theory all, and in practice a majority, of the students at CUHK have gone to the end of their secondary school with Chinese as the language of instruction: and this imposes a considerable burden of English teaching right across the University for the first two years (the basic course at The Chinese University of Hong Kong is four years). The fact that a similar across-the-board teaching of Chinese for the first year is also necessary is perhaps significant.

On the other hand there is the Anglo-Chinese secondary system in which the medium of instruction is English, and this is actually the larger of the two school systems. The University of Hong Kong also uses English as its medium of instruction and the whole of its intake comes from this system. Even so the general standard of English is often inadequate and this University also has to do a great deal of English teaching across its first year (the basic course here is three years).

In strict theory the reverse was supposed to apply too i.e. school leavers from the Anglo-Chinese system went only to the University of Hong Kong. This no longer applies and many Anglo-Chinese school leavers now go to The Chinese University of Hong Kong – in this year roughly 30% of their intake did so.

a few faculties

With such a secondary system and what seems to be less than satisfactory English teaching: with no serious possibility of clearing the tertiary level wholly in Chinese (either Cantonese or Mandarin) and with one University wholly, and the other heavily, committed to teaching in English: then clearly University problems here have a slightly different aspect before so much as looking at standards, courses, academic policies, research or anything else.

The Chinese University has only three Faculties – Arts, Science and Commerce and Social Science. Its campus is still being built. For the moment it has no proper central teaching accommodation and uses college accommodation, all of which is in varying degrees inadequate. Worst of all it has no central science laboratories. The University of Hong Kong has five Faculties – Arts, Social Science (which includes a new Law Department), Science, Engineering and Architecture, and Medicine. The three Engineering Departments (Electrical, Mechanical and Civil) are not as well equipped as they might be, but are improving their position as rapidly as funds allow. The Science Departments are fairly well equipped

guest column continued

and set very respectable undergraduate standards. The Medical School is a good one and relatively large, with an intake of 120 undergraduate students per year, which will rise to 150 per year in October 1970.

Both Universities are almost wholly undergraduate institutions. In 1968/69 they had between them only 62 post-graduate Science students and 17 in Engineering. This is not for lack of good teachers or of able students. The trouble is there is no separate organisation other than the University Grants Committee with a commitment to post-graduate work: and the University Grants Committee, although far from indifferent to post-graduate problems, has naturally had to concentrate on the main tasks of assisting both Universities to develop and actually getting the new Chinese University built. We have no Social Science Research Council, no Agricultural Research Council, no Medical Research Council, no Natural Environment Research Council and no Science Research Council, not even the equivalent of a Department of Scientific and Industrial Research. Moreover the University Grants Committee system in Hong Kong is not a weighted one and for all purposes – including equipment – a post-graduate student counts as *one* alongside an undergraduate student. Even if Hong Kong were not a comparatively old-fashioned laissez-faire society (which it is) the advocates of research would therefore have an uphill job no matter how orientated the research might be.

help from Atlas

Perhaps the most remarkable thing is that any gets done at all: but nevertheless some *is* done. None of it constitutes anything like a major programme, and perhaps such a programme would in any case be premature in Hong Kong. Quite the most interesting scheme has nothing to do directly with research although it will certainly radically affect further prospects. This is the development of a Joint Universities Central Computer project (just approved) under which the two Universities will jointly own and operate a central computer, with remote controls and displays at each University. A good deal of helpful advice on this has come from the U.K. University Computer Board and from Dr. Howlett of the Atlas Laboratory. The machine will be a middle-range type, roughly equivalent to a CDC 3300.

A third set of remote controls has been reserved for a Polytechnic now under planning and scheduled to have an intake of 4000 day-time students in 1973/74 (I should perhaps explain that in addition to being Secretary to the University Grants Committee I am also a Member and Secretary of the Polytechnic Planning Committee.) Both Universities already have small machines – the University of Hong Kong an IBM 1620 and The Chinese University of Hong Kong an IBM 1130 – and the joint central facility should enable them to tackle a range of work which at the moment is out of the question.

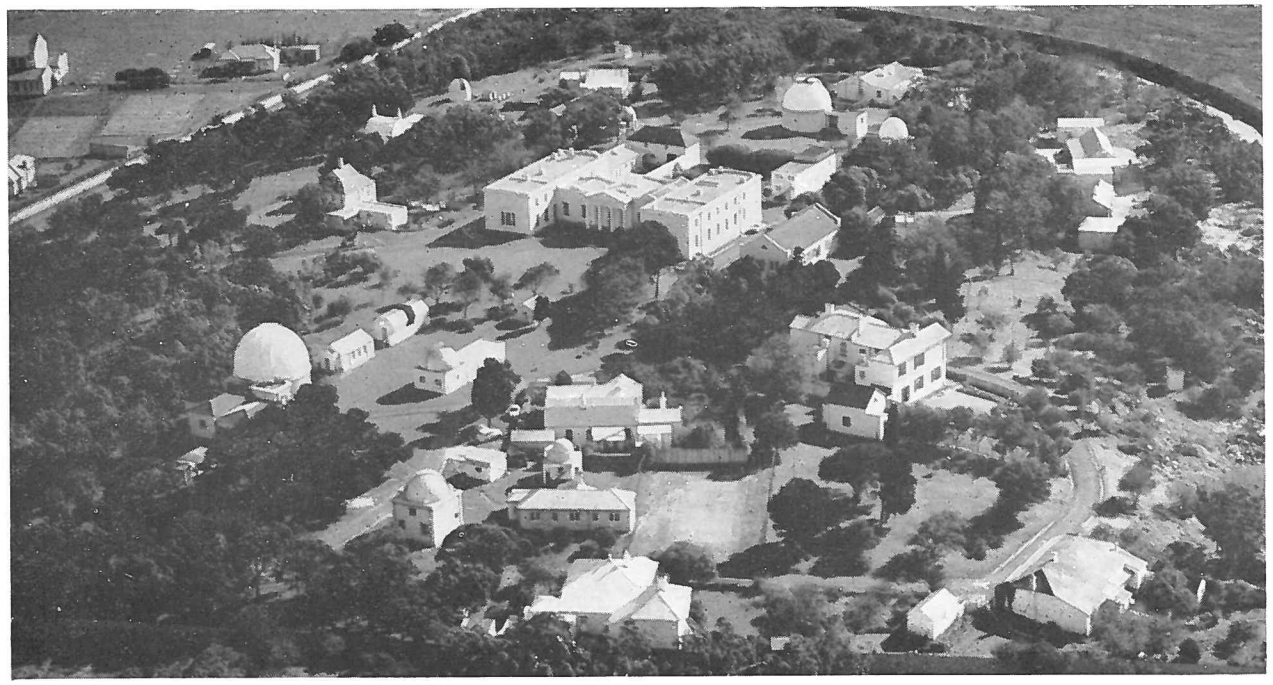
The total number of post-graduate students at the two Universities, including 39 in the two Schools of Education, is 224 or approximately 4.4% of the student body: and only 1.6% of the student body are in Science and Technology. It seems a small allowance for a country which has no physical resources and is wholly dependent on its people. But – and it is a large 'but' – there is no organisation with a primary commitment to post-graduate and research work. The University Grants Committee of Hong Kong has its primary commitment to the development of the Universities as a whole and it is heavily, although by no means exclusively, concerned with undergraduate development.

a brighter prospect

Hong Kong is a colony and, legally, entirely dependent on the UK. In, for example, such matters as air-transport, it counts as part of the UK: and it would be nice if in addition it counted as part of the UK for SRC grants. This is perhaps a bit unrealistic: Britain has other and more pressing demands on her resources, and Hong Kong is in monetary terms comparatively well off. The interesting question is not whether SRC can provide research grants, but whether Hong Kong by its own efforts can adapt the general education system better to twentieth century purposes. This is not just a matter of the Director of Education leaping into action but of a large number of people coming to recognise, however vaguely, that something needs changing: and that not all the old ways are going to work for ever.

It may be that the principle lever for change will (as some expect) be the development of the proposed Polytechnic. If the present time-table is maintained it will in three years increase the numbers in higher education (consisting at the moment of students at the two Universities plus a small Technical College) from the present target for 1973/74 of 7,500 to 10,000. This may not sound very much: but it can hardly fail to highlight problem areas at the secondary level.

How well, or how far, this will work out remains to be seen. It should be possible to appoint a Director of the Polytechnic within the next five or six months: and some of the pattern should begin to appear in about twelve months' time. If so it might justify another, and perhaps more exciting, report from Hong Kong.



above is the Royal Observatory at the Cape of Good Hope which will be celebrating its 150th anniversary later this year.

below is a Skylark rocket payload under pre-flight tests at the Woomera range (photo 1964).

quest abroad—south

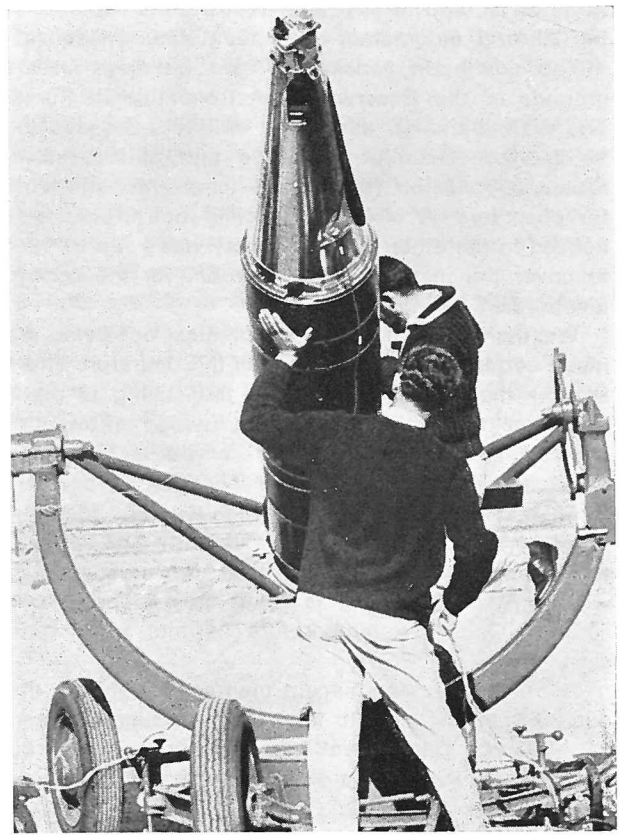
W. M. Burton

In South Australia staff from several SRC laboratories are working on the Woomera range preparing experiment payloads for 'Skylark' rockets.

The present launch campaign extends from March to April 1970 and seven rockets are scheduled to go up. They will carry payloads prepared by SRC groups working at the Astrophysics Research Unit, Culham Laboratory and at the Royal Observatory, Edinburgh as well as experiments from the Meteorological Office and the Space Research Groups of Leicester University and University College, London.

Each year there are three separate launch campaigns, when a series of Skylark rockets are fired during a two month period. SRC controls and plans the research programme, while the British Aircraft Corporation is responsible for firing the rockets from the Woomera Range.

Several of the rockets will carry very complex payloads which separate from the rocket motor when all of the solid fuel propellent has been burnt and then become stabilized in space, pointing very accurately towards the sun or the moon as the particular experiment requires. A typical Skylark payload reaches an altitude of 120 miles and this allows the experimenter just about three minutes of precious observing time in which to study the universe undisturbed by the effects of the earth's atmosphere – a very short time in comparison with the years required before to prepare the experiment and afterwards to analyse all of the data obtained.



quest abroad

they haven't kept us out of Europe

Besides contributing to CERN nuclear research at Geneva and ESRO space research at Kiruna, Sweden, SRC has selected some pleasant spots for astronomy. They are reported on in the two articles which follow.

Richard Dodd is the Scientific Officer in charge of the Schmidt telescope at the Monte Porzio outstation of ROE shown above.

resort to Italy

R. J. Dodd

The Monte Porzio outstation of the Royal Observatory Edinburgh lies some fifteen miles south east of Rome at an altitude of 1,200 ft. in the Alban Hills. To the south of the observatory one looks towards the vine, olive and pine covered hillside of Tusculum, an ancient Etruscan settlement. The plain of Rome lies northwards, and to east and west are the foothills of the Abruzzi mountains, and the Mediterranean sea.

The outstation consists of two buildings in the grounds of the Osservatorio Astronomico di Roma. The main building, a circular structure, houses the 16/24 inch Schmidt telescope and offices, storerooms, a workshop, rest room, kitchen and bathrooms for observers. A Michelson stellar interferometer is housed in the other building, which has a run-off roof to cover the instrument and a room for the control electronics.

Weather conditions for astronomical observing are much better in Monte Porzio than in Edinburgh. There are far more clear nights and the seeing is much better at the Italian outstation, which allows for shorter exposures. Also the more southerly latitude of Monte Porzio means that observing is possible throughout the year. The climate is typically Mediterranean with hot dry summers and warm wet winters, though snow in the Alban Hills is not uncommon in winter. Most observing is done during spring and summer when the temperature permits working in shirt sleeves.

There are three permanent members of staff at the outstation. From time to time they are supplemented by observers sent from ROE and occasionally by research students from the Astronomy Department of Edinburgh University.

The Schmidt telescope is used both for direct photography and for studies of stellar spectra; a great variety of observing programmes are currently being carried out with it. The quasar 3C 345 has been monitored with a view to finding periodicities in its light emission, the observations being processed with the Elliott 4130 computer at the Royal Observatory in Edinburgh. Some evidence of quasi-periodic outbursts has been obtained. Clusters of very young, hot stars have been photographed with different combinations of filters and photographic emulsions. It has been found that such clusters are often surrounded by dense shells of dust or smoke, which may be primordial material expelled from the cluster by pressure of radiation from the stars.

Work in the near infra-red is also carried out. A topic of particular interest has been a near-infra-red survey of red giant and carbon stars in part of the constellation Cygnus. This was a joint effort with the Rome Observatory and made use both of our own Schmidt camera and of a second Schmidt telescope at Camp Imperatore in the Abruzzi. The results will be published soon.

The Michelson interferometer is an instrument with a base line of two metres for observations of the pole star. It will be used to test methods of measuring, electronically, the 'seeing' spectrum that is the quality of a star's image after it has passed through the atmosphere. Binary star observations are to be made after the initial seeing experiments are completed and when the instrument has been mounted on an altazimuth. These will yield new data on the orbits and masses of such stars.

spain under the stars

When I first started astronomy I never thought that one day I would find myself walking across a mountain snowfield to work a telescope belonging to the Society of Jesus, but since June 1968 the RGO has had regular use of such a telescope in the Sierra Nevada in Spain.

The 12'' telescope is in a small building at a height of 8,700 feet some twenty miles from, and over a mile above, Granada. Observations are made with a photometer attached to the end of the telescope, so, with the aid of a set of colour filters, the magnitudes and colours of various celestial objects can be determined. This type of work needs very clear skies, for accuracies of the order of less than 1% are required and even very thin cloud can prevent this. Conditions in Britain are not at all good for photometry and it is hoped that a British observatory will be established, probably near the Mediterranean, where it will be a feasible proposition. In the meantime the Sierra Nevada site is being given a thorough test in the course of a programme of photometric observations.

The Sierra Nevada Observatory came into being a few years ago when the Observatory, a Jesuit institution, at the University of Cartuja, Granada, decided to take advantage of the road up from Granada to the Pic de Valeta in the Sierra, which was being extended. This road reaches 10,400 feet at the top.

The building, consisting of five rooms for living and working and the dome itself, was built near the road and within reach of a very isolated hotel. The telescope was a gift from Georgetown University in Washington, D.C., and was shipped by the US Navy as part of its goodwill programme. By an agreement between the Astronomer Royal and the Jesuits, the RGO has helped in the provision of electric power and other facilities, in return for time at the telescope.

As most photometry can only be done with a dark sky, there are only about seventeen days around new moon which can be used each month. This has shaped the present observing system whereby two observers go out to Spain for these days. Flying to Malaga, one drives the hundred miles to the Sierra, to stay at the hotel near the telescope. Then each clear evening, or as soon as the sky becomes clear, one goes to the Dome. In summer, the trip from the hotel is a car drive along the road and a walk of 100 feet upwards to the building itself. At 9,000 feet this is tiring.

In winter the whole area is thick with snow. This means donning army arctic clothing, including long woolly coms and hooded windjacket trimmed with wolverine fur, plus ski boots and crampons, then checking torch, compass and whistle and the snow goggles for the morning. The route is a dark, cold and tiring climb, which takes over half an hour and rises 500 feet. Night time temperatures can drop as low as –20°C, and a major problem is the freezing of the rotatable dome. When this happens the snow and ice is cleared from the skirt of the dome by climbing out on to a catwalk and hacking away with an ice axe.

At the dome observations are made until dawn or until clouds arrive. The preliminary reductions from the pen recorder output from the photometer are sometimes made during the day. But clear skies mean working all night and, especially in the summer, night after night. Sleeping and resting then become the main priorities.

Both the preliminary and the final computer reductions to provide magnitudes and colours are made at Herstmonceux. Work has been done already on variable stars, Kapteyn Selected Areas, the establishment of standards, a systematic survey of some nearby stars, and other subjects.

There are horror stories of belongings sliding over the precipices, people being marooned by bad weather, 'gyppy tummy' and trying to obtain equipment in Granada at temperatures of over 100°. But these are offset by the pleasure in actually doing photometry, such a rare occurrence in England, a nice climate, an interesting country and a holiday afterwards in Spain or North Africa.

Picture above shows the Sierra Nevada Observatory in winter.
The picture on right is A. J. Penny, a Scientific Officer at RGO, who wrote the article from on the spot.

people and their pastimes

Les Mitchell RSRS

In the last issue of Quest the story of Dave Boffin told how a radio amateur could progress from a bed-spring to a sixty foot tower. Now we tell how Les Mitchell uses the same activity to extend another; and include some suggestions on how to get 'tuned in' to this world wide network.

Les Mitchell with G3 EKL and two local scouts at Blandford Camp in Dorset.

'CQ Jamboree! CQ Jamboree! . . .'

The first time that call came over the radio made a day to remember for Les Mitchell. This special call sign of Jamboree-on-the-air, known as JOTA, was first heard eleven years ago.

Les Mitchell works on the office services side of the Radio and Space Research Station. He has not been 'on the air' there but he spends two hours every Saturday morning as a radio amateur, transmitting and receiving calls from his home on equipment he has built for himself over some years. The first hour is spent on messages for the boy scout movement in the British Isles and the second for Scouts in Europe.

war and friendship

During the war, Les Mitchell was a radio mechanic in the Fleet Air Arm of the Royal Navy, stationed at Lee-on-Solent. His interest in radio began there and the recommencement of post war amateur transmitting was a strong attraction, which led him to become a qualified operator. At the same time Les had continued to run a boy scout troop throughout the war and when posted to USA, in 1942–43, he became an assistant scoutmaster in Brunswick, Maine, and in 1945–46 he ran a troop in Sydney, Australia. He had always regarded the world scout movement as a valuable contribution to international friendship. It seemed especially important in war time.

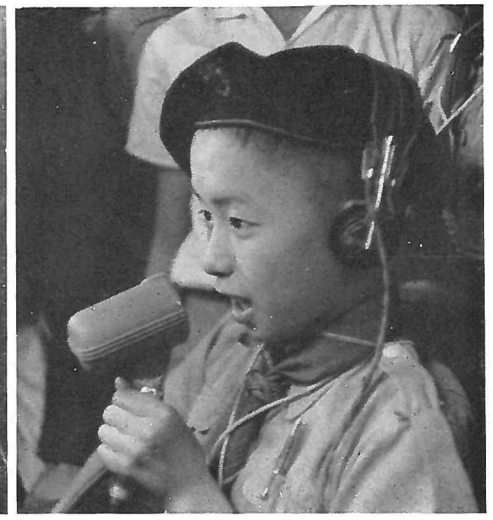
In the next ten years Les was an active radio amateur while equally active in his support of scouting – becoming District Commissioner of Scouts in the late 1950's. He introduced radio as an activity for his own scouts and ran several 'radio' camps at Reading. Then in 1957, at the World Jamboree held at Sutton Coldfield, he helped to set up a field radio station to contact some of the millions of scouts who could not travel to the jamboree.

This experiment raised such great enthusiasm that Les decided to try a jamboree 'on the air' and in May 1958, as Honorary Organiser, he ran the first one. So many scouts joined in that it was decided to make it into an annual scouting activity to supplement the meetings of the World Jamboree which are only held every four years. Organisation on an international level was passed to the Boy Scouts World Bureau (in Geneva) and Les continued to be National Organiser for Great Britain.

In this country there are about 8,000 licensed radio amateurs. Many are pleased to show their equipment to visitors or cooperate with organisations to provide transmitting facilities. Only licensed radio amateurs may make transmissions or speak through the microphone – to get a licence one has to pass a City and Guilds Technical Examination and the GPO morse code test. At this point you are given a call sign – CQ G3 BHK identifies Les. No technical qualifications are needed to become a *listener* and anyone may tune in to radio amateurs over a short wave radio receiver. Broadcasts are made within bands of frequencies that spread from just outside the medium wave up into the centimetre wavelengths.

In some countries, such as Australia, Norway

John Waters of 1st Edgware (Herons) scout group operating from Baden-Powell House, London, assisted by Richard Farm, Venture Scout of 3rd Harrow Weald.



Liu Tak On of 5th Kowloon group, Hong Kong.

and the United States, *anyone* can talk on the air, as long as they keep within the strict rules of broadcasting and use equipment operated by a licence holder. The Governments of a few other countries waive transmission restrictions especially for boy scouts and girl guides during the forty-eight hour period of the JOTA so that groups of people can make 'live' voice to voice contact and the organisation hopes to persuade more Governments to recognise the event in the same way.

yells into the ether

In 1967 the World Jamboree was held at Idaho, USA, and as this was the year of the Diamond Jubilee of Scouting and the tenth international jamboree-on-the-air, JOTA made special preparations. Les discovered that Idaho was not merely the other side of the Atlantic, it was another 2,000 miles beyond New York, so he asked a scout radio amateur who worked for the BBC to help. As a result JOTA transmitted through a special 700 foot long multi band aerial that year and, instead of the usual search round the wave band, immediate contacts were made with Idaho, and with Australia, New Zealand and stations all round the world. Like all good radio operators, scouts try to make worthwhile contacts; the number is not important. Last year for instance Les and the Dorset Scouts (who were his local troop before he moved nearer London) talked for thirty minutes to ZL3BT in New Zealand and were taught a camp fire yell in a mixture of Finnish and Swedish by SMOXAE until they were word perfect.

The time spent on radio for scouts does not end for Les with the annual JOTA. During the rest of the year he has numerous letters to answer or 'pass on'. Sometimes he meets visitors from abroad but regular operators can get to know their contacts quite as well over the air. He has made contact with Fr. Moran in Katmandu; Bill Pole-Evans in the Falkland Islands; also operators in St. Helena, Tasmania, Seychelles and other 'out of the way' places.

HV 3ST is unusual in that it comes from Vatican City. An ex-scout commissioner from England, Robin Paulson, at College in Rome has been assisting the local operator Ed Amram to contact scouts. In the USSR there are few amateurs and transmissions are usually made from club stations. Les heard recently that one operator there, contacted during JOTA, said that he was a member of a youth organisation based on the ideas of Baden-Powell. This is not known 'officially'.

To anyone who wants to find out how to become a radio amateur, Les recommends a radio club. There is one in practically every large town in Great Britain. They welcome new members and are always willing to help beginners. Once you hold a licence, you may operate by morse or voice or, on certain frequencies, transmit TV pictures. Permission can be granted to operate mobile from a car, sometimes from ships, and certain countries allow amateurs to transmit from aircraft.

On the subject of scouting Les is himself a good ambassador. One of the chief aims of scouting is he believes also true of radio operating: that is to provide a medium whereby people from anywhere in the world may converse with freedom and on an equal footing.

Q column by 'observer'

Have you noticed a tendency towards Internationalism in this issue of Quest? Just before the holiday season seemed a good time to mention some of the best of the resorts where one may go for a change entirely at Council expense. Booking by rail, sea or air is done by your friendly personnel office and first class travel is awarded on merit. A special bonus is the full itinerary and plans on how to spend your stay which you will receive—in good time to save you the trouble of making any plans of your own—from your cheery Head of Section.

● Even the least scientific must have heard of Pythagoras but may not know that his greatest success lay with music (and we don't mean the song about the 'right tri-angle').

Pythagoras observed that the strings of musical instruments delivered sounds of higher pitch as they were made shorter and that the pitch could be simply correlated with length. He discovered that if one string was twice the length of another, it emitted a sound one octave lower. If the ratio of the strings were three to two the musical interval called a fifth was produced and if it was four to three the interval was a fourth. Thanks to these observations, the study of sound is one branch of physics in which Greek views have lasted into modern times.

We found this in Asimov's biographical encyclopaedia of Science and Technology which contains brief histories of over 1,000 scientists from Thales (eclipses in 600 BC) to Galileo to Hoyle. (There is a copy in the LO Library).

● *A prize is offered for a short treatise of not more than 100 words in prose or verse on an invention to make a new kind of sound. If that is not in your line, we are also interested in ideas on how to suppress some of the most annoying of modern noises. The prize for the winner will be a £1 record token to spend on any favourite noise. We hope that even the most modest will expose their talent since you can always pretend that you only did it for the money.*

● A suggestion for study in a more traditional field that seemed both timely, for the present season, and promising appeared in a recent RSRS bulletin. We are duly grateful for permission to reprint as follows:

Dear Sir, As our research programme becomes more closely associated with problems of a practical nature I feel sure your readers will note with interest the following extract from a recent issue of Proc. IEE—'A noticeable reduction in noise pick-up took place when gooseberry bushes were removed from the front of the test site.'

Now, Sir, there's a fruitful topic for study! We know of course that such vegetation is correlated with one source of interference, having a noise spectrum dominantly in the audible range and exhibiting a diurnal variation with a maximum generally soon after midnight. But the possibility that these sources might possess a wider spectral output had not occurred to us, and their characteristics would seem to deserve further study. So far as we can determine, these sources are quite inexpensive to produce and I'm sure there would be no shortage of staff willing to assist in their construction, with a view to observations starting in the autumn. I propose to raise this at the next progress review. Yours hopefully—Volunteer.

. . . where all is revealed

Contrary to accepted practice and the IPCS handbook, a senior member of RSRS staff was found to be sharing his office. If you are hoping for revelations, nameless abominations, etc. dont bother to read on. The Senior member was not even aware of his partner. It was a Cox and Box arrangement and, curious paradox, the unofficial inhabitant was discovered only when he had no further needs. In short, a rat had run its last race and left the earthly remains in the ducting to lie in cold obstruction and to rot.

This fact of death soon manifested itself and a removal operation was mounted. Next, to crush the general cause of this particular complaint, the Health authorities were appealed to and a man arrived. In the best Holmesian tradition the expert spent little time dealing with the obvious and almost at once occupied himself with the seemingly irrelevant. He went for a stroll round the outside of the building. Returning shortly afterwards he pronounced — 'A simple case: block up a hole over by the boiler house and all will be well'. He then left, presumably to tackle more subtle problems worthy of his steel.

It was all very impressive, so much so that when this expert asks the corporation for a rise it would be as well for the Mayor to grant it. He seemed to like serious music while working, no one saw him with a radio but the sound of a flute or recorder was heard. A funny old tune it was — it seemed it might be sort of German, fourteenth century.

Quest Quarterly Quote

Among the favourable Press comments on GALAXY appeared the following:

'Senior Astrologer, Dr. Vincent Reddish, said "At dawn yesterday we made history".' The newly created grade, in place of SPSO, caused more stir than the quotation but, regretfully, we learn from official sources that both are fictitious. There were no predictions available for this issue of 'Quest'.

● We think though that whoever blue-pencilled 'SPSO' may have been right in intention. Like the anonymous 'public servant', it might have lacked impact beside news of a breakthrough in automation in an age of technology. Therefore we suggest you ACT NOW. Let's have our own campaign, properly placarded — with sit-ins, sit-downs and the rest of the trimmings — for the right of everyone to have a title that befits their role in the Council. If Fulton's practical pattern of pay is adopted heedlessly, we might even get labels like CSD scale II — and where's the titillation in that?

Footnote: *pseudonyms are acceptable on any contribution for 'Quest' providing that the identity of the author is admitted to the Editor.*

swinging space

*If you transfer to London Office you may find that there is actually no room for you: not a room — any room. With an eye to the minimum standards laid down by the Brambell Report, our man in the very middle * has thrown out a few suggestions as illustrated — thought out in no more than the space allotted to one waste paper basket.*

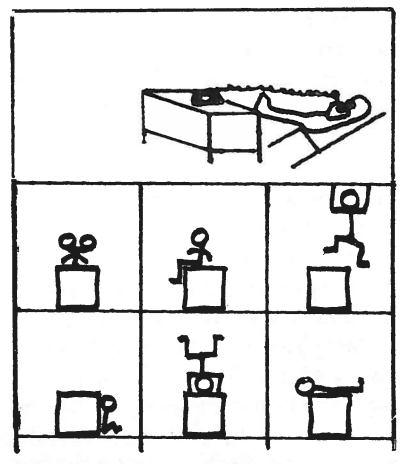
Some valuable space is occupied by those employed to consider the problem, yet they might do better to move outside to get a broader view. Around the London Office portion of State House there is nothing for miles except some pigeons and an occasional helicopter. Finance division, and we do understand this, haven't authorised even a very small helicopter but there are other resources. Window cleaners' cradles are nearly always vacant and every window on the twelfth to fifteenth floors is fitted with a ring to swing from like the fairy in a pantomime — though perhaps these are reserved for future O and M inspections. Obviously all of them are mere short term solutions. Our ultimate answer — which may be inexpensive in comparison with accommodation in London, from what we hear, and certainly more interesting — is to take the lead in being the first to move into a Jumbo satellite.

* cartoons by Tony Treglown, LO

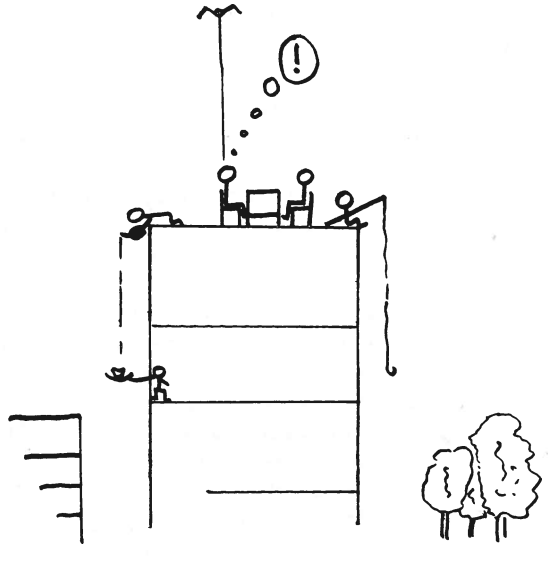
Oh rose
Do you suppose
That you were sent
To make me feel
That life is better
After all.

Nona

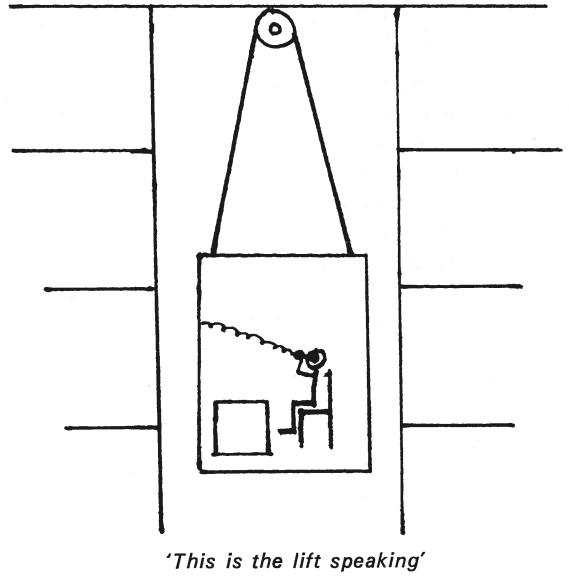
the human (?) zoo



'. . . as long as they can stand up and turn around it's humane.



But what if it rains?



'This is the lift speaking'

Enigmatic on the lawn she lies
Sunwarmed and black.
Unknowing bird pursues his search for food
Too near her paws.
She sleeps and pays no heed – apparently
– But then a flash
Of muscled movement swift and accurate.
The bird is dead.

Nona

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sports report

Even the most sporting may not realise that the SRC Sports and Social Association is nearly four years old.

It exists as a link between our own sports and social clubs and the Civil Service Sports Council to make sure that members' subscriptions to the CSSC are rebated to the various clubs in the correct proportion. Its prime object, though, is to encourage amateur sport and recreation in the SRC. Success depends on your enthusiasm.

The annual sports day comes high on the list of fixtures. This is the chance for your local talent to prove topdogmanship – so make a note that it will fall on Wednesday, 1 July this year, at the CSSC Sports Ground, Chiswick – and start practising!

Last year's visitors can tell you that there are plenty of playing fields, hard and soft courts, changing rooms and showers at Chiswick for most sports (and sexes) as well as a good bar and restaurant. Even if you don't shine on the turf, you can show off your capacity for beer and darts (friendly) and the strength of your shout (for your own team or anyone else's).

Work should *not* be brought and may be removed at the door for this occasion demands concentration and initiative as devoted to Lords and the World Cup (not perhaps often associated with the office). If local press gangs collect enough volunteers, the contest will be decided by matches of tennis, cricket, football, bowls, netball and athletics. Private enquiries have revealed that most of these go on in most local clubs.

At Daresbury they manage to fit in almost everything, including fishing and karate, and they take on outsiders at football, table tennis and netball in local leagues. In less than four years this association has made great progress. It also runs a club night, a film society, occasional dances and a traditional Hot Pot supper.

The Clubhouse at Herstmonceux was built at the Club's own expense and caters for most indoor sports, dancing and parties, and has its own bar. They play cricket, hockey, tennis and Stoolball – a traditional Sussex game. It might be described as something between cricket and rounders, for lack of space, but we think it merits a *Quest* article of its own (*over to you,* **Ed.**).

To the usual choice of indoor and outdoor sports, RSRS add motoring, bridge, photography, chess, billiards and snooker, amateur radio and wine making. The club bar is open at lunch time and on other occasions when the need arises.

(With gallons of home brew, the hangovers must be terrific, **Ed***).*

Unexploded bombs found in a piece of land marked off for a sports field have held up developments planned by the Rutherford and Atlas laboratories Recreational Society. Until the field is clear – all clear – activities are limited for lack of a nearby ground, but they do have football, cricket and putting. The lunch hour chess club and darts league are well supported *(see opposite page)*.

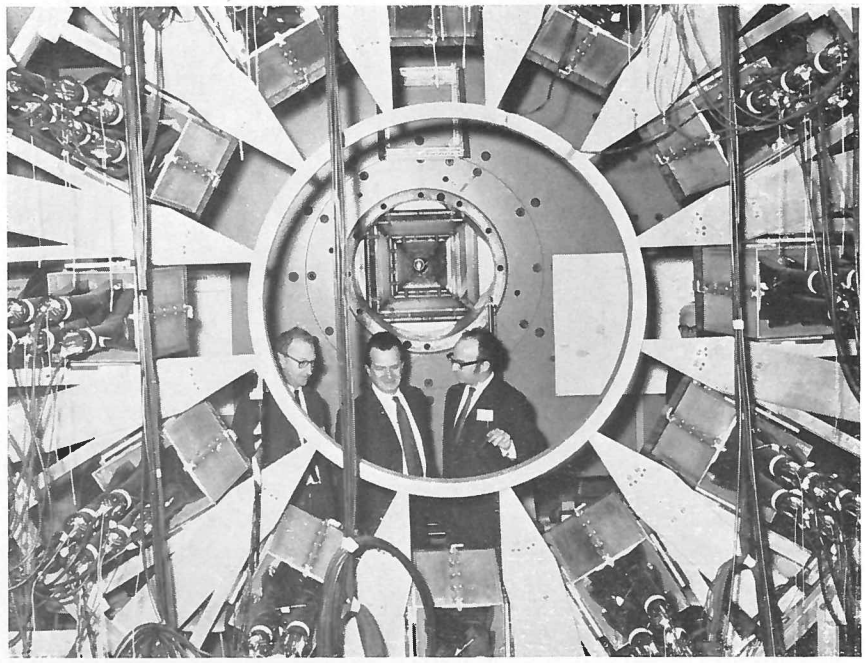
For lack of space, the LO sports and social club lost its club room but cricket, tennis, swimming and skating, using hired facilities, are catered for. Some go to the CSSC centre or belong to the Riding Club. Support out of office hours is light because of the wide selection of other activities but many join in to make the Christmas Party a great success. The lunch hour music society, which meets weekly to play recordings chosen by each member in turn, has totted up a score of 184 pieces by 78 composers to date.

Another combined effort, Sports Day being one, is the Curtis Bennett cricket competition, a tournament held for the whole of the Civil Service plus 'bodies' like us. All local clubs are invited to lend of their best for a SRC team of picked men – or eleven.

Evidently there are many ideas here on how to fritter leisure. Another time we will collect some from the outstations abroad who may even now be wishing they had a chance to meet the home teams. The SRC Sports and Social Association intends to encourage many combined activities between the SRC clubs. It means to play the game of bringing parts of SRC together – not as one but as a group of friendly rivals.

newsfront

Rutherford Laboratory visited by Minister of State



Dr. Stafford (Director of Rutherford Laboratory), Mr. Gerry Fowler M.P. (Minister of State for Education and Science) and Dr. H. Lipman framed by a ring of neutron counters used in the π 8 experiment on C-violation in the three pion meson decay. In the background is the large electromagnet in the gap of which can be seen the liquid hydrogen target and an array of spark chambers.

Emphatic discussion. *(below l to r) Dr. G. H. Stafford, Dr. T. G. Pickavance, Mr. Gerry Fowler and Dr. L. C. W. Hobbis.*

checkmate

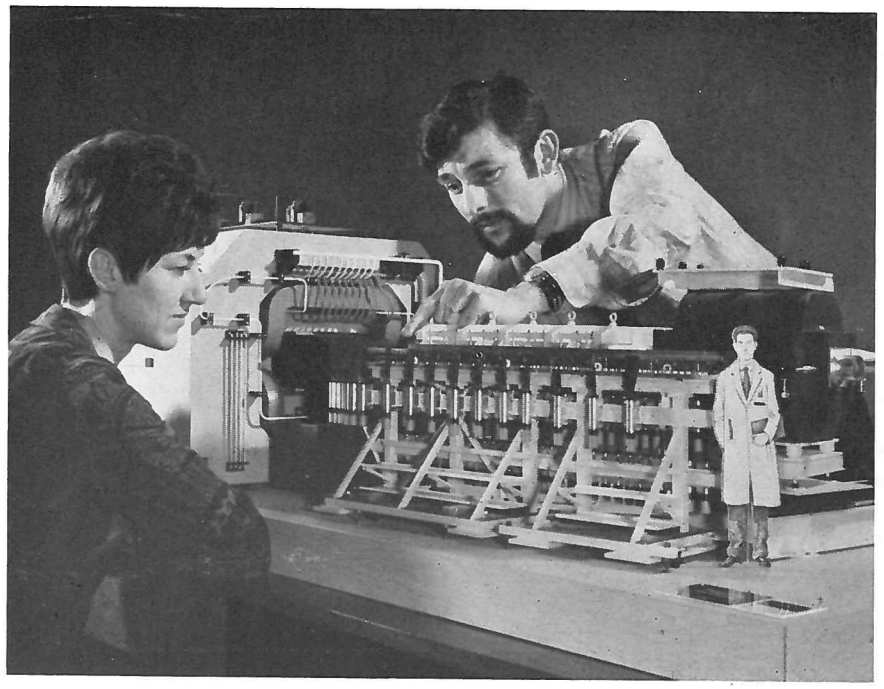
For the third year running, Bill Turner of the Applied Physics Bubble Chamber Group, has won the Rutherford/Atlas Chess Championship. He finished with a score of 8½ points out of a possible 9, remaining unbeaten once again.

Bill started playing at the age of 12 and by the ripe old age of 14, was a member of the Sussex junior and senior County teams. The same year, he became the youngest competitor in the British Boys' Championship, held at Hastings, collecting on the way the Sussex Junior Championship three years in succession.

After his National Service, during which time he played for Somerset, he went up to Oxford in 1958. By his final year he had worked his way up to Board 3 for the University and Board 4 for Oxfordshire. (Non chess players note – there are 50 boards in a County team – Board 1 being top).

After graduating in Physics in 1961, Bill spent a year in Chester, and of course, played for Cheshire, returning to Oxford in 1962 and has regularly played for Oxfordshire since then.

Bill confesses that these days he finds more pleasure in badmington and has therefore slipped to around Board 12 in the county team through lack of competitive chess. However he enjoys lunch time chess, finding this a good way of not losing touch. The twenty-seven other competitors in this year's tournament may have other ideas about his touch!



Daresbury exhibit in London

The intricacies of some apparatus used in high energy physics experiments at the Daresbury Nuclear Physics Laboratory being examined, in the picture above, by Mrs. A. J. Peatfield, an EO in administration and local 'Quest' correspondent, and Mr. A. J. Wardle, an Exp O in the Experimental Physics Group.
The $\frac{1}{8}$th scale model of the 'photon tagging system' has been on view at the Physics Exhibition, London. The equipment is used in conjunction with an extracted electron beam from the NINA accelerator to provide physicists with high energy photons of known energy.
There were seven SRC exhibits at the exhibition from both Daresbury and Rutherford Laboratories.

Professor Ford

towards dynamism

'Take overs can be a mistake unless there is adequate technology to back up management' Professor Ford told London office staff. The Chairman of the new Engineering Board was speaking of 'the way ahead' for engineering.

The dynamic situation that led to success depended on good management and good technology which would come better from within than from forming a merger. The Engineering Board therefore saw the importance of providing first rate training for engineers who would enter top management.

Professor Ford went on to describe how the Board hoped to influence the pattern of training for postgraduate engineers so that they would learn more of the importance of time, money, management, design and manufacture. This was how a real and living interface and industry would develop.

In many cases the M.Sc. courses were too rigid and academic for meeting the future needs of industry. Creativity should be encouraged and, from this point of view, the staff too needed to have a wide knowledge of industrial needs.

*The engineering board had been given responsibility for the 'non–R and D needs of Industry'. Professor Ford felt however that this was an unfortunate title, although it was difficult to think of a better one, and he offered a bottle of champagne to anyone who could give it a more promising name.**

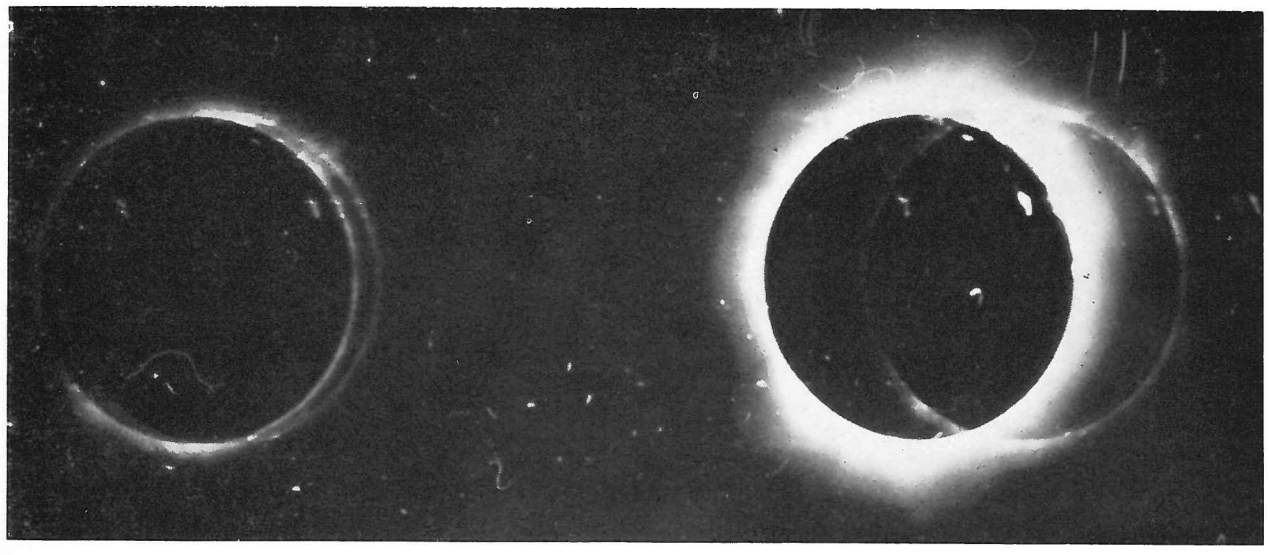
In reply to questions, he said that university staff were free to have their inventions developed by industry. If this practise increased, as it should, some rules on share out would be necessary. The Board would also have to consider the situation that might arise if public funds appeared to be helping one commercial firm in competition with another.

Asked if the Board placed any emphasis on social needs, particularly for underdeveloped countries, Professor Ford said 'no' although the interplay of social responsibility, time, cost and technology were all a part of real engineering. Many of these were covered in environmental engineering – pylons, polution, smoke and noise were a few examples – and the Board intended to look closely at this field. However there might well be end products of processes and research that would be of particular help to developing countries.

** [We understand that this offer is still open to any fairy godmothers who read 'Quest']*

mexico 1970

A team from the Astrophysics Research Unit and the Physics department of Imperial College London scored an outstanding success with the payload they designed and built for a rocket which was launched into the path of the total solar eclipse that crossed Mexico on March 7.



The experiment, which fully exploited the event in order to study the hot upper layer of the sun, was formulated by an international team of scientists drawn from Harvard College Observatory USA and York University, Toronto, as well as the team from Great Britain.

The Aerobee 150 rocket was launched from the NASA range at Wallops Island on the Virginian coast (about 150 miles from Washington) as the eclipse passed over there. The payload included scientific instruments to photograph the eclipse over a wide range of ultraviolet wavelengths from 850 angstrom to 3000 angstrom, also internal control and waterproofing systems to facilitate its recovery from the sea afterwards. Sequential observations of the ultraviolet emissions of the chromosphere and Corona were made as the moon passed over successive layers of the sun.

Shown above is part of the first photograph to reach this Country out of the many taken in the rocket. It shows multiple overlapping images of the sun's atmosphere revealed during the eclipse. Each image is in a different wavelength of ultraviolet light and shows hydrogen, oxygen and ion at successively higher temperatures. ...

Congratulations *to Mr. D. H. Sadler of the Royal Greenwich Observatory who has received an honorary degree from the University of Heidelberg. A DCSO (special merit), he has been granted special leave of absence from his post of Superintendent of the Nautical Almanac Office to continue his own research and to organise the 14th General Assembly of the International Astronomical Union at Brighton this year. Formerly Mr. Sadler was General Secretary of the IAU, from 1958–1964.*

D. H. Sadler

Another member of the staff of the Astrophysics Research Unit concerned with rocket launched experiments is Bill Burton, shown on right. He is a Senior Scientific Office engaged in spectrographic studies of the extreme ultraviolet spectrum of the sun and other stars, carried out by flying special optical instrumentation in stabilised Skylark rockets which are launched from the Woomera range in Australia. His account of the latest launchings is on page 15.