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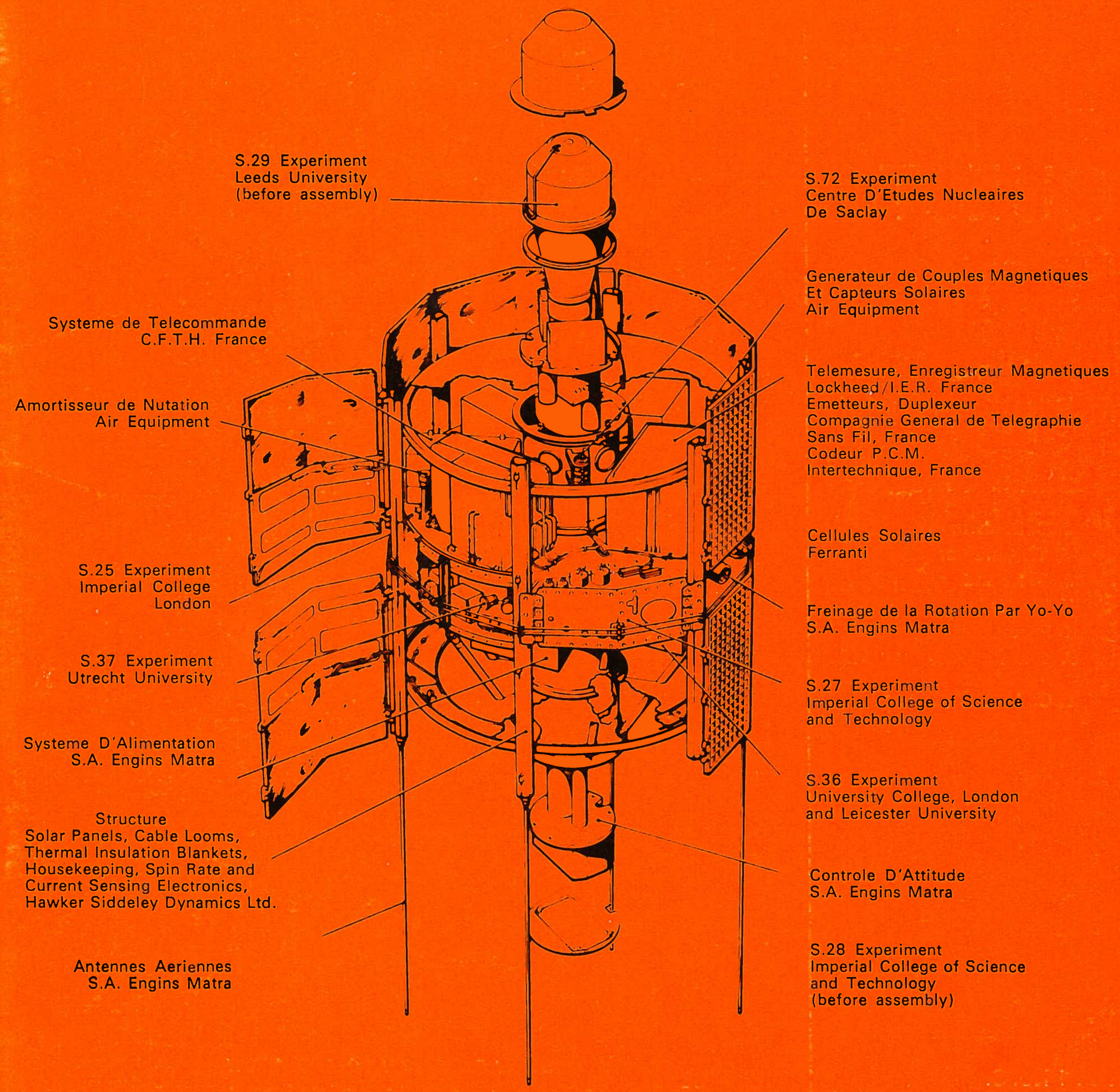

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QUEST

House Journal of the Science Research Council

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Vol. 1 No. 3.

July 1968

contents

A 'FIRST' IN EUROPEAN CO-OPERATION
ESRO II the first satellite to be produced on a European co-operative basis was successfully launched from the Western Test Range (USA) at three o'clock on Friday, May 17

The proposed 300 GeV accelerator

A message from the Chairman

The Government decision that the UK should not participate in the proposed European 300 GeV accelerator is, inevitably, a set-back to the Council's scientific plans even though we know that it was taken after very careful consideration. The Government fully appreciated that the project was well conceived and that their scientific advisers favoured participation but they were concerned at the effect which it might have on the balance of resources between high energy physics and other scientific activities. In view of the economic circumstances and the implications of the recent devaluation of sterling, the Government finally decided that expenditure on the project, rising to about £6m a year, would not be justified.

I am sure that many members of the staff will share my disappointment at the decision and my hope that when the economic situation has improved we will be able to participate in a major European high energy physics project.

Meanwhile the decision does not affect our other activities. Indeed, Government policy favours civil science relative to other forms of public expenditure, as is shown by the fact that our provisional allocation of funds for 1969/70 is about 6% higher than the current grant. Thereafter we can, I believe, look forward to continued modest growth so long as we continue to make good use of the resources entrusted to us.

Brian H. Flowers

the Mullard Space Science Laboratory University College London

E. B. Dorling

It is fitting that 1967, the year which marked the tenth anniversary of space research in this country, should also have seen the opening of the first laboratory devoted wholly to space science. The Mullard Space Science Laboratory came into being through a gift to University College London by Mullard Limited (whose help had already been marked in the related field of radio astronomy by the creation a few years earlier of the Mullard Radio Astronomy observatory at Cambridge). It was equally fitting that the Mullard Space Science Laboratory should have been opened by Dr. F. E. Jones, FRS, Managing Director of Mullard Limited, for, as Deputy Director of the Royal Aircraft Establishment, Farnborough in 1954–1955, it was with his support that the Skylark rocket was designed and developed. The first firing of this rocket, at Woomera in February 1957, can be said to have marked the start of the British space research programme.

University College London was involved in this programme from the very beginning. Indeed Professor Sir Harrie Massey, FRS, head of the Department of Physics at University College London, and Professor R. L. F. Boyd, who now heads the Mullard Space Science Laboratory, can be said to have initiated the programme by arranging in 1953, at Oxford, the first ever conference in this country on upper atmosphere research. (The nomenclature incidentally has changed with the years from upper atmosphere research to high altitude rocket research to space research and space science). The Oxford conference brought to this country a group of American scientists who, since 1945, had pioneered the new techniques of rocket research, and they inspired scientists and technologists in Britain to reconsider what start might be made, however modest, in this exciting new field of research. In June 1955 Treasury support was agreed to cover the design and provision of rocket vehicles by the Royal Aircraft Establishment, and also the cost of the experimental investigations. A working party met regularly at the physics department at UCL to plan the details of the programme. Many experiments were proposed and among the first was the so-called grenade experiment by Professor R. L. F. Boyd, which measures high level winds, temperatures and pressures by observing, at a number of points on the ground, a series of grenades fired from the rocket along the trajectory. In addition Professor Boyd proposed to fly a mass spectrometer for ion sampling in the ionosphere.

From these beginnings Professor Boyd built up over the next five years a group of scientists and technicians at UCL which had as its special study the structure of the neutral atmosphere and ionosphere. Little attention was paid at that time, however, to a topic which now dominates the laboratory's work – the study of far ultra-violet and X-radiation from the Sun. There is a very close connection between the ionosphere and solar radiation, because the various layers of the ionosphere, that electrified region of the atmosphere which reaches upwards from 60 km or so above us, are largely created and maintained by solar radiation in the far ultra-violet and X-ray bands. The reason for the apparent neglect of solar studies in these first few years lay in the fact that the Skylark rocket in its initial form would not fly quite high enough to take instruments to a point where the Sun's radiation could be observed without atmospheric absorption. The rocket needed a more powerful motor. In addition it needed a pointing device to aim instruments at the Sun whatever motion the remainder of the rocket performed. Both developments were destined to appear, but meanwhile more important events were taking place which gave Professor Boyd's expanding group the opportunity it needed for a more rapid development of the new branch of solar studies. In 1958 the International Geophysical Year took place and with it came the launching of the first earth satellites. In 1959, such is the pace of technological developments today, the USA was able to offer help to the international scientific community at large in carrying out satellite experiments. The offer was taken up enthusiastically in this country by the recently formed British National Committee for Space Research, a Royal Society committee chaired by Professor Sir Harrie Massey, and in 1960 work began on the first co-operative US/UK satellite ARIEL I. This satellite was built by the National Aeronautics and Space Administration at the Goddard Space Flight Center in Maryland, and of the total of seven British experiments which it carried, five instruments were provided by Professor Boyd's group at UCL. Two made ionospheric measurements, one measured the satellite's angle to the Sun, and two measured solar ultra-violet and X-radiation. Besides providing the major part of ARIEL I's payload UCL also gave a home to the small Royal Society group seconded from the Ministry of Aviation, which managed the programme and which later grew into the Space Research Management Unit of the Science Research Council.

Ariel I was launched from Cape Canaveral (now Cape Kennedy) in April 1962, went into a good orbit, and continued to send back useful information for the next three years. The UCL X-ray experiment made the first measurements of the sudden hardening of the spectrum of solar X-radiation which occurs during the eruption of a flare. Although the instrument survived for only three weeks, it was the beginning of this new branch of astronomy which now occupies an important position in research at the Mullard Space Science Laboratory, as at many other laboratories throughout the world. The ionospheric instrument in ARIEL I survived much longer, (no doubt reflecting the group's greater experience in this field), and contributed greatly to the rapidly increasing knowledge of topside ionospheric density, temperature, and composition data resulting from the US/UK, the NASA Explorer and the US/Canadian Alouette programmes.

Following the success of this first venture into satellite research Professor Boyd and his colleagues were quick to take up the further opportunities of assistance which NASA was now

Professor R. L. F. Boyd, Ph.D.
Professor of Physics, UCL, Head of MSSL

making. By this time NASA had moved on to the preparation of a new generation of large and complex observatory spacecraft, designed to concentrate solar research, geophysical research and stellar research into separate specialised payloads. Basing their designs to a large extent on lessons learned in the ARIEL I work and the SKYLARK flights at Woomera, the UCL space research group submitted to NASA a number of experiment proposals for the observatory satellites, and it was the success of these proposals which ensured the subsequent growth of the group. Four experiments were selected by NASA for solar radiation studies from the Orbiting Solar Observatory, to be carried in the fourth, sixth and seventh of these remarkably successful spacecraft. In November 1967 the first two experiments, one measuring far ultra-violet radiation from the Sun, the other measuring X-radiation, went into orbit successfully in OSO–4. One ionospheric experiment was selected for the fifth Orbiting Geophysical Observatory, and a stellar X-ray experiment for the third Orbiting Astronomical Observatory. During the preliminary work for these major enterprises two invitations to instrument smaller Explorer satellites with versions of the ARIEL I ionospheric experiments were received from the Americans, and this led to the orbiting of a second ion mass spectrometer in Explorer XX in 1964, and a third in Explorer XXXI together with an electron temperature probe in 1965. Indeed with the various experiments now in preparation, the group hopes to make continuous ionospheric measurements from satellites for at least ten years.

Such continuity will be possible because of the group's considerable contribution to ESRO through its satellite and rocket programmes. Professor Boyd and Dr. A. P. Willmore, the deputy head of the laboratory, have been active in ESRO since its earliest days, and have had many experiments flown already in rockets from Kiruna, Andoya and Sardinia. A solar X-ray experiment was carried aboard the ESRO II satellite, launched on May 17, 1968, and an ionospheric experiment will be carried on ESRO I when it is launched later this year. Two experiments have been planned for the larger Thor-Delta satellite, TD2 whose fate at present hangs in the balance.

A section of the electronic workshop at Holmbury House. The payload for a Skylark 501 rocket can be seen on the right.

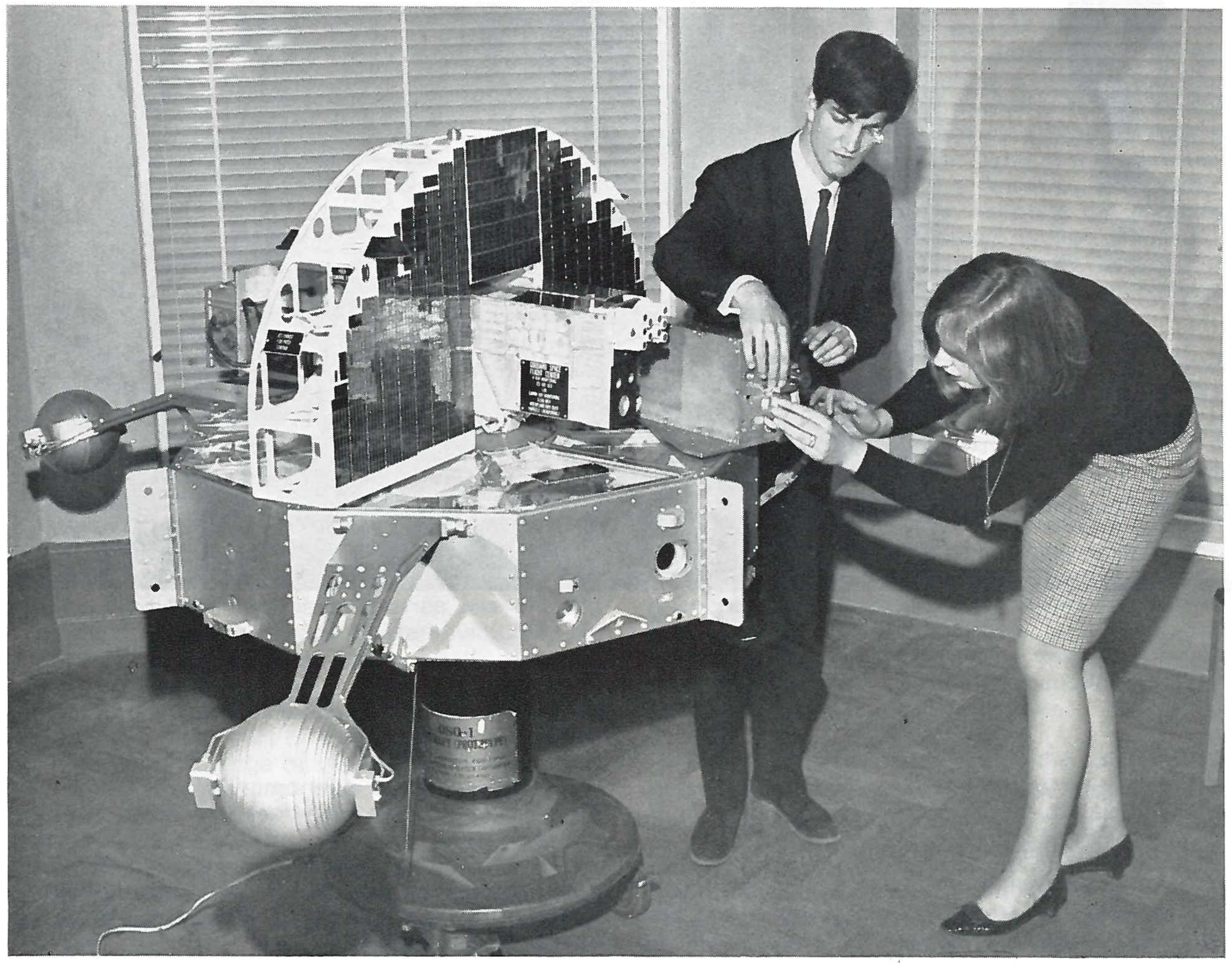
Meanwhile the national rocket programme still features many of the laboratory's experiments, from the complex solar ultra-violet experiments using pointed Skylarks to be flown from Woomera this year to the smaller experiments in the new SKUA II and PETREL rockets to be flown from this country.

Over a period from 1953 to 1968 the group has grown from one to a total of thirty-three scientists and thirty technicians. Demands on space at the physics department in Gower Street UCL increased as the satellite programme got under way, and hopes of a separate home for the group where for the first time all members could be under the same roof became a reality with the donation by Mullard Limited in 1965. This enabled the College to purchase a country mansion pleasantly situated in thirty acres of ground at Holmbury St. Mary, near Dorking. The conversion of the house, with the help of funds provided by the University Grants Committee, called for little structural alteration but almost entirely new services. A progressive move from London began late in 1965 and by September 1966 was complete.

The association of SRC and the Department of Physics, University College London (of which the Mullard laboratory is a part) dates back to 1959. The current annual grant is about £200,000 and out of the total of sixty-three laboratory staff, twenty-nine are supported by SRC grants.

Professor Boyd is a member of the ASR Board, the committee of the Royal Observatory Edinburgh and a member of three working groups of the Space Policy and Grants Committee.

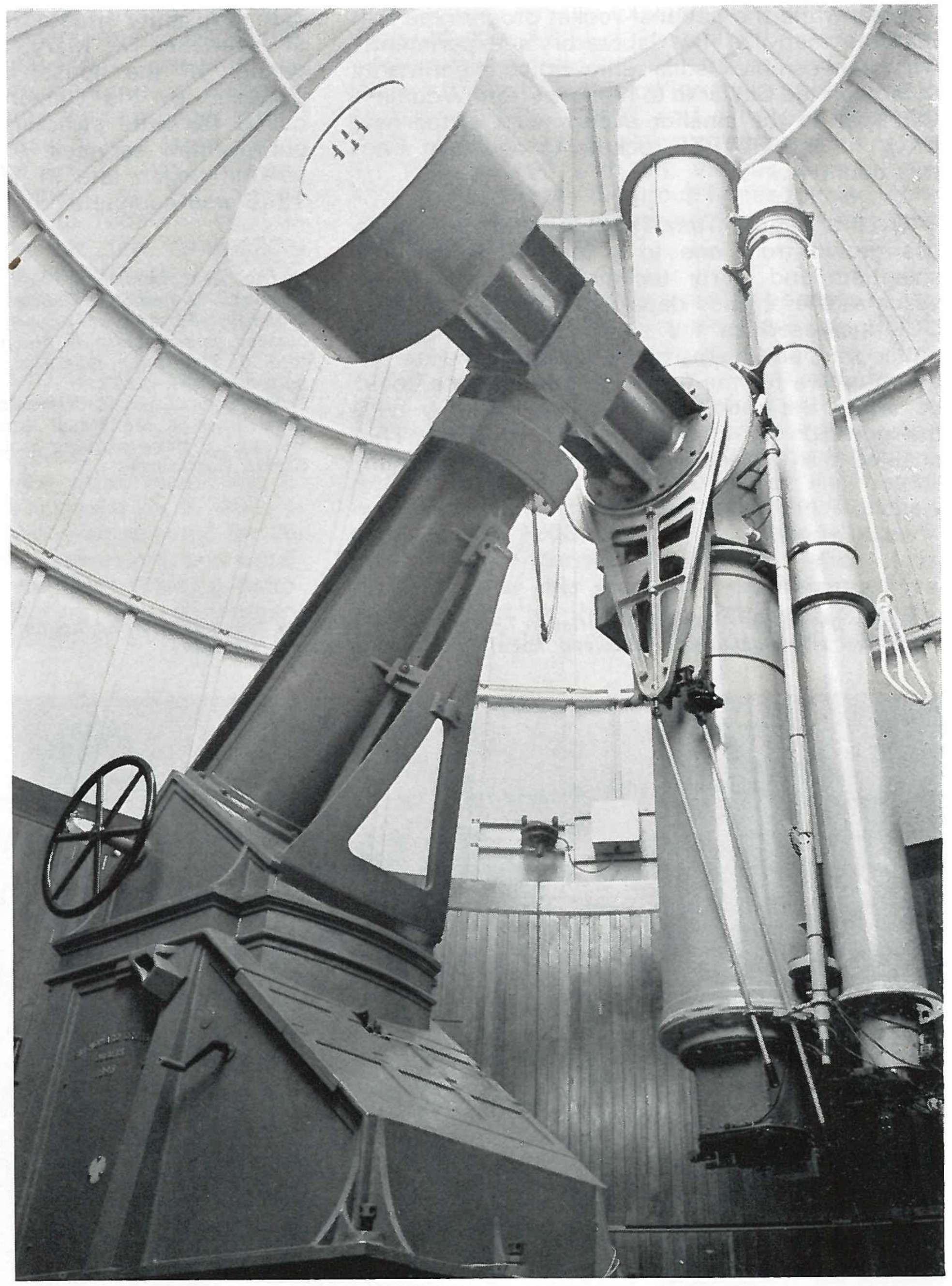
Graduate physicists Gethyn and Adrianne Timothy (claimed to be the only married couple working on space research) make final adjustments to a prototype model of an orbiting space laboratory.



Quasars

where...
what...
how...
when...
?

Michael Penston



Most people will now have seen in the newspapers reports of objects called quasars which have been exciting great interest in astronomical circles. Exactly what are quasars, and why do we find them so interesting? The answer to the first question is still that we just do not know the basic cause of this phenomenon; we do not even know how far away they are. However it is possible to give some answers to the second question and set down some of the clues which have been uncovered and that in the next few years should lead to a deeper understanding of the quasars.

The word 'quasar' is probably a development of the initials QSRS, which stand for quasi-stellar radio source. The first excitement concerning quasars came in late 1963 with the discovery of these strange objects. At that time the Third Cambridge (3C) catalogue of radio sources had been produced by Professor Sir Martin Ryle's team at the Mullard Radio Astronomy Observatory at Cambridge. It had been discovered that a number of galaxies (great systems of billions of stars like our own Milky Way) were emitting a large amount of radio noise and were detected by 3C.

Since then of course the process of 'optical identification' of radio sources, whereby the radio sources are identified with an optical object seen or photographed by a conventional optical telescope, has continued and now about two thirds of the entries in the 3C catalogue are identified. However by 1963 it appeared that some of the radio sources might have their origins in stars in our own galaxy. At the positions of the radio source, photographs showed not a fuzzy image indicating a galaxy but a steller point image.

When the light from these stars was split into its component colours in the spectrograph, it revealed a familiar pattern of spectral lines, but shifted from their usual position in the spectrum towards the red. The usual interpretation of this 'red-shift' is that the object emitting the light is receding from us at high velocity and the phenomenon is familiar since it occurs in galaxies. It is found that the higher the red-shift the more distant the galaxy, indicating that a general expansion of the universe is taking place. It seemed natural to attribute the red-shift of the quasars to the same cause – the so-called 'cosmological' interpretation of the red-shift. However the surprise was that the nearest and brightest of the quasars were almost as distant as the furthest galaxies. Since then as we shall see later, other explanations for the red-shift have been mooted but the distance to the quasars remains uncertain.

Professor Maarten Schmidt of the Mount Wilson and Palomar Observatories has set out five defining properties of quasars which make them different from other stars. Firstly they are starlike objects identified with radio sources. Secondly they may be variable in brightness. Then they emit a large part of their energy beyond the blue end of the range of visual light, in the ultraviolet. They are also characterised by broad emission lines in their spectra. Lastly these lines are displaced far to the red of the colour at which we would expect to find them in the laboratory. Since these definations were made, two new discoveries have caused them to be modified. Objects resemble quasars in all their optical properties have been found remote from the positions of known radio sources so that the first property is changed to 'they are starlike objects usually identified with radio sources'. The second change is the discovery of absorption lines in the spectra of some quasars.

One of the main difficulties in understanding the quasars is that we do not know the distances to them. Let us review the usual methods astronomers employ in finding the distances to a new class of astronomical object. The first method used is that of parallax. Parallax is the name for the apparent change of position of a nearby object against the background as the observer moves. In the case of stars this movement can be detected as the earth orbits around the sun if the star is within about 300 light years of the sun. No parallax has been detected in any quasar so they are further away than this limit. Another similar method is the measurement of the proper motion of the star across the sky. If we have some idea of the velocity of the star this enables us to gain some notion of its distance. Again no proper motion across the sky has been detected for any quasar and since the high red-shifts of the quasars indicate velocities approaching that of light, we can conclude that the quasars lie outside our galaxy. Another method of determining the distance of astronomical objects useful for star-clusters and galaxies is from the recognition of a component of the object as a familiar type of star, usually a variable star, so that if the intrinsic brightness of the star is known, its apparent brightness enables one to estimate the distance. However useful this method is for galaxies, it does not work for quasars simply because no components can be distinguishable in a single starlike image.

So far one can see that we have scant guide as to the distance of the quasars except that they are outside our own galaxy. The next method of determining the distance of the quasars is to study whether the light from them has been interfered with in any way by an intervening object, for example a galaxy or cluster of galaxies. In fact it is found that absorption lines with a red-shift characteristic of the Virgo cluster of galaxies are indeed present in the spectrum of the quasar 3C273. This shows that this quasar is at least on the far side of the Virgo cluster and thus at a distance of greater than thirty million light-years.

As we have already said the distance to galaxies is often measured from the red-shift of the object. This is because the red-shift is known to be due to the expansion of the universe. Thus the more distant the galaxy the faster it is receding from us due to this expansion. It is tempting to apply this 'red-shift-distance relation' directly to the quasars. This gives distances even to the nearest quasar comparable with the most distant galaxies yet discovered and suggests that the most distant quasars lie at distances of greater than several thousand million light-years. Indeed the light would have been emitted from these quasars before even the sun was formed. However several astronomers including Professor Fred Hoyle of Cambridge have claimed that these distances are incorrect. They point out that the deduction of these distances relies on the assumption that their red-shifts are due to the expansion of the universe – as we say, are 'cosmological' in origin. They suggest that if, for example, the quasars were fragments thrown out of our own galaxy by a vast explosion, then clearly their recession from us has nothing to do with the expansion of the universe. Nor is this the only possible explanation of the red-shifts if the quasars are 'local' – the other main suggestion is that the red-shift of the light from quasars is due to the great mass of the quasar. In accordance with the results of general relativity the light becomes redder as it climbs away from a very massive and compact object towards the observer.

The last consideration that might lead to an estimate of the distance of the quasars is their distribution in the sky. For example if the quasars tended to lie near galaxies in the sky we could deduce the distance of the quasar from the distance of the associated galaxies. On the other hand if the quasars clustered near the galactic poles (i.e. were seen in directions at right angles to the plane of our Milky Way) this would be evidence for the version of local theory which claims the quasars are ejected from our own galaxy. In fact it has been suggested by different authors that both of these ideas are supported by observations.

In particular the American astronomer Halton Arp claims that radio sources, among them quasars, tend to lie in pairs on opposite sides of peculiar galaxies. However investigation by a number of groups of workers has not substantiated this and the general feeling is that Arp is mistaken in his statistics.

Alternatively another group of astronomers led by Peter Strittmatter and John Faulkner of Hoyle's Institute of Theoretical Astronomy at Cambridge suggested that the quasars with largest red-shifts tended to lie near the poles of our galaxies. Together with Michael Rowan-Robinson of Queen Mary College, London, I looked into this and we noticed that in fact the main feature of the distribution of the quasars over the sky was a virtual absence of sources from the region of the sky accessible to Northern Hemisphere observers in the summer. We made the suggestion that not only are the nights shorter in the summer but that astronomers often attend conferences during these months. This idea has not been altogether popular in some quarters! In fact the subsequent identification of large red-shift quasars has tended to fill some of the blanks left earlier and although the situation is not entirely clear, it seems likely that as more quasars are found so the distribution will continue to become more uniform over the sky.

From all the foregoing discussion the reader will see that we do not at present have any conclusive evidence giving the distance of the quasars. To see just how important this is, let us compare the distances proposed by the local and cosmological theories. The most popular distance favoured by the protagonists of the local theory is about 100 million light years, whereas the cosmological picture would place them ten times further away. This may seem a somewhat academic discussion since whatever view is taken the distances involved are truly immense. However the importance of the argument is seen when one realises that to be ten times more distant and still appear as bright in the sky, the quasars must be one hundred times more luminous. Indeed the luminosity of quasars on the cosmological theory exceeds that of an entire galaxy of stars and it is partly this surprising fact that has led to the strong support the local theory has received.

Thus baulked in all approaches to finding the distance of the quasars, astronomers have fallen back on a number of efforts to prove that quasars and radio galaxies are essentially similar objects. There are some obvious similarities – both are radio sources and both possess large red-shifts. However the two groups of objects appear quite differently in the sky: as we have seen, quasars appear as star-like points of light, while galaxies are fuzzy objects on direct photographs of the sky. The main difficulty lies in the effort to show there exists an intermediate class of objects between the quasars and radio sources with some of the properties of both. If such a group can be found this might establish the 'continuity' of quasars and radio galaxies and show the quasars were at cosmological distances. Luckily it seems that the N (or nucleated) galaxies do fill this requirement. The N galaxies appear slightly fuzzy on plates of the sky, but they have very bright nuclei which have many of the properties of quasars. Pictures of a typical radio galaxy, an N-galaxy and a quasar accompanying this article show some of the similarities and differences among these types of radio source.

At Herstmonceux, Russell Cannon and I have been studying if and how quasars and associated objects vary in brightness. We have been using a 26-inch telescope which is relatively small by modern standards but it has been adequate to keep a watch on the brighter quasars. There are

These pictures show a quasar, N-galaxy, and a radio galaxy respectively. They are all negative prints of the sky (black stars on a white background) which are preferred by astronomers for making small detail clear.

Plate I shows the quasar 3C273 (the bright star in the centre). Its well-known 'jet' from which much of the radio emission comes is marked.

Plate II shows the N-galaxy 3C120 which is marked and is slightly fuzzy compared with the star images.

Plate III shows the radio galaxy Messier 87 which also possesses a jet. The original from which this print was taken was one of the first plates taken on the new 98 inch Isaac Newton telescope at Herstmonceux.

ACKNOWLEDGEMENTS

1. *J. L. Greenstein, M. Schmidt, Ap. J. 140, 1. Univ. of Chicago Press*
2. *1957 Nat. Geographic Soc. Palomar Observatory Sky Survey*

Plate I

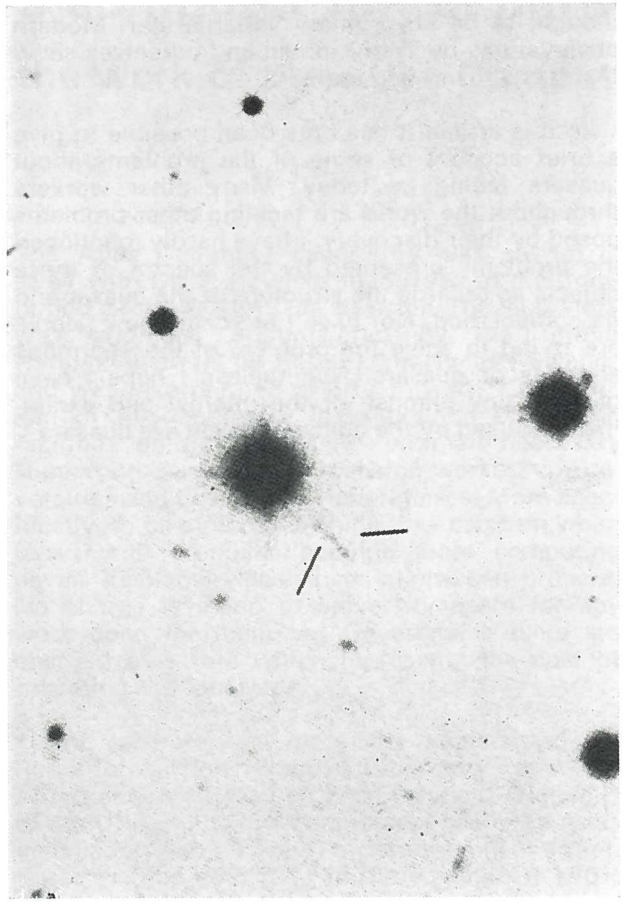


Plate II

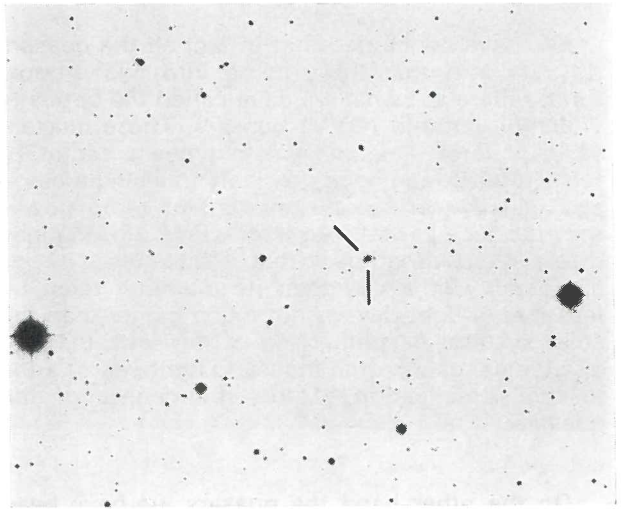
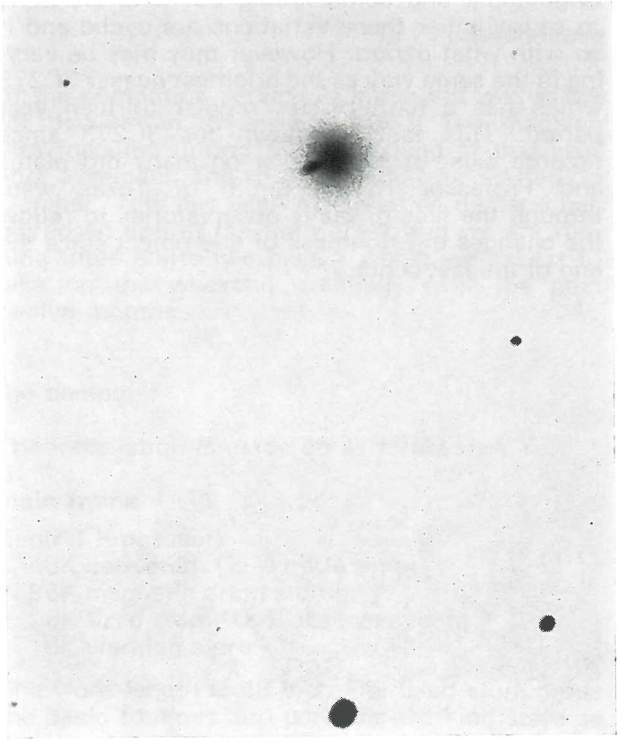


Plate III



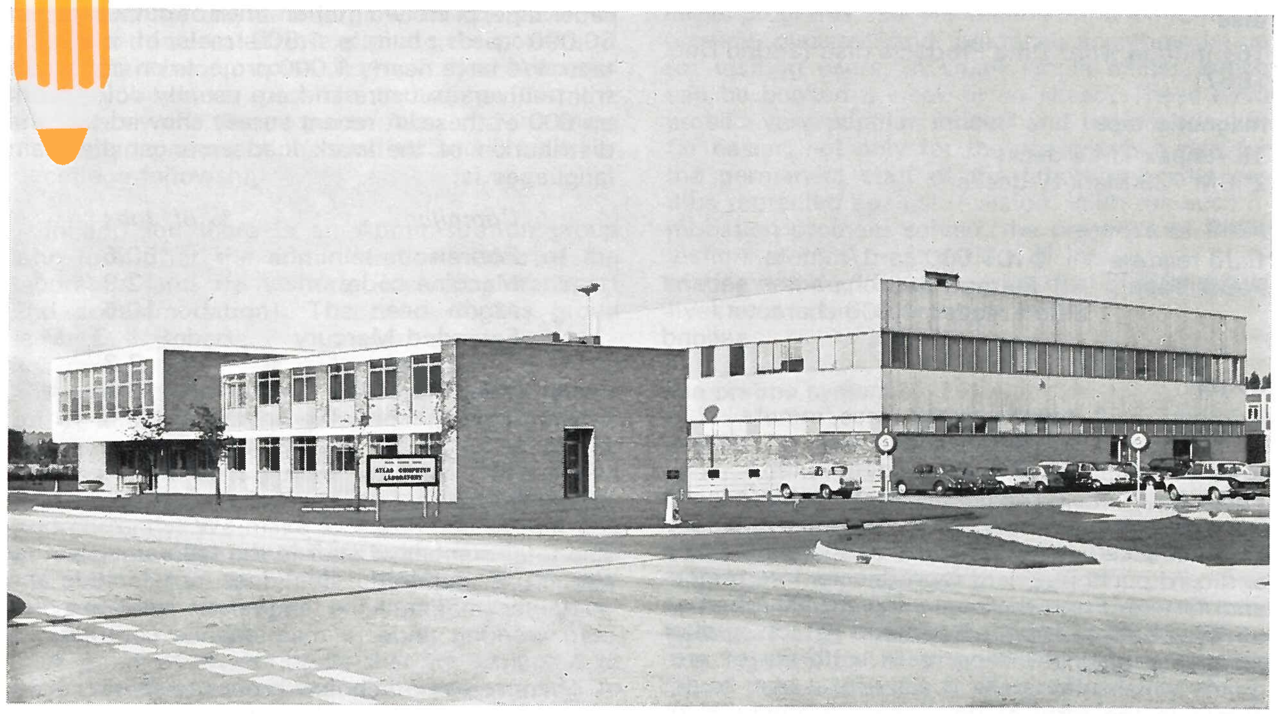
other groups, particularly one under Professor Tom Kinman at the Lick Observatory in California, who have been carrying out similar projects in different parts of the world. Whereas most of them have been concentrating on quasars already found to have variable luminosity, we have carried out a complete survey of all the quasars within reach of our telescope in order to establish whether they all vary and into what categories they divide.

We have concluded that in fact all the quasars do vary and that they divide into two groups. Firstly there are what we have called the optically violently variable (OVV) quasars. These quasars vary by large amounts – sometimes a factor of ten – often changing appreciably in a single day – and usually vary in the amount of radio power they produce as well. An interesting consequence of the rapid variation is that if the source varies appreciably in a day then its diameter must be less than a light-day, or not much bigger than the solar system. A comparison of this with the size of a typical galaxy (ten thousand light-years) adds to one's realisation of the strangeness of the quasars.

On the other hand the quasars we have been observing which have not turned out to be OVV also vary, but the pattern of this variation is quite different. We find after nearly three years study that they vary slowly, changing by an amount which we can just detect each year. Some are brightening and some fading but it is too early to say whether these variations are cyclic and if so with what period. However they may be varying in the same way as the brightest quasar 3C273 which has a more-or-less regular thirteen year period. This fact is known for 3C273 since records exist of this quasar on many old plates and Professor Harlan Smith of Texas went through the files of many observatories to follow the changes of brightness of this object since the end of the last century.

At Herstmonceux we have also been studying some of the N galaxies, hoping to confirm the link between these objects and the quasars by showing that they have similar variability. Now it has been found by Russell Cannon and myself and independently by the Californian astronomers that three of the brighter N galaxies show variations similar to the OVV quasars. We have also been examining these objects on the old plates taken when the Royal Greenwich Observatory was at Greenwich. We have found that two N galaxies 3C371 and 3C390·3 were considerably brighter between 1890 and 1910 than they are now. It gives me a strange feeling to look at these old pictures of the sky and to realise they were taken before my grandparents had started courting! A crucial conclusion from our results is that although these N galaxies are now fainter than almost all the quasars, at the turn of the century they were as luminous as at least some quasars. This shows an excellent continuity between quasars and radio galaxies since it is fair to say that if observed in the past, 3C371 and 3C390·3 would have been classed as quasars. Nor are these two the only N galaxies observed to vary, indeed the radio source 3C120 was discovered to be variable in 1940 by the great American astronomer Harlow Shapley. However at this time the existence of quasars and radio galaxies was unknown and this object was thought to be an ordinary variable star. Modern observations by Tom Kinman and ourselves show that it is still varying today.

In this article it has only been possible to give a brief account of some of the problems about quasars facing us today. Many other workers throughout the world are tackling other problems posed by their discovery. I have hardly mentioned the problems presented by the spectra of these objects as regards the structure of the quasar and its composition. Nor have I indicated how people are trying to solve the problem of the enormous energies of quasars. Nonetheless I hope I have given a tiny glimpse of the interest and excitement aroused by the question 'What are quasars?'



a computer for all purposes

the work of the Atlas Computer Laboratory

R. F. Churchhouse

The Atlas Computer Laboratory was set up in 1961 with Dr. J. Howlett, then Head of the Computing Group at AERE, as Director. The laboratory was originally administered by the former National Institute for Research in Nuclear Science and was incorporated in SRC in April 1965. The aim of the laboratory is to provide computing facilities on a large scale – with all necessary supporting services – to research workers in universities and government laboratories. More specifically, to be a place to which they can turn when faced with problems needing more computing power than their local installations can provide. No charge is made to university users for any work done for them but Government users are charged at a rate which represents the cost of operating the laboratory.

The laboratory is on a site adjacent to the Rutherford High Energy Laboratory and the Atomic Energy Research Establishment (Harwell) of the UKAEA. Its main equipment is a large Atlas installation which was ordered from Ferranti (later merged with ICT) in the summer of 1961. A building was designed with the special needs of the computing service in mind and was ready for occupation in January 1964. The machine was installed during May and June of that year and a regular one-shift service was started in October. This has been extended as demand has increased and at the time of writing we are running three shifts five days a week; we expect to take up the weekend gradually over the next twelve months.

the computer

The installation is made up as follows:

main frame

Central Processor,
  48K core store (2 μs cycle time)
  96K magnetic drum store
  8K fixed store (0.4 μs access time)
  16K working store

The word length is 48 bits. The fixed store holds the basic routines and uses the working store as working space

disc

16¾ million word Data Products disc (added Dec. 1967)

magnetic tape

16 Ampex TM.2 decks
2 IBM 729 Mark IV decks

input

Card readers	2 ICT 600 card/minute
Paper Tape	1 Ferranti 300 character/second 1 Elliott reader, 1,000 character/second

output

Printers	2 Anelex 1,000 lines/minute 120 character/line
Card Punch	2 ICT 100 card/minute
Paper tape	2 Teletype 110 character/second

This is backed up by standard equipment for tape and card punching, card reproducers, interpreters and sorters. From the beginning we have had an off-line Benson-Lehner Model J graph plotter driven by magnetic tape, with a library of programs which may make it easy for a user to get output in the form of point plots, histograms or continuous curves, including stereoscopic pairs for display of three-dimensional structures. This mode of output is so important that we have recently taken delivery of an SC4020. This is a microfilm plotter which can produce graphics on hard-copy, microfilm and cine film.

The machine runs at an average speed of 350,000 instructions per second. Floating point addition takes 1.8 to 2 μs, multiplication 5.9 μs, organisational instructions 1.6 to 2 μs. In machine code, inversion of a 100 x 100 matrix takes 17 seconds, sorting 5,000 floating-point numbers into numerical order takes 1 second. The operation of the machine is automatic and is normally under the control of a permanent resident program called the Supervisor, which monitors all its activities, organises the time-sharing of input, output and computation and of a number of programs held in the store at the same time.

One part of its action deals with automatic transfers between the core store and the magnetic drums, and enables the programmer to work as though the two formed a continuous directly-addressable store of 144K words. It also makes possible the use of many different compilers, and in fact Atlas users can (and do) write in Fortran, Algol, LISP, IPL-V, the Atlas Autocode produced by Manchester University, the Autocode produced originally for the Ferranti Mercury computer and since greatly extended, and several others.

The level of activity can be gauged from a few operating statistics. In a typical week we run 2,500 jobs, input a million cards and 24 miles of paper tape, print two million lines of output, punch 60,000 cards, handle 1,500 reels of magnetic tape. We have nearly 1,000 projects on our books from university users and are usually doing work on 600 of these. A recent survey showed that the distribution of the work load amongst the main languages is:

Compiler	*% of Jobs*
Fortran	50.6
Machine code	12.9
Algol	10.6
Extended Mercury Autocode	7.3
Atlas Autocode	3.6
Others	15.0

organisation

The total number of staff in the laboratory is now about one hundred. This does not include the computer maintenance engineers, who are ICT staff working under a maintenance contract.

There are four technical groups :

(i) The Operations group receives work (some of which is in manuscript and needs to be punched on to cards or paper tape), processes it through the main computer and any auxiliary machines, such as the SC4020, and despatches the results to the users. The head of the group is Mr J. E. Hailstone.

(ii) My own responsibility, the Programming group is concerned mainly with basic software – for example, changes or extensions to the Supervisor to incorporate new ideas or extensions to the installation – compilers and library programmes. It has built up an extensive library of programmes in Fortran and Algol. A small group are writing the software for the Sigma-2 Atlas on-line system. A number of programmers are engaged in more specialised activities associated with applications of computers, such as developing a system suited to the analysis of statistical experiments and an information retrieval project.

(iii) The Support group gives help and advice to users and is responsible for maintenance of the library programmes and various large 'packages' (such as the crystallographic programmes and the programmes for space research). This group also organises programming courses. The head of the group is Miss Barbara Stokoe.

(iv) There are posts for individual research: the laboratory has given fixed-term contracts of employment to research workers of established reputation whose particular interests demand the use of a large-scale computer, or who are interested in exploiting the powers of the machine in novel ways. It has been the policy wherever possible to arrange that the holders of these posts also have some academic connection, such as a university or college fellowship.

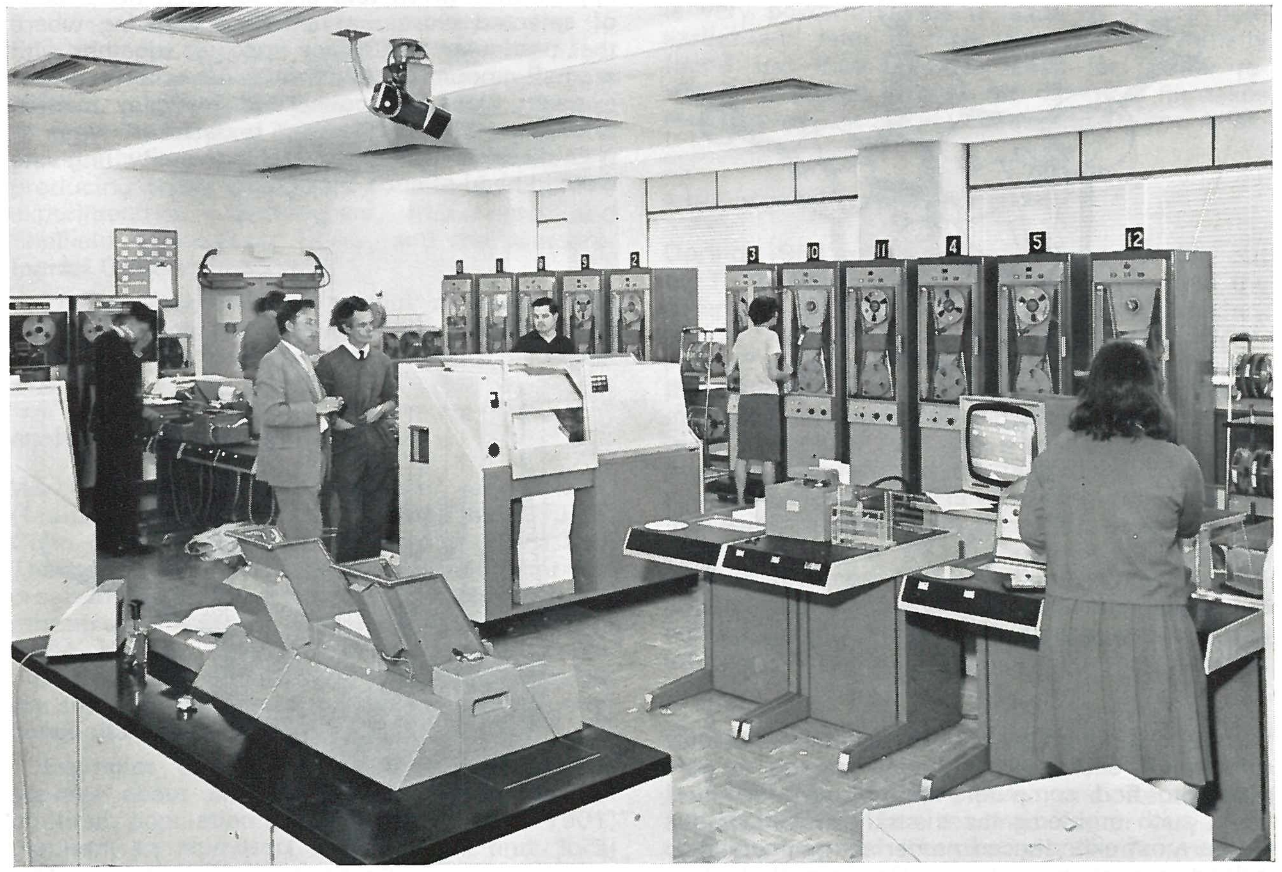
In addition there is an Administration group who look after the administration needs of the laboratory and its visitors (including transport and accommodation). The head of this group is Mr C. L. Roberts.

As can be imagined, we have had to give a lot of attention to the office-management aspect of the operation of the service, so as to ensure that the very large volume of work (with all its associated paper) is handled quickly, efficiently and correctly. We make as much use as possible of modern office machinery and, of course, we use the computer itself to produce all our accounts and statistics.

A point worth noting is that we expected to have significant numbers of people wanting to spend time in the laboratory, to develop large programs, so we planned the building to provide pleasant and practical accommodation for visiting users, in small single offices which can be booked a week or so ahead. These have proved very popular indeed and have made life far easier, not only for the visitors, but also for the permanent staff of the laboratory, who are thus protected against invasion. With the accommodation problem solved, the presence of many visitors, with a great variety of interests is stimulating and contributes a great deal of intellectual liveliness to the laboratory.

the on-line system

A small on-line system is being put together. In order not to downgrade the efficiency of Atlas the consoles are attached to a small computer, the S.D.S. Sigma-2, and this computer communicates with Atlas via the Data Products disc. There are very interesting technical problems on both the hardware and software sides. On the hardware side there is the problem of interfacing the Sigma-2 to the disc. Here we have had the good fortune to have Peter Wilde of RHEL Electronics group loaned to us for a year and he

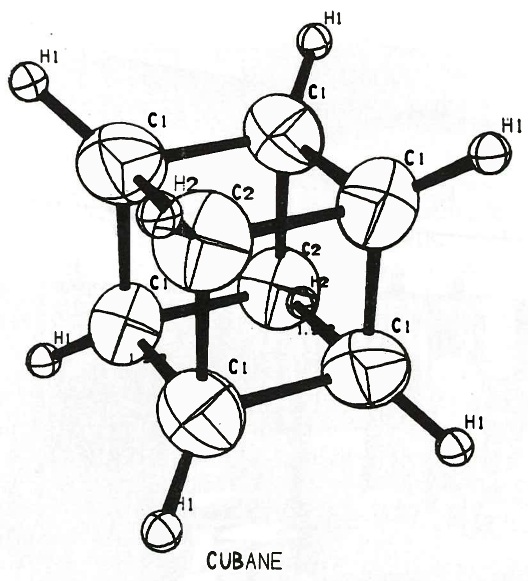


General view of the machine room

has designed and built the interface. All the software required for the on-line system is being written by a small number of members of the Programming group. We at present have six teletype consoles, but hope to increase this number before very long.

some examples of work done on Atlas

Big users of Atlas include the Meteorological Office, crystallographers, space research and people interested in survey analysis. At the other end of the scale quite small amounts of machine time may suffice for the development of some of our most important system programs (extensions to the Fortran and Algol Compilers, the Supervisor program etc.) as well as work on aspects of pure mathematics research (number theory, group theory, etc.). Here are brief accounts of some of the projects in which the machine is used. These are not necessarily the biggest users, but between them they give some idea of the wide range of application of the computer. I have made no mention of the more obvious applications of computers, such as the solution of partial differential equations. Although no-one is surprised to find computers being used for such work, such problems tax the skill and ingenuity of the most experienced numerical analysts and, indeed, one of our Fellows (Dr. Joan Walsh) is working on problems of this type.



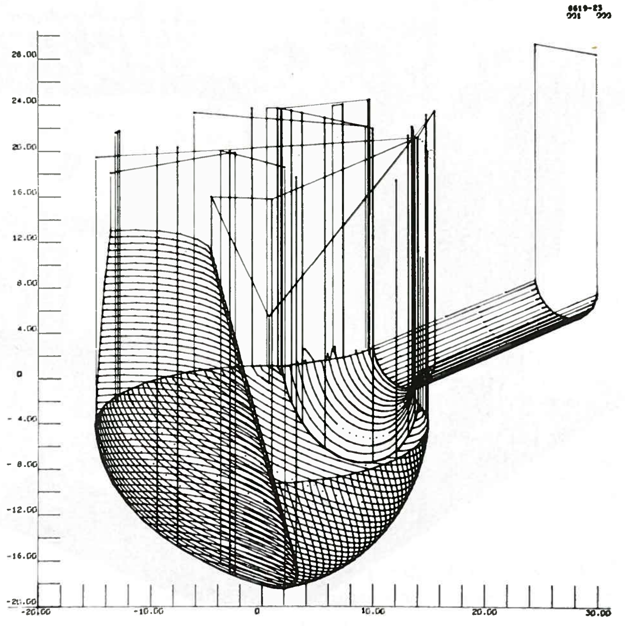
Cubane and Convolutes
Examples of graphic output of SC.4020 graph plotter.

crystallography (J. C. Baldwin)

Crystallographers have an inherent ability to use as much computing power as is made available to them and therefore they form a significant group among the users of a machine of the size of Atlas. By placing a crystal in a beam of X-radiation and studying the resulting diffraction pattern, it is possible to determine the approximate positions of the constituent atoms. Refinement of these and other parameters continues until close agreement is reached between the observed and calculated patterns. When complete, the crystallographer will wish to know the relative distances and angles between various atoms. Programs for these calculations are provided by an American system known as X-Ray 63 which has been adapted and expanded for running on Atlas and is currently used by research groups from fourteen universities.

literary concordances (D. B. Russell)

COCOA is a system which enables users to carry out quantitative analyses of literary texts punched on cards or paper tape. It can provide a count of the frequency with which words appear in a given text and for each occurrence of selected words; a reference showing where that particular occurrence appears; together with a small amount of its context. All occurrences of a given word are concorded for easy manual reference. This work was undertaken when it was discovered that several university linguists were in need of such a program.



Convolutes

simulation and analyses of compiler systems (P. Bryant)

The Brooker Morris Compiler Compiler system, which is a tool for easing the writing of compilers, has been exploited in the writing of a simulation compiler with the object of studying various facets of computer systems, in particular a study of the Atlas drum and disc interaction and also some multi-access problems. The compiler has also been used in a variety of industrial problems.

Work is also proceeding on the evaluation of computers. This work breaks down into three main sections namely the hardware, the operating systems and the compilers and we hope that the results will provide some guide lines in determining the factors which influence a computer's performance.

space research (Miss Barbara Stokoe)

The Atlas laboratory is processing data received from the satellite Ariel III, which was launched from Western Test Range, California, USA, on 5th May, 1967.

Information is received from the satellite by several tracking stations around the world, and these are sent to RSRS Slough, where the information is digitised onto $\frac{1}{2}$″ magnetic tape. These tapes are sent to AWRE Aldermaston, who perform a preliminary run, producing a further $\frac{1}{2}$″ tape. This is sent to the Atlas laboratory, who process it, (using a program initiated by AWRE), producing tapes of a form suitable for the five experimenters – Birmingham, Manchester and Sheffield universities, RSRS, and the Meteorological Office at Bracknell.

The average rate of receipt of tapes from AWRE is three per week, and the machine time involved is in the region of three hours per week.

analysis of surveys (Mrs. Judy Lay)

We have available a program called MVC (Multiple Variate Counter) written by A. J. T. Colin of London University (now at Lancaster). There is a continual large scale demand for this program. Of seventy-two surveys currently being processed, thirty-five are medical; examples of these include various cancer studies; peptic ulcer; convulsive disorders; tuberculosis; coronary study; bronchitis in the Welsh steel industry; congenital malformation; and jaundice in infants.

Examples of other surveys include various surveys about students, graduates and school children; population movement from 1851–1901; reaction to televison programmes and local radio; industrial studies; hospital manpower; and bird movement study.

statistical program package, ASCOP (B. E. Cooper)

ASCOP is a comprehensive statistical system. It has good editing and checking facilities, and data presented for it can be stored on magnetic tape for later use. Instructions are in the form of english sentences or Fortran-like equations, and may be formed into subroutines. The system is being extended continually, for example, to incorporate tabulation and graph plotting facilities, making it useful in the survey analysis field. It is currently being implemented on a number of other computers. ASCOP is useful for anyone who wishes to perform statistical analyses on data.

information retrieval (R. F. Churchhouse)

Information concerning about 5,000 articles in a dozen computer science journals has been written on magnetic tape. The information retrieval programs make it possible for a user to find out what papers have been written on topics in computer science, or works by particular authors. When a paper is retrieved, the papers to which it refers or which have referred to it, are also retrieved. This simple method of retrieval is very powerful since it leads to papers both earlier and later in time than the one initially found and thus provides leads for further retrieval. A search through the complete file takes less than ten seconds of computing time on Atlas.

work in collaboration with NERC

During 1967 an investigation was carried out by T. N. Gover of the Atlas laboratory into the computer requirements of the Institute of Geological Sciences, a branch of the Natural Environment Research Council (NERC). In the report that followed it was suggested that in order to make the data collected and held by each department universally available, a data bank should be created. In order to assess the feasibility of such a scheme, pilot projects are being conducted at the Atlas laboratory. A team of three, Gover, Miss Harvey and Mr. Turnbull of IGS, started work in December 1967. Coding has now reached an advanced stage and it is hoped that geologists will be able to put fairly simple requests for information to the system during this summer.

time series analysis (P. Kent)

In the examination of a problem one often obtains a sequence of data readings which vary in a consistent manner. For example, the air temperature at noon each day would vary with the seasons. In addition to this basic cycle there would be fluctuations from day to day and long term changes over periods of many years. The components of such a sequence can be separated and examined by means of 'Time Series Analysis'; a system of programs for the analysis of time series, written in America for the IBM 7090 computer by Sir Edward Bullard and others, and now in use on Atlas. The program, known as BOMM, has already been used in the analysis of daily water flow in the river Indus, temperature fluctuations at the bottom of the English Channel, electro-encephalograph records, and fluctuations in the national grid. It should also be of use in the fields of astronomy, geophysics, and economics.

radiative transfer (I. P. Grant)

We have developed new methods of solving the equations of radiative transfer numerically using difference techniques based on well-known principles of invariance. Such principles have been used before to calculate the reflection and transmission of light by plane scattering layers, but not to compute light fields within the layer.

Apart from tests to verify theoretical results concerning accuracy and numerical stability of the methods, the first practical application of these ideas has been to compute estimates for the radiation emerging from the top of the earth's atmosphere for wavelengths in the 8–150μ region in the presence of cirrus cloud, a problem of interest to a project for atmospheric temperature sounding by artificial satellite proposed by by joint groups at Oxford and Reading universities.

pure maths
(A. O. L. Atkin, J. Leech, J. K. S. McKay)

At the present time three of our Fellows are engaged in pure maths research (Dr. Atkin on number theory; the others on group theory). In addition another Fellow, Dr. Paterson, is working on theorem proving by computers. The work being done in these areas is particularly interesting for new results are being discovered which would not have been found if computers had not been available. The laboratory helped to sponsor and organise a highly successful conference in Oxford last summer on the use of computers in algebra and it is hoped to organise a similar conference relating to number theory in August 1969.

lessons learned

The laboratory has been providing a computing service for nearly four years, and very intensively for the past three years. The use made of this service shows how great is the need. We get work from every university in Great Britain, the demand is increasing and there is a steady increase in the general levels of size and complexity of the problems put on the machine. It is particularly pleasing to observe the rising demand from workers in the non-physical sciences – sociologists, psychologists, educationalists, biologists and others – as they begin to appreciate the help they can get from a powerful computer and a quantitative approach to their problems.

The Atlas laboratory is operating as a national facility for universities, and to a smaller extent for government research laboratories; it is a great deal bigger than anything else to which the universities as a whole have access and is comparable with anything in Europe. The scale of operations is great enough to justify the provision of many technical and administrative services and we have come to the conclusion that these are valued almost as highly by our customers as is the computing power of the installation. Simple things like the supply of cards, paper tape, coding forms and stationery generally are very important; people need ready access to card and tape preparation equipment and to desk calculators for odd checks and minor pieces of arithmetic; help in arranging transport and booking accommodation is very welcome; and of course somewhere to work is essential. On the technical side, and taking for granted the vital need for first class basic software and library programs, we found a great demand for a general advisory service for users. To satisfy this demand we created the 'support group'. In order to improve communications between the distant users and the support group we have recently installed a Telex. This has the great merit of producing at low cost a printed copy, essential where modifications to programs are concerned.

Finally, all experience has confirmed the view with which the laboratory started out, that the presence of research activities in the building and easy contacts with the academic world and with other computing centres are essential to the intellectual health of the members of the laboratory. A large-scale computing service is really a very sophisticated and highly professional undertaking which makes demands at all levels and is always needing both stimulation and criticism; without these it is fatally easy for the people who are providing the service to become stale and unenterprising, and the standard of the service to decline.

GLOSSARY of computer terms

FORTRAN, ALGOL, etc. are languages which allow the user to express a problem without a knowledge of the machine's order code.

COMPILER, program which does the necessary conversion.

HARDWARE, the actual electronic equipment within a computer system.

SOFTWARE. the programs.

INTERFACE, can be either hardware, software, or a combination, to facilitate the joining of two (otherwise incompatible) pieces of hardware.

BITS, binary digits. i.e., 48 bits = 48 binary digits of either 0 or 1.

old scientific instruments

radio telegraphy

part 1. circa 1899 to 1922

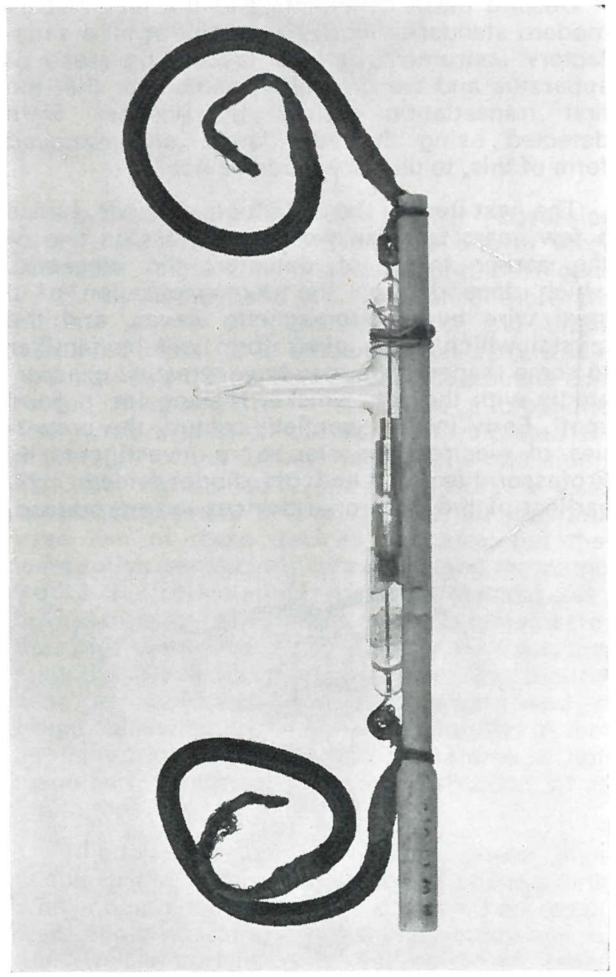
G. W. Gardiner

Research progresses and techniques change so rapidly these days that an establishment only a few years old may well possess apparatus of some historical interest. However, the odds against the apparatus being recognised as possessing historic value and surviving the period between obsolescence and ectopia are rather long. Unless a device has produced epoch making results which makes it an obvious candidate for preservation, it may well be cast on the scrap heap, or reduced to unconnected component parts which only serve to delay the inevitable limbo. It is therefore fortunate that in most groups of scientists and research workers, there is to be found at least one person with squirrel-like tendencies and an interest in the history of his occupation. Such is the case at Ditton Park where the Radio and Space Research Station has been established for almost fifty years and where successive workers have made considerable contributions to the understanding and growth of the science of radio communication. This is then a description of items from a collection of instruments and components which have contributed to the development of radio from its very early days.

The oldest surviving item in our collection is a book; this is perhaps not surprising because books have a habit of appealing to otherwise quite ruthless 'spring cleaners'. It dates from 1899 and is a history of radio as seen by John Joseph Fahie Esq. It may come as a surprise to readers to learn that at the end of Queen Victoria's reign, wireless telegraphy was sufficiently well established to warrant a historical record, but this was indeed the case.

The history spans about fifty years of attempts to signal without wires and lists the various methods which had been tried since the 1840's. These earlier methods usually made use of the properties of electromagnetic or electrostatic induction, conduction through the earth or through water, or a judicious mixture of both. Fahie was a telegraph engineer of considerable experience who survived into the twentieth century to become a veteran member of the Institution of Electrical Engineers. This book, together with an earlier one dealing with the history of line telegraphy, provides valuable source material for investigators of the dawn of electrical communications.

As events were to prove, the 'Electric Wave Method' triumphed and one of the main components of that success was the detecting device called the *Coherer*. This was a curious piece of apparatus which depended on the change in conduction of metal filings when electromagnetic waves impinged upon them. This effect had been noticed as far back as the middle part of the nineteenth century, but, except for one application as a lightning safeguard, had never properly been studied until researchers in the late 1870's and onwards brought it to the notice of the early experimenters in wireless telegraphy in the mid '90s. Its early form was improved upon by Marconi for use in his system of wireless.

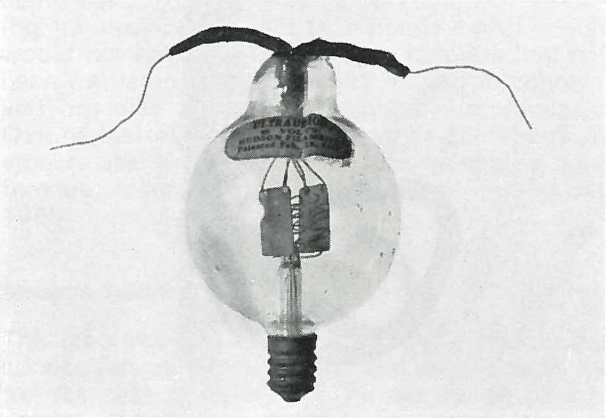


Marconi Coherer

Quite how this came to be at Ditton Park, when the Station was not founded until long after such devices were no longer in current use, is not obvious until we remember that the coherer continued to play a part for about the next twenty or so years as a lightning flash detector and it is almost certain that this little gadget has survived because it was used by Watson-Watt in his experiments in the counting of lightning flashes. The coherer is a small glass tube a few inches long, containing metal filings between two contacts, mounted on a cylindrical rod made of bone, one end of which has the letters M.W.T. engraved upon it. (Marconi's Wireless Telegraph Co.) No doubt it was one of a number of surplus detectors which must have been freely available in the early part of the century. It is unfortunately broken, but the author possesses another, which is still in reasonable working order, although it is, as the text books of the time assure us, 'a capricious and uncertain device'. Indeed Watson-Watt himself had written of it '. . . an intractable principal member, . . . little is to be hoped from any coherer recorder'.

Despite these comments and the fact that by modern standards the coherer isn't at all a satisfactory instrument, it is a fascinating piece of apparatus and we do well to remember that the first transatlantic signals by wireless were detected using the very latest and improved form of this, to us, very crude device.

The next item in the collection, a *Triode*, jumps a few years because we do not possess two of the earlier forms of detector; the magnetic, which depended on the demagnetization of a steel wire by electromagnetic waves, and the crystal which in its older form will be familiar to some readers who may have wrestled exasperatedly with the cats-whisker looking for 'a good spot'. Early in the twentieth century the properties of electron emission were investigated by Professor Fleming; and his diode detector, the earliest of the electronic devices, was produced.



DeForest Triode

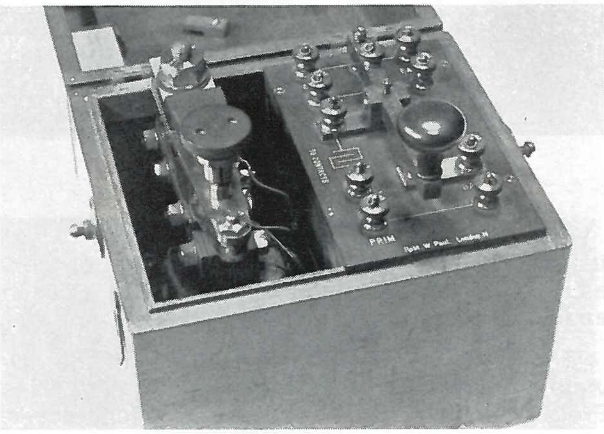
This was more reliable than the crystal but no more sensitive. In a year or two a third electrode, the grid, was added to the diode by the American, DeForest, making it the triode, and with it we see the beginnings of the vast range of thermionic devices which for the next forty years were to dominate the field of electronic research.

DeForest's triode went into commercial production round about 1910 and one of these early production models is now in our collection. It consists of a small glass globe a couple of inches in diameter in which can be clearly seen the filament flanked by two zig-zag plates to form the grid and with two parallel plane electrodes outside the grid which form the anode. The filament is connected by an ordinary miniature screw lamp fitting, exactly like a modern torch bulb, and two wires sprout from the top for grid and anode conections. Made before the first world war, these valves continued in use throughout it, although other and improved forms were being developed. It wasn't until the 1920's that they were beginning to be old-fashioned, though occasionally still used. We have in this triode an example of the progenitor of all the many valves which followed.

Within a year or two of the start of production of these early valves the World War began and, just as the 1939–45 war led to rapid advances in radar technique, so the needs of 1914–18 led to rapid advances in valve research and circuitry and to the improvement of wireless telephony. Another similarity between the two wars is a tendency for applied research to look at devices and methods which had long been discarded, in the hope of finding new fields of work for them. As in 1939–45 the depised crystal and cats-whisker re-emerged triumphant as a valuable component in very high frequency research, so in 1915 one of the early wireless telegraphy methods, mentioned by Fahie, that of earth conduction, formed a useful addition to the telegraphist's art for signalling between the trenches.

The basic requirement for an earth conducting system of telegraphy, which has a range of a mile or so, are very simple. They consist of a transformer or induction coil, a self-acting make-and-break device, to break up the direct current and to cause pulses in the primary, and a morse key to break up the pulses into short or long trains so that morse signalling can be achieved. From the secondary, wires are led to earth stakes about one hundred yards apart. When the key is pressed, high voltage alternating currents are caused to pass into the soil. The receiving equipment is even simpler, consisting merely of a pair of headphones and two earth points a similar distance apart and parallel to the sending 'aerials'. The alternating current generated at the transmitter is detected at the receiver earth terminals, producing a weak alternating current which actuates the ear phones, making a buzz of similar frequency to that of the self-acting interruptor.

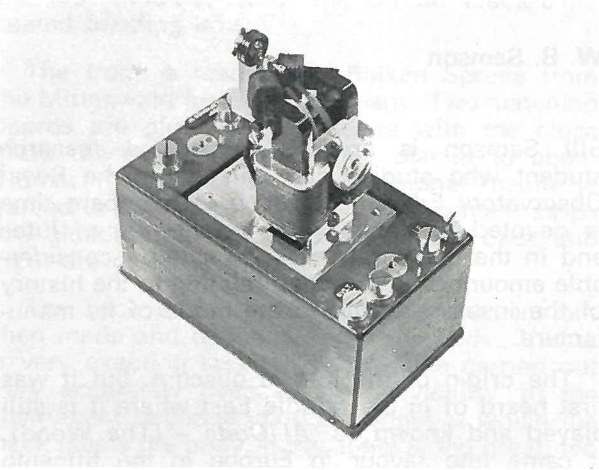
This is basically one of the wireless systems proposed shortly after the invention of the telephone, about 1878. For wartime use the system was greatly improved by employing the new fangled triode valve amplifiers which greatly increased the sensitivity of the detector and obtained a useful increase in range. It had disadvantages; the enemy using similar, more sensitive triode amplifiers could intercept the signals, and it was while attempting to do this that the German physicist Barkhausen was able to contribute to the study of a natural phenomenon known as the Whistler atmospherics in a more detailed way than earlier observers who had not had the benefit of the valve amplifier. All these improvements in earth telegraphy were made at the receiving end, the transmitter really didn't differ very much from that of thirty odd years before and we have such a *Transmitter* in our collection.



Earth Conduction Transmitter

It is a splendid laboratory type instrument in a polished wooden case, the automatic make and break is made of heavy brass and to one side is a lacquered morse key. It gives a sizeable voltage when the battery is connected and the key pressed, quite sufficient to deter one from touching the terminals. The whole instrument looks suspiciously well kept and clean and one feels that it may not have participated in the war, but been drawn from some stores well behind the line and from there found its way, for some long forgotten experiment, to our laboratories at Ditton Park. It is an interesting link, not only with the first World War, but, in a sense it looks back even further to those early systems of communication used in the late 1870's.

The invention and development of the triode valve marked a watershed in radio communication history. True, before it had appeared on the scene many aspects of radio communication had been achieved with continuous wave generation: wireless telephony and even, in a very limited way, experimental broadcasts; a commercial transatlantic radio telegraph service had been operating for some years and rudimentary experiments in radio control had been carried out. All these things had been attained, however, by stretching the pre-valve technology to the utmost limits. In a few cases valve and non-valve techniques survived for a while, side by side.



Brown Amplifier

The *Mechanical Amplifier* in our possession which dates from about 1922, is one of these examples. It was manufactured and developed by S. G. Brown and Co. and once more the familiar theme of polished wood and bright lacquered metal is in evidence. Basically it was nothing more than a very sensitive earphone connected mechanically to a carbon microphone. The weak signals in the earphone vibrated the diaphragm of the carbon microphone and amplified the signals sufficiently 'to work a loud-speaking telephone or a relay'. The full apparatus used two of these devices in series, but they were rather sensitive to vibrations and the output would scarcely satisfy the requirements of a hi-fi enthusiast. However it must be remembered that they were very often used for no more than magnifying a weak morse signal so that faithfulness of reproduction over a wide band of frequencies was not important. It formed in fact, as many triode amplifiers did at the time, a 'note magnifier', which gives some indication of its limitations.

Although but four in number, these items enable us to reach back, through obvious links with modern techniques, to a time when results were achieved using astonishingly crude apparatus. The Victorians were self-confident people and for the birth of the wireless telegraphy they needed to be.

people and their pastimes

lute making and playing

W. B. Samson

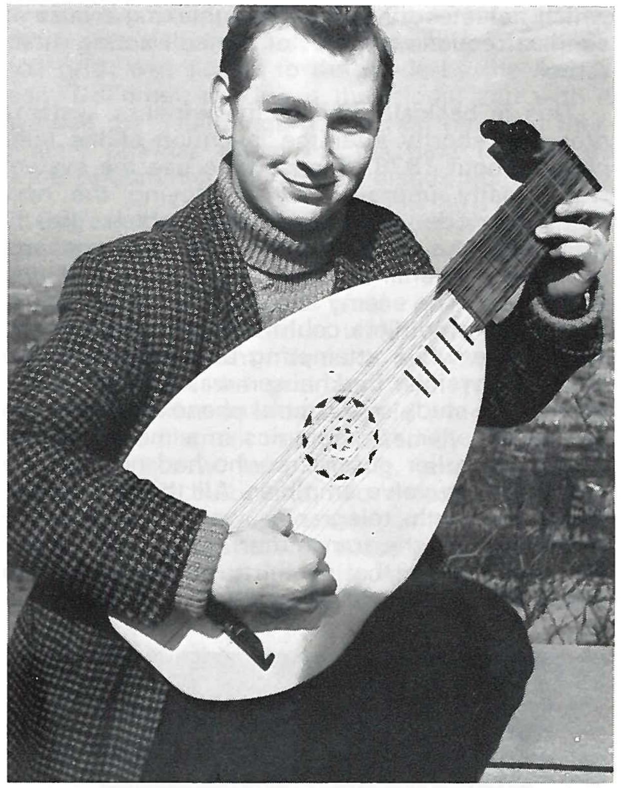
Bill Samson is an SRC supported research student who studies star clusters at the Royal Observatory Edinburgh. Much of his spare time is devoted to the making and playing of lutes and in the process he has collected a considerable amount of information relating to the history of the instrument and to the mode of its manufacture.

The origin of the lute is obscure, but it was first heard of in the Middle East where it is still played and known as *'Al Oude'* – (The Wood). It came into favour in Europe in the fifteenth century and a great deal of solo and consort music was written for it up to about 1700. The music is of special interest; whereas the majority of instrumental music is written in the familiar staff notation, lute music is written in tablature, which is easily understood by a lutenist, but is quite unintelligible to any other instrumentalist.

In its heyday the lute was a much prized instrument found only in the homes of the very rich; the violin on the other hand, was considered to be the instrument of common fiddlers and street musicians. To lend weight to this ancient opinion, a Stradivarius violin when new would have cost about £16, whereas a good lute would have cost about £100.

A Baroque lute had as many as twenty-six strings and a fingerboard more than four inches wide, which made it a most difficult instrument to play. All lutes are difficult instruments however, with their wide finger boards and groupings of strings, many of which are tuned in pairs; this together with the desire to fit even more strings, led to the decline of the instrument. Another great hazard was the maintenance of the 'tune' of the strings. We take nylon strings for granted, but in the heyday of the lute, it has been said that if a lutenist lived for eighty years, at least sixty of them would have been spent in tuning the gut strings of his instrument.

Lutenists were normally retained by the nobles and rich gentry of the period but it was often necessary also to retain the services of a lute tuner. Small wonder therefore that it often cost as much to keep a lute as it did to keep a coach and pair!



The great lute makers, or Luthiers, of the day were of German origin but working in Italy; Hans Frei, Wendelin and Gaspard Tieffenbrucker, Maler and Hartung, being the best known. Unfortunately few of their instruments survive in their original form. The fashion for more strings to increase the repertoire, caused the instruments to be modified and strengthened to support the increase in string tension and this usually succeeded in damaging the instrument or at least severely diminishing the tone.

Bill Samson was converted from an electric guitar – that cacophonous symbol of present day 'pop' music – to the more melodic and infinitely more demanding lute and its music after watching a performance on television given by Julian Bream, the celebrated guitarist. The conversion was a systematic affair, graduating through a year's study of the classic guitar, which gave him experience of intricate fingerwork and so building up the dexterity which the wide finger board and the many strings of the lute would demand.

When it came to buying an instrument, the local music shops could offer no help, nor were they forthcoming with literature, so with just two prints of old lutes to help him, he set about building his own. The result was a not-very-good copy of an eleven stringed early sixteenth century instrument, made with insufficiently seasoned wood and an internal support structure that would have given the early German masters heart failure. The tone was weak, but during its short life it did at least provide a platform for practice sufficient to whet the appetite for better things, so he set about the construction of Lute Mk. II.

This time he had some help; during the short life of the first instrument he had been introduced to a classical guitarist who had constructed a passable lute with the aid of a book from the Dundee reference library. The book, *'Musick's Monument'* by Thomas Mace contained a section on the upkeep and repair of lutes which included a suggestion that to maintain the tone of the instrument it should be kept in 'a well used bed!' Another book which contributed much to the venture was *'Musical Instruments through the Ages'* edited by Anthony Baines, which contained an article by M. W. Prynne, together with a photograph of the internal structure of a Hans Frei instrument.

The story of how Mk II was built is best told in Samson's own words:

Lifting the back from the mould.

'Apart from finding the materials which was the biggest task of all, the construction of the instrument took about three months. This time could have been shortened, but I could only work on those weekends when I could get home to Forfar where I had my workbench and tools.

A mould of the inside of the instrument is made and the gourd-like back constructed around it. The back is usually made of nine or more strips of hardwood, no more than 1.5mm thick, which are first moulded to shape on an electrically heated bending iron.

The front is made from Balkan Spruce from the Mittenwald forests in Germany. Two matching boards are glued edge to edge with the close grain toward the centre, then planed to about 1.5mm. The elaborate and traditional rosette is carved in the centre, and six reinforcement strips are glued to the underside, then the back and front are glued together.

The neck and pegbox of the instrument are then made and dovetailed into the body. This is a very exacting task which must be carried out very accurately because the 'playability' of the instrument depends upon the angle at which the neck meets the body. If the angle is too great, too much pressure will have to be applied to depress the strings, if too shallow, the strings will buzz against the fingerboard when they are plucked. Finally, the bridge is glued on and the instrument is varnished. Strings are fixed and tuned and the acid tests applied – the tone! If this is very poor then it may necessitate unglueing the front and modifying the thickness of the panel or the support strips. The aim is to reproduce the authentic lute tone of the renaissance instruments.

I took Mk II to the Lute Society Summer School in August 1967, where apart from tuition in playing, most of my time was spent in discussion with others who, like myself, had built their own instruments, and with professional Luthiers like Ian Harwood, Maurice Vincent and Sandro Zanetti-Golay, the distinguished Swiss Luthier.

Lute makers exhibit a freemasonry quite unlike the makers of (for instance) violins, and will discuss their manufacturing techniques without reserve. This is probably due to the fact that many of them have long waiting lists for their instruments, some of them extending into years, so that they are not subject to the intense competition which exists among the manufacturers of other musical instruments.

I am now working on Lute Mk III and with the experience gained in the making of the first two, plus the knowledge acquired at Summer School and from talking with experts, I have high hopes of being able to produce quite a passable instrument'.

profile

Professor D. H. Wilkinson, FRS

Professor Denys Haigh Wilkinson the new chairman of the Nuclear Physics Board, was a founder member of the National Institute for Research in Nuclear Science which was incorporated in the SRC in 1965. He is an internationally respected physicist who is perhaps best known for two major contributions to the instrumentation and to the theory of the science.

Born in Leeds in 1922, Professor Wilkinson was unwillingly transported from the County of Cricket to Leicestershire at the age of six months, but he still remains a loyal Yorkshire supporter. His education began at Loughborough where he showed a preference for chemistry and physics. He won a scholarship to Cambridge in 1940 and worked equally on both subjects until events confirmed physics as the subject of his choice. He became involved in atomic weapons research and this led, in 1943, to participation in the British and Canadian atomic energy projects, firstly at Cambridge, then at Montreal and Chalk River. In fact he was the first scientist to carry out an academic experiment on a nuclear reactor outside the United States.

One of the absorbing interests in Professor Wilkinson's life has been the study of birds and the first scientific paper he ever published was on the subject of bird navigation. This was in 1946 when he was forced by ill health to 'retire' from nuclear research. He had contracted radiation sickness and was given only six months to live, but within a year he had 'mysteriously recovered' and was back at work at the Cavendish laboratory where he set out to explain and improve the electronic devices used to detect and analyse nuclear particles. He was the first to give a coherent account of the operation of a Geiger counter and his book has become a classic. He also invented the principle of analogue to digital conversion which is now the basis of a multi-million pound instrument industry. Unfortunately the Professor did not take out a patent so has not received any financial reward for his invention.

Professor Wilkinson has lectured extensively in the United States and in the five continents. He was made a Fellow of the Royal Society in 1956 at the age of 33 and among the many honours which have been granted to him are included the Holweck Medal of the French and British Physical Societies and the Hughes Medal of the Royal Society.

The pressure of his professorial and committee duties inhibit his ability for experimental work in this country, so the Professor largely confines his experimental research activities to Brookhaven in America where he is undisturbed and free from official distractions.

In his early years, the Professor was a keen sportsman; at college he took part in athletics and rock climbing, gained a Blue for the high jump and was in the first team for lawn tennis. He was also interested in literary matters; he edited the school magazine and was for many years the drama critic of the Cambridge Review. He has always been very fond of music and possesses what is probably the largest private collection of pre-Bach recorded music in Oxford. Nowadays his main outside interests are medieval art and church architecture.

newsfront

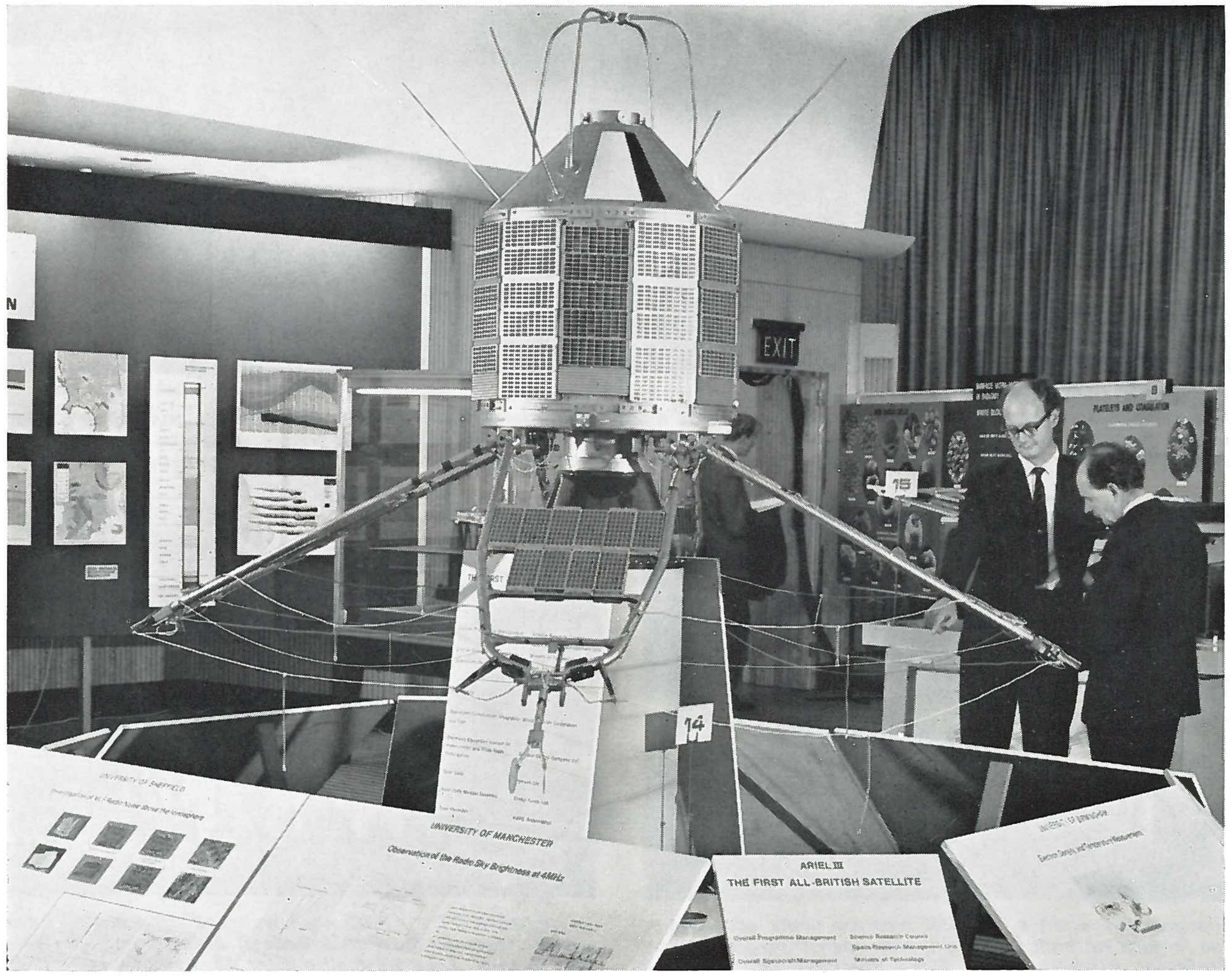
HAPPY BIRTHDAY

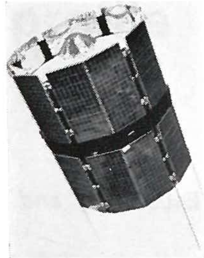
How many members of SRC Space Division remembered to 'tip a cup' to Ariel III during Sunday tea on May 5th?, because at precisely five o'clock that day the satellite completed 5,518 orbits and exactly twelve months in space.

This first all-British satellite is a great success and has sent back to earth something like four hundred million words of data from the six experiments it carries. Most of the data has been processed by the Atlas Computer Laboratory and RSRS.

Some of the final results were displayed by SRC around the flight engineering model of the satellite at a symposium held in the beautiful new home of the Royal Society in Carlton House Terrace.

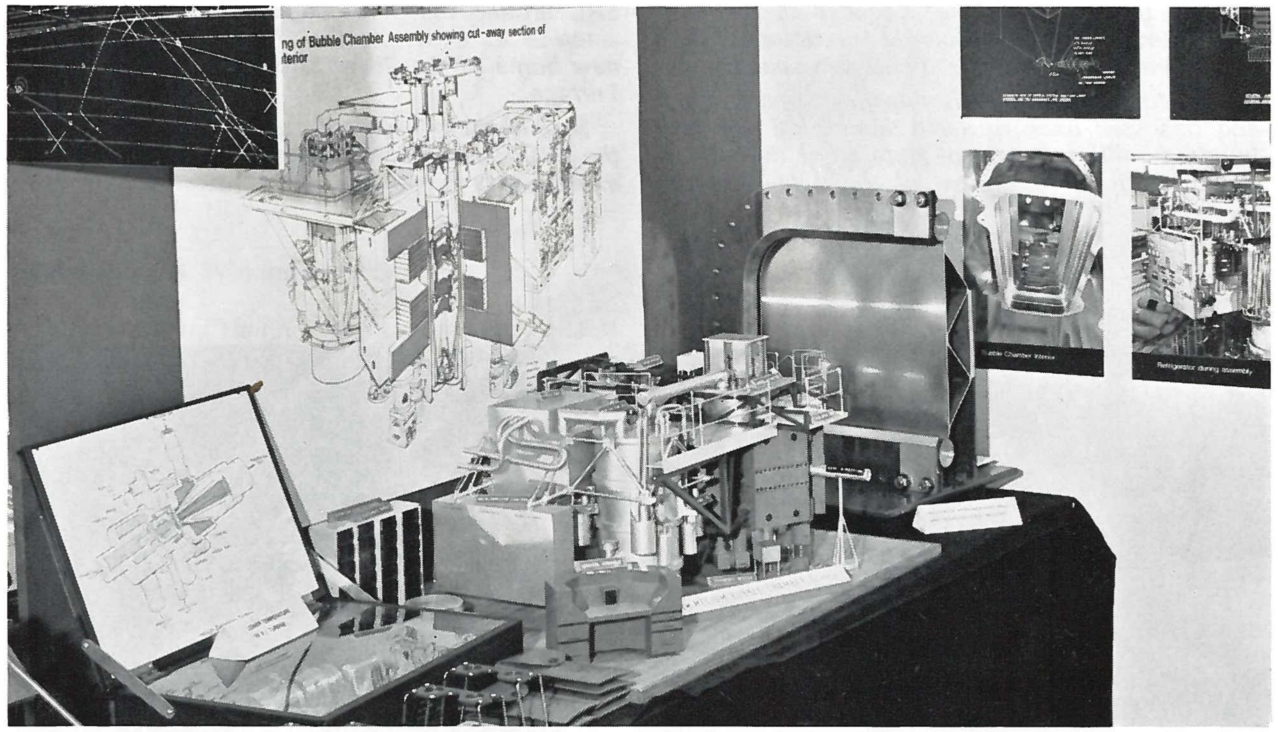
In the photograph, Mr. J. F. Smith, who was the SRC Project Co-ordinator, explains one of the experiments to a visitor.



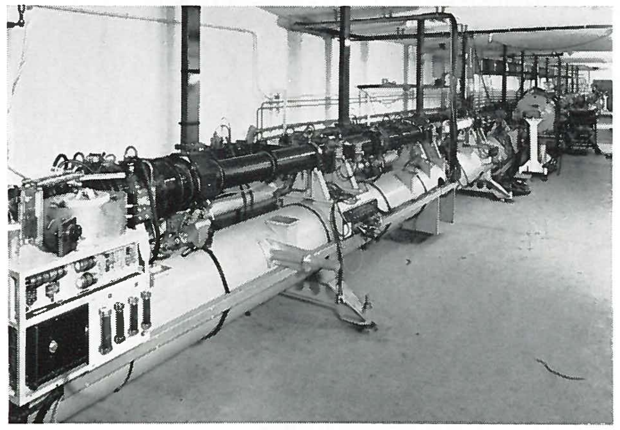


ESRO II carries seven experiments designed to study the sun and cosmic radiation. Five of the experiments are from British universities and will continue measurements similar to those carried out by Ariel III.
SRC is the agency carrying responsibility for UK participation in ESRO. In 1967/68, the UK contribution was 4.5 million pounds.

For the technically minded, the satellite weighs 163 lbs. It has a polar orbit with a perigee of 217 miles and an apogee of 684 miles. It will circle the earth in 99 minutes and each day its orbit will move one degree eastward to keep it within sight of the sun.

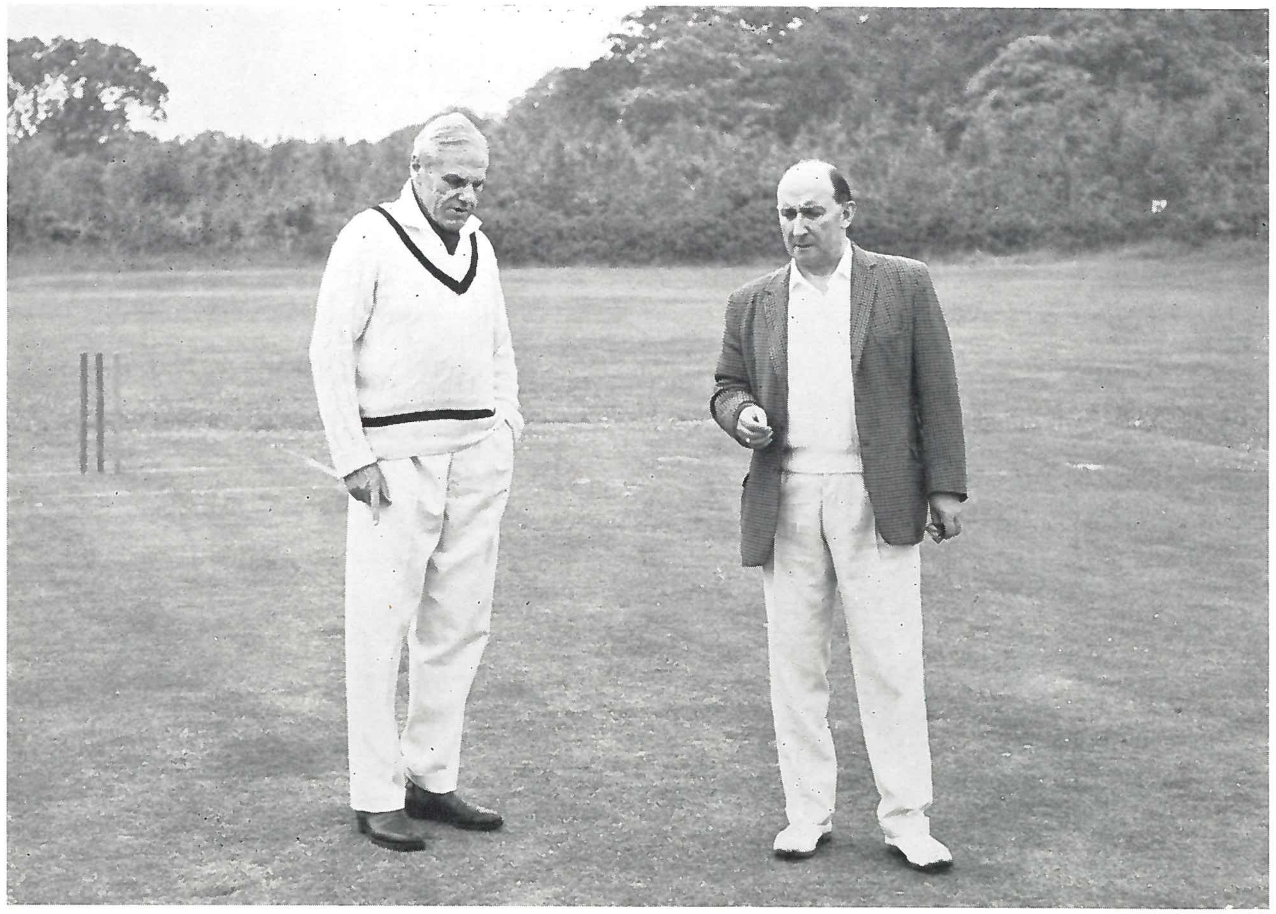


RUTHERFORD'S BUBBLE CHAMBER IS LARGEST IN THE WORLD
Also on display at the Royal Society symposium was a model of the large helium bubble chamber constructed as a joint project by the Oxford University Department of Nuclear Physics and the Rutherford Laboratory. It is the largest of its type in the world and contains 200 litres of liquid helium; the internal dimensions are 81cms by 40cms by 43cms deep.



Glasgow University's 100MeV electron linear accelerator, the largest yet built in Britain, was opened on June 10 by Professor Blackett, O.M., C.H., President of the Royal Society. There are now eight nuclear physics accelerators in British universities and the Glasgow linac is intended to serve the needs of Scottish universities.

VANQUISHED . . . SRC were well and truly beaten by a MPBW team in the Curtis Bennett Shield match at Harwell in May. They were all out for 48, Kershaw of MPBW taking eight for nineteen. In reply, MPBW made 52 for 2. Top scorer for SRC was Ray Smith (11).



'NO . . . IT ISN'T A QUASAR OR A QUARK . . . I THINK IT'S JUST A WORM-CAST.'
In fact it was a (seemingly pessimistic) inspection of the wicket by the Astronomer-Royal (left) and Dr. Saxton during a match which was played between RGO and RSRS on June 16.
'Greenwich' bowled out 'Radio' for 122 and went on to get the winning runs for the loss of only three wickets.
Top scorer for Greenwich was J. Hobden (44 n.o.). J. Philcox took 4 for 20, J. Hutchins 4 for 41 and Sir Richard 1 for 11.
Top scorers for Radio were N. Hussain 40, C. Bolton and E. Bramley 29. photo D. Calvert

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contributors

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