Printed by The Mount Press Ltd., Hungerford Road, Bristol 4.
Published by The Science Research Council, State House, London W.C.1.

QUEST

QUEST

House Journal of the
Science Research Council

VOL. 1 No. 2
APRIL / JUNE
1968

contents

Cover

"The Tree House"

An early Smith-Rose experiment (circa 1929) using the Adcock system of direction finding. In order to ensure that the apparatus was in the electrical centre of the aerial, the platform was hoisted up between the guide poles and secured to the brackets.

editorial

Many factors contributed to the delays in the printing and distribution of the first issue, in many instances copies did not arrive in time to permit reasoned comment for publication in this issue. However, the editorial board met in London in February to discuss the general make-up of the journal and its future policy and they were able to present a fairly representative interpretation of the comments received. A summary of these will be found in the newsfront section.

First issues are always a problem, but now that we have overcome that particular obstacle and arranged firm printing and production schedules, future issues should appear promptlv at the beginning of each quarter, — July, October, and December, although we might decide to delay the December issue in order that we may report the Christmas celebrations in the various establishments.

The content of future issues will maintain the same basic formula of four or five technical articles, features, articles of general interest, further explanation of the organisation of SRC and a section which deals informally with news of people and interesting events.

It must be remembered that our brief is to produce a "house" journal. We do not set out to present a glossy image of SRC to the outside world; copies of the journal are intended for SRC distribution only.

We will endeavour to maintain a balanced content, but this will not be a prime consideration. For example, the first edition was predominantly astronomy but in a future edition when for instance we deal with a history of the Rutherford Laboratory, the content may be overwhelmingly high energy physics. We make no apologies for this, we have a broad spectrum of choice and it would be a pity to be restricted by fears of parochial affront.

'we must grant the artist his subject, his idea, his donné : our criticism is applied only to what he makes of it'.

contributors

Edwin. N. Shaw
Head of Information, CERN. Formerly founder editor, 'Nuclear Engineering'.

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Experimental Officer. Concerned with instrumentation and experimental physics, mainly in radio-meteorological field. Currently employed in RSRS solar radio astronomy laboratory.

Dr. P. F. Smith
Principal Scientific Officer, Rutherford Laboratory. Responsible for directing laboratory's research programme in superconducting magnet technology and studying future applications in high energy physics.

Dr. D. B. Thomas
Principal Scientific Officer, Rutherford Laboratory. Currently leading design study and development programme for proposed high field bubble chamber.

The origins & objectives of the S R C

Part 2
The London Office

In the first issue, we described how Council's work is organised through its Boards.

The work of the office is carried out through five divisions whose functions are illustrated by the chart.

The cost of this administration, including the fees and expenses of Council, Board, and Committee members represents about two per-cent of the expenditure of the SRC. In the current year, this will amount to about thirty-eight million pounds. The Nuclear Physics Division spends £16.5 m., ASR £9 m., and the UST Division, £11.7m. The annual report of the Council which is published in the autumn of each year describes the work of the Council and the underlying policy. Copies of the report are obtainable through the Stationery Office or through your own library.

The Council

Dr. D.G. Christopherson, O.B.E., F.R.S.
Dr. E. Eastwood, C.B.E.
Professor H. Ford, F.R.S.
Dr. M.R. Gavin, C.B.E.
Professor J.C. Gunn, F.R.S.E.
The Earl of Halsbury
Professor F. Hoyle, F.R.S.
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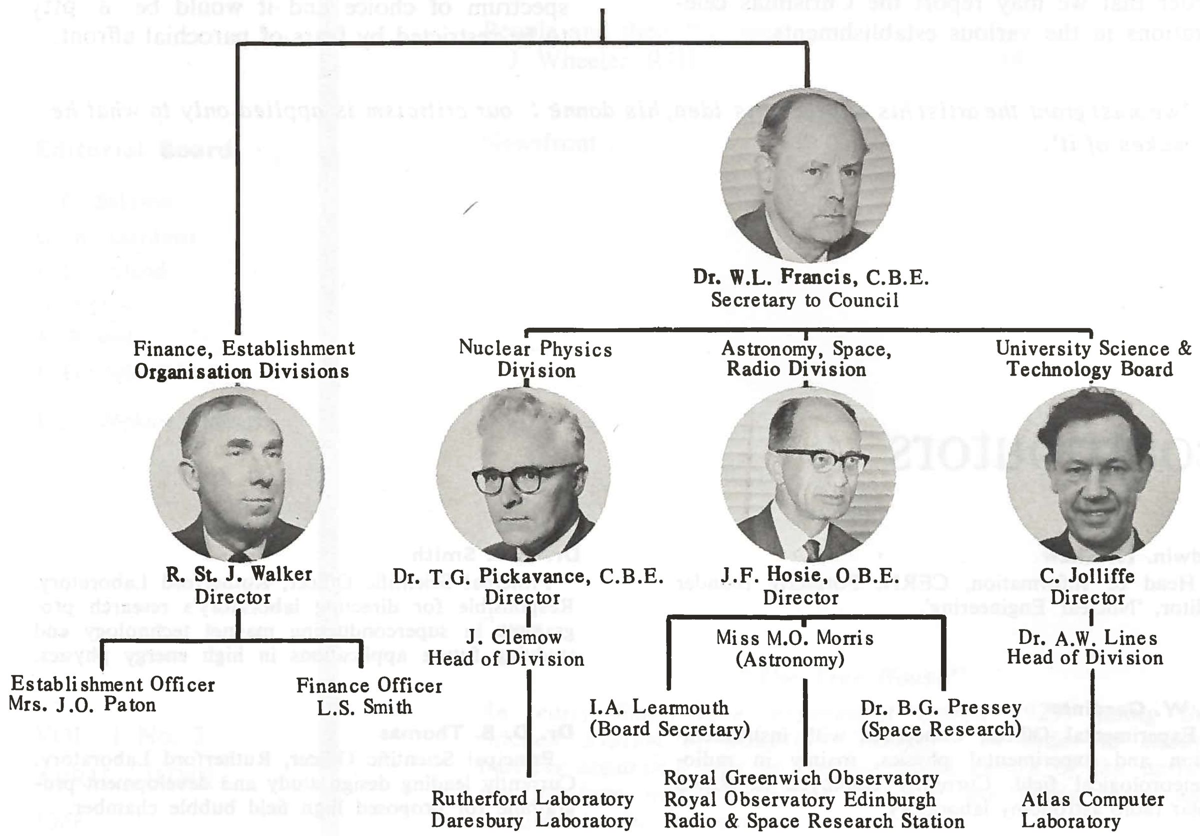
Chairman: Professor B.H. Flowers, F.R.S.



profile

Professor Sir Ewart Jones F.R.S.

Wayneflete Professor of Chemistry at Oxford University since 1965 and a Fellow of Magdalen College, Professor Jones is the Chairman of the University Science and Technology Board. Prior to the merger in 1965, he was a member of the Council for Scientific and Industrial Research and Chairman of the Research Grants Committee.

Born in 1911 in Wrexham, Professor Jones was educated at Grove Park School, Wrexham, the University College of North Wales and the University of Manchester.

• • •

Professor Jones obtained his first teaching post at the age of 27 when he was appointed Assistant Lecturer in Organic Chemistry at the Imperial College of Science and Technology. Soon after the outbreak of war, the Head of Department, Professor Heilbron became heavily involved in work at the Ministry of Supply and the Ministry of Aircraft Production and Professor Jones gradually had to take over the responsibility of running the Department.

Those years were exciting in many respects and whilst the world seemed bent upon its own destruction, it also had the effect of persuading many would-be undergraduates who might otherwise have applied for universities in the provinces, to remain in London close to their families. With the result that Imperial College produced a vintage crop of Chemistry graduates. Many of these one-time students of Professor Jones' now occupy Chairs of Chemistry at universities throughout the country. The Professor, recalling those hectic war years, when in addition to his normal tutorial duties, he trained nearly 2000 Gas Identification Officers, commented ruefully, 'like the Windmill, we seemed never to close!'

Professor Jones returned to Manchester University in 1947 as Head of the Department of Chemistry. He was the first Arthur D. Little visiting professor at the Massachusetts Institute of Technology in 1952 and since then has given lecture series at Illinois UCLA, Edmonton, New South Wales, etc. He has been awarded the Meldola (Royal Inst. of Chem.) 1940, Fritzshe (American Chem. Soc.) 1962 and Davy (Royal Soc.) 1966 Medals and honorary doctorates from several universities. He has been very active in the affairs of the Chemical Society, was its president from 1964-66 and is now Chairman of its Publications Board.

The Professor lives on the outskirts of Oxford, is married with a son and two daughters, all involved in academic careers. Recreation figures but lightly in the Professor's life; in his own words, he is fond of music, especially opera, likes walking in the countryside, gardening and photography, but has not time yet to take any pastime seriously.

The European Organization for Nuclear Research

Edwin. N. Shaw

Rebuilding and reconstruction were the pre-occupations of the post-war years. New homes, new roads, new factories, new schools, new universities, new institutions. Replacement was not enough, the world had changed fundamentally. Socially the countries of Europe were going through a period of rapid evolution: at the political level, new alliances were being sought under the spectre of atomic energy.

Science had come down from its ivory tower with a vengeance, and physics, even to the lay man, was no longer a subject of purely academic interest but a dominating force in the world.

The balance of power was not wholly vested in the bomb. For the first time the relation between science and industry was concerning the leaders of European countries. The popular phrase "technological gap" had yet to be coined, but the disparities in technological achievement particularly between the United States and Europe were becoming appreciated. It was also being realized that a basic element in this difference was research.

In the late 1940's and the early 1950's the distinctions between the various aims of research were not always understood but atomic energy was recognized by all as a major growth point, offering on the one hand opportunities for discovery and development and on the other, the possibility of major commercial and political gain.

Even before the end of the war the UK had decided to establish its own independent nuclear weapon which later extended to an independent nuclear power industry with the consequent imposition of secrecy restrictions of military and then commercial origins.

Pure Research

This approach was to be followed elsewhere. But there was an early recognition that high energy physics was a field apart. Here was a subject where the old rules of science, of collaboration, of exchange, of co-operation, of openness, of mutual interest could still apply. Burgeoning out from the confused but wealthy springs of atomic energy the study of the fundamental nature of matter could become again, natural philosophy.

There was however a fundamental change coming over the science itself. Until the advent of the first major accelerator, the majority of new discoveries in the sub-nuclear range had come from the study of cosmic rays where the basic equipment was cheap and the means of research available to all. The arrival of the big accelerators changed all this, and physicists in Europe realized that if they were to have at their disposal, machines of comparable power and comparable interest to those which were being developed in the United States and the Soviet Union then a combined effort was going to be necessary. The urgency was perhaps less

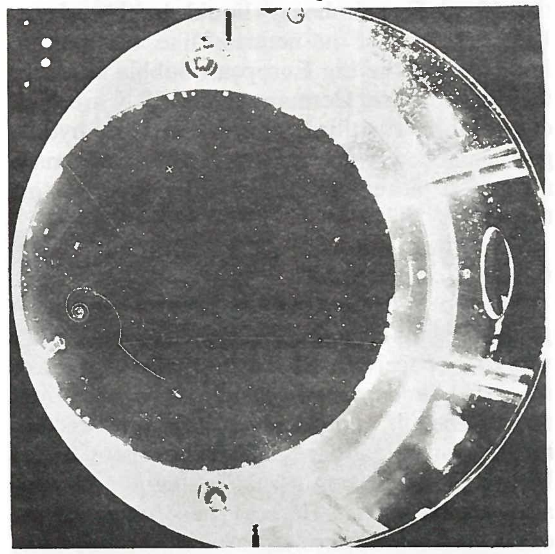
felt in the United Kingdom in view of the existence of the Harwell cyclotron, the Liverpool project, the Birmingham synchrotron project and the operation of the first 5 MeV electron linear accelerator at Malvern.

First Negotiations

Stimulated principally by Professors Auger and Amaldi, UNESCO took upon itself the job of bringing together the European governments to discuss the possibility of setting up a joint European nuclear research establishment. There was probably at that time in non-scientific circles some uncertainty as to its real *raison d'être* and the possible applications of its work, although it was recognized from the beginning that the time-scale associated with such applications would be long.

Amongst the scientists however there was little confusion—indeed the overall unanimity was remarkable. It was the sub-nuclear world that was of the greatest importance and the supreme purpose; the science itself and not the applications. So it is today.

At the UNESCO meeting in December 1951 and February 1952 the UK delegation led by Prof. G. P. Thomson was not completely in line with the other countries, as the UK was advocating the utilization by Europe of the laboratory being built at Liverpool. Some European participation at Liverpool was forthcoming, but when a Convention setting up a provisional Conseil Européen pour la Recherche Nucléaire (CERN) was signed at the second UNESCO meeting, the UK retained the status of observer. This did not prevent UK scientists from taking an active part in the project and the report of Sir John Cockcroft in the Spring of 1952 on the progress that was being made with the Brookhaven machine was a profound stimulus. In the event, the Conseil was able at its sixth meeting in July 1953 (attended by UK 'observers') to agree a Convention establishing the European Organization for Nuclear Research (still called CERN).



A neutrino event in the heavy liquid bubble chamber.

In this interim period whilst Britain was clearly differentiated from the signatories to the provisional Convention, Prof. Blackett was a prominent figure in the discussions as was F. Goward from the Harwell accelerator group. UK sympathy was expressed by a gift of money to the Conseil made by Sir Ben Lockspeiser (then Secretary of DSIR) who was personally active in the drafting of the final Convention. Sir Ben was made Chairman of the first administrative and finance Committee and following the ratifications, became the first President of Council when in September 1954 the new Organization came into formal existence.

Britain was the first country to ratify the permanent Convention, eleven other states quickly following, viz: Belgium, Denmark, Fed. Rep. Germany, France, Greece, Italy, Netherlands, Norway, Sweden, Switzerland and Yugoslavia. The following year, Austria became a member of CERN and in 1961 Spain making the total 14. In June 1962 Yugoslavia had to withdraw owing to financial difficulties but retained the status of observer in company with Poland and Turkey.

Start of Construction

The Convention stipulated that two machines were to be built at the new laboratory near Geneva, one a Synchro-cyclotron of 600 MeV and the second a Proton Synchrotron whose energy was finally scaled up to 28 GeV. It was natural that British design teams should play a dominant role because only Britain in the early 1950's had had an opportunity of large scale accelerator design and construction. The early proton synchrotron group had in fact been set up under Prof. Dahl of Germany, but his deputy was F. Goward of the UK and under him J. Adams. The major influx of UK people was in October 1953 and for a time the comment could be heard in Geneva that CERN was that British laboratory out at Meyrin.

In the Organization, Adams was made head of the Proton Synchrotron Division and with the death of Prof. Bakker in 1960, became Director General. It is interesting to note also that the first experiments on both the synchro-cyclotron after it came into operation in September 1957 and then 2 years later on the P.S. itself were made by teams led by Prof. A. W. Merrison now of Liverpool (Director of DNPL) in conjunction with Prof. Fidecaro.

UK contribution

UK participation therefore in the growth of CERN during the first years was heavy, not to say massive, but the demands made by the design and commissioning of Nimrod and its subsequent operation, followed by Nina, led to a smaller use of the experimental facilities than might have been expected.

The UK financial contribution is based simply upon its net national revenue in comparison with the other member countries and is currently established at 22.16%. This remains fixed regardless of the number of UK employees at CERN (10%) or the number of experiments made on the machines. Similarly there is no correlation between this investment and the number of contracts which are placed with UK companies. Contracts are placed by CERN for equipment on a straight-forward price basis providing that technical competence and delivery times are also acceptable. Concern has been expressed in the UK for example, by the special Committee of the British Nuclear Forum at the small number of contracts going to Britain (amounting since 1952 to approximately 4½% of the total) but this is an expression of lack of interest on the part of British industry rather than evidence of any differentiation or absence of technical competence in the UK

Developments at Meyrin

The second major step in the development of CERN Meyrin was the decision by the CERN Council in December 1965 to add to the 28 GeV Proton Synchrotron (PS), Intersecting Storage Rings (ISR) to allow collision beam physics to be undertaken at a centre of mass energy of 56 GeV. To achieve the same interaction energy in a conventional accelerator using a stationery target would require a beam energy of 1700 GeV. The British at that time gained the reputation of being luke-warm on the project and adopting the same un-European attitude that had been adopted towards Euratom and certain ENEA projects.

It was not generally realized that for legitimate scientific reasons, UK physicists were in general more anxious to go ahead with a 300 GeV accelerator and feared that the interposition of this major project—costing more than twice the original PS—would prejudice the chances of the next big accelerator. The present postponement of a decision on this project, partly as a result of the need to reconsider UK overseas commitments in the light of devaluation, gives some point to this attitude. It should neverthless be said that the ISR which are scheduled for completion in 1971 look progressively more and more attractive and should provide Europe with a quite unique experimental machine for much of the 1970's.

In addition the 'improvements programme' to augment the performance of the PS is now getting under way. During the coming summer shut-down, the new PS power supply will be coupled in, allowing a threefold increase in repetition rate. Work has begun too on the booster injector which will raise the injection energy into the main ring from the 50 MeV output of the linear accelerator to 800 MeV. This will allow a tenfold increase in the beam current. Other immediate projects of a major nature include the installation of Gargamelle, the 12 m³ French heavy liquid bubble chamber at the end of the neutrino line, for start up in 1969, and the big European bubble chamber to which France, Germany and CERN are each contributing one third. This 3.7 m, 22 m³ hydrogen chamber with a superconducting main magnet is scheduled to go into operation at the end of 1971.

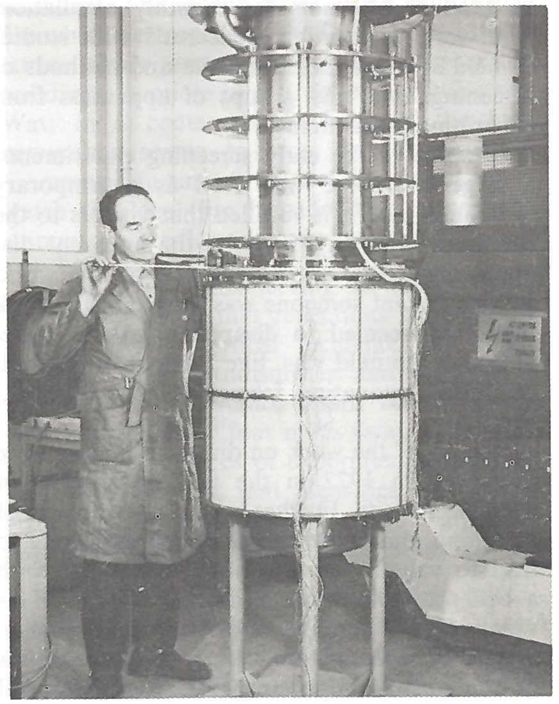
CERN's contribution

The world of fundamental physics has undergone startling changes in the years since CERN was first conceived. At that time the number of so called fundamental particles was small and the number of anomalies in their apparent behaviour sufficiently restricted for there to be hope that elucidation would follow in a reasonably short period. But, as has happened so often before in physics, an era of apparent order has given place to a period of growing confusion.

The number of so-called fundamental particles or resonances now approaches 200 and we are still some way from providing a sufficiently clear pattern of experimental evidence for adequate theoretical explanations to be forthcoming.

In this scene of mounting complexity, and mounting interest, CERN has enabled European physicists to play a leading role. It is not so much that individual experiments conducted at CERN are unique in the world as that in the growing pool of knowledge, the contribution of physicists in Europe, working with the CERN machines, has been at least on a par with that from other laboratories. Certain experiments, have, perhaps, become a CERN speciality such as muon physics including its electron and Beta decay and the measurement of the gyromagnetic ratio to ever increasing accuracy to determine in what way the muon can be distinguished from the electron other than by its mass. The missing mass spectrometer has provided direct information of the existence of many resonances which could be said to bear a specific CERN hall-mark.

Probably the most publicised experiment at CERN was the one which gave the negative result that charge conjugation was not violated in the three pion decay of the eta meson—the statistics of the CERN experiment being an order of magnitude better than those obtained in the US upon which provisional evidence of such violation was based. The existence of a sudden change at approximately 10 GeV of the proton-proton wide angle scattering cross-reaction is another result where CERN's effort has been dominant as also in the use of polarized targets. The very recent run of neutrino experiments is also unique and the analysis of the 90 free proton-neutrino events photographed during the period is awaited with keen anticipation. Nevertheless this is a field where world research moves forward together.



CERN has made many contributions also to theoretical advance but, so great is the collaboration between the senior laboratories, the distinctions between them and their results are continually blurred. It suffices to say that in the big league of world sub-nuclear physics, CERN is considered to be among the leaders —even perhaps at this moment, the top laboratory.

Maintaining Impetus

Its position does of course depend upon the machinery it has at its disposal and the quality of the physicists who come to use it. The majority of these are from the universities and research centers of Europe and the process is one of positive feedback; the better the machines, the better the physicists, and the better the physicists the better the work done on the machines. So it is natural that with a 70 GeV accelerator coming into operation at Serpukhov in the Soviet Union and work going ahead rapidly on the 200/400 BeV American machine, there should be anxiety amongst European physicists over delays in reaching a decision on the 300 GeV project.

Undoubtedly the attitude of the UK is crucial. From the scientific point of view a clear answer in favour of the project has been given; the vital question remaining is finance. Whilst only 3 countries have stated their intention of joining the project so far—Austria, Belgium and France, there seems little doubt that a clear cut assent on behalf of the UK could be decisive in influencing the remaining nine. As in the past, so in the present, Britain is in a position to play a key role in the future of CERN.

Left. Braracourcix, an experimental superconducting magnet for tests prior to freezing the 3.7 m bubble chamber design.

A History of the Radio and Space Research Station

G. W. Gardiner

Situated in the grounds of Ditton Park, a 'Domesday' manor on the edge of Slough in Buckinghamshire the station is bounded by the A4 and Slough to the North and the M4 which runs within feet of the South entrance. Windsor Castle and Eton College chapel are visible when winter denudes the screen of trees, London Airport is a too-close 7 miles away and Reading lies 20 miles to the West.

For nearly fifty years Ditton Park has been the scene of continuing investigations into the problems of radio propagation and allied subjects; dating back to the formation in 1920 of the Radio Research Board which was constituted under the DSIR to 'direct any research of a fundamental nature that may be required, and any investigation having a civilian as well as a military interest'.

The Board first met in February of 1920 and as a result, four sub-committees were formed to deal with Propagation, Atmospherics, Direction Finding, and Thermionic Valves. Among the famous people composing the first board were Lord Rutherford and Admiral of the Fleet Sir Henry Jackson, who was perhaps mainly responsible for the station being sited at Ditton Park. On the sub-committees were more famous names, among them Appleton, Smith-Rose and Watson-Watt. Admiral Jackson, the first Chairman was an enthusiastic and successful experimenter in wireless signalling; he was outstripped by Marconi and probably hindered by the need to observe security regulations, but his interest in the subject never flagged. It is said that during the nine years of his chairmanship he personally read every official paper produced by the Board's research workers.

In 1920 the Ditton Park site was manned by one scientific officer and an assistant, under the supervision of the NPL. A year later a translator with scientific qualifications joined them to produce abstracts for monthly circulation. The work was mainly concerned with studies of field strength measurements and methods of screening units and groups of apparatus from electro-magnetic fields.

In some of the early screening experiments, a large iron pipe was used as a temporary laboratory and it is recalled that visitors to the site were often mystified by the apparent disappearance of scientists engaged on the work. At one instant someone was visible in the Park then they seemed to disappear without trace, although the field was, like Prospero's Isle, full of noises emanating from this curious workshop!

Results of the work on direction finding were published in 1922 in the first of a series of special reports. Further studies were made of screening and 'experiments which are likely to lead to valuable results have been made with a coil rotatable about a horizontal axis'. This was work on the angle of arrival of RF energy, a type of investigation shortly to yield results of fundamental importance. Another directional experiment at this time was the simultaneous location by receivers at Ditton Park and Orfordness in East Anglia of a sender installed on 'a vessel of the Great Eastern Railway Company'. By this time the Board constituted five sub-committees, a further one having been formed to consider problems in wireless telephony. That year, at the International Conference on Scientific Wireless Telegraphy, it was decided to adopt the committee's programme as suitable for international research.

The years 1925-27 were of great importance to the science of Geophysics because it was in that period that Appleton and his co-workers proved the existence of an ionised layer at a height of about 80 Km., soon to be followed by the discovery of a further layer at a height of some 250 Km. Workers at Ditton Park had provided a great deal of the substantiating evidence relating to the existence of the ionosphere (christened thus by Watson-Watt) which was to occupy the attention of research workers for many years to come.

Two events occurred at the end of this period which had a profound effect on the workers at Ditton Park. The trinity of Direction Finding, Field Strength and Atmospheric Research were combined to form the Radio Research Station with Watson-Watt as Superintendent. The second event was a catastrophic fire which destroyed the Station's 210ft. wooden lattice tower and many of the surrounding buildings. A quote in caustic terms by Watson-Watt in a contemporary issue of the local newspaper seems to sum up the situation. '. . . arrived in time to do nothing useful but to watch the local fire brigade do a remarkable amount of needless damage!'

In the course of observing the ionosphere, it had been noticed that reflections were obtainable at nearly vertical incidence, so it was arranged that a transmitter and receiver be placed a short distance apart, one at Ditton Park and the other four miles away in Windsor Great Park. A series of experimental measurements of heights and densities of ionised layers was undertaken which gradually developed into an observational routine.

Meantime, a method of ionospheric investigation using radio wave pulses had been started in America and experiments were made at Slough to compare it with the continuous wave method employed by Appleton. The first transmitter was based on a simple, self-pulsing valve oscillator derived from a time base circuit produced at Slough for a Cathode Ray Oscillograph. This device was the ancestor of the modern automatic ionospheric sounding equipment.

It was eventually operated exclusively at Slough and when, shortly afterwards, an improved pulse transmitter developed by Ratcliffe and White was installed, the Ionospheric Laboratory may be said to have been truly established.

During the Second International Polar Year (1932-33), a party from Ditton Park operated equipment from Tromso and a loan of equipment was also made to Ratcliffe of the Cavendish Laboratory in Cambridge. Subsequent analysis of the collected data suggested that solar ultra-violet light accounted for the normal ionisation of the two main regions of the ionosphere and for the daily and seasonal variations. Abnormalities at lower levels might be due to charged particles entering the atmosphere and being acted upon by the earth's magnetic field. There was found to be a high correlation between thunderstorm activity and an increase in ionisation in the lower layer.

1933 saw the amalgamation of RRS and the Wireless Division of NPL to become the Radio Department, with Watson-Watt as Superintendent. Two years later, in January of 1935, Watson-Watt was approached by H. E. Wimperis of the Air Ministry to investigate the possibility of radiating energy at a sufficient flux density to cause damage to an aircraft or its occupants—the dreaded "Death Ray" of science fiction!

The impracticability of the suggestion was demonstrated when it was shown that to raise the body temperature of a man 600 yards away by two degrees in ten minutes, would require 5,000 MW of power. Even if practical transmitting powers were considered, the size of the aerial system to give the same effective radiated power, would have been prohibitive. These facts were communicated to the Air Ministry by Watson-Watt and in a final paragraph he said 'Meanwhile, attention is being turned to the still difficult, but less unpromising problem of radio detection . . . and numerical considerations on the method of detection by reflected radio waves will be submitted when required.'

The AM was intensely interested in these 'numerical considerations' and required them as soon as possible. Watson-Watt and co-worker Wilkins (now Deputy Director of RSRS) therefore calculated the amount of energy capable of being reflected from an aircraft when it was illuminated by realisable transmitter powers. The answers gave them grounds for supposing that a detection scheme was practicable even if the results were an order of magnitude smaller than predicted. Consequently on February 12th 1935 Watson-Watt prepared a draft memorandum entitled 'Detection and Location of Aircraft by Radio Methods'.

This communication has been called one of the most prophetic scientific documents ever produced. It stated the case for detection by reflected radio energy; showed the importance of pulse techniques in determining distance, and proposed the use of rotating beams to provide a system showing range and direction on a cathode ray oscilloscope display at a single station. The eventual desirability of using shorter wavelengths and a possible means of distinguishing between friend and foe was also considered.

The memo had an immediate effect upon the defence experts and an ad hoc experiment was arranged for the 26th February. Apparatus from Ditton Park, was positioned near the BBC's 50m transmitter at Daventry which was to provide the energy to illuminate a Heyford aircraft which was to fly on a pre-arranged course along the axis of the beam transmitted from Daventry.

Watson-Watt and A. P. Rowe of the Air Ministry, together with an assembly of defence experts were to watch the experiment. At 0945 hrs. on February 26th the aircraft duly appeared, not quite on the pre-arranged course, but near enough to reflect detectable energy into the receiver and a detection range of eight miles was estimated.

'Considering the crude nature of the apparatus and the lack of preparation, the results obtained were quite creditable'. Rowe was moved to exclaim that it was the most successful experiment he had ever witnessed. 'It was clear to all who watched the tube on that occasion that we were at the beginning of great developments in the art of air defence'. (A more detailed account of the experiment is contained in an article Wilkins wrote for Electronic Engineering). (Vol. 30, 1958).

An immediate result of the experiment was a strict security blanket and the movement of the relevant staff to Orfordness in East Suffolk where they formed the nucleus from which grew the vast complex of radar. The original apparatus used in that experiment was rescued from a store hut in Ditton Park, refurbished and presented to the Science Museum in 1958. For the benefit of the technically minded, the equipment was essentially a receiving system so arranged that the main Daventry signal was minimized. However, the Daventry signal reflected from the aircraft, arrived at a different angle to the aerial system, so was not much affected, and a signal appeared in the receiver which was displayed on the cathode ray oscilloscope.

The outbreak of war accelerated the evolution of the Ionospheric Forecasting Service to supply predictions of parameters to aid long-distance communication. The observatory which originated in the early '30's gradually acquired improved techniques which covered a range of ionospheric sounding from 0.5 to 20 Mc/s made at hourly intervals and recorded photographically.

The original sounding apparatus was operated manually and had a range of 2.5 to 5 Mc/s in steps of .1 Mc/s. The sounder of the mid-40's was not unlike present equipment, in which transmitter and receiver are kept in tune electromechanically, whilst the apparatus sweeps over the 20 Mc/s scan in about five minutes. It was at this time that an Ionospheric Substation was installed at the BBC transmitting station at Burghead, Scotland to provide additional information for the prediction service.

After the war it was realised that it was time to consider a revised programme of research more suited to the estimated needs of the future and in 1946 a report was submitted by the Board to the Committee of the Council for Scientific and Industrial Research.

It was implicit in this report that the direct connection which had long existed between the Radio Research Station and the National Physical Laboratory should cease and that the Department should have its own director. This was agreed and the Radio Research Organisation was formed with Dr. R. L. Smith-Rose as its first director.

Sir Henry Jackson, F.R.S.

First chairman of Radio Research Board. Admiral of Fleet 1919.

Pioneer worker in wireless telegraphy. Responsible for equipment of many naval vessels with wireless installations 1900.

Sir Robert Watson-Watt, F.R.S.

Superintendent Radio Research Stations DSIR 1921-33; Supt. Radio Dept. NPL 1933-36; Supt. Bawdsey R.S. 1936-38. Director of Communications Development Air Ministry 1938-40. Responsible for development of UK radar systems.

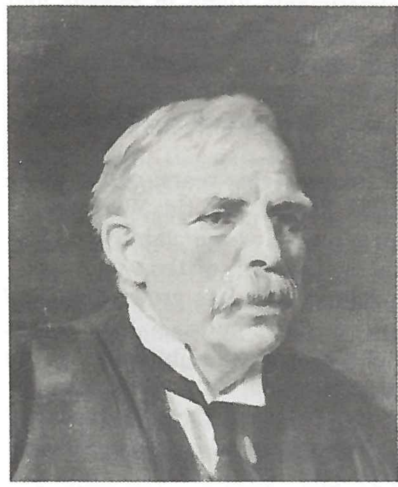
Dr. R. L. Smith-Rose.

Superintendent RRS 1936-48. Pioneer work in radio direction finding and study of radio wave propagation. First Director Radio Research Organisation 1948. Ret. 1960. President International Scientific Radio Union 1960-63.

Some of the famous people who have been associated with R.S.R.S.

Member of original Radio Research Board. Chairman Advisory Council DSIR 1930. Pioneer worker in radio transmission. Disintegrated the nitrogen atom with alpha particles from radium. Nobel Prize for Chemistry 1908.

Lord Rutherford of Nelson, F.R.S.



Director R.S.R.S. 1960-1966. Hon. Fellow of Sidney Sussex College and formerly Reader in Physics at Cambridge University. Associated with Appleton in pioneer studies of the ionosphere.

J. A. Ratcliffe, F.R.S.

Secretary D.S.I.R. 1939-49; Principal and Vice-Chancellor of the University of Edinburgh. Played major part in creation of science of ionospheric physics. Nobel Prize for physics 1947.

Sir Edward Appleton.

A number of outstations had already been set up and now more followed; the ionospheric observatory at Burghead was closed and replaced by one near Fraserburgh. In the southern hemisphere at Port Stanley, Falkland Islands, RRS personnel took over in 1947 an ionosonde station previously operated by the Royal Navy. In the next year, a similar installation commenced operation in Singapore for measurements in the equatorial region. In March of the same year the operation of low-powered apparatus at Port Lockroy in Grahamland provided the first ionospheric observations ever to be made in Antarctica. Nearer home, sites at nearby Sunnymeads and Winkfield were being used for directional measurements.

The increasing diversity of the work being handled by the Station accelerated the decision to build a new laboratory capable of combining the facilities previously supplied by the NPL with those existing at Ditton Park. There were known technical disadvantages attached to the Slough site and for some years, a thorough examination of alternative sites had been made; however, the investigations provided nothing materially superior to Slough so a start was made on a new laboratory in the West Park of Ditton Park in 1954. It was inaugurated with due ceremony in June 1956 and the man invited to perform the ceremony was Sir Edward Appleton who had long been associated with the Department and had made many great contributions to ionospheric research.

The International Polar Year of 1882-83 had been followed half a century later by a similar venture in 1932-33, in which staff and apparatus from RRS played a significant part. These two events had taken place at periods of minimal sunspot activity; now, after a period of twenty-five years, an International Geophysical Year was planned. This was to be a programme of observation and experiment not confined to the Polar regions, but extending over the whole globe during a period of sunspot maximum.

Within two weeks of being officially opened, the Station was thus committed to play a most important part in the enterprise. One of the four World Data Centres for the collection and exchange of ionospheric information was established at Slough and the activities of RRS now ranged from Singapore and Nigeria to South America and the Antarctic.

On the 4th October 1957 SPUTNIK, the first artificial earth satellite began to orbit the earth, so providing a completely new tool for investigating the earth's environment. Whereas to some it appeared as a prodigy of fear and a portent', to the Ditton Park workers it was an opportunity for a quickly contrived experiment in which bearings were taken on the satellite's transmitter. The apparatus used was the cathode ray direction finder, a device invented by R R S.

It is true to say that ever since about 1894 when Lodge used 'Hertz wave' methods in an attempt to detect long wave emission from the sun, radio workers have been concerned with events outside the immediate atmosphere. All the ionospheric work and the solar noise experiments of 1948 have made space science no new thing to Ditton Park, but now it was possible to place apparatus actually within these regions.

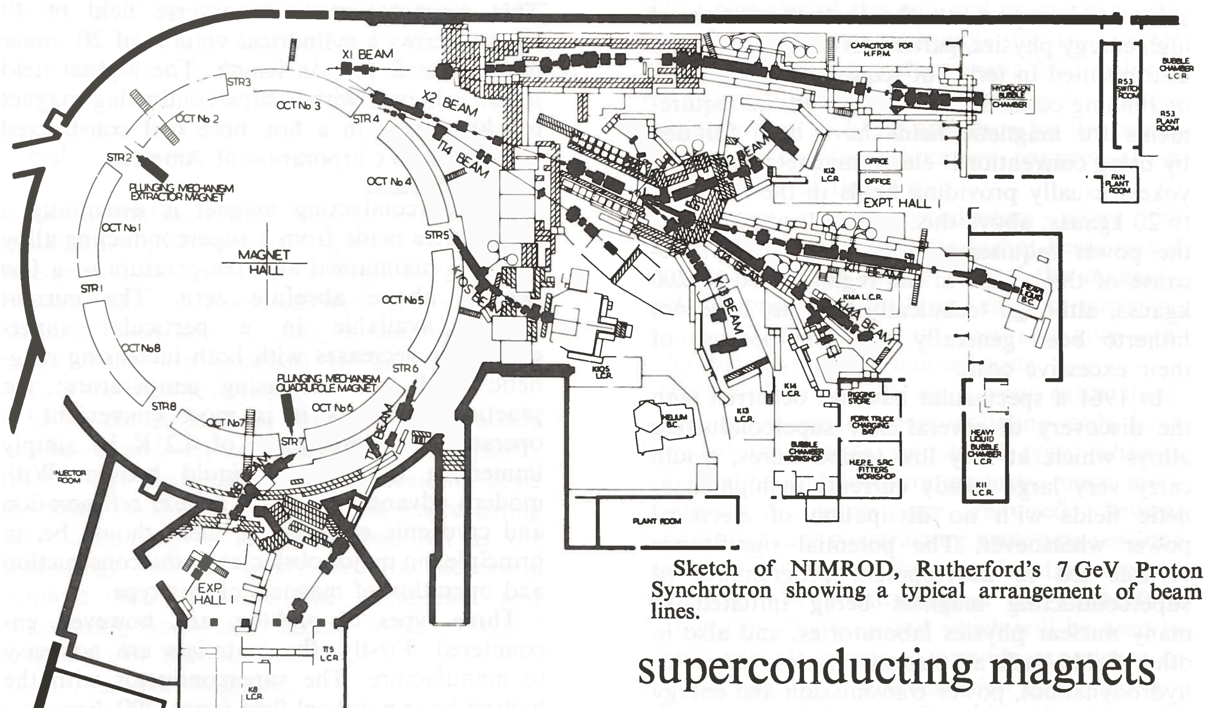
SPACE was added to the Station's title in 1965, appropriately because of the considerable interest in research on the propagation of radio waves through the troposphere and ionosphere, which had now been extended to include regions beyond the ionosphere.

In addition to what might be regarded as classical studies of propagation and their application to communication problems, new techniques arising from the developments in space research began to be used to improve the knowledge of the properties of the atmosphere important for an understanding of propagation phenomena and to undertake basic investigations of solar-terrestial relationships.

Currently about half of the work of the Station is concerned with space research; it has its own experiments flying in rockets and satellites. The satellite orbit prediction service co-operates with others on a world-wide basis and at the outstation at Winkfield, R.S.R.S. controls the main U.K. centre for satellite tracking and data acquisition.

So to 1968—forty-eight years of development, accelerated by two World Wars and a sphere of polished metal whose plaintive 'bleep-bleep' fired the imagination of the world.

The staff at Ditton Park has grown from the original two workers to almost 300. In recent years the output of papers published by the Station has risen to about fifty, covering subjects infinitely more diverse than those earlier contributions so carefully studied by Admiral Jackson.



Sketch of NIMROD, Rutherford's 7 GeV Proton Synchrotron showing a typical arrangement of beam lines.

superconducting magnets in high energy physics

P. F. Smith
D. B. Thomas
Rutherford High Energy Laboratory

In recent years in the high energy physics laboratories of the world, a large number of elementary sub-nuclear particles have been discovered by studying the interactions produced when suitable targets are bombarded with beams of charged particles from giant accelerators. These accelerators and their associated equipment use highly sophisticated experimental techniques, which rely on the use of magnetic fields in a variety of ways.

For example, during acceleration in a proton synchrotron, the particle beam is confined to a closed circular orbit by a ring of powerful electro-magnets. After acceleration, the primary beam can be either extracted from this circular orbit and directed at a target, or made to impinge on a target in the machine. In both cases secondary particles are produced and these have to be transported to experimental equipment often situated a hundred feet or so from the accelerator. Here again magnetic fields play an important part, magnetic lenses provide the necessary focusing; and bending magnets are used to steer the particles along the desired paths. In other experiments, separated beams consisting only of particles of the desired type and momentum are selected from the wide spectrum of secondary particles. For such beams, a bending magnet with collimating slits is used in an analogous fashion to a glass prism in an optical spectrometer. In the nuclear experiments themselves, the momenta of particles created by interactions within the experimental apparatus can often be determined by measuring the actual curvature of the paths of the particles in a known magnetic field. An elegant example of this type of apparatus is the bubble chamber, where the curved tracks of charged particles can be seen as lines of minute bubbles in a superheated liquid. The entire liquid volume is immersed in a high magnetic field and measurement of stereo photographs of the curved tracks allows the momenta of the particles to be calculated.

Any technological breakthrough in the generation of higher magnetic fields would have a substantial impact on the instrumentation of high energy physics, particularly so if economies also resulted in terms of reduced capital outlay or running costs. So far virtually all the requirements for magnetic fields have been fulfilled by using conventional electromagnets with steel yokes, usually providing fields in the range 10 to 20 kgauss; above this, the steel saturates and the power requirements increase sharply. Because of this, fields in the region of 30 to 200 kgauss, although technically feasible, have not hitherto been generally available because of their excessive cost.

In 1961 a spectacular advance occurred with the discovery of several new superconducting alloys which, at very low temperatures, would carry very large steady currents in high magnetic fields with no dissipation of electrical power whatsoever. The potential significance of this led to development programmes of superconducting magnets being initiated in many nuclear physics laboratories, and also in other fields such as plasma physics, magnetohydrodynamics, power transmission and energy storage for space research.

In spite of considerable technical difficulties, much progress has been made, and already a liquid helium bubble chamber of 10 inches diameter equipped with a pair of superconducting coils giving a field of over 40 kgauss has been used in nuclear physics experiments at Argonne National Laboratory in America. A polarized target with a superconducting magnet has been used in experiments at Cambridge Electron Ecceleator, Massachusetts. One of the largest super-conducting magnets yet to be successfully tested was built by the Avco-Everett Research Laboratory, in the U.S.A.

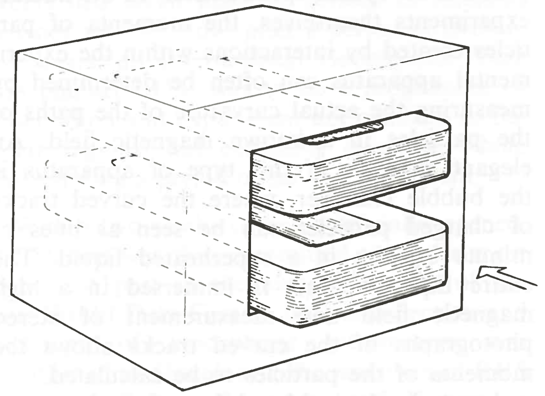


fig 1 (a) A conventional iron-cored bending magnet.

This magnet gives a transverse field of 40 kgauss across a cylindrical volume of 2ft. inner diameter and 10ft. in length. The highest field so far achieved with a superconducting magnet is 140 kgauss, in a 6in. bore coil constructed by the Radio Corporation of America.

Present Status.

A superconducting magnet is essentially a coil of wire made from a superconducting alloy which is maintained at a temperature of a few degrees above absolute zero. The current density available in a particular superconductor decreases with both increasing magnetic field and increasing temperature; for practical purposes it is most convenient to operate at a temperature of 4.2°K by simply immersing the coil in liquid helium. With modern advances in liquid helium refrigeration and cryogenic engineering, there should be, in principle, no major obstacles to the construction and operation of magnets of this type.

Three types of problem are, however, encountered. Firstly, the materials are not easy to manufacture. The superconductor with the highest known critical field (over 200 kgauss) is niobium-tin, but this is a brittle compound which cannot be drawn into a wire. Somewhat easier to handle are the strong and ductile alloys niobium-zirconium and niobium-titanium which are suitable for fields up to 80-90 kgauss. These can be made into strong wires but require special manufacturing techniques to achieve the required high current densities. Secondly, the superconducting state tends to be unstable under the conditions existing in large coils, and intensive efforts are being made to understand and eliminate this effect. Thirdly there are several major mechanical and electrical problems to be faced in the design of large

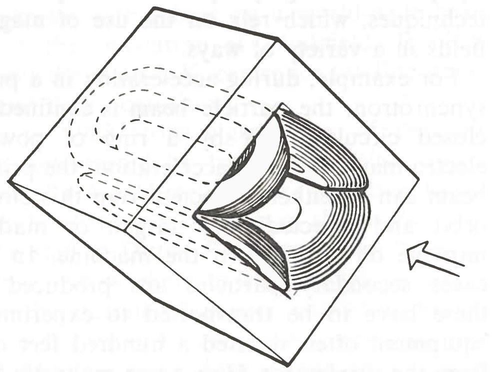


fig 2 (b) A conventional iron-cored quadrupole focussing magnet.

superconducting coils. Perhaps the most significant of these is the containment of the large electromagnetic forces on the windings at high magnetic fields and the need for protection circuits to extract from the coil most of the stored energy in the event of an accidental transition to the normal (resistive) state.

As an indication of the present position, small coils up to about 10 cm bore are now in common use, coils up to 30 cm bore can be constructed and operated without too much difficulty, and several coils in the region 2-5 metres bore are expected to be constructed during the next few years.

So far the demand for superconductive alloys has been relatively small and has yet to justify really large scale production. Processing costs are high, with the basic metals representing only a fraction of the total cost, but as the technology becomes established the increasing demand will decrease the conductor and engineering costs and larger, more powerful magnets will become possible.

Beam Transport Magnets.

Two kinds of magnet are of particular importance in beam optics, the first, generally known as a bending magnet (fig. 1a) provides a channel of uniform field and is used to change the direction of a particle beam and also to select particles of the required momentum; the second, known as a quadrupole (fig. 1b) provide a special distribution of magnetic field to focus the particle beam. Typical sizes are 1-2 metres length, with a 10-20 cm aperature for the beam; a large accelerator laboratory requires about 150 magnets of this type.

The use of superconductors offers the possible advantages that the higher fields would allow a reduction in the size of the magnets, and, if produced in large enough numbers, would reduce the capital cost and give considerable savings in running costs.

Development is still at a very early stage, since so far most superconducting coils have been of the simple cylindrical type, whereas for bending and focusing magnets, much more complicated shapes are required. Several laboratories are constructing prototype versions however and fig. 2 shows a bending magnet which will be constructed at the Rutherford Laboratory this year and which will be used in actual particle beams to provide experience in the engineering, instrumentation and operation of this type of magnet. Considerable effort will be made during the next few years to study and simplify the design of these types of magnet so that they can be produced reliably and economically in large numbers.

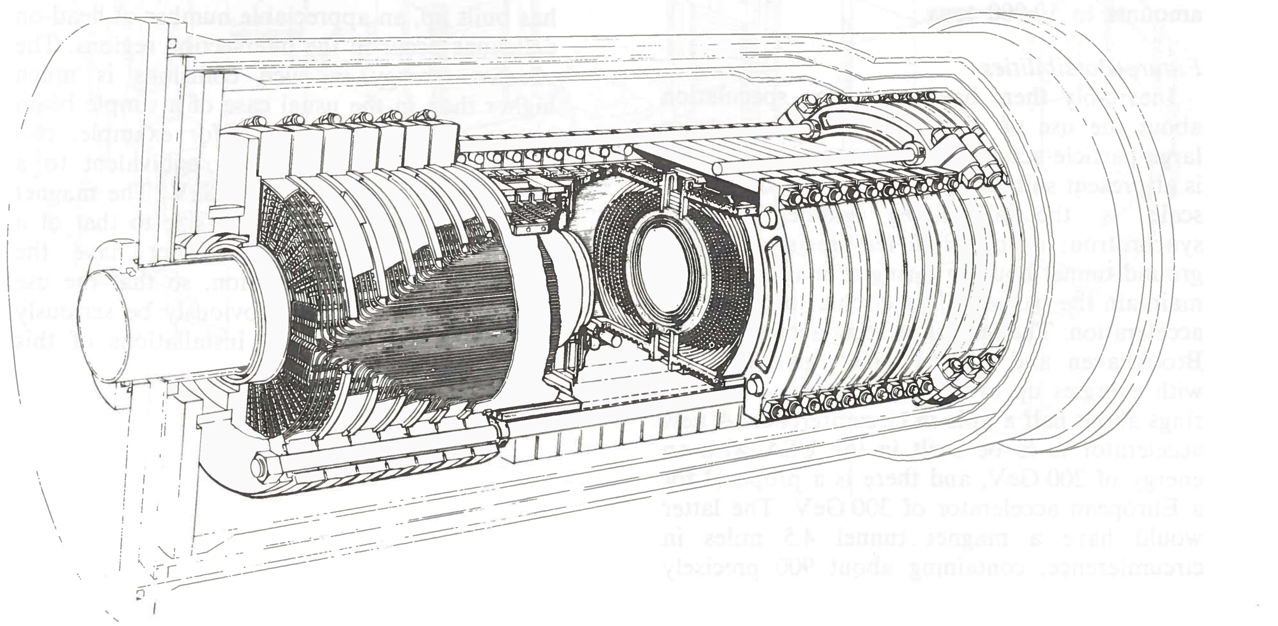


fig 3 Impression of a superconducting magnet now under construction at the Rutherford Laboratory. The coils are shaped to produce a uniform field of 40 - 45 kgauss in a channel 140 cm. long by 18 cm. diameter.

Bubble Chamber Magnets

The new generation of hydrogen bubble chambers will all be equipped with superconducting magnets. It is the advent of this type of magnet which has made possible chambers of the size now contemplated, because the cost of powering conventional coils to produce magnetic fields of the required magnitudes and volumes would be prohibitive. There are at present two large magnets under construction in the USA and several others are at an advanced stage of planning in Europe and Russia. An artist's impression of the proposed 1.5m diameter high field chamber for the Rutherford Laboratory is shown in fig. 3. By modern standards this is a chamber of rather modest dimensions but it will be equipped with a superconducting magnet capable of providing an unusually high field strength of 70 kilogauss throughout the working volume of the chamber.

With these large coils, the engineering problems which dominate the design are principally those connected with the mechanical constraint of the massive electromagnetic forces within the windings, which amount for example to almost 4,000 tons for each of the two coils in fig. 3. In addition, to allow access for beams of particles, it is necessary to separate the coils typically by 20cm, and they must then be held apart against the attractive force between them which amounts to 10,000 tons.

Future Possibilities

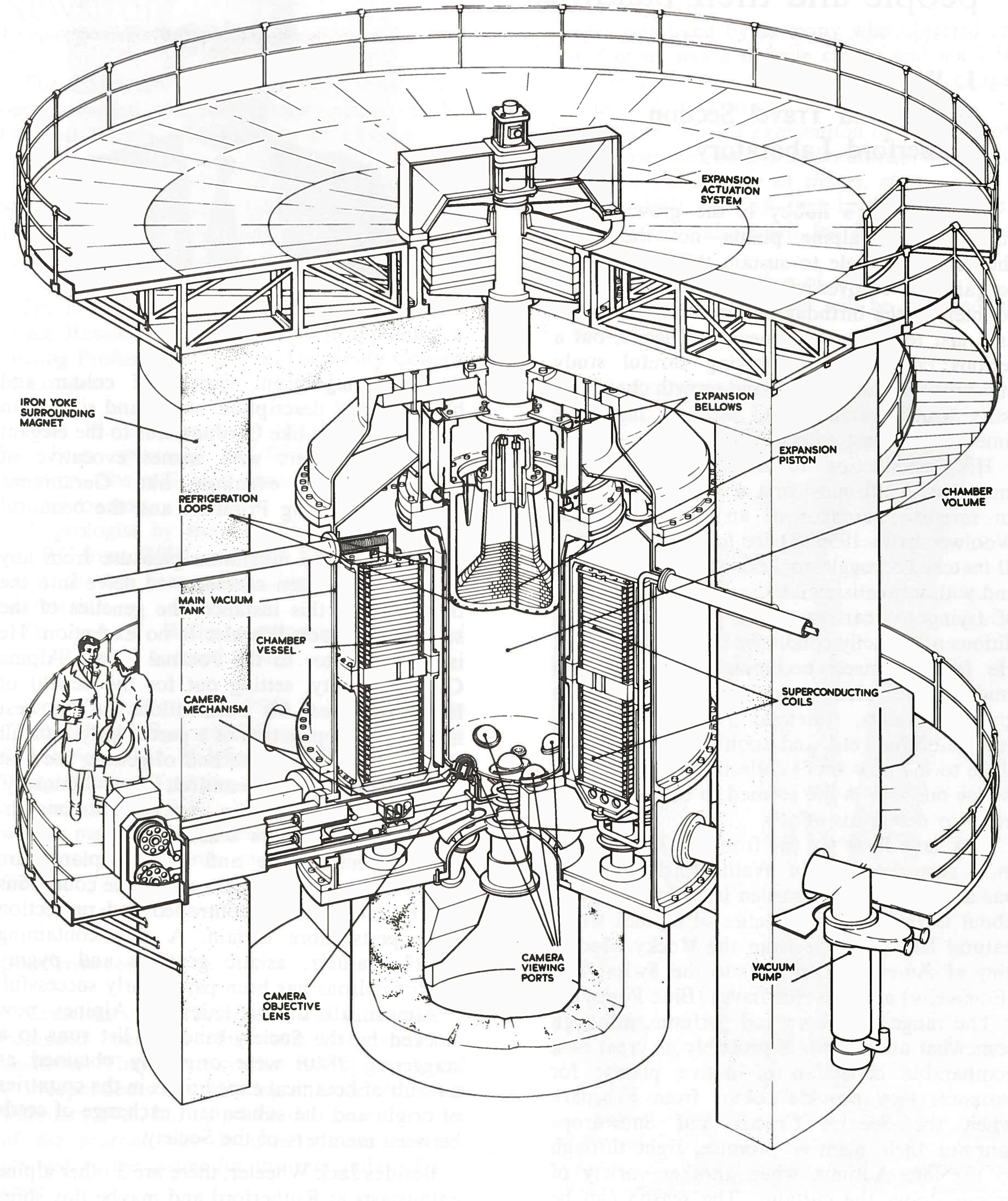
Inevitably there has been some speculation about the use of superconducting magnets in large particle accelerators. The only type which is at present suitable for construction on a large scale is the alternating gradient proton synchrotron; its principal feature is an underground tunnel housing a ring of magnets which maintain the particles in a circular orbit during acceleration. The largest existing accelerators at Brookhaven and CERN which give particles with energies up to 30 GeV* and have magnet rings about half a mile in circumference. A new accelerator is to be built in the USA with an energy of 200 GeV, and there is a proposal for a European accelerator of 300 GeV. The latter would have a magnet tunnel 4.5 miles in circumference, containing about 900 precisely aligned individual magnets, each 6m. long. The magnets alone will cost £16 million and the estimated capital cost of the project is £148 million.

These magnets have to be operated in a pulsed manner, in contrast to the previously discussed applications which are all d.c. It is not yet clear whether suitable superconducting magnets of this type can be developed. If they can, then the higher field should allow a large reduction in the diameter of the magnet ring and there should be a significant lowering of overall cost. An alternative idea is the possibility of converting a conventional accelerator to a higher energy. For example, a 300 GeV machine built in the near future would have to use conventional magnets; but in ten to fifteen years' time, with superconducting technology in a more advanced stage, these might be replaced by high field magnets, thus converting the machine to perhaps 1,500 GeV at only a fraction of the cost of a completely new machine of this energy.

Another possible accelerator application would be the use of superconducting magnets in particle storage rings. In this technique, beams of particles from an accelerator are fed into two intersecting rings of d.c. magnets; the two beams of particles circulate continuously and when a sufficiently high density of particles has built up, an appreciable number of head-on collisions occur in the intersection regions. The effective energy in such collisions is much higher than in the usual case of a simple beam hitting a stationary target; for example, two colliding 30 GeV beams are equivalent to a single beam of energy 2,000 GeV. The magnet rings are similar in type and size to that of a particle accelerator, but do not have the problems of pulsed operation, so that the use of superconductors will obviously be seriously considered for any large installations of this type in the future.

*** *1 GeV is equivalent to acceleration by* 10^9 *volts.***

This is an edited version of an article which first appeared in Nature, Vol.216. 9.12.67.



Impression of proposed new hydrogen bubble chamber for the Rutherford Laboratory. A pair of cylindrical coils produced a field of 70 kguass, uniform to a few percent, over the working volume of the chamber 1.5m. diameter by 1 m. deep.

people and their pastimes

J. Wheeler
Claims and Travel Section
Rutherford Laboratory

Jack Wheeler's hobby is the growing and cultivation of alpine plants—not the usual short-lived struggle to sustain the knock-down bargain due to over-exposure on a self-service counter, or the birthday or Xmas present given as a last resort by well meaning friends, but a serious commitment involving careful study into propagation methods and growth characteristics which has absorbed most of his spare time for the past fifteen years.

His introduction to the hobby began as innocently as do most first acquaintanceships—an impulse purchase of an Edelweiss from Woolworths in 1953. There followed the usual ill-matched struggle to keep the plant healthy and without realising it he took up the challenge of trying to rear an exotic plant under conditions not exactly conducive to healthy growth. He found himself becoming engrossed in a study of the plant's natural environment, its growth habits, method of propagation, susceptibilities, etc. and soon became a happy slave to his now small collection of tiny plants whose one aim in life seemed to be a determination to defeat his efforts.

Jack now lives not far from the Laboratory, in a semi-detached in Wallingford where he has a 600 sq. ft. rock garden in which he grows about three hundred varieties of alpines who's natural habitat range from the Rocky Mountains of America (Lewisias) to the Swiss Alps (Edelweiss) and the Himalayas (Blue Poppy).

The range of colour and perfume, although somewhat attenuated, is probably as great as a comparable collection of native plants; for instance, they provide colour from February when the Species Crocus and Snowdrops murmur their plantive promise, right through to the late Autumn when another variety of crocus draws the curtains. The season can be further extended if required, but the majority of people are not too keen on 'gardening' in the snow. In between these extremes of season there is magnificent variety of colour and blooms of all description, shape and size, from the spiky thistle-like Carduncellus to the elegant Irises, and others with names evocative of balmy summer evenings like Geraniums, Dianthus, Evening Primrose and the beautiful Campanulas.

To obtain the maximum pleasure from any pastime, it is often necessary to delve into the theory, or in this instance, the genetics of the subject and Jack Wheeler is no exception. He is a contributor to the Journal of the Alpine Garden Society, setting out for the benefit of fellow devotees, his observations on the best method of propagation of a particularly difficult subject, or a proved method of getting the best results from the beautiful, but 'finickety' Lewisias which has been exercising his imagination for the past few seasons.

The most minute and difficult plants are successfully grown in sinks where the conditions can be more closely controlled and protection from pests more certain. A sink containing dwarf heathers, asiatic gentians and pygmy rhododendrons has been particularly successful.

Almost all the varieties of Alpines now stocked by the Society (and the list runs to a staggering 2840) were originally obtained as a result of botanical expeditions in the countries of origin and the subsequent exchange of seeds between members of the Society.

Besides Jack Wheeler, there are 3 other alpine enthusiasts at Rutherford and maybe this short article will encourage an exchange of ideas and comment among devotees in other establishments of the SRC

Newsfront

The Chairman, Professor B. H. Flowers, has been awarded the Rutherford medal of the Physical Society and Institute of Physics.

Professor C. F. Powell, Chairman of the Nuclear Physics Board, has been awarded the 1967 Lomonosov gold medal, the highest award of the Soviet Academy of Sciences.

Dr. J. A. Saxton, Director of the Radio and Space Research Station, has been appointed a visiting Professor of Physics, University College of London.

Miss M. O. Morris of the London Office has been appointed an SPSO in the ASR Division. She will have special responsibilities for Astronomy.

A geologist by training, Miss Morris came to SRC from DSIR and until her new appointment, she has been responsible for the Council Secretariat.

Dr. J. A. V. Willis, previously Secretary of the NP Board succeeds her.

Dr. W. G. Potter, a PSO in charge of the Chemical and Biological Group, UST, and the Secretary of the Halsbury Working Party on Postgraduate Training Awards, has been appointed an SPSO. In his new post, Dr. Potter will be responsible for developing the industrial relevance of research projects supported by SRC.

post mortem

Criticism of the first issue was fairly evenly balanced between the technical and the aesthetic. They were synthesized by the Local Correspondents at a meeting at State House on February 14th, during which the general format of the journal was discussed as well as the content of the issues for the remainder of this year.

Much of the criticism was self-cancelling as one might expect with such a wide readership, but these are the outstanding observations :—

Uneven printing and non-uniform type size :
These are acknowledged faults and will be rectified in future issues.

Colour of cover :
This was liked by as many who objected to it. Colour was a definite choice and not left to the discretion of the printer. It will change with each issue to suit the cover picture.

Not enough detailed explanation of the work of the Observatories and Laboratories, how they fit into the scheme of things, etc. :
If we dealt with all that in the first issue, there'd be nothing left for future issues . . . give us time.

No description of author of article :
Short biographical notes will be included in future issues.

"Meridian" a modern sculpture by Barbara Hepworth which is an integrated architectural feature of State House.

Civil Service Recreation Centre,

Monck Street, London, S.W.I.

The CSRC is situated in one of the new tower blocks at present being built on the Horseferry Road site. The entrance is in Monck Street.

The Centre will cater for a great many facets of Civil Service Sports Council activities and seems destined to become the 'home base' for all people connected with Civil Service sport. It will provide club and recreational facilities for many civil servants in the Central London area and for members visiting London.

The space available for the Centre is on two floors and in planning the use of it, the upper floor has been regarded in general as the social part, allying casual recreational facilities such as table tennis, billiards, darts, skittles, with social facilities like bars, light refreshments, lounges, etc. The lower floor has been used to cater for the more specialised sporting requirements such as rifle range, match table tennis rooms, gym, cricket and golf nets, etc.

The Planning Committee has catered for as many interests as possible whilst remaining flexible as regards future developments in the light of changing interests. For example, the Exhibition Room for art, photographic, and other displays, can be used as a cinema or lecture room seating fifty people. It can also be used as a TV room for special large audiences, e.g. for test matches.

The younger members will be specially catered for, they will have certain rooms allocated for their particular interests, i.e. discotheque, record sessions, informal dancing.

Rutherford Laboratory Chess Club

Thirty-eight players have taken part in a four month Swiss tournament to decide the title of Rutherford Chess Champion. Played during the lunch periods, the tournament attracted a great deal of interest and ended with an exciting tussle which produced not one but two champions!

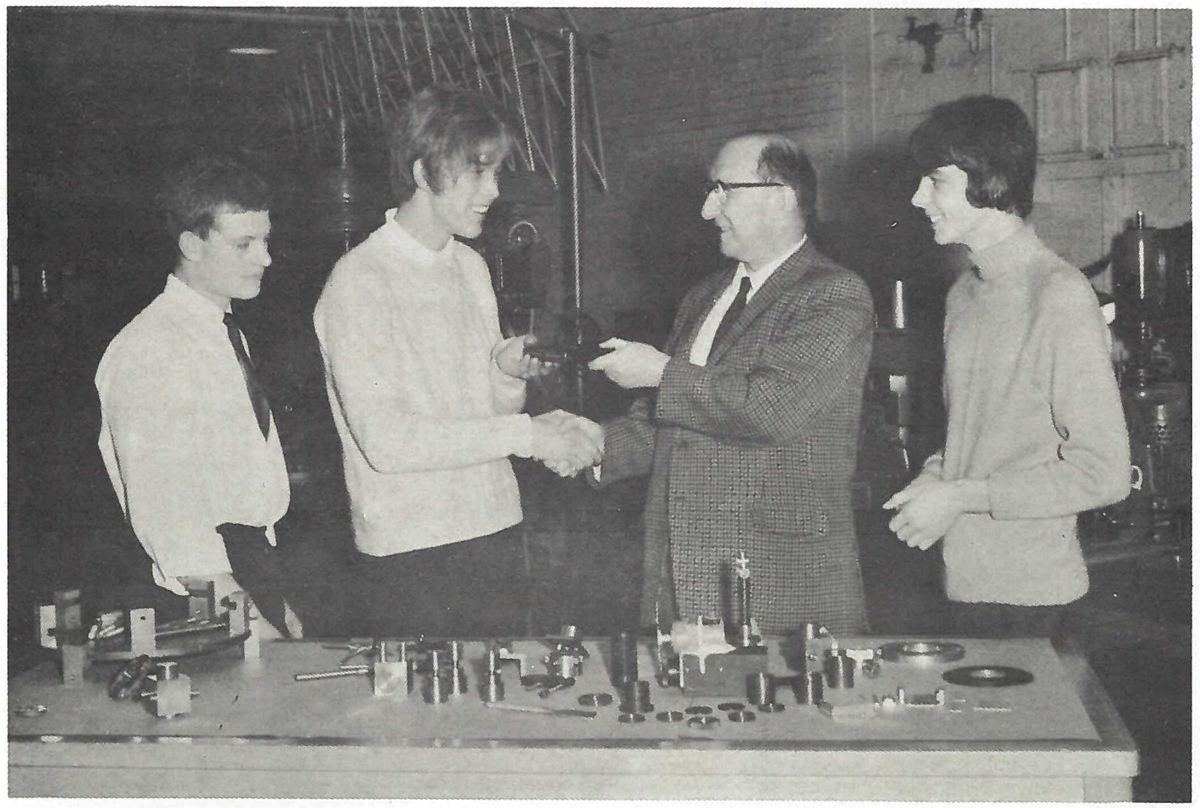
The title was shared between Bill Turner of the Applied Physics Bubble Chamber Group and Dr. John Davies who is in charge of the K12 beam line. Each won five games and drew three.

As a result of the tremendous interest shown in the tournament, and in chess generally in the Laboratory, a club has now been formed to organise future tournaments and to arrange matches with other clubs. Further information can be obtained from P. Craske, ext. 225.

If the same degree of interest in chess exists in other SRC establishments, it ought to be possible to arrange 'postal' competitions, they should'nt be too difficult to organise. How about it....? Ed.

As we intimated in the previous issue, the Local Correspondent for the Daresbury Laboratory has been changed. The production of the Bulletin is now a Library commitment and as the editor is obviously in a good position to act for Quest; Mrs. J. Peatfield has taken over from Mrs. Chisholm.

Jill Peatfield spent five years with UKAE at Winfrith before joining the Daresbury Laboratory in November 1964. Recently promoted to Executive Officer, Jill now works in the library and is responsible for the production of the weekly Bulletin.



Dr. J. A. Saxton, Director of RSRS, presenting the first prize in the Station's first ever apprentice's prize-giving ceremony, to R. Dorey. The standard of work was so high that the runners up, R. Adlam (l) and A. Thackray, both received awards.

Science Research Council, Sports and Social Association

The association was inaugurated on 10th March 1967, and became affiliated to the Civil Service Sports Council on 1st May 1967.

The following clubs have been accepted into membership of the association.

Atlas Computer Laboratory
Daresbury Nuclear Physics Laboratory
London Office
Radio & Space Research Station
Royal Greenwich Observatory
Rutherford High Energy Laboratory

The Royal Observatory Edinburgh are affiliated to a regional association which is more suitable for their requirements.

Through the S R C association, clubs will be able to apply for financial assistance for development of their facilities from the Civil Service Sports Council.

The committee of the association, which consists of four officers and a representative from each club, will meet at least three times a year to consider any matter placed before it by a club.

The aims of the association are to :

1. Act as co-ordinating body between sports and social clubs within the association for the purpose of encouraging the pursuit of amateur sport and recreation.
2. Liaise between the various clubs within the association and the Civil Service Sports Council.
3. Encourage the formation of clubs within the S R C at establishments where none exist.

All members of clubs affiliated to the association are eligible to play for the Civil Service in representative matches. If any club has a member who is outstanding at a particular sport, the Secretary should forward details to the secretary of the association.

The Civil Service Sports Council also arranges inter-departmental competitions in most sports, and it is hoped to enter S R C teams in these events.