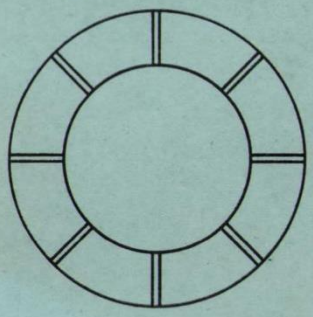
SCIENCE RESEARCH COUNCIL

RUTHERFORD LABORATORY

OPEN DAY
1966



SATURDAY 21ST MAY

2·00 – 5·30 P.M.

THE RUTHERFORD LABORATORY

The possibility that the physical world might be made up from vast numbers of similar small units or "atoms" has attracted the curiosity of man since the time of ancient Greece, but until the nineteenth century theories based upon this possibility had been purely speculative. At the beginning of the last century, however, Dalton provided the first scientific account of the atomic nature of matter. In the latter part of the century Mendeleef published his Periodic Table which classified the properties of the chemical elements and indicated that they could be related to some far-reaching scheme of unification. After the discovery of the electron at the turn of the century and the work of Rutherford and Bohr a decade or so later, it became clear that the regularities of the Periodic Table could be explained in terms of atoms consisting of very dense nuclei surrounded by orbiting electrons. By the nineteen thirties this atomic theory had been practically perfected and the most fundamental problems centred on the nucleus itself, its constituents the neutron and proton and the forces which bind them together. The subsequent investigation of these problems has led to the discovery of a hundred or so difference elementary particles which today are as much in need of a theoretical scheme of classification as were the chemical elements in the earlier era. In the last few years there have been some very promising advances in this direction, and many physicists believe that we are on the point of discovering a far-reaching synthesis of the phenomena of elementary particles.

The traditional home for basic studies of this kind is the University but as they have developed there has been a need for experimental facilities of such great complexity and on such a scale that they are beyond the resources of any single university. To meet this problem the Rutherford Laboratory was set up as a national centre for research in elementary particle physics and the physics of the nucleus. It is intended primarily for the use of physicists of British Universities but also caters for other institutions conducting basic research in these fields.

The heart of the Laboratory is the proton synchrotron Nimrod which is the central experimental facility for the teams of elementary particle physicists. The Nimrod complex consists of the machine itself with its beam injection and extraction equipment, its power supply, and two experimental halls. These two halls are protected against the intense radiation from Nimrod by a large steel and concrete shield wall through which pass "beam lines" carrying high energy particles to the experiments. Eight or nine experiments are usually set up on the experimental floors, and during periods when Nimrod is operating at high energy about four of these collect data. The experimental teams operate in turns whilst the machine works round the clock for weeks at a time.

There is a broad distinction between "counter" experiments and bubble chamber experiments. In the counter experiments the interesting events, that is particle collisions or disintegrations, are recorded only when they are "recognised" in the apparatus by producing a particular response in a system of particle counters. In the bubble chamber experiments hundreds of thousands of events occurring in the bubble chamber liquid are photographed and scrutinised later, so that the significant ones can be identified. At present there are two bubble chambers in operation, one a heavy liquid chamber and the

other a liquid hydrogen chamber which is on loan from the C.E.N. laboratory at Saclay in France. Two more bubble chambers are being assembled.

For the study of nuclear physics there is also a central experimental facility, the 50 MeV Proton Linear Accelerator or PLA. It is smaller than Nimrod and less complex but its method of catering for the experimental teams is similar. Here too are two experimental halls in which a number of experiments share beams of accelerated protons from the PLA. All these low energy experiments are counter experiments, the bubble chamber being very much a high energy facility. The PLA is one of the most reliable accelerators in the world and has some special features which make it one of the most versatile. These are a polarised proton source, a neutron time of flight facility and a double-focusing magnetic spectrometer. Attached to the PLA is a Nuclear and Radiochemistry Group which carries out research in these fields. The group works in a close reciprocal relation with both the PLA and Nimrod.

About 160 visiting scientists base their research on Nimrod and the PLA. The Laboratory itself has three elementary particle physics groups one of which attaches individual physicists to visiting teams in order to promote good liaison with the Laboratory. Another Laboratory group specialises in nuclear physics on the PLA. There are also a number of applied physics groups concerned with accelerator physics, bubble chambers, experimental data processing equipment, apparatus for experiments in elementary particles, and other applied research related to the main experimental programmes. Nimrod has two engineering groups one concerned with the accelerator and the other with the experiments. The PLA has its own engineering group whilst a central group provides engineering services through-out the Laboratory.

A special group is responsible for the radiological protection of the staff who work on the accelerators and in the experimental halls.

The Laboratory has a centralised double computer time sharing system which is used mainly to analyse the data from experiments on Nimrod. The Computers are managed by a group in which programmers and theoretical physicists work closely together.

The Laboratory has a permanent staff of about 1,100 and the budget for 1966/67 is £6.2 million.

The Rutherford Laboratory has a sister establishment the Daresbury Nuclear Research Laboratory in Cheshire. This Laboratory is based on the 4 GeV electron synchrotron NINA which will, when it comes into operation later this year, provide to elementary particle physicists in the north of England facilities similar to that provided by Nimrod. Both Laboratories became establishments of the Science Research Council in April last year.

EXHIBITS

Both Nimrod and the Proton Linear Accelerator are open to visitors; in addition there is a wide range of scientific and engineering exhibits set out in laboratories and workshops. For safety reasons children under ten years of age will not be allowed within the machine and experimental halls of Nimrod and the P.L.A.

Technical Leaflets giving a description of the exhibits will be available for the majority of exhibits.

A general plan of the Laboratory is shown on pages 6 and 7.

HIGH ENERGY PHYSICS AND NIMROD (Building R.5 and R.6)

Nimrod and its experimental halls will be open to visitors. A plan is shown on page 5 and due to the limited space within the Nimrod area, it is essential that visitors follow the route set out.

EXPERIMENTAL HALL NO. 2

K7 Experiment - Scattering of Pi-Mesons and K-Mesons in a Polarised Proton Target. (Rutherford Laboratory Resident Group: Dr. J. J. Thresher)

Polarised Proton Target - (General Physics Group: Dr. H. H. Atkinson)

$\emptyset$ 1 Experiment - A search for the $\emptyset^{\circ}$ Meson. (Imperial College/Rutherford Laboratory Group: Dr. J. Walters and Dr. P. Palit)

THE INJECTOR

The Injector Control Room, the ion gun, and the linear accelerator may be seen. The Injector gives the initial acceleration and the protons emerge with an energy of 15 MeV.

THE MAGNET ROOM

The magnet (7,000 tons and 155 feet in diameter) is made up of octants separated by eight straight sections which accommodate the radio frequency accelerating cavity, beam control, beam extraction and other facilities. Between the poles of the magnet is a toroidal shaped vacuum chamber made from glass fibre epoxy resin within which the protons are accelerated. Protons are extracted with an energy of up to 7 GeV.

EXPERIMENTAL HALL NO. 1

K6 Experiment - A measurement of the K^- nucleon total cross sections in the range 0.7 - 2.4 GeV/c (Cambridge University/Birmingham University/Rutherford Laboratory Group: Dr. K. F. Riley, Dr. J. D. Dowell and Dr. D. V. Bugg)

K4 Experiment - A study of the leptonic decay modes of positive K Mesons. (Oxford University Group: Dr. P. B. Jones, Dr. A. B. Clegg and Dr. W. S. C. Williams)

π2 Experiment - Differential cross section measurements in the $\pi^{\pm}$ = p elastic scattering near 2 GeV (University College London/Westfield College Group: Dr. F. F.

Heymann and Professor E. H. Bellamy)

P 3 Experiment - A search for Multipion resonances in the process $\pi^- + p \rightarrow \begin{pmatrix} n+x \\ p+x \end{pmatrix}$ (A.E.R.E./Southampton University/University College London/Rutherford Laboratory Group: Dr. C. Whitehead, Professor G. W. Hutchinson, Dr. R. E. Jennings, and Dr. E. G. Auld)

K1 Experiment - Interactions in the hydrogen and deuterium bubble chamber. (Universities of Birmingham/Cambridge/Glasgow/Imperial College London/D Ph PE Saclay/Rutherford Laboratory)

ENGINEERING SUPPORT FOR HIGH ENERGY PHYSICS

Subject to the requirements of the experimental programme, visitors will see a demonstration of the movement of beam line components and radiation shield blocks.

BUBBLE CHAMBER ANNEXES

The 1.5 metre Hydrogen Bubble Chamber is now being re-assembled on its return from CERN, Geneva.

The 82 cm Hydrogen Bubble Chamber from C.E.N. Saclay is being used at Nimrod in a research collaboration between French and British physicists.

The 1.4 metre Heavy Liquid Bubble Chamber was designed and constructed as a joint project of University College London and the Rutherford Laboratory. It was recently employed in an experiment to study the decay modes of the η^0 Meson using Freon as the liquid filling.

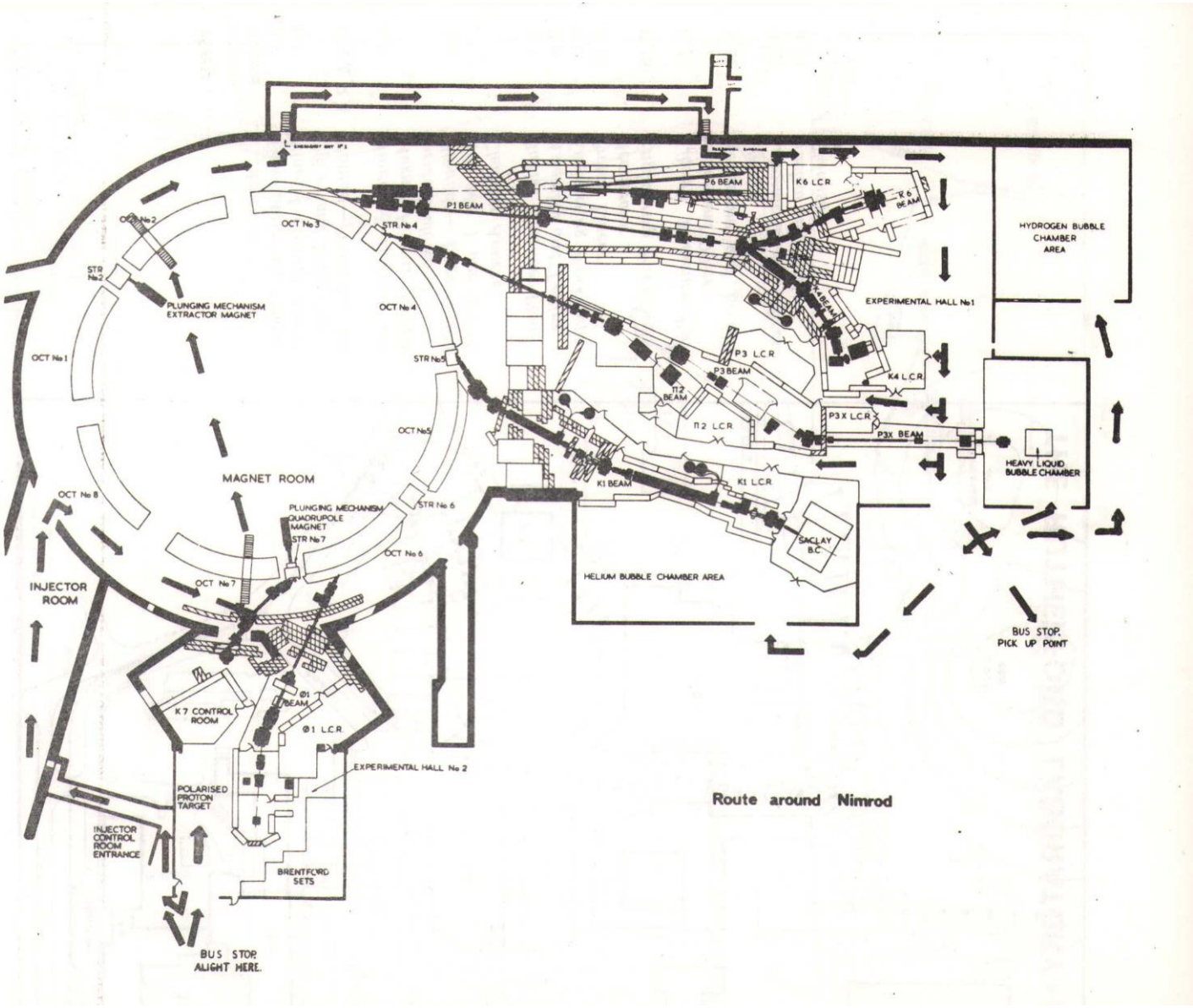
The 80 cm Liquid Helium Bubble Chamber is a joint project of the Oxford Nuclear Physics Department and the Rutherford Laboratory.

MAIN CONTROL ROOM (Building R.2)

Nimrod can be remotely operated for long periods from the Main Control Room, which provides comprehensive control and monitoring equipment housed in more than 50 electronic racks.

POWER SUPPLIES (Building R.3 and R.4)

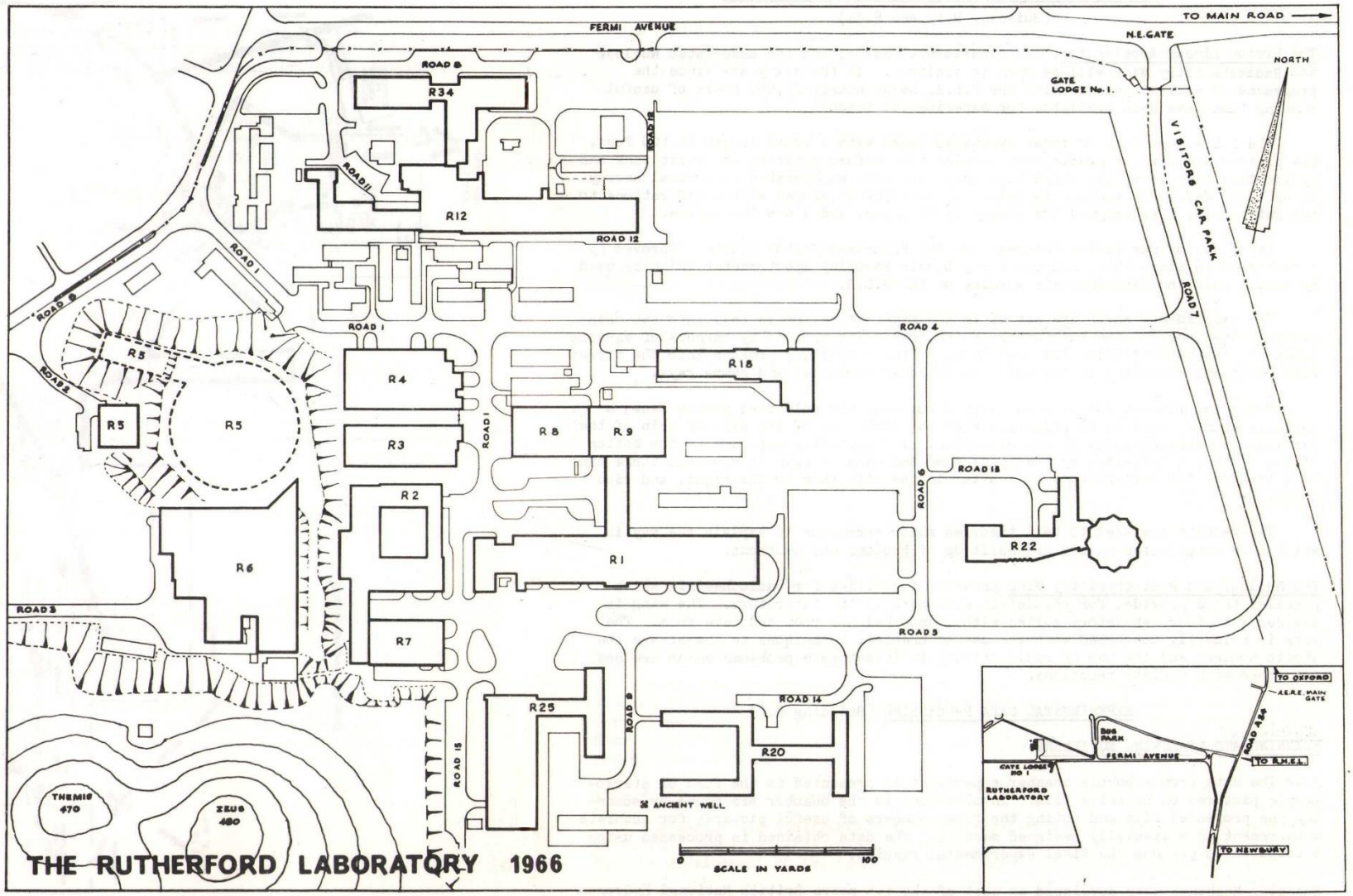
Nimrod's magnet power supplies are provided through two motor alternator sets using heavy currents of up to 10,500 amps at up to 15,000 volts. These are connected to the magnet via phase splitting transformers and 96 single anode water cooled mercury arc rectifiers.



Route around Nimrod

Key

Building Number	Function
R.1	*Laboratories and Offices*
R.2	*Nimrod Control Room, Offices and Workshops*
R.3 & R.4	*Nimrod—Power Supplies*
R.5	*Nimrod — Injector and Magnet Rooms; Experimental Hall No. 2*
R.6	*Nimrod — Experimental Hall No. 1 and Bubble Chamber Annexes*
R.7	*Bubble Chamber Plant*
R.8	*Assembly and Testing*
R.9	*Engineering Workshops*
R.12	*Proton Linear Accelerator*
R.18	*Engineering Workshops*
R.20	*Library, Radiation Protection and Offices*
R.22	*Restaurant and Lecture Theatre*
R.25	*Laboratories and Offices*
R.34	*Nuclear and Radio-Chemistry*



NUCLEAR SCIENCE AND THE PROTON LINEAR ACCELERATOR

(Building R.12 and R.34)

The Proton Linear Accelerator, its experimental halls, and the associated Nuclear and Radiochemistry Wing will be open to visitors. In the six years since the programme of nuclear physics with the P.L.A., began nearly 23,000 hours of useful running time have been available for experimental teams.

The P.L.A. consists of three evacuated tanks with a total length of 100 feet. The protons are given a preliminary acceleration before entering the first tank and by the time they leave the third tank they have been accelerated to a final energy of up to 50 MeV. The machine is being continuously developed with modifications to the duty cycle, a redesigned low energy drift space, and a new ion course.

Two items of particular interest are the Polarised Proton Source, improved by a factor of 16 since 1961, and the $n = \frac{1}{2}$ Double Focusing Spectrometer which is used by nearly half the experimenters working on the P.L.A.

The experiments which are set up in the Experimental Halls fall into two main groups. One concerns the scattering of the bombarding protons by targets of various elements; the other studies the absorbtion of the bombarding protons into the target with reactions resulting in the emission of other particles and gamma rays.

These experiments can also be carried out with the polarised proton beam; a particle beam is said to be polarised when the direction of the axis of spin of the particles is predominantly in one direction. In scattering experiments the motion of the protons is affected by the spin; when the axis of spin is vertical there can be a tendency for more protons to scatter to the left than to the right, and vice versa.

The results are used to test theories which endeavour to explain the way in which more complicated nuclei are built up of protons and neutrons.

The Nuclear and Radiochemistry Wing provides facilities for radiochemists which parallel those provided for physicists elsewhere in the Laboratory. The wing is divided into four laboratory suites with common balance room and cave room. The work is primarily concerned with the use of chemical techniques to investiage the atomic nucleus and the use of radioactivity to investigate problems which are not concerned with nuclear reactions.

EXPERIMENTAL DATA PROCESSING (Building R.1)

SCANNING AND MEASURING EQUIPMENT

The data from a bubble chamber experiment is presented in the form of stereoscopic pictures on negative film. Interactions in the chamber are found by scanning the projected film and noting the frame numbers of useful pictures for accurate measurement in a specially designed machine. The data obtained is processed using a computer to produce the final experimental results.

Scanning Machines were developed as part of the 1.5 metre British National Hydrogen

Bubble Chamber project.

A variety of Measuring Machines are on display:

The National Machine;

The Duff Machine;

Image Plane Digitiser, Mk I and II;

"D Mac" Digitisers;

Flying Spot Digitiser (Hough Powell Device);

CRT Device.

ORION AND DDP-224 COMPUTER COMPLEX

The two computers are fully integrated into a coupled time-sharing system which is arranged to allow simultaneous access to the computers by several users. Orion is a larger, slower computer than the DDP-224 with fully protected time-sharing; the DDP is particularly suited to interruption by external signals such as are produced in the course of an experiment.

The Laboratory will take delivery of an IBM 360 model 75 in November, 1966.

OUTSIDE PROJECTS (Building R.1)

A display of models and photographs is in the Main Entrance, Building R.1 illustrating the Variable Energy Cyclotron (A.E.R.E. Harwell) and the Electrostatic Generator (Nuclear Physics Department, Oxford University).

ACCELERATOR DEVELOPMENT AND EXPERIMENTAL TECHNIQUES

A significant part of the Laboratory's effort is devoted to the development of accelerators and devising new techniques to be used in experiments.

Superconducting Magnets (Building R.1)

Nearly all the practical aspects of superconducting magnet technology are being studied at the Laboratory. Considerable attention is also being given to the theoretical problems. Several magnets are under construction for uses connected with the Nimrod external proton beam, for the study of new materials, and for experience in magnet operation.

Vacuum Development (Building R.8)

The design and construction of the Nimrod vacuum system posed many difficult problems. The experience gained in their solution has made the Laboratory a centre for the development of the techniques for large high vacuum systems for accelerators.

Development work for new vessels and improvement of the present system is

continuous, particular attention being paid to new materials which will withstand possible increase in machine intensity.

Machine Physics (Buildings R.2 and R.25)

The success of a large complex machine such as Nimrod depends greatly on the reliability of a large amount of high performance equipment; much effort is directed to the improvement in reliability and performance. As an aid to the early diagnosis of faults a Data Recording System has been developed for the Nimrod Main Control Room.

General Physics

The work of the group covers some special developments immediately connected with Nimrod and high energy physics experiments. At present the main interests lie in two general fields: firstly, in the production and acceleration of intense charged particle beams; and secondly, in making a polarised proton target for use in high energy physics experiments. The target may be seen in Nimrod Experimental Hall No. 2; other exhibits are:

Dynamic Stress Analysis Electron Beams	Laboratory 3 Building R.1
Duoplasmatron Ion Source	Laboratory 6, Building R.1
Single Gap Ion Gun	Building R.25

ENGINEERING

The Laboratory demands a wide range of support in civil, chemical, electrical, electronic, and mechanical engineering. The Engineering Division employs a staff of about 220 which includes professional grades, technicians, draughtsmen and skilled craftesman. The Division is responsible for the comprehensive design and supply of engineering equipment together with all services including electric power, air, water, gas, special plant, and electronic instruments; in addition it provides normal heating and lighting. New Buildings and additions or modifications to existing ones, chemical analysis, material selection, and radiation dosimetry are also covered. The Safety Group is a part of Engineering Division.

Private industry is used considerably for manufacture, for assistance in design detail, for building, and for mechanical and electrical installation. The Division's workshops provide the more specialised or more urgently required equipment and implement changes made necessary by experimental or operational experience.

Design and manufacture	Building R.9
Electronics and Instruments Group	" R.18
Electrical Services Group	" R.18

Mechanical Services Group	Building R.9
Building Group	" R.9
Industrial Chemistry Group	" R.8 and R.9
Safety Group	Display Cabinets in main buildings and Building R.13
Engineering Divisions part in the design manufacture and installation of the V.E.C. and E.S.6.	Building R.1 Entrance Hall

RADIATION PROTECTION (Building R.20)

The Radiation Protection Group has as its primary task the protection of staff and visitors from harmful radiation. This involves measuring the general level of radiation and the actual radiation received by an individual. In addition the group are preparing a programme of research which will increase the understanding of the fundamental processes involved in radiation fields.

Displays will include the operation of the film badge service, and the scanning and counting techniques used to measure radiation.

FILMS — LECTURE THEATRE

"The Rutherford Laboratory" (26 minutes)
2.30 and 3.45 p.m.

Children's Cartoons (20 minutes)
3.15 and 4.30 p.m.

GENERAL INFORMATION

ADDRESS:

The Rutherford Laboratory, Chilton, DIDCOT, Berkshire.

Telephone: Abingdon 1900

EMERGENCIES:

Use any G.P.O. telephone within the Laboratory.

FIRE - Dial 2222
MEDICAL ASSISTANCE - Dial 6217

In the event of an emergency, visitors are asked to follow the local instructions posted widely throughout the Laboratory.

INFORMATION DESK:

An information desk will be in the Main Entrance Hall, Building R.1 (Telephone Extension 6340)

FIRST AID:

Members of the St. John's Ambulance Brigade will be on duty in the Messengers' Room, Building R.1. This room is on the Ground Floor next to the North-west entrance to the building. (Telephone Extension 6217)

CAR PARKS:

Drivers are asked not to park on the roads but to use one of the official car parks. In addition cars may be parked on the hardstanding which runs along the EASTERN boundary of the Laboratory.

REFRESHMENTS:

The Restaurant will be open from 3 p.m. A set tea will be served in the Dining Room at a charge of 2s. 6d. per head. Tea and biscuits will be served in the Coffee Lounge.

Vending machines are in all main buildings.

TRANSPORT:

Service 30	Depart Didcot Station	2.30 p.m.
	Depart A.E.R.E. Main Gate	5.05 p.m.
Service 12 or 112	Departs from Oxford and Newbury	1.30 p.m., 2.30 p.m.
	Departs A.E.R.E. Main Gate for Oxford	4.20 p.m., 5.20 p.m.
	A.E.R.E. Main Gate for Newbury	4.21 p.m., 5.21 p.m.

A connecting service will be run between the Rutherford Laboratory and the A.E.R.E. Main Gate. The connecting bus for homeward journeys will leave the Main Entrance Building R.1 at 4.10 p.m. and 5.10 p.m.

RUTHERFORD LABORATORY

Open Day

SATURDAY, 21st MAY, 1966

Admit One

№ 0462

Rutherford Laboratory, Chilton

OPEN DAY TEA TICKET

(Valid for one person)

0410

Saturday, 21st May, 1966

To be surrendered in the Restaurant