MYRA S. GILBERT

# THE NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

## FIFTH ANNUAL REPORT

1961—1962

RUTHERFORD HIGH ENERGY LABORATORY
CHILTON, DIDCOT, BERKSHIRE

THE NATIONAL INSTITUTE
FOR RESEARCH IN NUCLEAR SCIENCE

# Fifth Annual Report

for the period 1st October, 1961
to 30th September, 1962

Presented to the United Kingdom Atomic Energy Authority
in pursuance of Article 13 of the Institute's Royal Charter

RUTHERFORD HIGH ENERGY LABORATORY
CHILTON, DIDCOT, BERKSHIRE

# THE NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

## FIFTH ANNUAL REPORT

**for the year ending 30th September, 1962**

## INTRODUCTION

1. This report covers the work of the Institute during the academic year October, 1961 to September, 1962. In previous reports the period was the financial year, April to March, and last year's report included a short supplement dealing with the period April, 1961 to September, 1961. The change has been made in order to present a more up-to-date report at the time when the accounts have been audited and are available for publication. There has been one change in membership of the Governing Body of the Institute during the year: Professor R. E. Peierls, one of the original university members retired on 15th February, 1962 and was succeeded by Professor B. H. Flowers. The full membership is given in Appendix IV. The present membership of the Institute's committees is given in Appendix V. The accounts for the year ending 31st March, 1962 are given in Appendix II and a brief analysis of the current expenditure and of the capital assets is given in Appendix III.

## PRINCIPAL EVENTS OF THE YEAR

2. In July, 1962 the Government approved the Institute's proposal to establish a second high energy physics laboratory in the North of England, containing a 4,000 million electron-volt electron synchrotron. Professor A. W. Merrison has been appointed Director of the new laboratory, on secondment from the University of Liverpool for five years from 1st October, 1962.

3. The decision to install an "Atlas" computer at the Rutherford Laboratory, for use in research in other fields besides nuclear science, was briefly reported last year. Dr. J. Howlett has been appointed Head of the Atlas Computer Laboratory and he took up the post on 1st December, 1961. The computer has been ordered and construction of the buildings has started.

4. The main activities of the Institute have centred round the accelerators at the Rutherford High Energy Laboratory: the Proton Linear Accelerator which is fully operational and Nimrod which is approaching completion. The construction programme for Nimrod had to be revised during the second half of 1961 mainly because of delays with the main vacuum chamber. The new target date set in December, 1961 for the start of commissioning was 1st October, 1963. All the problems subsequently encountered have been overcome without any further postponement of this date. Nuclear physics research with the proton linear accelerator has been continued with great vigour, and since January, 1962 the accelerator has normally been in use for 24 hours a day. The polarized proton source for the P.L.A. has worked well, and has opened up new fields of experiment. The design and construction of accelerators for two other bodies (Oxford University and the Atomic Energy Research Establishment, Harwell) is now in progress. The Institute have agreed to arrange and support several major university experiments in high-flux reactors. They have also built a radio-chemical laboratory at the Rutherford Laboratory, for university experiments involving chemical

operations on materials irradiated in the accelerators of the Rutherford Laboratory or in the reactors or accelerators of the Atomic Energy Research Establishment, Harwell. Further details of all these activities are given in later sections of this report.

NIMROD

5. In the past year progress has been maintained on the construction of the 7 GeV (i.e. 7 thousand million electron volt) proton synchrotron, Nimrod. A description of the machine has been given in previous annual reports. Several sections of the machine have operated successfully for the first time and it is expected that the first commissioning experiments will be carried out in August or September, 1963.

6. As reported in the supplement to the fourth Annual Report the Nimrod Injector, which accelerates protons to 15 MeV before they enter the main magnet ring, first delivered a full energy beam on the 1st August, 1961. Several major difficulties with the linear accelerator and its associated radio frequency power unit have delayed progress over much of the past year but these difficulties have now been successfully overcome. Installation work is virtually complete and experiments with 15 MeV beams have been proceeding to optimise the performance of the Injector before it is required to provide beams for the synchrotron. These experiments have been going well. Towards the end of the year a 10 milliamp beam current was accelerated to 15 MeV and the indications are that much higher beam currents will eventually be achieved.

7. The installation work connected with the 7000 ton magnet yoke has proceeded very smoothly during the past year. The copper coils are installed and all the pole pieces have at some stage been installed although in six octants temporary shims were used in lieu of outer vacuum vessels. (These six octants are now being fitted with outer vacuum vessels and final installation of pole pieces and poleface windings should be complete early in 1963). An extensive survey of the magnetic fields in the magnet octants and the straight sections interspaced with them is almost complete and the results are very satisfactory. They indicate that the magnetic field shapes required to hold the protons in a circular orbit as they are accelerated, have been achieved with a high degree of accuracy.

8. The radio frequency cavity, which accelerates the protons in the magnet ring, has been rebuilt using copper clad steel for magnetic shielding and new radio frequency coupling has been built in. The cavity has successfully undergone a trial installation in the straight section assigned to it. It has also been vacuum tested to a satisfactory pressure and has withstood electrically the maximum voltage which will be applied. A new drive chain which supplies the radio frequency power to the cavity was recently completed. Some self oscillation when this is coupled to the cavity remains to be cured. Other associated equipment is available or nearing completion.

9. The toroidal-shaped vacuum vessel in which the protons travel around the magnet ring is of double walled construction, consisting of outer and inner vessels, together with header vessels fitted with pumping ports and access windows. It is made of epoxy resin reinforced with glass-fibre cloth and is being fabricated in eight sections corresponding to the magnet octants. In February,



the first production outer vessel was tested at the Laboratory and its leak rate was found to be much better than the specified maximum permissible value. Since then both outer and inner vessels have been arriving regularly in progressively better condition and the repair work and testing routine has been conducted well within the programmed dates. The vacuum performance of the vessels is generally better than was anticipated. Vacuum tests on outer vessels installed in the machine complete with pole pieces have also been satisfactory. Considerable difficulties have been encountered in the production of header vessels but the first vessel is expected shortly.

10. The power plant required to supply current to the electromagnet consists basically of a motor-alternator set with flywheels for energy storage, 8 phase splitting transformers and converter equipment comprising 96 mercury arc rectifiers. The converter equipment was installed and successfully tested during the year. One of the two alternators is installed and working well. The other alternator has been rebuilt by the manufacturers and is now undergoing tests. In February the commissioning tests on the power plant were carried out, with the installed alternator and half the converter equipment supplying current to four of the magnet octants. The plant operated successfully up to currents well in excess of its required performance, supplying 11,000 amps to the magnet. Since then the power plant has worked well with remarkably few shut downs.

NUCLEAR EQUIPMENT AND RESEARCH PROGRAMME ON NIMROD

11. To use the accelerator effectively a large quantity of ancillary equipment is required. The primary protons can be made available for some purposes by a simple scattering target in the machine but for most experiments and for efficient use of the machine a complex beam extraction mechanism is essential. The extraction has to be done with good beam geometry and the beam has to be transported with systems of quadrupole magnets. Beams of secondary particles have to be produced with targets either in the machine or in the external proton beam. The secondary beams in general require similar transport systems but for many experiments particle separators are required to select the wanted particles within a small energy bite. Bending magnets are generally used in all these schemes to overcome spatial limitations and (or) for analysis. Massive and elaborate shielding arrangements are required to restrict radiation hazards and to limit the background in experiments.

12. Much work has been done on the detailed design of plant necessary to fulfil these requirements, and orders have been placed for many of the major items. It is planned to have the bulk of this equipment available in time for the completion of Nimrod itself, so that the machine may be used as fully as possible from the start. Those parts of the proton extraction system which are within the accelerator proper will be in place when the machine is commissioned.

13. The bubble chamber has, since its invention only ten years ago, become one of the most important tools of research in high energy physics, because it enables the paths and interactions of individual particles to be studied with great precision. Three large bubble chambers will eventually be used with Nimrod. Each will be used for the particular types of experiment, for which it is best suited, so that together a wide range of important experiments will become feasible.

14. The British National 1·5 metre Hydrogen Bubble Chamber is a joint venture by several universities financed by the Department of Scientific and Industrial Research. A combined team of university physicists, technicians and Rutherford Laboratory staff have been working for some time on the assembly of components and installation of the chamber and ancillary plant in an annexe specially built as an extension of the Nimrod experimental area, and the year saw the virtual completion of this project. After commissioning tests, it is proposed to transport the chamber to CERN, Geneva (the magnet of the chamber has already been sent) to be used initially with the 25 GeV proton synchrotron there until it is eventually returned to the Rutherford Laboratory for use with Nimrod.

15. The other two large bubble chambers are projects financed by the National Institute. In both cases however the original proposal for the chamber has come from a university, which also is providing the bulk of the design effort. This illustrates a general policy of the Institute which is to encourage the universities to play a major role in the planning and detailed design of experimental facilities at the Laboratory which they will eventually be using.

16. The decision to build a 1·5 metre Heavy Liquid Bubble Chamber was announced in last year's report. This project was originated by University College London, where a strong team is working on the design. Several major plant items have been ordered, including the magnet, although difficulties have been encountered in arranging manufacture of other items (particularly the accurate machining of chamber components to the close tolerances necessary) and this will delay completion of the chamber until 1964. The special building to house the chamber has been completed at the Rutherford Laboratory and is at present being used for testing some of the first components.

17. Financial approval to proceed with the third bubble chamber was received during the year. This is the 80 cm helium bubble chamber, a project proposed by the Clarendon Laboratory of Oxford University. A design team has been built up there and work has progressed satisfactorily; tenders have already been invited for the manufacture of the magnet and refrigerator. Building work is well advanced on the extension to the Nimrod experimental area where this chamber is to be assembled.

18. A large part of the experimental work with bubble chambers consists of the examination of the photographs taken of the particle tracks. Many hundreds of thousands of photographs will be obtained from one chamber alone in a year and the detailed scrutiny of the photographs and the measurement of lengths, curvatures and angles of the tracks (from which information concerning the nature of the particles and their interactions can be deduced) cannot be regarded as a feasible proposition without the aid of some kind of automatic measuring technique. Machines have been designed at Imperial College, London and elsewhere in which the position of any selected track is automatically recorded as a series of geometrical co-ordinates. Machines of this kind have been ordered, but even these will not be fast enough to analyse all the data produced when Nimrod becomes fully operational and studies are being made in collaboration with CERN and various universities of more advanced types of very fast track measuring machines in which the tracks are located automatically. The data from these measuring machines will be fed directly to, and be analysed by the new



Orion computer soon to be installed at the Laboratory. A smaller manual machine, of a type developed by University College London, is working successfully and two more have been ordered for use with spark chamber photographs.

19. During the year planning has started on the experimental programme initially to be carried out on Nimrod. This has been done in close collaboration with physicists from many of the universities in the United Kingdom and from the U.K.A.E.A. From requirements already known it is estimated that there will be upwards of 150 physicists interested in carrying out their research work on Nimrod.

## THE PROTON LINEAR ACCELERATOR

20. The most notable feature in the operation of the 50 MeV Proton Linear Accelerator (P.L.A.) during the year has been the marked increase in the effective utilization of the machine. This is illustrated by the steady increase in the number of hours per month made available to research workers, rising from an average of 344 hours per month in 1961 to 505 per month for the first eight months of 1962. The improvement is mainly due to the change from 16 to 24 hours per day operation which came into effect in January 1962, and secondly to the significant reduction in time required for maintenance. The proportion of the time scheduled for experiment during which the machine did in fact operate successfully has also shown a worthwhile increase.

21. Even so, there is still a heavy demand for machine time from the fifty or so research workers using the machine. A noteworthy development has been the closer association of university visitors and N.I.R.N.S. staff to produce teams strong enough to carry on experiments for 24 hours per day in an efficient manner. Operation and maintenance staff and workshops have responded splendidly to the heavy burden of the more concentrated working pattern.

22. The installation of the polarized proton source was described in the last annual report. It has been used for about one third of the experimental time, and has worked well and consistently, producing $5 \times 10^7$ protons per second with a 33% polarization. Beams can be produced with any desired direction of polarization; that is the proton spins may be directed either perpendicular to or parallel with the direction of travel. The importance of the polarized beam, lies in the fact that the forces which hold nuclei together are known to be spin dependent, and therefore much greater light can be thrown on the nature of these forces if experiments can be performed in which the spin direction is defined.

23. A very important feature of the P.L.A. is that protons do not arrive at the target as a steady stream but are concentrated in bursts: each burst lasts only $3 \times 10^{-10}$ seconds and the instant of arrival at the target can be determined from the waveform of the accelerating radio-frequency voltage. With this knowledge of the protons' arrival time, which coincides with the time a nuclear reaction product departs, one can determine the velocity of the emitted particle using a detector with a sufficiently fast response placed a suitable distance from the target. This 'time of flight' technique has been used with many types of accelerators; the P.L.A., with its very short bursts and its high intensity is

very well suited to the technique and it is being used for the accurate determination of the energy of the emitted particles in several different types of experiment, and also for the detailed study of the energy of the accelerated protons themselves.

24. There have been several alterations to the P.L.A. installation, notably the redesign of the vacuum rigs and mountings of the grounded grid triodes supplying the radio frequency power, the fitting of deuterium thyratrons to the modulators and the completion of the second experimental area. This new area will house two large analyzing magnets, at present under construction, and these will considerably increase the scope and precision of experiments which can be performed. In addition it has made available space for five more beam lines along which protons can be directed to different sets of apparatus. This has reduced the congestion experienced in the first experimental area. Furthermore it is now possible for the first area to be in use for experiments while apparatus is being set up in the second. The effective utilization of the machine has thereby been considerably increased.

25. Research on proton linear accelerator design has been applied principally to four problems. Firstly, the behaviour of the P.L.A. has been investigated by the time of flight method, mentioned above, and the results of this work have been compared with calculations based on the theory of phase oscillations and satisfactory agreement obtained. Secondly, a study of the problems involved in rebuilding tank 1 of the P.L.A. (which accelerates protons to 10 MeV) with quadrupole focusing has shown that the project is feasible and detailed mechanical design has started. Thirdly, studies are under way on the possibility of using superconducting cavities in linear accelerators. Such devices hold out the promise of reducing by orders of magnitude the high frequency power requirements, so that continuous rather than pulsed operation can be contemplated. Fourthly, accelerating structures for high energy linear accelerators are being studied both experimentally and theoretically. This work includes an investigation of two radio frequency structures which have not so far been used in an accelerator.

26. During this period, the first two doctorates have been awarded to research students all of whose research was carried out on the P.L.A.

## OTHER ACCELERATOR PROJECTS

27. Apart from the design and construction of their own accelerators, it is the Institute's policy to assist the universities and the Atomic Energy Authority in the design of their accelerators. Two such projects are currently under way each occupying a substantial group of accelerator physicists and engineers.

28. As announced in the supplement to the last report, the Institute are playing a major role in a new project at Oxford University. Protons of energy 20 MeV (and heavier ions of appropriate energy) are required from an electrostatic accelerator for basic research into nuclear structure particularly of the heavier elements. The first stage of the accelerator will be a 8–10 MeV vertical machine which is being designed and built by the Electrostatic Generator Group at the Rutherford Laboratory. The second stage is a commercially available horizontal tandem generator and the Group is also responsible for the integration of the whole system.



29. Good progress has been made during the year with the vertical machine. Contracts have been placed for all the major items, such as the pressure vessel and accelerator column and the magnets needed to bend the particle beams into the required paths. A pilot machine has been built and successfully operated and is being used for testing various components and design features of the main machine. Installation of the major components is expected to begin towards the middle of 1963 in the new Nuclear Physics Laboratory at present under construction in Oxford.

30. The Institute are also giving considerable assistance to the Atomic Energy Authority in a project first announced in August, 1962. This is the construction of a new cyclotron to be known as the Variable Energy Cyclotron, at the Atomic Energy Research Establishment, Harwell. The Cyclotron Group at the Rutherford Laboratory are designing this machine for the A.E.R.E. and will also be responsible for supervising construction, installation and commissioning.

31. This cyclotron will be the most versatile of its kind in Western Europe and will provide high intensity beams (up to 100 micro-amps) of protons, deuterons or alpha particles having energies up to 50 MeV, or heavy positive ions having much greater energies (e.g. nitrogen, neon or argon ions with energies up to 10 MeV per nucleon). It will also be possible to carry out internal target irradiations. The cyclotron will have a 200 ton magnet with a pole-face diameter of 70 inches. The poles will be fitted with spiral ridges to permit the acceleration of continuous beams.

## RESEARCH REACTORS

32. The Institute through their Research Reactor Committee have continued to review the requirements of universities for nuclear reactors for both teaching and research purposes. Following the recommendations made to the Government and the subsequent announcements by the Department of Scientific and Industrial Research concerning the provision of low power reactors for particular universities (Scottish Group, Liverpool/Manchester and London universities), the Institute have turned their attention more to the needs of universities for high power reactors to be used for research.

33. Reactors regarded simply as neutron sources now play a vital role in many fields of research. The effect of neutron irradiation on matter is an important field of study in many branches of science, not only because of the obvious technological implications, but also because such studies frequently throw light on the nature of matter itself.

34. Some important fields of research demand the availability of intense beams of neutrons as produced in high flux reactors. The low power (and consequently low flux) reactors mentioned previously, to be located at universities will be primarily used for teaching purposes and will be of only restricted use for research in fields other than reactor physics itself. It is for this reason that the Institute are currently giving detailed attention to university needs for space in high flux reactors. The Institute do not themselves own a high flux reactor, and to meet university needs they have arranged for access to reactors owned by other organizations (principally the Atomic Energy Authority).

35. As a start, the Institute have decided to support three major research programmes requiring high flux reactor facilities, which have been proposed by groups at the Universities of Birmingham, Cambridge and Reading. Broadly the research topics lie in the fields of solid state and reactor physics. In view of a generous offer by Associated Electrical Industries Ltd. of space in their high flux reactor Merlin, it had been hoped to accommodate the experiments on this reactor, but these plans had to be abandoned on A.E.I.'s decision to cease to operate Merlin. However, the Atomic Energy Authority have agreed to the use of their research reactor Herald situated at the Atomic Weapons Research Establishment, Aldermaston, for university experiments and it is planned to transfer the three experiments mentioned to this reactor before the end of 1962.

36. Meanwhile the Institute have continued to support university requirements for more modest irradiation facilities. For example they are meeting the costs of irradiating archeological specimens as part of a research programme carried out at the University of Oxford.

## RADIOCHEMICAL LABORATORY

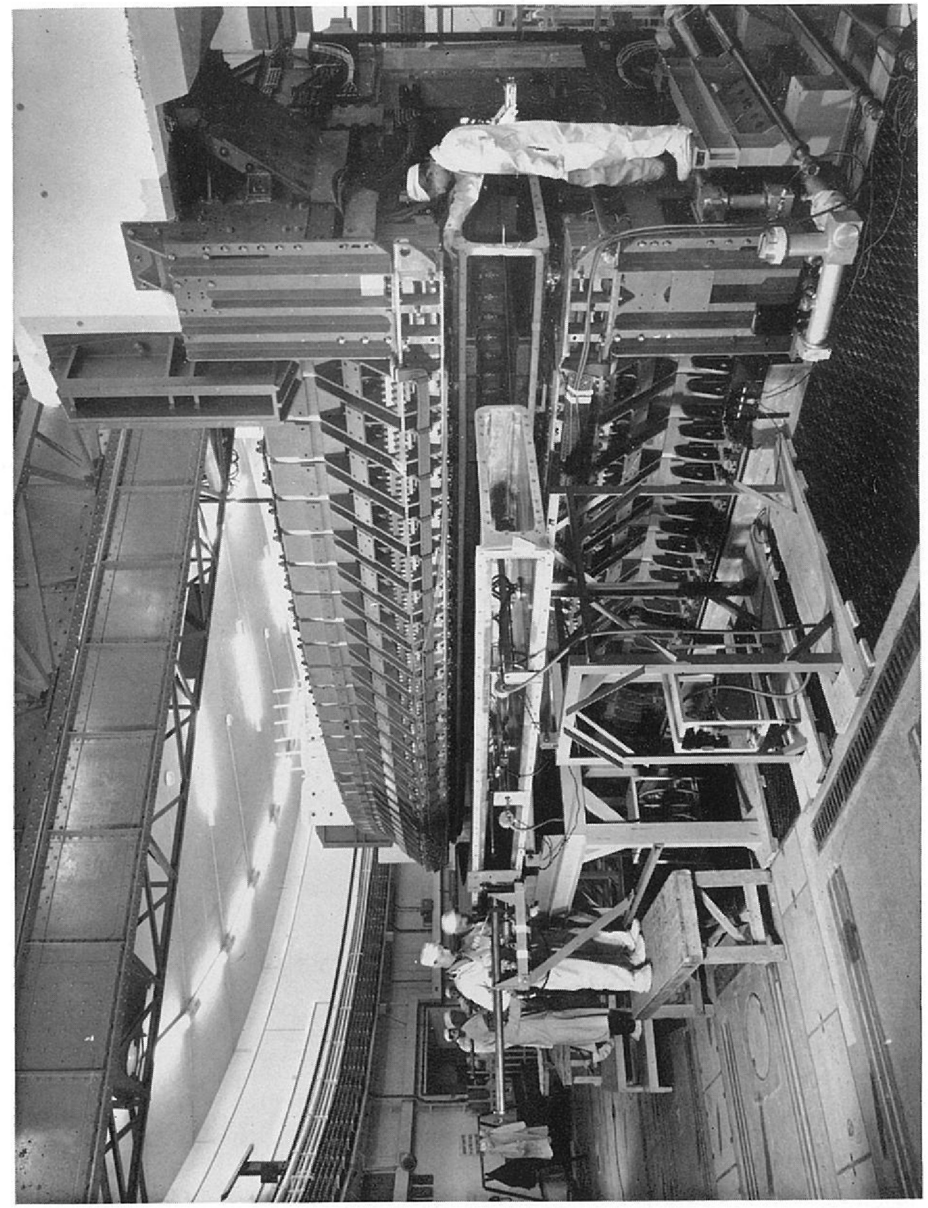
37. In certain types of experiment, chemical operations need to be carried out on materials irradiated in the Rutherford Laboratory accelerators, or in reactors or accelerators of the Atomic Energy Research Establishment, Harwell. These together make up a unique range of irradiation facilities in one place, and with the co-operation of the A.E.R.E., the Institute have provided a radiochemical laboratory for university scientists who need to carry out chemical operations on the spot. The radiochemical laboratory will shortly be ready to receive university visitors. Information about it has been sent to all university chemistry and physics departments in the country.

## THE ATLAS COMPUTER LABORATORY

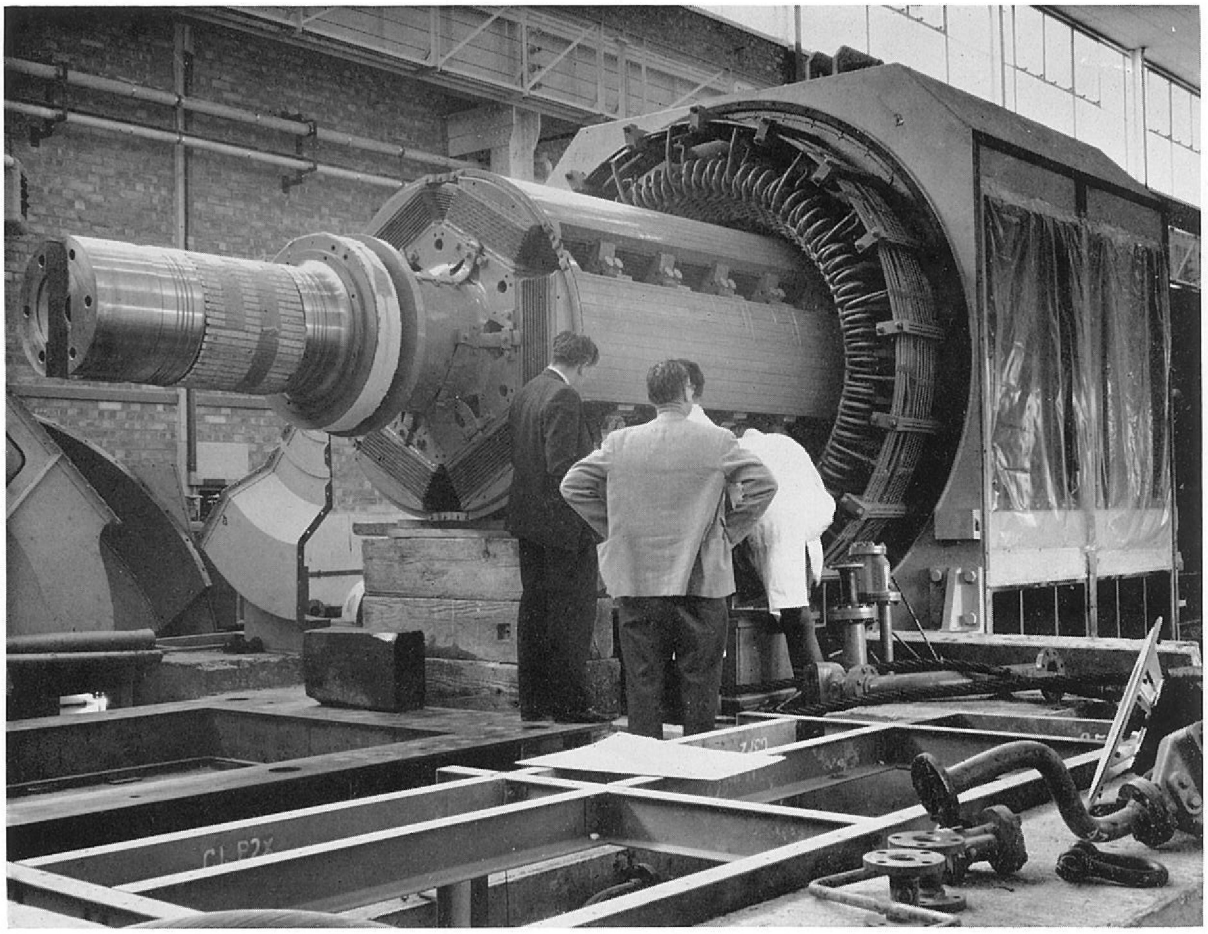
38. The Government's request to the Institute to operate an Atlas electronic digital computer was reported briefly in the supplement to the last report. The computer, together with the necessary buildings will cost about 3½ million pounds. It will be installed at the Institute's Rutherford High Energy Laboratory, for common use by the universities, the United Kingdom Atomic Energy Authority, Government Departments and the N.I.R.N.S. itself. It should be ready for use in 1964. As in the case of the Institute's other facilities, university requirements for use of the computer will be judged on their scientific merits, and when accepted will be met without charge to the universities.

39. The management of the computer will be under the control of the Atlas Computer Committee including amongst its members many leading computer specialists and users (see Appendix V). The Committee, which reports directly to the Governing Body of the Institute, has in the course of its first three meetings settled the main lines along which the computer project shall be conducted.

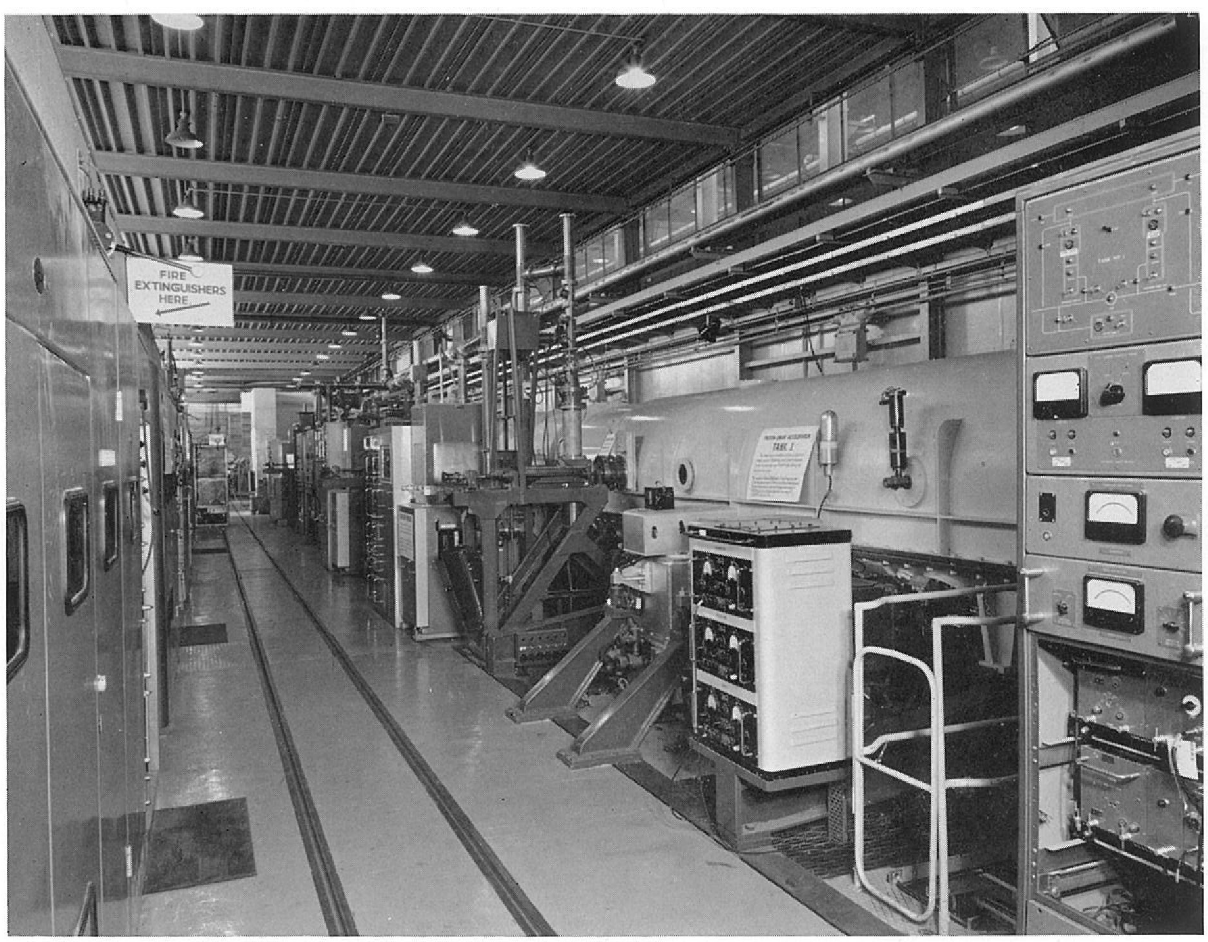
40. The buildings housing the computer, auxiliary plant, staff and visiting users of the computer are to be known as the Atlas Computer Laboratory.



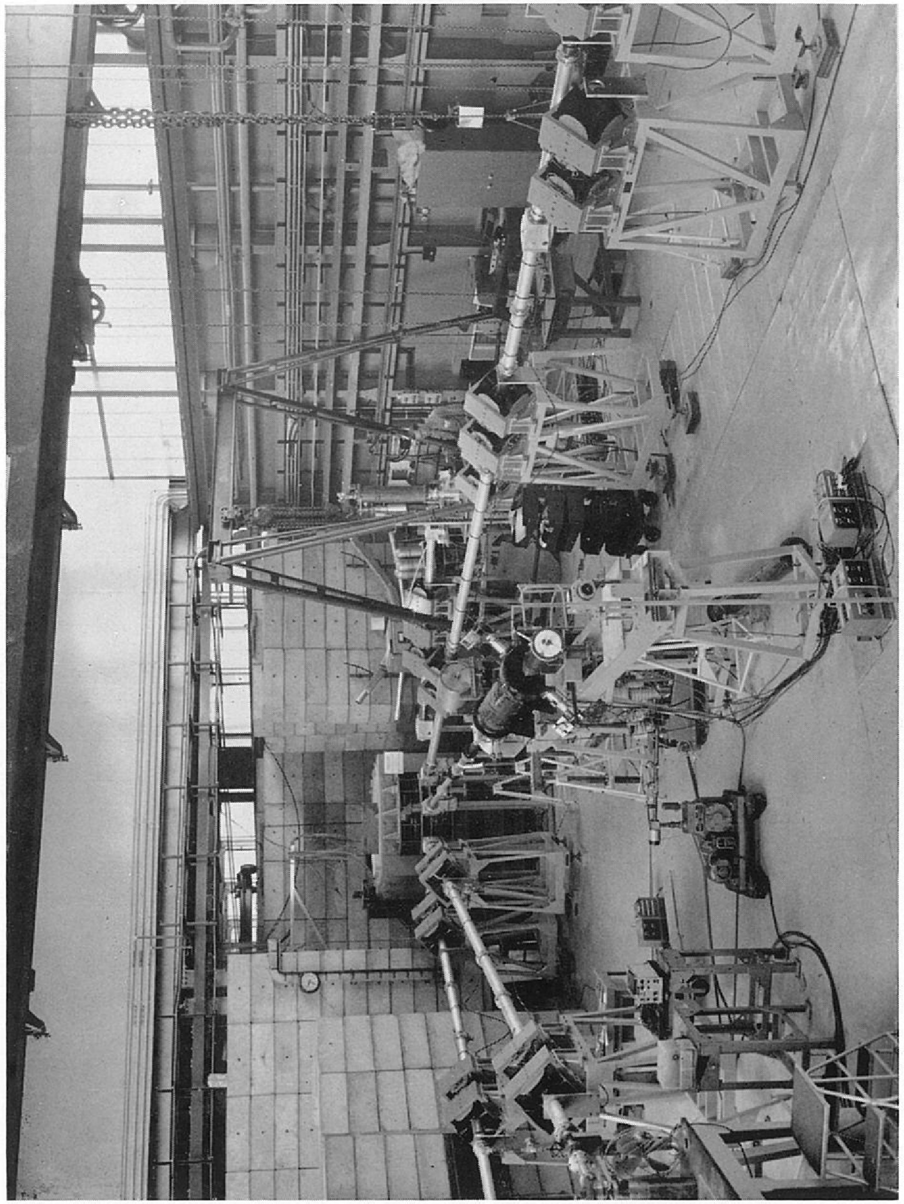
Nimrod Magnet Room showing installation of vacuum vessel.



Assembly of alternator for Nimrod Power Supplies.




The 50 MeV Proton Linear Accelerator.



The new P.L.A. Experimental Area.



41. The Head of the Atlas Computer Laboratory reports direct to the Atlas Computer Committee, but for most administrative purposes the laboratory is part of the Rutherford Laboratory. Dr. J. Howlett, previously the Head of the Applied Mathematics Group at A.E.R.E., Harwell, has been appointed Head of the Atlas Computer Laboratory. He took up the post on 1st December, 1961.

42. The Atlas computer is made by Messrs. Ferranti. It has been developed in co-operation with the scientists at the University of Manchester, where the first model has recently been completed. The Institute machine which will be much larger and more elaborate than the first model, will have an immediate access (magnetic core) store capable of holding nearly 50,000 'words', each word having a length of 48 binary digits, equivalent to about 15 decimal digits, and will have a computing speed averaging about 500,000 instructions per second.

43. When completed, this will be one of the most powerful computer installations in the world. Manufacture of the computer is well under way and is scheduled for completion by September, 1963. Commissioning in the factory is expected to take six months, so that installation at the Laboratory should start about April, 1964. Work on the buildings to house the computer has commenced and should be completed by the end of 1963.

44. It is expected that the eventual complement for the Laboratory will be about 50. The staff will be organized into three groups, for operations, programming and mathematical research respectively. In addition maintenance engineers will be provided by Ferranti under a separate contract.

## THE ELECTRON LABORATORY

45. For some time now the Institute have been considering the future needs of this country for high energy accelerators. A working-party, under the chairmanship of Professor J. C. Gunn, of the University of Glasgow, recommended to the Institute in November, 1960 that they should undertake the construction of a 4 GeV electron synchrotron. The field of physics open to such a machine would be complementary to that which will be covered by Nimrod and there was a very strong case for a high energy electron synchrotron available to physicists in the U.K. After full consideration of this proposal by the Physics Committee and the Governing Body, the Institute recommended to the Minister for Science that a 4 GeV electron synchrotron should be constructed in a new Institute laboratory set up for the purpose in the Liverpool-Manchester area, and that this laboratory should be particularly associated with the Universities of Liverpool, Manchester and Glasgow, where the Physics Departments are particularly interested in this field of physics. The Minister for Science announced in July, 1962 that approval had been given to this proposal and that Professor A. W. Merrison, of the University of Liverpool had been appointed as the first Director of the new laboratory.

46. The electron synchrotron, although in principle similar to Nimrod, will be of the strong-focussing type. The advantage of such a machine is that the magnetic guide field can be provided by a comparatively small magnet which will weigh about 500 tons compared with the 7,000 tons of the Nimrod magnet. This magnet, however, must be aligned on a circle of 200 ft. diameter with an accuracy

of 0·005 ins., and so there are very strict requirements for the foundations and sub-soil supporting them. Several sites in the North Cheshire area have been investigated but none has yet been selected.* The capital cost of the synchrotron and the laboratory which will house it, will be about 3½ million pounds and the staff will eventually total about 250.

47. In recent years a new and exciting field of physics has been opened up by experiments where high energy electrons are scattered on protons and neutrons. In this way the structure of these particles, which are $10^{-13}$ cm. in diameter, has been revealed and it is clear that the new electron synchrotron will make possible the investigation of quite fundamental problems in the physics of elementary particles.

## ADMINISTRATIVE MATTERS

48. During the year, additional staff of all grades have been recruited for the Rutherford Laboratory and the total strength is now 840 and in addition there are 7 Atlas Laboratory staff. Recruitment for the Electron Laboratory is about to start. All staff matters both industrial and non-industrial are now administered by the Laboratory's own personnel section. The Institute's Whitley Council, and Joint Industrial Negotiating Committee and the Rutherford Laboratory Joint Consultative Committee have been set up and many matters affecting the staff have been discussed within the framework of this machinery. The conditions of service in the Institute are broadly the same as those in the Atomic Energy Authority.

49. The junior staff are encouraged to take part-time courses at Technical Colleges and Colleges for Further Education leading to National Certificates and other recognized qualifications. 166 Institute employees attended such courses in the academic year 1961–62. Facilities for more advanced study up to degree standard are provided for those who show particular promise.

50. The Institute have entered into an arrangement with the A.E.R.E. for participation in their Apprenticeship Scheme; six apprentices were enrolled in 1961 and five more have been accepted for 1962.

51. The Institute are very conscious of the need to develop and maintain close relations with other centres of nuclear and high energy physics, not only those at British Universities with whom of course the Institute have special ties, but also with similar laboratories overseas. To this end many visits and exchanges have been arranged and several members of staff have been sent to the laboratories at Berkeley and Brookhaven in the United States and to CERN in Switzerland in order that they might gain experience of the problems connected with research on high energy accelerators.

52. The building programme at the Rutherford Laboratory has continued during the year. A major extension to the main laboratory and office block has been completed and occupied, also new buildings required to give improved laboratory and office accommodation for the Proton Linear Accelerator Group, including a new experimental area. The low-activity radiochemical laboratory mentioned in paragraph 37 has been completed and will shortly come into operation. Construction of several new buildings has begun, including a new laboratory required for development and testing of nuclear equipment to be used with Nimrod, and general accelerator research, together with an associated office block; these should be ready for use early in 1963. Work has also started on a major extension to the control and counting room block to provide laboratory and office accommodation with supporting workshops, for those concerned with the eventual operation and use of Nimrod. A restaurant for the laboratory is under construction and should be in use in the summer of 1963.

* It has since been announced that the Institute have applied to the Runcorn Rural District Council for outline planning permission to build the Laboratory at Daresbury in North Cheshire. The site which the Institute wish to develop is at present owned by Imperial Chemical Industries Ltd.



53. In view of the rapid growth of the Laboratory the long term requirements for accommodation are kept under constant review and proposals for a new combined laboratory and office building—mainly to house the electronics groups—and a new general purposes office block, are under consideration. It is also planned to have a lecture theatre to seat 200. This is needed to permit Laboratory staff and the many university staff engaged in research there to meet and discuss their work collectively.

54. Progress has been made in landscaping and in improving the general appearance of the Laboratory. Trees, shrubs and flowers have been planted and large areas including the protective mount to Nimrod, have been grassed. The large heap of spoil from the Nimrod foundations has been shaped to harmonise with its surroundings and this too has been sown with grass.

55. Owing to the rural situation of the Rutherford Laboratory the Institute are obliged to provide a considerable number of houses if the necessary staff are to be recruited. During the year, the Institute have bought 38 houses at Abingdon, Didcot, Newbury, Wallingford and Wantage. In addition, an estate of 37 houses is being developed at Didcot. When this estate is completed, 229 houses (including A.E.R.E. and Local Authority houses) will have been made available for Rutherford Laboratory staff and university visitors. Proposals for further housing developments at Abingdon are being considered, but funds will not be sufficient to provide for all staff who have hitherto been regarded as eligible for housing. The Cosener's House continues to be used as a residence, primarily for university visitors, and plans are now being examined for providing additional accommodation of this type. The A.E.R.E. continue to provide hostel accommodation for Institute staff.

56. Notable visitors to the Rutherford Laboratory during the year included the Rt. Hon. Edward Heath, Lord Privy Seal, Dr. Glenn T. Seaborg, Chairman of the United States Atomic Energy Commission, Dr. Bhabha, Chairman of the Indian Atomic Energy Commission and Sir Roger Makins, Chairman of the United Kingdom Atomic Energy Authority.

## APPENDIX I

### Objects of the National Institute for Research in Nuclear Science

The objects for which the Institute are established and incorporated are set out in the Royal Charter as follows:

(a) To carry out research of any nature in connection with nuclear science or any matter related thereto.

(b) To provide, equip and operate facilities of any description which may, in the opinion of the Institute, be required for the purposes of any such research as aforesaid.

(c) Without prejudice to the generality of the foregoing, to provide, equip and operate, for common use by Universities and by other institutions and persons engaged in research in nuclear and related matters, facilities which by reason of their size or cost or otherwise howsoever are beyond the scope of individual Universities, institutions or persons as aforesaid.

(d) To permit and encourage scientists of Universities, Colleges and the United Kingdom Atomic Energy Authority and other institutions, as well as scientists of industrial laboratories, to make such use of facilities provided as aforesaid as the Institute may determine to be appropriate.

(e) To co-operate with the United Kingdom Atomic Energy Authority in the solution of specific problems in the field of nuclear or related research.

(f) To train scientists and engineers in matters relating to nuclear science.

(g) To disseminate scientific and technical knowledge in the field of nuclear or related research.

(h) To acquire from the United Kingdom Atomic Energy Authority or from any other body or person whatsoever any property, equipment or other assets of any kind which in the opinion of the Institute are requisite for or conducive to the carrying out of research in connection with nuclear science or any matter related thereto and to enter into any contracts or agreements in furtherance of any such research.

(i) Generally to do all things necessary or expedient for the proper and effective carrying out of any of the objects aforesaid.



## APPENDIX II

### NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

#### Revenue Account for the year ended 31st March, 1962

| *31st March, 1961* £ | | £ |
|---|---|---|
| *241,573* | Salaries and Wages | 749,251 |
| *16,809* | Employers' Superannuation Contribution | 52,812 |
| *4,107* | Employers' National Insurance Contribution | 16,098 |
| *18,721* | Travel and Subsistence Expenses | 40,174 |
| *192,005* | Material and Services | 610,817 |
| *39,504* | Research and Development by Universities and Industry | 54,777 |
| *4,638* | Expenses on Hostel and Houses | 8,475 |
| *10,791* | Miscellaneous Expenses | 42,425 |
| *1,377,480* | Supplies and Services by the United Kingdom Atomic Energy Authority | 1,113,176 |
| *£1,905,628* | | £2,688,005 |

| | £ | *31st March, 1961* £ |
|---|---|---|
| Grant from United Kingdom Atomic Energy Authority to meet Recurrent Expenditure | | |
| Research, Administration, etc. | 2,622,746 | *1,901,271* |
| Capital Expenditure | 8,938 | *1,537* |
| Receipts from Hostel and Houses | 6,680 | *2,186* |
| Miscellaneous Income | 49,641 | *634* |
| | £2,688,005 | *£1,905,628* |

#### Capital Account as at 31st March, 1962

| *31st March, 1961* £ | *Capital Grant Account* | £ |
|---|---|---|
| *5,662,134* | Balance as at 1st April, 1961 | 8,867,623 |
| *3,203,952* | Add Grant from United Kingdom Atomic Energy Authority to meet capital expenditure for the year ended 31st March, 1962 | 2,929,963 |
| *1,537* | Expenditure from Revenue Account | 8,938 |
| | | 11,806,524 |
| — | *Deduct*—Amounts written off for Assets no longer in service | 422 |
| *£8,867,623* | | £11,806,102 |

| *Assets at Cost* | £ | *31st March, 1961* £ |
|---|---|---|
| Land and Buildings | 4,209,598 | *2,541,106* |
| Plant and Machinery, Ancillary Installations and Motor Vehicles | 2,729,646 | *2,329,502* |
| Loose Apparatus, Tools, Furniture, Fittings and Office Machinery | 175,153 | *92,766* |
| | 7,114,397 | *4,963,374* |
| Assets in course of construction | 4,691,705 | *3,904,249* |
| | £11,806,102 | *£8,867,623* |

*NOTE.*—Capital Expenditure authorized but not provided for in these Accounts amounted to £9,631,860 of which £6,281,926 has been committed contractually.

BRIDGES, *Chairman.*
J. A. V. WILLIS, *Secretary*

I have examined the above Accounts. I have obtained all the information and explanations that I have required, and I certify, as a result of my audit, that in my opinion the above Accounts are correct.

EXCHEQUER AND AUDIT DEPARTMENT,
*15th November, 1962.*

E. G. COMPTON,
*Comptroller and Auditor General.*

### Personnel Committee

| | |
|---|---|
| *Chairman* *THE RT. HON. LORD BRIDGES, G.C.B., G.C.V.O., F.R.S. .. .. | |
| MR. H. G. LINDSELL, C.B. .. .. | *Atomic Energy Authority* |
| *SIR HARRIE MASSEY, F.R.S. .. .. | *University College London* |
| DR. T. G. PICKAVANCE .. | *Rutherford High Energy Laboratory* |
| PROFESSOR A. W. MERRISON .. .. | *Electron Laboratory* |
| DR. F. A. VICK, O.B.E. .. .. | *Atomic Energy Authority* |
| *SIR JOHN WOLFENDEN, C.B.E. .. .. | *University of Reading* |

*Secretary :* DR. J. A. V. WILLIS

### Atlas Computer Committee

| | |
|---|---|
| *Chairman :* *SIR WILLIAM PENNEY, K.B.E., F.R.S. .. .. .. .. | *Atomic Energy Authority* |
| *DR. J. B. ADAMS, C.M.G. .. .. | *Atomic Energy Authority* |
| DR. R. A. BUCKINGHAM .. .. | *University of London* |
| *SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S. .. .. .. | *University of Cambridge* |
| MR. C. JOLLIFFE .. .. .. | *Department of Scientific and Industrial Research* |
| DR. J. C. KENDREW, F.R.S. .. .. | *University of Cambridge* |
| PROFESSOR T. KILBURN .. .. | *University of Manchester* |
| MR. M. J. LIGHTHILL, F.R.S. .. | *Royal Aircraft Establishment, Farnborough* |
| *SIR HARRIE MASSEY, F.R.S. .. .. | *University College London* |
| **PROFESSOR R. E. PEIERLS, C.B.E., F.R.S. .. .. .. .. | *University of Birmingham* |
| DR. T. G. PICKAVANCE .. .. | *Rutherford High Energy Laboratory* |
| SIR GRAHAM SUTTON, C.B.E., F.R.S. | *Meteorological Office* |
| DR. F. A. VICK, O.B.E. .. .. | *Atomic Energy Authority* |
| DR. M. V. WILKES, F.R.S. .. .. | *University of Cambridge* |

*Secretary :* DR. J. A. V. WILLIS

### Physics Committee

*Note.* The Physics Committee, which advises the Governing Body on matters relating to new physics projects, has been reconstituted with a smaller membership drawn from members of the Institute who are physicists with a few additional members. The joint Consultative Panel for nuclear research which advises both the D.S.I.R. and N.I.R.N.S. and has a wider membership, remains unaffected by this change, and the Institute will continue to refer to it for discussion and advice on matters requiring broad representation.

| | |
|---|---|
| *Chairman :* *SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S. .. .. | *University of Cambridge* |
| *DR. J. B. ADAMS, C.M.G. .. .. | *Atomic Energy Authority* |
| PROFESSOR C. C. BUTLER, .F.R.S .. | *Imperial College of Science and Technology* |
| *PROFESSOR J. M. CASSELS, F.R.S. .. | *University of Liverpool* |
| *PROFESSOR P. I. DEE, C.B.E., F.R.S. .. | *University of Glasgow* |
| *PROFESSOR B. H. FLOWERS, F.R.S. .. | *University of Manchester* |
| *SIR HARRIE MASSEY, F.R.S. .. .. | *University College London* |
| PROFESSOR A. W. MERRISON .. .. | *Electron Laboratory* |
| **PROFESSOR R. E. PEIERLS, C.B.E., F.R.S. .. .. .. .. | *University of Birmingham* |
| *SIR WILLIAM PENNEY, K.B.E., F.R.S. | *Atomic Energy Authority* |
| DR. T. G. PICKAVANCE .. .. | *Rutherford High Energy Laboratory* |
| *PROFESSOR D. H. WILKINSON, F.R.S. | *University of Oxford* |

*Secretary :* DR. J. A. V. WILLIS



### Rutherford Laboratory Visiting Committee

| | |
|---|---|
| *Chairman :* *SIR HARRIE MASSEY, F.R.S. | *University College London* |
| DR. E. BRETSCHER .. .. .. | *Atomic Energy Authority* |
| PROFESSOR W. E. BURCHAM, F.R.S. .. | *University of Birmingham* |
| PROFESSOR C. C. BUTLER, F.R.S. .. | *Imperial College of Science and Technology* |
| *PROFESSOR J. M. CASSELS, F.R.S. .. | *University of Liverpool* |
| *PROFESSOR P. I. DEE, C.B.E., F.R.S. | *University of Glasgow* |
| *PROFESSOR B. H. FLOWERS, F.R.S. .. | *University of Manchester* |
| PROFESSOR O. R. FRISCH, O.B.E., F.R.S. .. .. .. .. | *University of Cambridge* |
| PROFESSOR A. W. MERRISON .. .. | *Electron Laboratory* |
| PROFESSOR P. B. MOON, F.R.S. .. | *University of Birmingham* |
| **PROFESSOR R. E. PEIERLS, C.B.E., F.R.S. .. .. .. .. | *University of Birmingham* |
| DR. T. G. PICKAVANCE .. .. | *Rutherford High Energy Laboratory* |
| PROFESSOR C. F. POWELL, F.R.S. .. | *University of Bristol* |
| PROFESSOR A. SALAM, F.R.S. .. .. | *Imperial College of Science and Technology* |
| DR. G. H. STAFFORD .. .. .. | *Rutherford High Energy Laboratory* |
| *PROFESSOR D. H. WILKINSON, F.R.S. | *University of Oxford* |

*Secretary :* DR. J. M. VALENTINE

### Research Reactor Committee

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| *Chairman :* *SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S. .. .. | *University of Cambridge* |
| DR. V. S. CROCKER .. .. .. | *Atomic Energy Authority* |
| DR. S. C. CURRAN, F.R.S. .. .. | *Royal College of Science and Technology, Glasgow* |
| **PROFESSOR J. DIAMOND .. .. | *University of Manchester* |
| DR. P. A. EGELSTAFF .. .. .. | *Atomic Energy Authority* |
| *SIR HARRY MELVILLE, K.C.B., F.R.S. | *Department of Scientific and Industrial Research* |
| *SIR KEITH MURRAY .. .. .. | *University Grants Committee* |
| DR. T. G. PICKAVANCE .. .. | *Rutherford High Energy Laboratory* |

*Secretary :* DR. J. M. VALENTINE

*A Member of the Governing Body of the Institute.
**A former Member of the Governing Body of the Institute.

## *APPENDIX VI*

## List of the Senior Staff

## September, 1962

### Rutherford High Energy Laboratory

| | |
|---|---|
| *Director* .. .. .. .. .. .. .. .. .. | DR. T. G. PICKAVANCE |
| *Assistant Director (Accelerator and Applied Physics)* .. | MR. L. B. MULLETT |
| *Chief Engineer* .. .. .. .. .. .. .. .. | MR. P. BOWLES |
| *Proton Linear Accelerator and High Energy Physics Research* .. .. .. .. .. .. .. | DR. G. H. STAFFORD |
| *Secretary* .. .. .. .. .. .. .. .. | DR. J. A. V. WILLIS |
| *Head of the Electrostatic Generator Group, and Head (designate) of Nimrod Operations Group* .. .. | DR. W. D. ALLEN |
| *Head of the Theoretical Studies Group* .. .. | MR. W. WALKINSHAW |
| *Head of the Nimrod Injector Group* .. .. .. | DR. L. C. W. HOBBIS |
| *Head of the Cyclotron Group* .. .. .. .. | MR. J. D. LAWSON |
| *Head of the Nimrod Engineering Group* .. .. .. | MR. J. C. LOUTH |
| *Head of the P.L.A. Engineering Group* .. .. .. | MR. J. B. MARSH |
| *Head of the Central Engineering Group* .. .. .. | MR. G. E. SIMMONDS |
| *Head of the Bubble Chamber and Radiation Protection Groups* .. .. .. .. .. .. .. | MR. M. SNOWDEN |
| *Assistant Secretary* .. .. .. .. .. .. | DR. J. M. VALENTINE |
| *Head of the Engineering Supply Group* .. .. .. | MR. G. N. VENN |
| *Head of the Nimrod Magnet and Beam Handling Group* | MR. J. J. WILKINS* |

#### Atlas Computer Laboratory

| | |
|---|---|
| *Head of the Laboratory* .. .. .. .. .. | DR. J. HOWLETT |

### Electron Laboratory

| | |
|---|---|
| *Director* .. .. .. .. .. .. .. .. .. | PROF. A. W. MERRISON |

*Since deceased