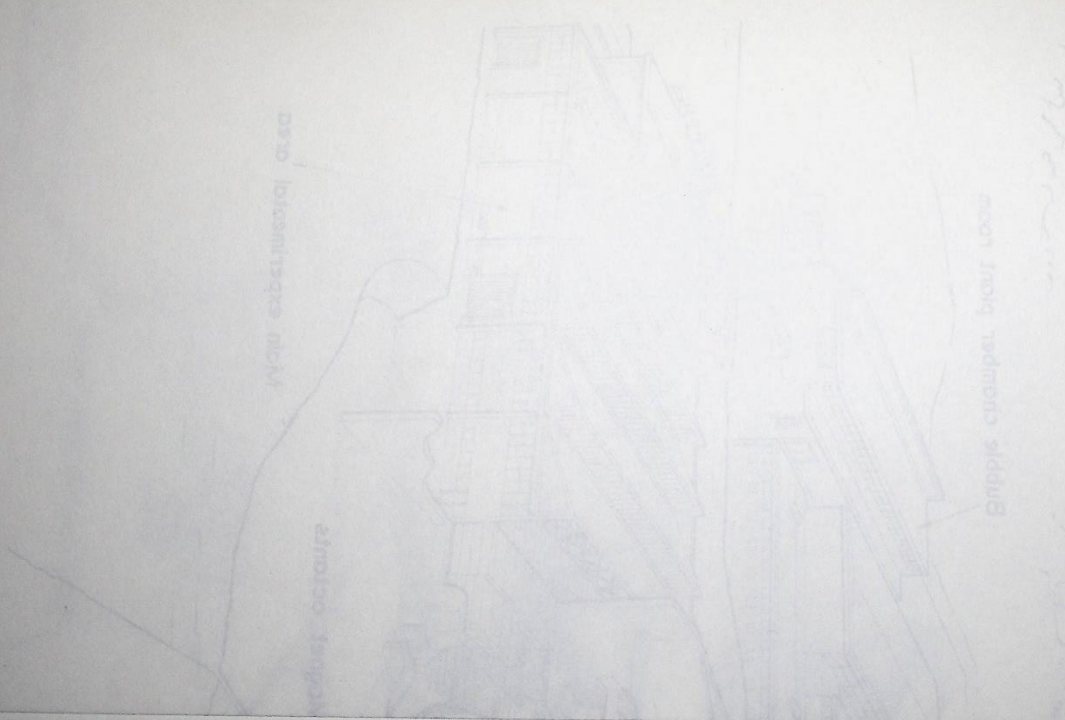
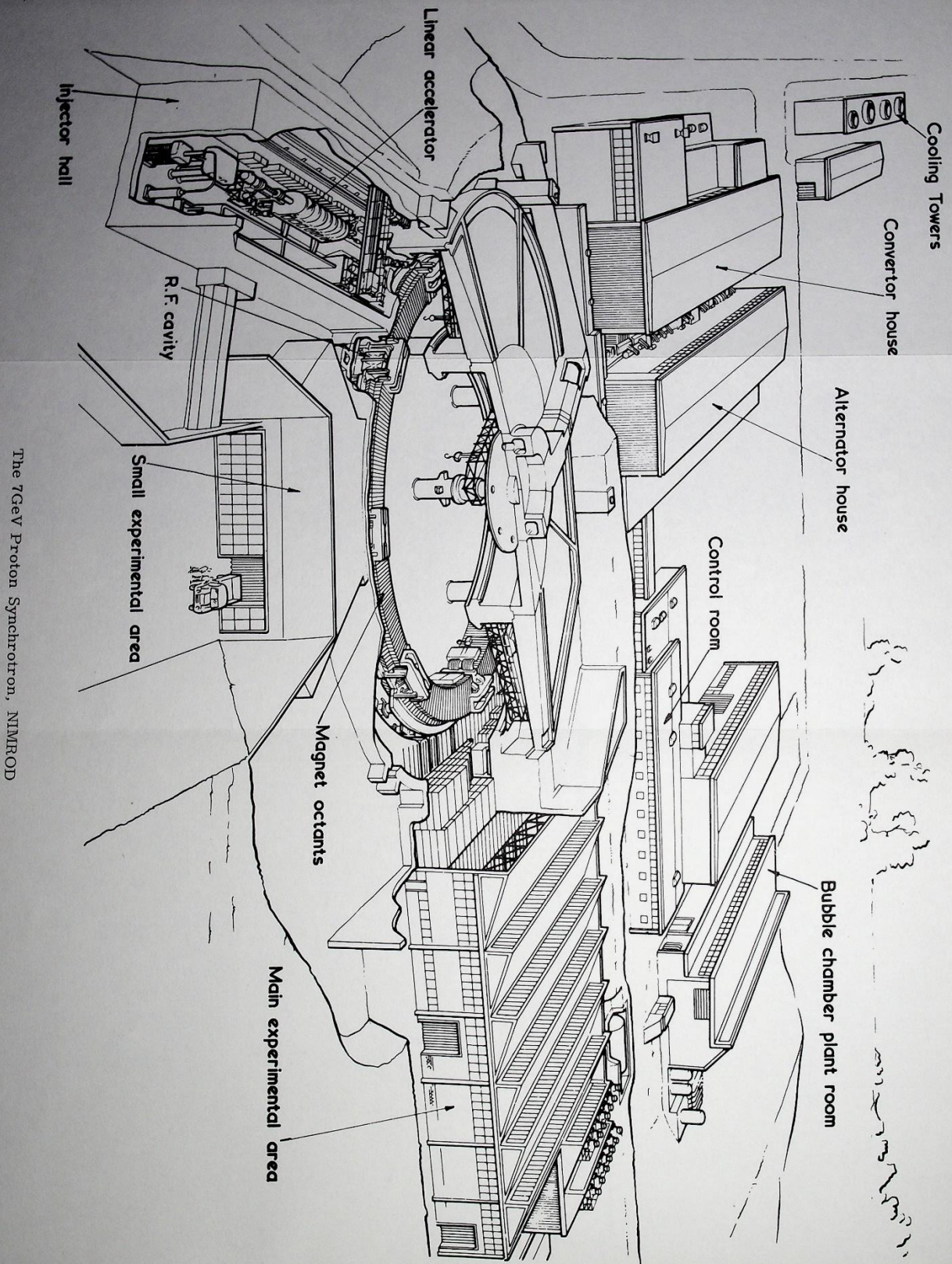


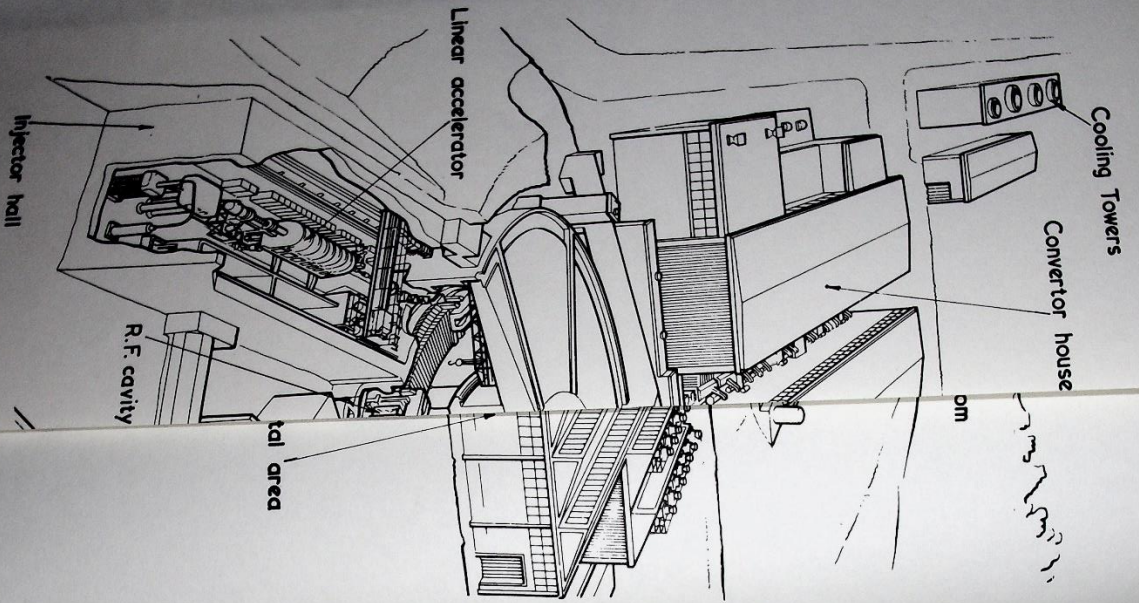
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The 7 GeV Proton Synchrotron, NIMROD

Australian National University
 Department of High Energy
 Physics, Canberra, A.C.T.
 1965



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NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

NIMROD

A 7 GeV Proton Synchrotron

(Part 1)

Edited by

B. G. Loach
B. Southworth

Rutherford High Energy Laboratory,
Chilton,
Didcot, Berkshire.
March 1965.

EDITORS' NOTE

This is the first part of a comprehensive report on the design, construction, commissioning and operation of Nimrod. The amount of information which is worth recording is too extensive to include in one document and also, to publish at least part of the report comparatively quickly, it was necessary for authors of individual sections to make contributions long before the commissioning of the machine was complete.

Work on the report was initially started with the object of producing a "progress report" covering all aspects of the work on Nimrod during the five years from the original decision to build the machine in 1957 up to the end of 1962. It soon became obvious that the report provided an opportunity (possibly the only opportunity) to record the work involved in designing and building the machine in some detail. Consequently it was decided to modify the original conception of a comparatively brief progress report to that of a much more comprehensive and detailed document which would allow the publication of all development, measurement and testing work of a sufficiently interesting or unusual nature, and allow a description of the methods used in overcoming any difficulties peculiar to the construction of Nimrod. (Previously published work, or work about to be published, is generally not recorded in detail but is covered by lists of references.)

This decision meant that the dividing line at the end of 1962 need no longer be strictly adhered to but, in order to complete the first part of the report, writing had to proceed to a conclusion as quickly as possible and the final document is still influenced by the earlier progress report scheme and does mainly describe work on the machine up to the end of 1962.

The second part of the report (to be published later) will cover all aspects of the work on each section of the machine which were not described in the first part; i.e., it will mainly be concerned with the period: January 1962 to October 1964 (including the achievement of the design intensity of 1012 protons per pulse in August 1964) and will describe the problems and achievements of the final commissioning of the machine, targeting, the external beam and the experimental area facilities.

B. G. Loach
B. Southworth

Rutherford High Energy Laboratory.
11th March, 1965

ACKNOWLEDGEMENT

It is impossible to acknowledge adequately all individual contributions in the case of a complex project such as Nimrod, which has occupied many years and involved many people at different stages of the work. However, lists of staff who collectively contributed to the various main sections of the project will be given in part 2 of this report. The following had major responsibility for the preparation of part 1 of the report:-

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The editors would like to thank all those concerned for their assistance and patience during the long drawn-out task of preparing this report.

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FOREWORD

The Nimrod project like all other accelerator projects, was never more than a means to an end. It was specified in 1956 in very simple terms, after much discussion by many physicists who craved for up-to-date facilities for high energy research, as a source of at least 1011 protons per second with at least 6.5 GeV kinetic energy. The sights were subsequently raised to 5 x 10¹¹ protons per second, at 7 GeV. Strictly speaking, therefore, the real story began only in February 1964, 6½ years after construction started, when the reliability and intensity of Nimrod justified its scheduled operation for research.

But for the many physicists, engineers, technicians and craftsmen who struggled during those years with the many problems discussed in this report, Nimrod necessarily seemed very much an end in itself. In all work of this kind, done against a ruthless timetable, it is difficult to find time or energy for recording properly the way in which the problems have been tackled. When the job is done, everyone is anxious to adapt himself to his real work of operating, developing, or exploiting the monster he has helped to create. It often happens, therefore, that only brief outlines of the highlights are put on record. This is a pity, because the future exploitation of such a valuable and complicated instrument as a high energy accelerator, eventually by people who played little or no part in its original design or construction, could be greatly aided by full and professionally prepared records. Similarly, there would be much in such records to help engineers and physicists working on similar problems in other projects - not only for high energy physics, because accelerators cover a wide range of engineering and technology.

For these reasons, I am sure that this report will be valuable to many people, and the Editors and contributors deserve our thanks for their hard work in preparing it. I hope that the report will also serve as a tribute to the hundreds of members of the Nimrod project teams who contributed so much during 6 years to the successful completion of a major enterprise.

T. G. Pickavance
Director, Rutherford Laboratory.

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(11) Polarity of 150 c/s I.P.R. voltage waveforms.
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(X) Interphase transformer waveforms with no premagnetisation.
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- Fig. 5.3.2(1111) Sequence of operation of primary protection.
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- 6.1(1) Simplified block diagram showing the principle of the planned r.f. accelerating system.
6.2.1(1) Relationship of r.f. frequency to magnet guide field.
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(11) Permissible frequency error during current rise.
(111) Frequency determining tank circuit of oscillator.
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Fig. 6.3.3(viii)

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- (xiv) Winding arrangement on the driver output transformer.
- (xv) Phase splitter/cathode follower driver circuit.
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- (iii) Block diagrams of the first phase detector circuits.
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- (vi) Waveforms transmitted through the phase lag network.
- (vii) Diode limiters on the semiconductor phase detector input.
- (viii) Mark I thermionic bias supply circuit.
- (ix) Arrangement of voltage feedback loop.
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- (xi) Auxiliary amplifier response.
- (xii) Plot of closed loop response against frequency.
- (xiii) Initial transient phase error.
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- (xv) Transistor voltage-current locus at turnoff.
- (xvi) Arrangement of control unit, power unit and load.
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- (xviii) Layout of high power r.f. equipment in the magnet room.

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Fig. 7.1.1(i)

- (ii) Piccioni system.
- (iii) Paths of protons, Nimrod extraction system.
- (iv) Fast kicker coil.
- (v) Basic fast kicker circuit.
- (vi) Plunging mechanism.
- (vii) Design of externally supported vessel.
- (viii) Isometric cross section of an octant.
- (ix) End pole piece assembly.
- (x) Vacuum vessel sealing arrangement.
- (xi) Pole face windings.
- (xii) Inner vessel crowning and header supports.
- (xiii) Closure plate tie rods.
- (xiv) Outer vessel splices.
- (xv) Curving a section of an outer vessel on a die bed.
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- (xvii) Cross section of vessel and flanges showing "gn" stage blocks and "wet packs".
- (xviii) View of a vessel side.
- (xix) Dorsal splicing in progress.
- (xx) Diagram of the side moulding bed.
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- (xxii) View of a transporter carrying a vessel.
- (xxiii) Vessel test rig.
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- (xxv) Typical section through test seal on front flange.
- (xxvi) Top lifting arrangement for outer vacuum vessel.
- (xxvii) View inside an outer vessel. (The wooden jigs are for packing purposes only).
- (xxviii) Inner vessel assembly rig.
- (xxix) Leak detection sensitivity.
- (xxx) An area of vessel shrouded for test.
- (xxxi) "Top hat" for local testing of a repaired area.
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- (xxxiii) An installed header vessel (octant 6).
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Fig. 8.6.4(111)

- (11) Pump down of octant 2.
- (11) An area of a vessel showing resin starvation.
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- (111) A cut out repair area showing the half inch steps.
- (111) Typical repair profile.
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- (111) Accidental damage to an outer vessel.
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- (11) Stability of PVC nitrile under irradiation.
- (11) 24 in oil diffusion pumping unit.
- (11) Pump header and gate valve suspension.
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- (11) Layout of roughing system.
- (11) Thermistor vacuum switch.
- (11) Mechanical safety device.
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- (11) Shut off valve housing and body sealing plate.
- (11) Schematic layout of a typical beam line vacuum system.
- (11) 8 in fast shut off valve.
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- (11) Machining of the linac vacuum vessel.
- (11) O-ring corner joint of the linac vacuum vessel.
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- (11) View of part of the liquid air system.
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Fig. 9.2.2(1)

9.2.3(1)

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- (11) Vacuum system mimic diagram and control panels (in main control room).
- (11) Block diagram of a straight section interlock and roughing system.
- (11) Temperature monitoring equipment for the injector.
- (11) Thermistors mounted on pole face winding connections.
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- (11) Temperature monitoring control panel (in main control room).
- (11) Seven-way water flow monitor.
- (11) Layout of main control room.
- (11) General view of main control room during installation.
- (11) Control racks installed in the main control room.
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- (11) Diagrammatic arrangement of water cooling system.
- (11) Schematic diagram of Kennicott water treatment plant.
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- (11) Chilled demineralised water systems; circuit No.1.
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- (11) R.F. chilling equipment.
- (11) 10.4.2(1)
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- (11) 10.8.1(1)
- (11) 10.9(1)

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