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Account of the
Establishment

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MINISTRY OF SUPPLY

EXPLOSIVES RESEARCH & DEVELOPMENT ESTABLISHMENT WALTHAM ABBEY

A Brief Account of the Establishment

Waltham Abbey
Essex.

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MINISTRY OF SUPPLY

EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT, WALTHAM ABBEY

A Brief Account of the Establishment

Approved: L.T.D. Williams
L.T.D. WILLIAMS
~~Director~~
1st July, 1957.

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MINISTRY OF SUPPLY

EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT

WALTHAM ABBEY

INTRODUCTION

The Explosives Research and Development Establishment occupies a site on which explosives have been manufactured for four centuries.

In view of the historical associations of this place with the manufacture of gunpowder it might not be out of place, in a brochure of this kind, to trace the history of cannon and gunpowder in mediaeval times, and lead up to the present date.

The earliest known record concerning gunpowder, "ignis volans", is the Marcus Graecus manuscript, which dates not later than the first quarter of the 13th century, perhaps somewhat earlier, and its writer clearly contemplated the employment of a detonating mixture, described therein, as a military agent. It is practically certain that Albertus Magnus, the Spanish monk Ferrarius, Roger Bacon, and the surgeon John Anderne, all drew their knowledge of gunpowder directly or indirectly from this source.

According to Brackenbury (Proc. Royal Artillery Institute, 4 1865)the earliest authentic document proving the existence of cannon bears the date, 11th February, 1326, and gives authority to manufacture cannon for the defence of Florence. In 1338, we find in a French document, the statement that similar weapons existed in the Arsenal at Rouen, along with ingredients for gunpowder.

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These cannon were small, and probably similar in shape to the "dart throwing vases", described by Walter de Millemete in a Latin M.S. belonging to Christ Church, Oxford, dedicated to Edward III, and dated 1326.

Brackenbury finds no corroborative evidence for the statements, made by other historians, that cannon were first used by English soldiers on land during Edward III's northern expedition against the Scots in 1327. John Barbour, Archdeacon of Aberdeen, describing the scene in a poem dated 1375, writes of "crakys of war" which is interpreted to mean cannon, but since he was born between 1320 and 1326, this is almost certainly hearsay, and is unauthenticated. There is conclusive evidence however, that Edward III's ships carried cannon and gunpowder when they set sail, in July 1346, on their expedition to France, and it is of interest to examine the evidence for the claim that, only a few weeks later, cannon were used by English soldiers in the field, for the first time, at the Battle of Crecy.

In the Issue Rolls of the Exchequer, 1345 - 47, reference is made to the purchase of ingredients for gunpowder, and to "ribalds", which appear to have been similar to the "ribaudequins" used on the Continent, and consisted of groups of barrels of small calibre, made of wood and bound in iron, which travelled on a small carriage. One hundred of these equipments were ordered by the King, on 1st October, 1345, to be made in the Tower of London, together with provision of ingredients for gunpowder, and quarrels, or shafted bolts, for ammunition.

Four independent writers state that cannon were used by the English at the Battle of Crecy, two of them at least being contemporary, namely, Villani (Muratori Scriptores, XIII, 946-8) and the anonymous author of Istorie Pistolesi (Ibid, XI, 516). Their testimonies are confirmed by the Grandes Chroniques de France, V, 460, and to this must be added the evidence of Froissart, (Chroniques, iii, 416). The effect of these "gonnes" was to throw

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the Genoese archers into confusion, but whether this had a decisive effect on the battle, considering that only three were employed, is open to conjecture. As a field trial, however, it seems to have been successful, for, on 1st September, before the army laid seige to Calais, the King ordered all guns and engines then in the Tower to be shipped to that port, among them some larger guns, which fired "great pellets of lead". From then onwards, the development of guns of larger calibre, made of iron and bronze, and firing stone, iron, and lead shot, and the advent of hand guns and muskets, is amply documented.

In the earliest days of its use, gunpowder seems to have been mixed from its ingredients in the field, but in the Exchequer accounts dated 1353 - 1360, there is a statement of the purchase of a copper mortar with iron pestle for mixing gunpowder in the Tower. Thereafter it is accounted for in barrels. Throughout the fourteenth and fifteenth centuries it was made in the Tower, and in several small manufactories situated in or near London, the saltpetre for it being leached from weathered piles of animal refuse.

The earliest record of the Gunpowder Mills at Waltham Abbey is dated 1560, but is probable that they were established many years previously. Power was originally supplied by horses, but the potentialities of the River Lea, which flows through the grounds, were early realised, and a gradual conversion to water power took place, until, by 1814, it had entirely replaced horse power. Steam power was to some extent introduced in 1870, but water power remained the chief source until manufacture of gunpowder ceased here in 1941.

Prior to the Dissolution of the Monasteries, the lands were owned by the Abbots of Waltham Abbey, and afterwards presented by Henry VIII to his Chamberlain, Sir Anthony Denny. They remained

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in private ownership until 1787, when the factory was acquired by the Board of Ordnance, and became the Royal Gunpowder Factory. Its area was enlarged in 1795 by the purchase of surrounding lands, and between 1805 and 1853 water rights over the whole length of the River Lea, from King's Weir in Nazeing to Black Ditch, just South of the factory, were purchased, thus ensuring conservation of water power.

Some years after the introduction of guncotton in Germany, plant was laid down for its manufacture at Waltham, coming into production in 1872. This was followed by so called "brown powder", and soon afterwards by cordite, made by a process devised by Sir Frederick Abel. As demand for these commodities grew, it became necessary to enlarge the factory still further, and in 1885 the Quinton Site or South Site was bought, whereon were set up new plants for the manufacture of nitroglycerine, acids, guncotton and cordite, all in production by 1890. In 1909, besides making gunpowder, the factory was turning out fine grain powder for fuzes and primers, picric acid, nitric acid, guncotton, cordite, and refined sulphur and saltpetre. Plant scale production of tetryl began in 1912; of picrite in 1928; of T.N.T. in 1933, and of R.D.X. in 1938. During the Second World War, 6000 people were employed in the factory, on a shift rota.

In 1945, as part of the reorganisation of the Defence Departments, the factory was closed down, but was immediately taken over by the Armament Research Department with a view to setting up a new Department to pursue research on explosives, propellants, and intermediates from fundamental aspects to full scale production. Thus, on October 1st 1945, the Chemical Research and Development Department came into being, the nucleus of scientific staff being transferred from the explosives, propellant, and analytical branches of the old A.R.D. at Woolwich. The title was changed to its present one in 1947.

Conversion of an old factory site to meet the needs of a modern research station presented an immense task. No priority for materials and labour could be had, but fortunately the factory had maintained a Building Works Department, and a few labourers and

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skilled craftsmen were still available and were re-employed. The only laboratories on the site were equipped for nothing more than process control. The only roads led no further than the boiler houses, all internal traffic up to then having been carried on the waterways or on narrow gauge railways. Until laboratories were provided, most of the staff remained at Woolwich, and a small unit was located at Volkenrode in Germany, gathering information on liquid propellants for rockets. Housing was extremely difficult to find, and for many months staff had to travel daily from the Woolwich and London Areas, some assistance being provided by official transport.

Gradually, rehabilitation proceeded. The broad policy was to select the best buildings for conversion, and locate Research work on the North Site and Development on the South Site. Late in 1946 the first laboratory range was completed and taken over by the liquid fuels section, and a proof stand was in course of erection. During 1947 - 48, the latter was completed; a miniature rocket motor testing unit with ancillary equipment and workshop were installed, and work was well advanced on organic, sensitiveness, ballistics, and applied research laboratories. An outside firm had begun to strip all the old machinery from the cordite, guncotton, and acid installations, and a small plant for production of fine picrite was in operation. As part of the development of the South Site, a road had been built from the gate to the south west corner, where the Inter Services Research Group had been located.

1949 saw the completion of most of these projects, and the modernisation of the main laboratory. The boiler houses were re-equipped and the steam, power, and water services overhauled. Planning was started on the new plastic propellants development project. As laboratories were taken over, staff and work were brought over from Woolwich, and a small library started, although the information section still remained at Woolwich. A small hostel was built and occupied late in that year.

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In 1950, the Ministry of Works began work on the plastic propellant installations. Rheological laboratories were equipped and occupied on the North Site, and an annexe to the sensitiveness laboratories opened for work on initiators.

Engineering services were reorganised in 1951, and a new machine shop completed. The cast double-base propellant project was begun, and a road laid along the North Site eastern boundary. Work had also begun on an estate of 100 houses for staff, just east of the town.

1952 saw the completion of the plastic propellant project, work begun on the cast-double base project, and occupation of the housing estate. Planning was started on a laboratory for the Materials Group, and on the cordite development area. Pilot plants for picrite were in operation on South Site, together with laboratories for the Chemical Engineering Branch.

Since then all the Woolwich installations, with the exception of the initiator manufacturing unit, have been brought over, and at this date the Cordite development area is coming into operation. Road networks give access to all parts of the site; waterways and drainage systems have been replanned, and housing provided for police; a new surgery with modern equipment, and a new fire station have been built on South Site, and additional laboratories provided for D.M.X.R.D. Materials Groups.

/ORGANISATION ....

ORGANISATION AND FUNCTIONS

EXECUTIVE STAFF

DIRECTOR - Mr. L.T.D. Williams
DEPUTY DIRECTOR - Dr. A. Lovecy

Superintendent of Propellant Research I (S.P.R. I)
Dr. G.H.S. Young

Superintendent of Propellant Research II (S.P.R. II)
Mr. G.K. Adams

Superintendent of Propellant Research III (S.P.R. III)
Dr. W.G. Williams

Superintendent of Explosives and Intermediates Research (S.E.I.)
Dr. A. Lovecy

Superintendent of Chemical Engineering R. & D. (S.C.E.)
Mr. R.G. Ross

Superintendent of Analytical Services (S.A.S.)
Dr. L.J. Bellamy

Chief Administrative Officer (C.A.O.)
Mr.S.F.M. Whiteside

/FIELDS ....

FIELDS OF WORK COVERED BY E.R.D.E. BRANCHES

Propellant Research I

The branch is concerned with research and development of composite propellants of all types. The main effort is on plastic propellant, and a pilot production plant with an output of about 2 tons/week is operated on the South Site. On the North Site, laboratory small-scale facilities are also available for long term research, and a special study is made of rheology. On this site small-scale evaluation of polyurethane propellants is now being undertaken, and a limited amount of work on pressed propellants is carried out.

One section is responsible for development of mechanical tests for propellants of all types, and is giving particular attention to high-rate testing. An ultrasonic method for inspection of propellant charges has been developed and the applications of this method are being studied. A specially instrumented set of laboratory cordite rolls is available for study of the problems of roll fires and the rheology of new propellant formulations. Some photo-elastic examination of model charge shapes is carried out, and a small effort is devoted to the effects of irradiation on propellants of all types.

Senior Staff: Mr.P.R.Freeman
Dr.B.H.Newman
Dr.J.H.C.Vernon

/Propellant ....

Propellant Research II

The Branch is responsible for the development of propellant and explosive assessment methods, and the provision of assessment services for the other branches of E.R.D.E. These services include; (a) ballistic assessment on propellants such as small scale rocket firings, strand burning rate determinations, vented and closed vessel methods, calorimetric determinations, and hot and cold storage facilities; (b) evaluation of impact, shock, friction and electrostatic sensitiveness of liquid and solid propellants, explosives and initiators.

These services are complemented by research activities on the mechanism of combustion and the initiation of explosion. Current activities include the study of reactions occurring in the decomposition and combustion of nitric esters and solid propellants, theoretical studies on the relationship between burning velocity and reaction rates, investigations into the mechanism of initiation of solid explosives by shock and fragment attack, impact sensitiveness of H.M.X. polymorphs, and the initiation of liquids by adiabatic compression of gas bubbles.

Senior Staff: Dr. J. Powling
Mr. E.G.G. Whitbread
Mr. P.D. Verschoyle

/Propellant Research III ....

Propellant Research III

This branch is responsible for the formulation of new colloidal propellants with the required ballistics and storage life and their subsequent development to the factory production stage. The new facilities just becoming available cover the manufacture, using full sized equipment, of single-base and double-base propellants, by solvent, solventless, and casting methods, for all weapons, including small arms, guns, mortars and rockets. Quantities up to about one ton may be manufactured in new sizes and shapes from new and established compositions, to assist weapon development by the design establishments. In addition, advice is given to the production factories on processing problems, and special experiments are conducted to resolve difficulties. Considerable assistance is given to the Inspection authorities on the preparation of specifications for propellant ingredients, and the setting up of acceptance standards. This branch is also responsible for the detailed technical control of the extra-mural contracts on C.D.B. propellant work.

At present, the major effort is being devoted to the development of improved platonised rocket compositions, and the factors governing their hot storage life. The characterisation and reproducibility of the lead compounds involved in these improved compositions has presented many difficulties. In view of the installation of a Ball Powder plant at R.O.F. Bishopton, effort has been devoted to obtaining background information on this method of powder processing.

/Explosives .....

Explosives and Intermediates

The making of the individual ingredients from which propellants and other explosive compositions are formulated involves both chemistry and chemical engineering, and this Branch is responsible for the chemistry concerned. Investigations are made to maintain or improve the supply of raw materials and intermediates used, one example being the selection of suitable woodpulps for paper from which nitrocellulose is produced. (This illustrates what is meant by the title "intermediates".)

Research into the chemistry of existing methods of manufacture, and into possible alternative ways of synthesising compounds already known to be useful, forms a substantial part of the work. This provides a fund of basic information on chemical efficiencies, reaction kinetics and mechanism, by-product formation, etc., for use in the related chemical engineering work, and in advisory service to the Royal Ordnance Factories on their development programmes, and on problems arising in current production. This knowledge also proves valuable in assessing the advantages and drawbacks of novel substances which attract attention from time to time.

In the special case of initiatory explosives, the Branch has a section which, in addition to research on the preparation and properties of these sensitive compounds, is responsible for developing processes of manufacture to the full scale for direct adoption by the Filling Factories. In this work, and in establishing the requisite characteristics of materials to suit the needs of filling and functioning, close collaboration is maintained with the appropriate branches of A.R.D.E.

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At the present time, a considerable effort is devoted to studies on the stability and stabilisation of High Test Peroxide; and a beginning has been made on research into the preparation of boron hydrides, in response to the interest C.A. has in their potential use as high energy fuels.

Senior Staff: Dr. E. Roberts
Dr. T.M. Walters
Mr. G.W.C. Taylor
Dr. L.H. Gerty

Chemical Engineering Research and Development

This Branch is concerned mainly with the development of new and improved manufacturing processes in the explosives and intermediate field, excluding solid propellants, and with the underlying chemical engineering research. It also undertakes experimental manufacture of miscellaneous materials as a service to other groups. It cooperates in its projects mainly with S.E.I. Group on the one hand, and with the development and design sections of the Royal Ordnance Factories (Explosives) on the other.

Recent activities have included the successful pilot plant development of two new steps in the manufacture of picrite from nitrolim: the "Direct (or Wet) Fusion" process and the "Low-Ratio Nitration" process, which resulted in their adoption (one or both) for full-scale installations at Bishopton, and Pryor, Oklahoma. Again, an HMX pilot plant was built, including a new process for recovery of the spent acetic acid; and these have

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been translated to manufacture at Bridgwater. A new continuous TNT process is in course of development, and a broad investigation is proceeding on crystallisation, with the immediate objective of finding how to control grist, acidity and pourability in RDX manufacture, and to overcome icing troubles.

Another important Section is doing basic research in the fields of high temperature gas heat transfer as in rocket motors; measurement of the thermal conductivities of oxygen, nitrogen, argon and other substances; and small mobile equipments for manufacturing liquid oxygen.

Senor Staff: Mr. H. Ziebland
Dr. A.W.H.Pryde
Mr.R.P.Ayerst

Analytical Services

This Branch has a number of distinct functions as follows:

1. It develops new analytical methods for all experimental compositions which subsequently form the basis for specification and factory control tests. It also provides an analytical service for the establishment as a whole and assists other branches in any specialised analytical applications which may arise in their research.

2. It advises on all aspects of stability and surveillance testing of propellants, Work in this field ranges from climatic trials to studies of possibilities of differential thermal analysis, thermogravimetry and the oxygen Taliani test.

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3. It is responsible for all questions of compatibility of materials with propellants, high explosives, and initiators, and carries out the considerable volume of testing and advisory work which this entails.

4. It develops new instrumental techniques which are likely to find applications in the explosives field. Development work is going on, for example, on gas chromatography, electron microscopy, infrared spectroscopy and X-ray crystallography. A certain amount of fundamental research is carried on in these last two fields.

Senior Staff: Mr. H.R. Broomhall
Mr. E. Brown
Dr. R.L. Williams.

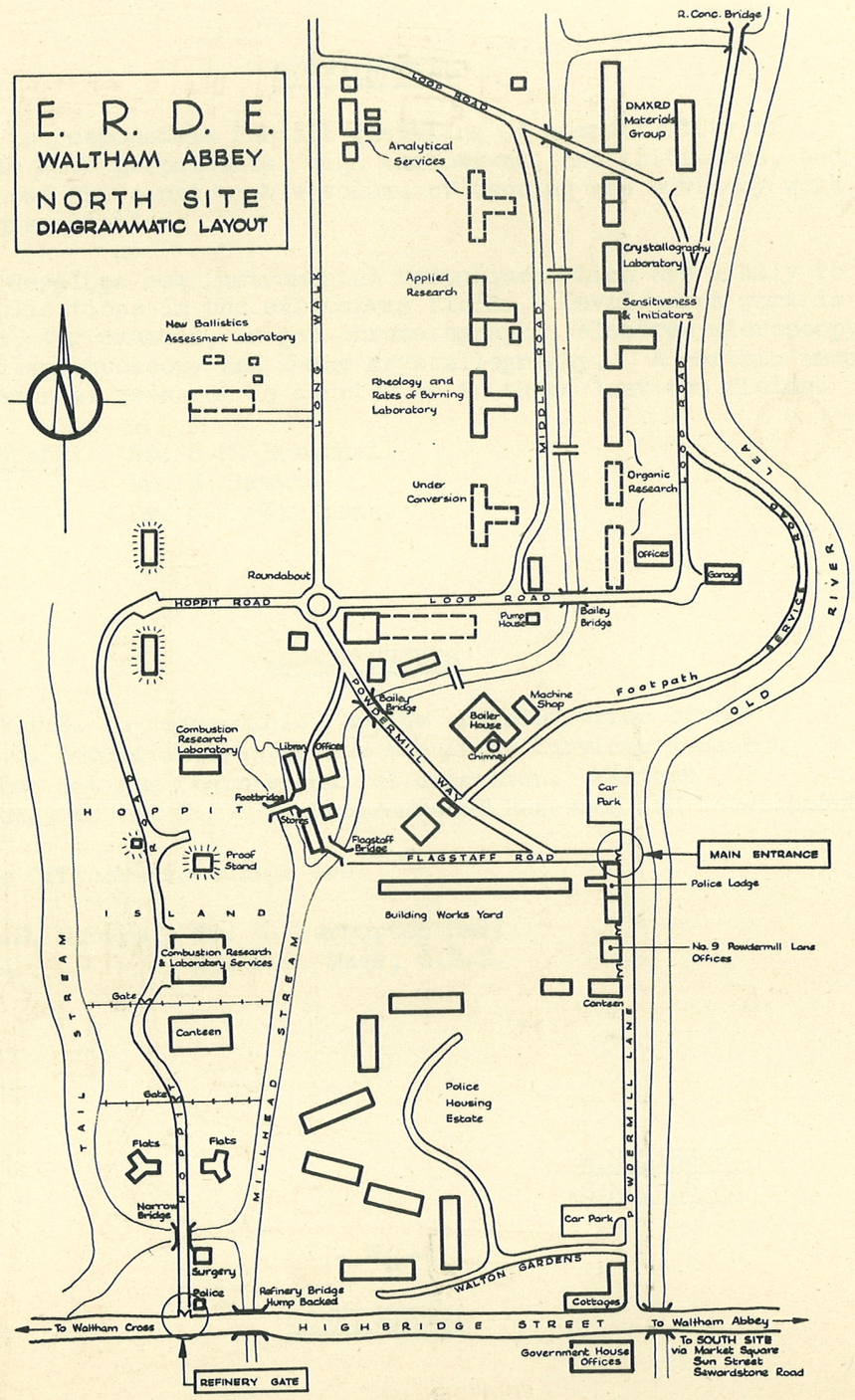
LODGER GROUPS

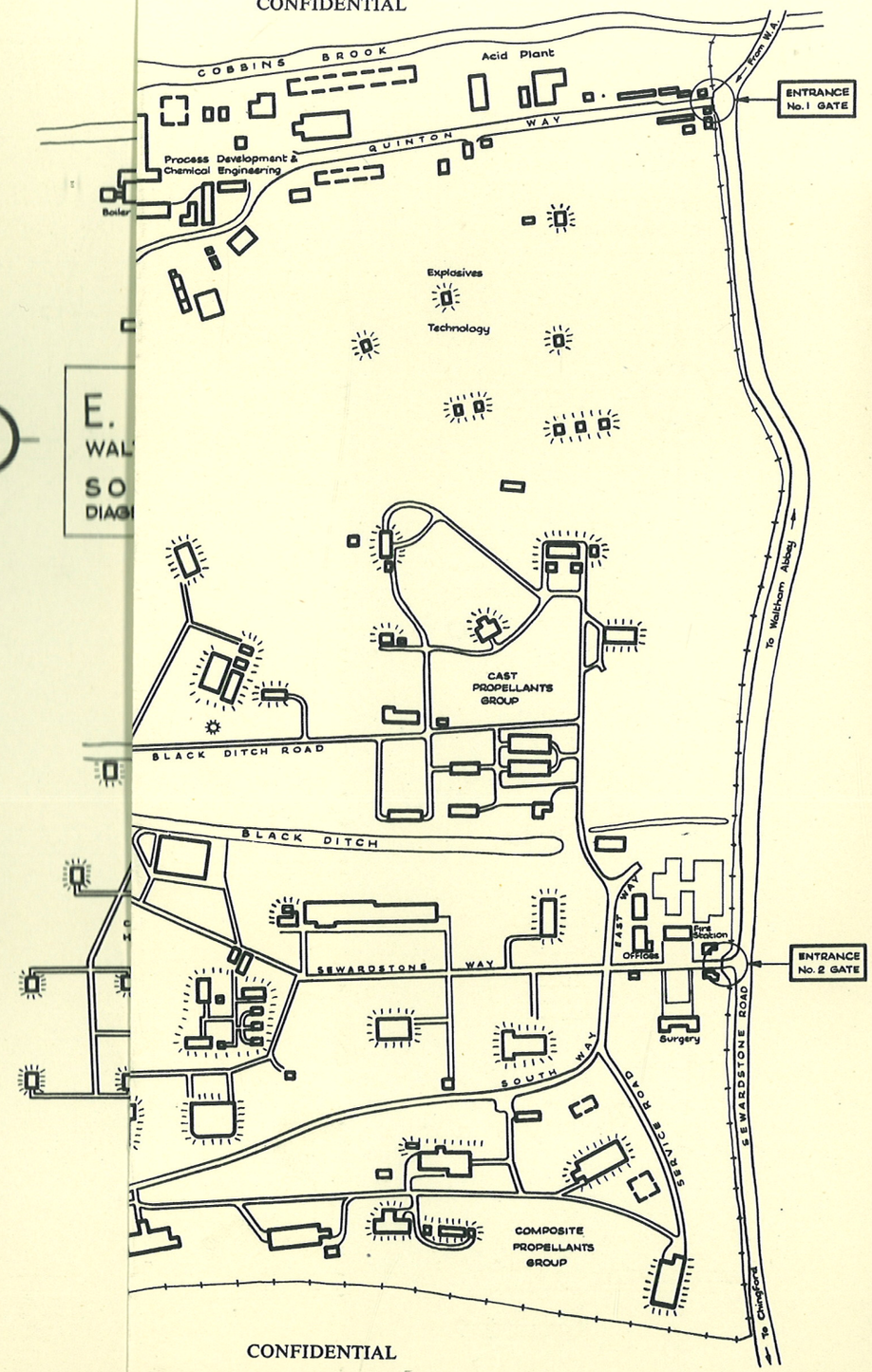
E.R.D.E. is responsible for the administration of the D.M.X.R.D. Materials Groups, and the Inter Services Research Group, but not for their technical direction. Neither contributes to the E.R.D.E. Programme of Research and Development.

The Officers in charge are:

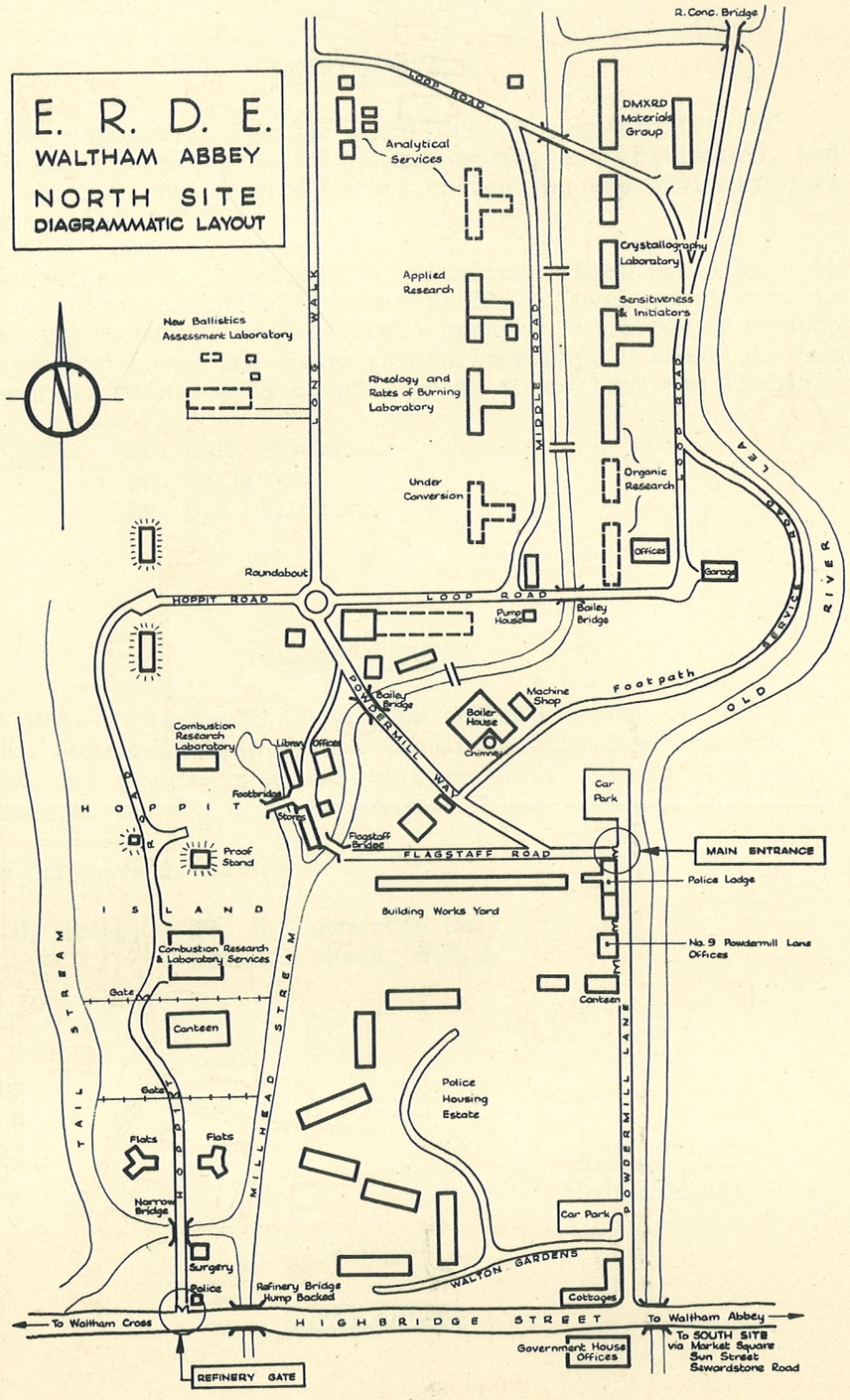
D.M.X.R.D. Groups - Mr. H. Warburton Hall
I.S.R.G. - Mr. C.A. Meek, O.B.E.

E. R. D. E.
WALTHAM ABBEY
NORTH SITE
DIAGRAMMATIC LAYOUT

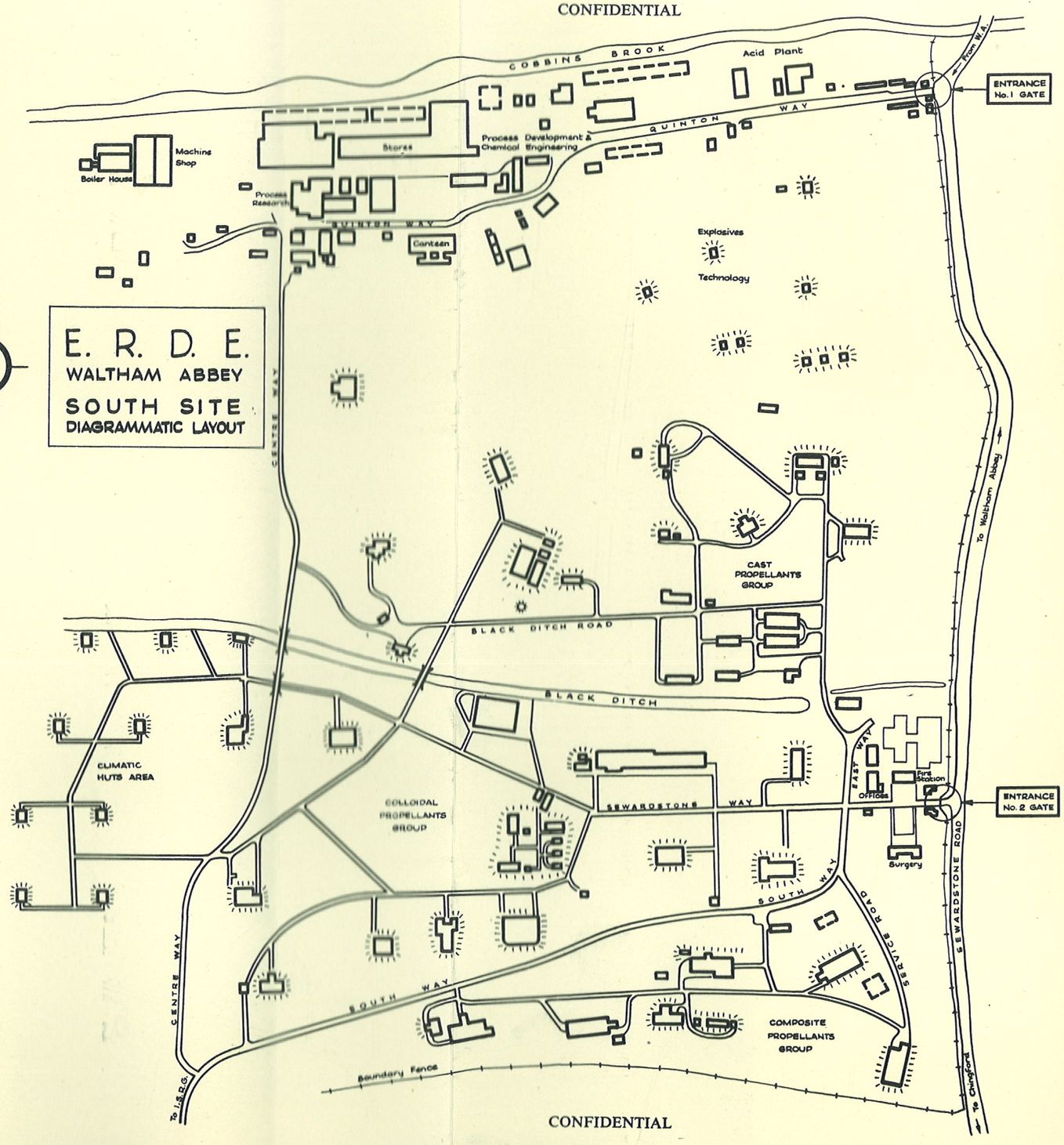


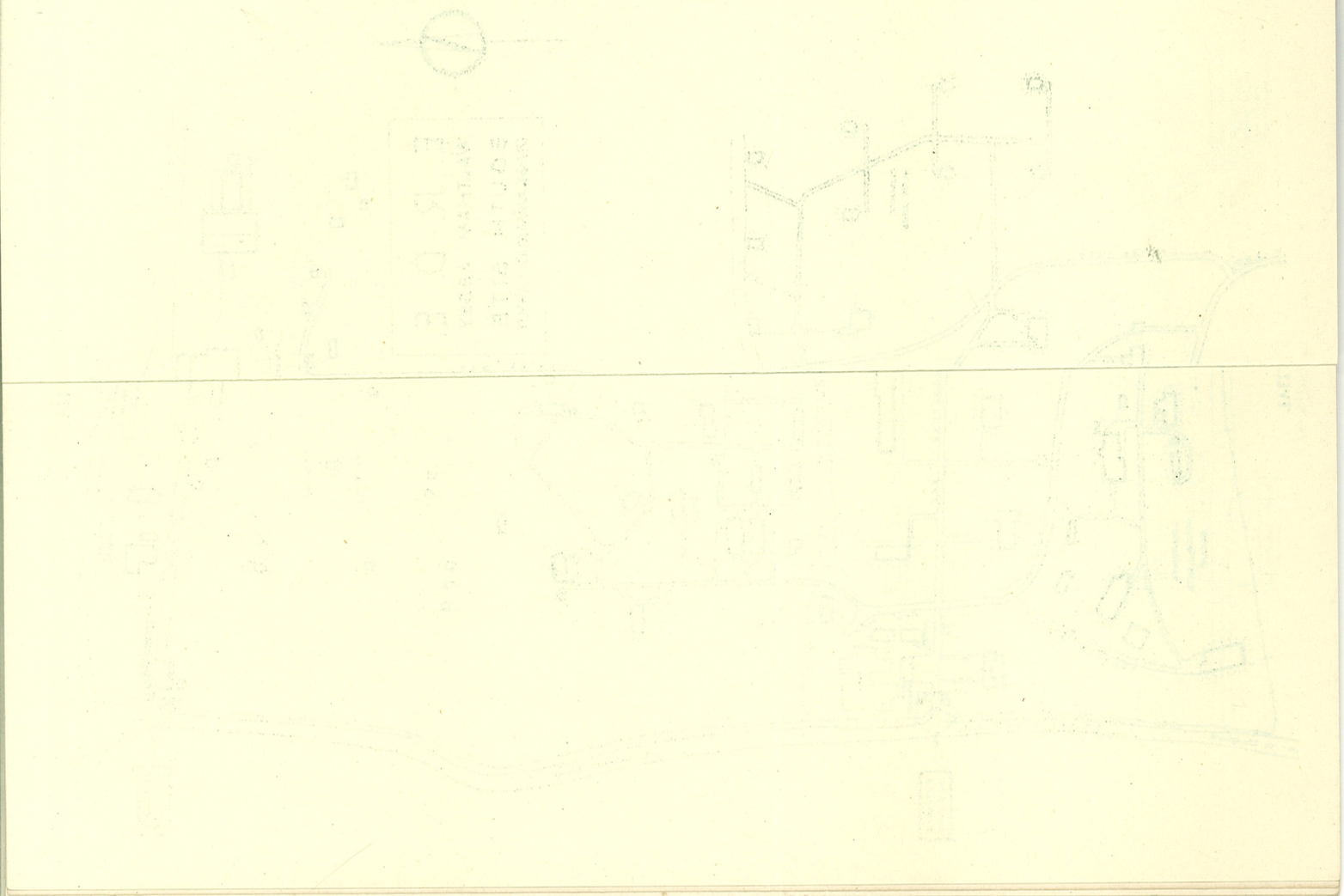


E. R. D. E.
WALTHAM ABBEY
NORTH SITE
DIAGRAMMATIC LAYOUT



E. R. D. E.
WALTHAM ABBEY
SOUTH SITE
DIAGRAMMATIC LAYOUT





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