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MINISTRY OF SUPPLY

DIRECTORATE OF MATERIALS & EXPLOSIVES
REASEARCH & DEVELOPMENT

EXPLOSIVES RESEARCH & DEVELOPMENT
ESTABLISHMENT WALTHAM ABBEY

Programme of Research and Development
1954-55

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MINISTRY OF SUPPLY

DIRECTORATE OF MATERIALS AND EXPLOSIVES RESEARCH AND DEVELOPMENT
EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT, WALTHAM ABBEY.

PROGRAMME OF RESEARCH AND DEVELOPMENT

1954 - 55

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INTRODUCTION

1. Format

The Programme of Research and Development for the current year, 1954/55, like that for 1953/54, has four main divisions, each covering the work of a Superintendent's Branch:-

1. Propellant Research I: 'Development' and processing of all types of solid rocket propellants; analysis and testing; materials.
2. Propellant Research II: physico-chemical research on many aspects of combustion; rheological research; sensitiveness of explosives.
3. Explosives and Intermediates: organic chemical research; laboratory investigation of new processes; initiators.
4. Chemical Engineering: pilot plant operation and applied research.

The somewhat stereotyped pattern of subject-titles and code numbers in the Programme is taken from the 'Progressing and Planning' scheme which it is bound to follow. Thus, the main fields of current activity are summarised under one or more of five 'P and P' headings; namely, Dated Projects (a Project being a specified Service demand), Undated Projects, Post-Design Services (i.e. modifications and improvements in existing Service stores), Basic and Applied Research and Development, and Design and Development of Testing or Laboratory Equipment. Wherever possible, work of the types indicated by the last two headings is included under one of the other three against the appropriate Projects.

All items in this Programme will be worked upon continuously or intermittently during the year April 1954 to March 1955. A cross reference (marked +) is given where a particular item and code number is shared between two or more Branches. Inactive items are shown separately on the lists of deferred subjects. Items completed during 1953/54 are tabulated at the end of each Superintendent's programme, together with those deferred or abandoned.

2. Priorities

Inevitably, a very large proportion of the items on E.R.D.E.'s Programme is of the undated kind. Relatively few can be linked exclusively, or without some ambiguity, to specific Service Projects. Various reasons for this state of affairs were illustrated and discussed at some length in the Introduction to the 1953/54 Programme, so they will not be repeated here. Many R. & D. items, though not endowed with a Service priority-rating, stem from the declared policies of Controller of Munitions or P.D.S.R.(D), or of Committees such as E.D.P.C. whose Chairman is C.M. An asterisk (*) in the second Priority column indicates that the item so marked is regarded by D.M.X.R.D. and C.S./E.R.D.E. as being of particular importance, though carrying no Service or Ministry priority rating, and due to receive the maximum amount of attention within the Establishment's resources.

3. Trends

Development and research during the past year in the propellant Branches S.P.R.I. and S.P.R.II. have revealed many subtle aspects of 'plateau' and 'mesa' phenomena underlying the pressure-independence and temperature-independence of rate-of-burning of the new rocket cordites. In this connection the incorporation of lead compounds in cordite raises many problems, as yet not completely solved, bearing upon the control of manufacture and the reproducibility and

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RESEARCH PROGRAMME, 1954 - 55.

Reference should be made to the Introduction, p.1.

PROPELLANTS:

Dated Work for

Services.

Platoon A/T Rocket

E4F

Development of M.7.
propellant.

E4F1

Cutting techniques.
Development of stick propellant (Trefoil).

E4F1A

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Propellants Research I (Contd.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>UNGUIDED ROCKET</u> <u>PROPELLANTS:</u> <u>Dated Work for</u> <u>Services (cont.)</u>	E.4 (Cont.)	High Performance Aircraft Rocket Battery (2-inch)	E4J	Motor, plastic propellant.	E4J1	Development of charge (battery firing).	E4J1A	1	
				Motor, cordite	E4J2	Development of fast-burning mesa composition (battery). Climatic trials.	E4J2A E4J2B		*
		ABC Rocket (2-inch Aircraft)	E4K	Motor, various propellants.	E4K1	Cordite. Plastic.	E4K1A E4K1B	1 1	* *
<u>UNGUIDED ROCKET</u> <u>PROPELLANTS:</u> <u>Undated Work for</u> <u>Services.</u>	E.5	Rocket, Signal, Distress, No. 1, Mk.I.	E5G	Motor, propellant, to match Oerlikon.	E5G1	Development of propellant and charge.	E5G1A	2	
<u>UNGUIDED ROCKET</u> <u>PROPELLANTS:</u> <u>Post-Design Work</u> <u>for Services.</u>	E.6	Cordites.	E6A	Climatic and climatic ballistic trials.	E6A2	Climatic ballistic trial of motor, rocket, 3-inch, No.13 Mk.1/1. Compositions based on sulphite pulps (climatic trials).	E6A2A E6A2B		
		Aircraft Rockets (Cordite Charges)	E6B	Serviceability of inhibition.	E6B1	Improvement of inhibition and method of application.	E6B1A		*

Chemical analysis.

E13B9

Methods for D.C.I. and
D.O.F. (x).

E13B9A

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	Colloidal Propellants (Cordites).	E13C	Compositions with improved mechanical properties. Extension of temperature range.	E13C3	Toughness. Resistance to cracking. With reference to large webs.	E13C3D		
				Manufacturing techniques.	E13C4	Back-pressure and long- parallel die techniques of extrusion.	E13C4B		*
						Segmented charges.	E13C4C		*
						High-frequency heating before pressing.	E13C4G		
						Automatic rolling of solventless sheet.	E13C4H		*
						Reduction in extrusion pressure.	E13C4J		
						Treatment of 'rework'.	E13C4K		
						Factors affecting fires on rolls.	E13C4L		*
						Improvement in extrusion accuracy.	E13C4M		*
				Rate of burning.	E13C6	Compositions containing + platonisers.	E13C6B		*
						Effect of the nature of + nitrocellulose on platonisation.	E13C6E		
						Effect of plasticisers on platonisation.	E13C6F		
						Slow-burning compositions containing cellulose acetate	E13C6G		*
						Water-insoluble plasticisers for cellulose acetate.	E13C6H		
						Alternatives to cellulose acetate.	E13C6J		
						Effect of nitric ester variants.	E13C6K		

+ shared work - p. 28

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Propellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
G.W. ROCKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development (Cont.)	E.13 (Cont.)	Colloidal Propellants (Cast Double-Base) (Cont.)	E13D (Cont.)	Safety.	E13D7	Electrostatic hazards.	E13D7C		
				Chemical analysis.	E13D9	Casting powder. Finished propellant. Casting liquid.	E13D9A E13D9B E13D9D		
				Control of burning rate and/or plateau range.	E13D11	Effect of plasticiser. Effect of platoniser. Effect of other ingredients.	E13D11A E13D11B E13D11C		
				Processing of chopped extruded powder.	E13D14	Effect of ingredients. Effect of techniques.	E13D14A E13D14B		
				Alternative casting base.	E13D15	Other methods of making base grain.	E13D15B		
				Casting liquid.	E13D16	Methods of preparation, mixing, and control. Stability, sensitiveness.	E13D16A E13D16C		
				Restrictive containers.	E13D17	Methods of manufacture from film. Use of extruded tubes. Centrifugal casting. Reinforced plastics.	E13D17A E13D17B E13D17C E13D17D		
				Manufacture of new charge designs.	E13D18	Sustainer A (tubular slotted) Sustainer B (double end burner). Duplex. Simplex. Dual cone.	E13D18A E13D18B E13D18C E13D18D E13D18E		* * *

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SECRETPropellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
G.W. ROCKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development (Cont.)	E.13 (Cont.)	Inhibitors (Cont.)	E13H (Cont.)	General requirements. (Cont.)	E13H1 (Cont.)	Physical properties of inhibitors. Adhesion to propellant. N.G. and plasticiser migration.	E13H1D E13H1E E13H1F		*
				Materials and techniques.	E13H2	Elastic materials (rubber etc.) Potting techniques (polyester resins). Screw extrusion coating. Polystyrene. Specifications (as required).	E13H2A E13H2B E13H2D E13H2G E13H2H		
				Service to other Establishments.	E13H3	Effect of changes of manu- facturing techniques on properties of convolute wound containers.	E13H3D		
				E.M.R. - British Celanese - Develop- ment of new cellu- losic derivatives and formulations.	E13H5	Preparation and character- istics of cellulose acetates of varying acetyl content. Effect of plasticisers on physical properties. Effect of surface treatment (e.g. saponification, cross- linking).	E13H5A E13H5B E13H5C		
		Spin-Stabilised Rocket.	E13J	Development of charge.	E13J1	Cordite. Cast double-base. Plastic propellant.	E13J1A E13J1B E13J1C		

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Propellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>ORDNANCE & S.A.</u> <u>PROPELLANTS:</u> <u>Post-Design Work</u> <u>for Services.</u>	E.16	Cordites.	E16B	Climatic and climatic-ballistic trials.	E16B1	Suitability of selected sulphite pulps for Service nitrocellulose.	E16B1A	1	
<u>ORDNANCE & S.A.</u> <u>PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.17	General.	E17A	Manufacturing methods.	E17A3	Manufacture of small ballistic sizes from large horizontal presses. Moderation of double-base propellants for use in small arms.	E17A3A E17A3B		
				Ballistic behaviour.	E17A6	Effect of processing factors. (Irregularity of A.C.Ws. of Cordite N.).	E17A6A		
				Flash and smoke.	E17A8	Improved non-blinding propellants for Naval Guns.	E17A8B		
				Stability, climatic and climatic-ballistic trials.	E17A9	Imperfectly sealed S.L. cartridges. Compositions containing substitutes for nitroglycerine. Picrite propellants containing oxamide, D.B.P. or D.E.G.N.	E17A9A E17A9B E17A9C		

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Propellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>MATERIALS AND</u> <u>AMMUNITION SEALING</u> <u>& PROTECTION:</u> <u>Other Research and</u> <u>Development.</u>	E.29	Sealing.	E29A	New compositions.	E29A1	Luting serviceable over "Universal" temperature range. Improvements to existing self-setting cements. Improved fenestrating varnishes. Miscellaneous problems. Evaluation of synthetic rubber cements. Improved semi-solvent cements. Lutings with improved low-temperature properties.	E29A1A E29A1B E29A1C E29A1F E29A1G E29A1H E29A1K		*
				Cocooning and sheathing.	E29A2	Wax dipping of fuzes.	E29A2B		
		Materials.	E29B	Protective for surfaces of explosive stores.	E29B1	Varnishes and paints for special purposes e.g.R.D.1177 type. Internal lacquering of cartridge cases. Hot-melt compositions for H.E. stores.	E29B1A E29B1B E29B1D		*
				Cartridge-bag materials.	E29B2	Alginate fabrics. Terylene fabrics.	E29B2B E29B2C		
				Plastics.	E29B3	Specifications and miscellaneous applications. R.D. Cements on rubbers.	E29B3A E29B3B		

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Propellants Research I (Cont.)

Items Completed in 1953/54.

E6A2A	Climatic ballistic trial of motor, rocket, 3-inch, No. 13 Mk.1/1.
E13B8D	Control of grist of ingredients.
E13C7C	Compositions containing mechanically nitrated cellulose.
E13C7E	Charges inhibited with PQ (including Swallow).
E13C8C	Compatibility with rocket cordites of R.D. cements and lutings containing substitute ingredients.
E13C8E	Potassium perchlorate with metals.
E13H2A	Application of elastic materials i.e. rubber etc.
E13H2C	Wrapping crepe materials.
E13H3C	Use of British cellulose acetate in place of American flake (30 foil trial).
E13H4A	Improvement of cellulose acetate formulations.
E13H4B	Improvements of ethyl cellulose formulations.
E14A18A	3.3-inch gun for coastal craft - Development of propellant and charge (with C.S.A.R.).
E14B4A	Improved flashless charges.
E14B5A	Flashless charges.
E17A5A	Gunpowder. More regular burning properties. Analytical work.
E17A10C	R.D. Cements and lutings containing substitute ingredients.
E25C1A	Silver azide.
E25C1D	Compositions R.D. 1650, S9, St.3.
E25C1E	Barium styphnate.
E25C2B	Fuze 254, unplated and timplated.
E25D1B	Silver azide.
E25D2A	Lead azide with substitutes for Composition A.
E25D2B	Lead azide with R.D. 1650.
E28A6A	Waterproofing of safety cap end.

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SECRETPropellants Research I (Cont.)Items Deleted or Deferred.

E4A3A E4H1A	Climatic trials of 2-inch rocket propellant. Development of charge.	Deleted - requirement cancelled. Deleted - requirement cannot be met.
E5C1A E5D1A	Development of charge. Development of platonised medium-slow composition.	Deleted - requirement cancelled. Deleted - requirement cancelled.
E13C3E	Fast-burning mesa compositions of improved characteristics in substitution for F.478/148K.	Deleted - covered by other items.
E13H1A	Strength of bond to propellant necessary to prevent separation during burning, and thickness of restriction, with or without additional coating necessary to give adequate protection.	Deleted - covered by new item.
E13H2E	Centrifugal casting.	Deferred - lack of staff.
E13H2F	Hot moulding of containers from foils.	Deferred - lack of staff.
E13H3A	Nitric ester and plasticiser migration.	Deleted - now covered by E.13H1C.
E13H3B	Effect of changes of composition of inhibitor on adhesion.	Deleted - now covered by E.13H1B.
E14A2A	5-inch Mk.N.1. and N.2. gun - Development of propellant and charge (with C.S.A.R.).	Deleted - Project abandoned.
E14A10A	Red Mail (5-inch FSDS) - Development of propellant and charge (with C.S.A.R.).	Deleted.
E16B1A	Compositions based on sulphite pulps.	Deleted - covered by E6A2B.
E17A9E	Compositions containing pulp-boiled N.C.	Deleted - covered by E13C7D.
E20C1A	Depth charges, etc.	Now covered by E20D1A.
E21A1C E21D2B	R.D. cements and lutings containing substitute ingredients. Crystallographic examination of R.D.X.(B) for presence of H.M.X. polymorphs.	Deleted - covered by E21A1G. Deferred - lack of staff.

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PROPELLANTS RESEARCH II.

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.13	General.	E13A	Theoretical studies.	E13A1	E.M.R. - Prof. C.E.H. Bawn. University of Liverpool - The preparation and properties of the polyhydrides of non-metals. Numerical integration of com- bustion equations for systems involving consecutive reactions. A routine service to research. E.M.R. - University of Manchester and University College of North Staffs - Thermochemistry and stability of molecules. The work at Manchester will aim at providing more precise thermo- chemical data on elements and compounds; that at North Staffs. will seek to resolve anomalies in data on compounds, indicating defects in our knowledge of structures.	E13A1D E13A1E E13A1M		
				Solid propellants.	E13A2	Ballistic assessment in test motors. A routine service to research.	E13A2A		
				Measurement of rates of burning.	E13A3	NO/fuel and NO ₂ /fuel combustion processes. A chemical and spectro-chemical study of gas reactions.	E13A3A		

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SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D
<u>G.W. ROCKET,</u> <u>TORPEDO. SUBMARINE</u> <u>& LRM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	Composite Propellants.	E13G	Elastic composite propellants.	E13G1	E.M.R. - Monsanto Chemicals, Ltd., - Study of the feasi- bility of producing and of the physical and ballistic prop- erties of, composite propell- ants having rubbery matrices.	E13G1A		
				Pressed and cast propellants.	E13G2	Exploration of the use of cheap and available binder materials in propellants, e.g. pitch and certain U.K.- produced synthetic plastics.	E13G2A		
<u>ORDNANCE & S.A.</u> <u>PROPELLANTS:</u> <u>Undated Work for</u> <u>Services.</u>	E.15	Charges for New Equipments.	E15A	Liquid propellant gun.	E15A4	Assessment of liquid propell- ant systems.	E15A4A		*
						Sensitiveness of liquid propellant systems.	E15A4C		*
<u>FUZES & INITIATORS</u> <u>Other Research and</u> <u>Development.</u>	E.25	Sensitiveness of Initiators.	E253	Electrostatic hazards.	E25E1	Spark ignition: analysis of factors determining ignita- bility. Assessment of electrostatic charges formed when initiatory substances are poured.	E25E1B E25E1C		*
				Development of significant routine tests.	E25E2	Assessment of the sensitive- ness of initiators to friction, impact or electrostatic dis- charge.	E25E2A		*

SECRETPropellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.
<u>GENERAL RESEARCH</u> <u>AND DEVELOPMENT:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.45 (Cont.)	Explosives and Propellants in General.	E4.5C	Combustion.	E4.5C4	Rates of burning of solid and liquid explosives. A service to research.	E4.5C4A		
				Electrostatic hazards with H.E. and pro- pellants.	E4.5C5	Measurement of the electro- static energies required for the initiation of explosives. A service to research.	E4.5C5A		
		Sensitiveness and Detonability.	E4.5D	Sensitiveness of explosives to friction and impact.	E4.5D1	E.M.R. - Dr. F.P. Bowden, University of Cambridge - Mechanism of the initiation and growth of the detonation wave in explosives.	E4.5D1A		
						Development of a test for δ the sensitiveness of explosives to friction, having no impact component.	E4.5D1B		
				Impact sensitiveness.	E4.5D3	Application of the 'gap test' to colloidal propellants and to explosive liquids rendered viscous by the addition of polymers. Sensitiveness of explosives to high velocity fragments: statistical examination of the 'rifle bullet test'.	E4.5D3C E4.5D3E		

Propellants Research II (Cont.)Items Deleted or Deferred

E13A1H	Thermochemical data on propellant ingredients.	Lack of staff. E.M.R.s proceeding (E13A1M).
E13A8D	Effect of lead oxide on NO ₂ flame reactions.	No effects could be traced and staff is lacking to pursue the work.
E13C6L	Effect of additives on the rates of burning of cordites of different calorimetric levels.	Lack of staff.
E13C6P	Miscellaneous calorimetric value determinations on cordites.	Work will be included in E45A5A.
E13E7F	Tests of a vent for H.T.P. containers at A.D.E.B.	Work will be included in E13E7A.
E45A4C	Cold flow of cordite.	Lack of staff.
E45A4D	Dependence of the physical properties of cordite on the type of nitrocellulose employed in its composition.	Lack of staff.

Explosives and Intermediates (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.
FUZES & INITIATORS: Dated Work for Services (Cont.)	E.22 (Cont.)	Delay Composi- tions for Fuzes and Detonators, (20 mm, 30 mm, 40 mm, A/B Detonators).	E22D	Study and development of compositions.	E22D1	(a) Barium styphnate types. (b) Lead dinitroresorcinate types. (c) Lead styphnate types.	E22D1A	1	
		Channel Initi- ation Systems (20 mm.).	E22E	Provision of explosives in appropriate form for functioning tests.	E22E1	(a) Pentaerythritol tetranitrate. (b) Other explosives.	E22E1A	1	
FUZES & INITIATORS: Post-Design Work for Services.	E.24	Detonators, General.	E24B	Study and improvement of physical properties of initiating explosives in relation to filling and functioning.	E24B1	Modification of preparation and properties of lead azide. Collaboration in production and user trials of modified forms of lead azide.	E24B1A E24B1B	1 8 1 8	
		Detonators, Pricking Sensitive.	E24C	Preparation of explo- sives and ingredients for compositions of improved sensitivity.	E24C1	Control of physical form of lead dinitroresorcinate and other ingredients as re- quired for sensitivity studies.	E24C1A	1 8	
GENERAL RESEARCH AND DEVELOPMENT: Other Research and Development.	E.45	Propellant Ingredients.	E45B	Picrite manufacturing processes.	E45B2	Ammonium thiocyanate provision: E.M.R. - Dr. Sykes, Swansea - Direct conversion of H ₂ S to CS ₂ . E.M.R. - Prof. D.M. Newitt, Imperial College - Indirect conversion of H ₂ S to CS ₂ .	E45B2B E45B2C		

+ Shared work - p. 30

8 Associated with items on A.R.E.
programme which carry Service
priorities.

SECRETExplosives and Intermediates (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.
<u>GENERAL RESEARCH</u> <u>AND DEVELOPMENT:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.45 (Cont.)	Propellant Ingredients (Cont.)	E4.5B (Cont.)	Nitrocellulose (Cont.)	E4.5B3 (Cont.)	Investigations on nitro- cellulose stabilisation chemistry. Degradation - measurements on nitrocelluloses from cordite stability trials, etc. Fractionation studies for characterisation of nitro- celluloses.	E4.5B3F E4.5B3H E4.5B3J		
				Nitric esters.	E4.5B10	E.M.R. - Prof. Gwyn Williams, Royal Holloway College - Kinetics of nitration of alcohols.	E4.5B10A		
				Stabilisers.	E4.5B12	Study of stabiliser sub- stances and reactions involved in their use.	E4.5B12A		
		General Explo- sives and Propellant Applications.	E4.5C	Study of crystalli- sation problems.	E4.5C2	(a) Crystal size control. (b) Crystal habit control. (c) Polymorphism. (d) Surface condition and deposition.	E4.5C2H		

CHEMICAL ENGINEERING

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.
G.W. ECKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development.	E.13	General.	E13A	Heat transfer.	E13W4	Thermal conductivity of liquid oxygen. Measurement of radiational and convectional heat transfer in rocket motors.	E13W4A E13W4C		
		Liquid Propellants.	E13E	Corrosion by red fuming nitric acid.	E13E8	E.M.R. at C.R.L. - Aluminium alloys, study of films produced by hydrofluoric acid. Storage tests in cast and welded aluminium alloy closed vessels.	E13E8A E13E8C		
				Manufacturing processes.	E13E9	E.M.R. - Genatosan - Process for concentrating aqueous hydrazine; pilot plant development. E.M.R. - B.O. Co. - Mobile oxygen plant for interceptor fighter boost motor: separator unit. E.M.R. - Howden - Ditto: engine/compressor unit.	E13E9B E13E9E E13E9F		
ORDNANCE & S.A. PROPELLANTS: Other Research and Development.	E.17	Ingredients.	E17B	Picrite processes.	E17B1	Calcium Cyanamide Pilot Plant: End-gas separation and recovery Mutual utilisation of by-products with the 'direct fusion' process. Investigation of optimum reaction conditions.	E17B1G E17B1H E17B1S		

HIGH EXPLOSIVES:

E.20

R.D.X.

E2CB

Manufacture.

E2CB1

Vacuum concentration with separation of ammonium salt and improved yield of picrite.

Small pilot plant with acid recirculation, separate fuse-off and modified crystalliser.

E2CB1C

Post-Design Work

SUBJECT

PROJECT

SUB-PROJECT

SUB-PROJECT SUB-TITLE

PRIORITY

Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
COMPRESSED GAS PLANTS: Dated Work for Services.	E.30	New Equipments.	E30A	Standard mobile oxygen plant.	E30A1	E.M.R. - B.O. Co. Ltd. - Development of prototype.	E30A1A	3	
				Mobile dissolved acetylene plant.	E30A2	E.M.R. - B.O. Co. Ltd. - Development of prototype.	E30A2A	3	
COMPRESSED GAS PLANTS: Undated Work for Services.	E.31	New Equipments.	E31A	On-site air transportable oxygen plant.	E31A1	E.M.R. - Ricardo & Co. (1927) Ltd. - Development of prototype.	E31A1A	3	
COMPRESSED GAS PLANTS: Other Research and Development.	E.33	Mobile Liquid Oxygen Plants.	E33A	Research on liquid air separators.	E33A1	E.M.R. - Ricardo & Co. (1927) Ltd. - Development of rotating still.	E33A1A		
						Performance of packed columns in liquid air fractionation	E33A1B		
						Performance of centrifugal stills in liquid air fractionation.	E33A1C		
				Research on materials.	E33A3	Properties at very low temperatures.	E33A3A		

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oted in 1953-54.

M.No. 14/54
S.No. 357 BM

SECRET

Chemical Engineering (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>GENERAL RESEARCH</u> <u>AND DEVELOPMENT:</u> <u>Other Research and</u> <u>Development.</u>	E.45	Chemical Engineering Research.	E4.5E	Distillation.	E4.5E7	E.M.R. - Birmingham University - Study of the vapour-liquid equilibria of the system nitric acid-sulphuric acid-water.	E4.5E8A		
				Studies on continuous reactors.	E4.5E8	Review of knowledge and formulation for its application to practice.	E4.5E8A		
		Miscellaneous Services.	E4.5H	Planning and design of facilities and equipment.	E4.5H1	Chemical Engineering Laboratory and Area.	E4.5H1A		
				Manufacture of experimental quantities of materials.	E4.5H2	For other Branches. For other Establishments.	E4.5H2A E4.5H2B		

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SECRET

ALWAYS TRANSMITTED IN 2025-26.

E13E8A

E13E8E

E.M.R. at C.R.L. - Corrosion of aluminium alloys by R.F.N.A: Study of films produced by phosphoric and hydrofluoric acid inhibitors.
Corrosion of platings and rarer metals by R.F.N.A.

Work on phosphate films wound up, work on fluoride films continuing. Limited to ad hoc testing of a few materials - to be reported. This phase is completed with the

C.O.

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
ORDNANCE & S.A. PROPELLANTS: Other Research and Development (Cont.)	E.17 (Cont.)	Ingredients (Cont.)	E17B (Cont.)	Picrite processes (Cont.)	E17B1 (Cont.)	Nitrolim to picrite: 'Direct fusion' pilot plant- final development at 100 lb/ hour output.	E17B1J		*
						Nitration pilot plant - final development at 50 lb/hour with neutralisation and re- cycling of spent liquor.	E17B1K		
						Spraying and drying pilot plants.	E17B1L		
						Isourca Route: Joint Programme with D.O.F.(X) - Pilot plant development of selected stages.	E17B1N		
						Recovery of nitration spent acid: Review. Vacuum concentration with separation of ammonium salt and improved yield of picrite.	E17B1P E17B1R		*
HIGH EXPLOSIVES: Post-Design Work for Services.	E.20	R.D.X.	E20B	Manufacture.	E20B1	Small pilot plant with acid recirculation, separate fume-off and modified crystalliser.	E20B1C		*
				Purification.	E20B2	Joint Programme with D.O.F.(X) - Continuous recrystallisation from cyclohexanone. Pressure boiling.	E20B2B E20B2C		*

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
COMPRESSED GAS	E.30	New Equipments.	E30A	Standard mobile oxygen plant.	E30A1	E.M.R. - B.O. Co. Ltd. - Development of	E30A1A	3	

Explosives and Intermediates (Cont.)

Items Completed in 1953-54.

E20B1B	Laboratory studies of (a) icing, (b) control of grist and acidity.	Work no longer shared by S.E.I. Studies continuing under E20B1C.
E21B1A	E.M.R. - Prof. R.D. Haworth, University of Sheffield.	E.M.R. Terminated.
E22A3A	Collaboration in production and confirmatory trials using R.D.1339.	Process fully developed, Service use expected.
E45B2A	<u>Thiocyanate route</u> : integration of stages CS ₂ to guanidine for assessment of prospects.	Completed. Further development awaits policy decisions.
E45B2E	Investigations on reactivity and availability of alkylating agents.	Completed.
E45B2G	Exploration of routes alternative to alkylation, e.g. sulphamic reaction.	Terminated. Theoretical and exploratory study not encouraging.
E45B3D	Yield of nitrocellulose in relation to purity of cellulose.	Completed. Report in draft.

Items Deferred or Inactive.

E24A2A	Applicability of lead styphnate, beta form, to percussion caps.	Inactive while assessment proceeds (R.D. 1318).
E45B3B	Continuous centrifugal separation of spent acid from nitrocellulose.	Deferred awaiting progress on previous item.
E45B3G	Provision of nitrocellulose for rate-of-burning studies.	Inactive until requirements arise again.
E45B9A	Provision of guanidine derivatives for stability and user assessments.	Inactive until fresh requirements arise.

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
G.W. SOCKET,	E.13	General.	E13A	Heat transfer.	E13W4	Thermal conductivity of liquid oxygen.	E13W4A		
						Measurement of radiational and convective heat transfer in	E13W4C		

Explosives and Intermediates (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
GENERAL RESEARCH AND DEVELOPMENT: Other Research and Development (Cont.)	E.45 (Cont.)	Propellant Ingredients (Cont.)	E4.5B (Cont.)	Picrite manufacturing processes (Cont.).	E4.5B2 (Cont.)	Iso-urea Process	E4.5B2D		
						Identification of secondary products - mechanism. Determination of reaction con- ditions for continuous operation:			
						(a) Conditions for premixing and alkylation, (b) Time-temperature studies of amination, (c) Time-temperature studies of hydrolysis.			
						Assessment of methods of pro- ducing diethyl sulphate.	E4.5B2H		
						Calcium cyanamide synthesis: Studies of mechanism and kinetics:	E4.5B2Q		
						(a) Kinetic studies on CaO-CO-NH ₃ reaction,			
						(b) Effect of CO ₂ , etc., on HCN-CaO interaction, (c) Mechanism of CaCN ₂ synthesis in relation to ammonia-cracking.			
				Nitrocellulose.	E4.5B3	Continuous disintegration and nitration of pulp board. Thermal degradation of nitro- cellulose in solution.	E4.5B3A E4.5B3C		

Explosives and Intermediates (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
			E4.5B	Nitrocellulose (Cont.)	E4.5B3 (Cont.)	Investigations on nitro- cellulose stabilization	E4.5B3F		

SECRET

EXPLOSIVES AND INTERMEDIATES

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB -TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
G.W. ROCKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development.	E.13	Cast Double Base Propellants.	E13D	Ingredients.	E13D8	Preparation and characterisa- tion of compounds for use in platonisation studies.	E13D8		
HIGH EXPLOSIVES: Post-Design Work for Services.	E.20	R.D.X. Manufacture	E20B	Purification.	E20B2	Investigation of causes of coloration found in R.D.X./T.N.T. fillings.	E20B2A		
				Chemistry of manufacture.	E20B3	Conditions of formation and separation of intermediate compounds.	E20B3A		
FUZES & INITIATORS: Dated Work for Services.	E.22	Caps, Electric, (30 mm. Aden).	E22C	Study of ingredients of compositions.	E22C1	Collaboration on production and specification of lead styphnate (R.D.1303). Development of process for barium styphnate manufacture.	E22C1C E22B1D	1 1	
		Igniters, Electric, (F.85 and Improved Types for VT Application).	E22C	Studies in development of compositions, less liable to deteriora- tion of performance.	E22C1	Provision of lead styphnate (R.D.1303), lead dinitro- resorcinate, and other sub- stances to suit A.R.E. devel- opment work.	E22C1A	1	

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SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
FUZES & INITIATORS:	E.22 (Cont.)	Delay Composi- tions for Fuzes and Detonators	E22D	Study and development of compositions.	E22D1	(a) Barium styphnate types. (b) Lead dinitroresorcinate types.	E22D1A	1	

Propellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E
GENERAL RESEARCH AND DEVELOPMENT: Other Research and Development (Cont.)	E.45 (Cont.)	Sensitiveness and Detonability (Cont.)	E4.5D (Cont.)	Impact sensitiveness (Cont.)	E4.5D3 (Cont)	Development of a test for the liability of an explosive to propagate explosion. The Rotter machine: extension and interpretation of results. Mechanism of the initiation of explosion in the 'gap', 'fragment' and 'rifle bullet' tests: photographic study.	E4.5D3F E4.5D3G E4.5D3H		*
				Sensitiveness of solid explosives and propellants.	E4.5D6	Sensitiveness of homogeneous explosives as a function of chemical nature, particle size and voids: study of T.N.T. and picric acid in both solid and liquid phases. Sensitiveness of binary explos- ive systems based on ammonium perchlorate as a function of the particle size of the oxidant and of voids in the system. Sensitiveness of R.D.X. as a function of the size and habit of the crystals: effect of admixture with water/or nitric acid.	E4.5D6A E4.5D6B E4.5D6C		*

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E
GENERAL RESEARCH	E.45	Sensitiveness	E4.5D	Sensitiveness of solid explosives	E4.5D6 (Cont.)	Routine assess			

Propellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
FUZES & INITIATORS Other Research and Development (Cont.)	E.25 (Cont.)	Sensitiveness of Initiators (Cont.)	E25E (Cont.)	Friction sensitiveness.	E25E3	Effect on the sensitiveness of initiators to friction of the size and hardness of crystals of the initiatory substance and of particles of contaminants.	E25E3A		
		Physical Proper- ties of Initiators	E25G	Rates of burning.	E25G4	Relationship of sensitiveness to rates of burning.	E25G4A		
				Detonability.	E25G5	Build-up of explosion wave + to detonation velocity in initiating explosives con- tained in small channels.	E25G5A		
GENERAL RESEARCH AND DEVELOPMENT: Other Research and Development.	E.45	Propellants in General.	E45A	Combustion.	E45A1	E.M.R. - Dr. P. Gray, University of Cambridge - Thermal ignition and com- bustion in the vapour phase of self-combustible com- pounds, e.g. hydrazine.	E45A1C		
				Rheology.	E45A4	Behaviour of colloidal and + plastic propellants under high rates of compressive strain.	E45A4B		
				Miscellaneous assessments.	E45A5	Routine cal. val. deter- minations.	E45A5A		

+ Shared work - pp. 37, 20

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
GENERAL RESEARCH	E.15	Explosives and	E15G	Combustion.	E15G4	Rate of burning of solid and	E15G4A		

SECRET

Propellant Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E
G.W. ROCKET, TORPEDO, SUBMARINE & LFM PROPELLANTS: Other Research and Development (Cont.)	E.13 (Cont.)	Cordites.	E13C	Rates of burning.	E13C6	Development of specific plato- ⁺ nised propellants for Service use. Research aspects.	E13C6B		*
						Effect of the nature of nitro- ⁺ cellulose on plateau burn- ing rates.	E13C6E		
						Effect of chemical nature of platonising agent on platon- isation.	E13C6M		
						Platonisation at low rates of burning.	E13C6N		*
		Liquid Propellants.	E13E	Proofstand assessment of propellants.	E13E2	Monopropellants based on ethyl nitrate and isopropyl nitrate.	E13E2C		
				Physical properties.	E13E6	E.M.R. - Prof. W.F.K. Wynne- Jones, University of Durham - Physico-chemical problems of concentrated hydrogen peroxide.	E13E6A		
				Stability.	E13E7	Trials at T.T.E. on bulk storage of H.T.P. under tropi- cal conditions. Materials and methods of construction of storage vessels.	E13E7A		

+ Shared work - p.9

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.
G.W. ROCKET,	E.13 (Cont.)	Composite Propellants	E13G	Elastic composite propellants.	E13G1	E.M.R. - Monsanto Chemicals, Ltd., - Study of the feasi- bility of producing and st-	E13G1A		

SECRET

Propellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	General (Cont.)	E13A (Cont.)	Measurement of rates of burning (Cont.)	E13A3 (Cont.)	Combustion of solid binary systems based on ammonium perchlorate. Studies of the factors influencing the rates of burning of composite pro- pellants. Vented vessel. Crawford "Strand" burner. Micro rockets (solid). "Slab" burner. These items are routine services for solid propellant research.	E13A3B E13A3D E13A3E E13A3F E13A3G		
				Combustion.	E13A8	Effect of lead compounds on the burning of liquid nitric esters. Combustion studies on colloidal systems simu- lating cordites. Combustion of liquid nitric esters. Chemical and spectro- chemical studies of the com- bustion products. Effect of lead compounds on the combustion products of liquid nitric esters. Chemical and spectrochemical studies.	E13A8A E13A8B E13A8C		

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SECRET

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. ROCKET,</u>	E.13 (Cont.)	General (Cont.)	E13A (Cont.)	Combustion (Cont.)	E13A8 (Cont.)	Reaction of nitric oxide with formaldehyde in first stage in a synthesis study of	E13A8E		

SECRET

Propellants Research I (Cont.)

Items Deleted or Deferred

E25C3B	Correlation of chemical deterioration with effective life.	Deleted - covered by E25C3A.
E28A2B	V.T. and C.V.T. waterproofing.	Deleted, and dealt with under E28A11A.
E29B1E	Conducting varnish for cartridge cases.	Deferred - awaiting further proposals.

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SECRET

PROPELLANTS RESEARCH II.

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
						Prof. G.E.H. Bawn.	E13A1D		

SECRET

Propellants Research I (Cont.)

Items Completed in 1953/54.

E29A1D	Wax-resistant cements.
E29A1E	Improved cement RD1A.
E29A2A	Plastic sheaths for fuzes.
E29B2A	Alternatives to silk, viz. viscose, box cloth.
E29B5A	Fuze 208.
E45A2A	Potassium perchlorate propellants.
E45B6A	X-ray determination of crystal structure.

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SECRET

Propellants Research I (Cont.)

Items Deleted or Deferred.

E1A3A	Climatic trials of 2-inch rocket propellant.	Deleted - requirement cancelled. Deleted - requirement cannot be met.
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SECRET

Propellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>MATERIALS AND</u> <u>AMMUNITION SEALING</u> & <u>PROTECTION:</u> <u>Dated Work for</u> <u>Services.</u>	E26	Assessment of Materials and Waterproofing.	E26A	Cartridges.	E261	For battalion A/T gun (120 mm. RCL)	E26A1A		
						Q.F. 20-pr. A.P.D.S.	E26A1B		
						Suitability of protective treatment for steel cases of 3-inch/70 cal. ammunition.	E26A1C		
<u>MATERIALS AND</u> <u>AMMUNITION SEALING</u> & <u>PROTECTION:</u> <u>Post-Design Work for</u> <u>Services.</u>	E.28	Waterproofing.	E28A	AP. Mine No. 6. Mk.I	E28A1	Waterproofing and climatic trials of Mk.II fuze.	E28A1C		
				Gun ammunition detonators.	E28A3	Waterproofing: External varnishes. Alternatives to shellac.	E28A3A E28A3B		*
				Q.F. Cartridges.	E28A4	Waterproofing.	E28A4A		
				Tubes V.E.	E28A5	Waterproofing.	E28A5A		
				A/C Bomb detonators.	E28A8	Waterproofing.	E28A8A		
				Grenade igniter.	E28A9	Waterproofing.	E28A9A		
				V.T. fuzes.	E28A11	Miscellaneous waterproofing problems.	E28A11A	1	

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SECRET

Propellants Research I (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>MATERIALS AND</u>	E 29	Sealing	E29A	New compositions.	E29A1	Luting serviceable over "Universal" temperature range.	E29A1A		*

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
ORDNANCE & S.A. <u>PROPELLANTS:</u> <u>Other Research and Development (Cont.)</u>	E.17 (Cont.)	General (Cont.)	E17A (cont.)	Stability, climatic and climatic-ballistic trials (Cont.).	E17A9 (Cont.)	Compositions containing mechanically-nitrated cellulose. Compositions containing pulp-boiled N.C.	E17A9D E17A9E		
				Compatibility with materials.	E17A10	R.D. cements and luting containing substitute ingredients. Miscellaneous.	E17A10C E17A10E		
				Safety.	E17A11	Habitability: D.E.G.N. cordites.	E17A11B		
				Foreign propellants.	E17A12	Analysis, stability and climatic trials.	E17A12A		
				Cool non-picrite propellant.	E17A13	Development of solvent type (short term solution). Development of solventless type (long term solution).	E17A13A E17A13B		*
		Ball Powder.	E17C	Methods of manufacture.	E17C1	Processing variables. Double-base formulations. Moderation.	E17C1A E17C1B E17C1C		* *
<u>HIGH EXPLOSIVES:</u> <u>Post-Design Work.</u>	E.20	Torpex.	E20C	Stability.	E20C1	Depth charges, etc.	E20C1A		
		General Fillings	E20D	Compatibility.	E20D1	Minol with coating compositions.	E20D1A		
		Tetryl.	E20E	Stability.	E20E1	Acetone-granulated tetryl.	E20E1A		

<u>HIGH EXPLOSIVES:</u>									
<u>Other Research and Development.</u>	E.21	General.	E21A	Compatibility of H.E. with materials.	E21A1	R.D. cements and luting containing substitute ingredients. Barrier creams. Miscellaneous.	E21A1C E21A1E E21A1G		
<u>FUSES & INITIATORS:</u>	E.25	Chemical Stability of Initiators	E25C	Mechanism and assessment of deterioration.	E25C1	Mercury fulminate. Substitutes for Compositions A and B.	E25C1B E25C1C		

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
ORDNANCE & S.A. PROPELLANTS: Dated work for Services.	E.14	Charges for New Equipments.	E14A	3-inch 70 cal. gun.	E14A1	Development of propellant and charge (with C.S.A.R.)	(E14A1A	1	
				Light A.A. L. 70.	E14A5		(E14A5A	1	
				" " -ADE 42 mm.	E14A6		(E14A6A	1	
				4-inch full calibre.	E14A8		(E14A8A	1	
				120 mm. gun for FV.24 (Red Adder).	E14A11		(E14A11A	1	
				3-inch gun for armoured car.	E14A12		(E14A12A	1	
		Charges for Improved Ammunition.	E14B	30 mm. ADEN gun.	E14A15	E.M.R. - I.C.I., Ardeer - Granular powder for air-craft guns.	E14A15A	1	
				105 mm. gun.	E14A17	Development of propellant and charge (with C.S.A.R.)	(E14A17A	2	
				6-inch Mk.5 gun.	E14A19		(E14A19A	1	
				Q.F. 17-pr., and 77 mm. A.P.	E14B3	Development of propellant and charge (with C.S.A.R.).	E14B3A	1	
ORDNANCE & S.A. PROPELLANTS: Undated Work for Services.	E.15	Charges for New Equipments.	E15A	New automatic rifle.	E15A2	E.M.R. - I.C.I., Ardeer - Propellant loads for 0.30 ammunition.	E15A2A	1	
		N.A.T.O.	E15C	Harmonisation of propellants.	E15C3	Use of ball powder. Ad hoc problems.	E15C3A E15C3B		

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Name	No.	Name	No.	Name	No.	SUB-PROJECT SUB-TITLE	No.	PRIORITY	Service	E.R.D.
ORDNANCE & S.A. PROPELLANTS: st-Design Work Services.	E.16	Cordites.	E16B	Climatic and climatic-ballistic trials.	E16B1	Suitability of selected sulphite pulps for Service nitrocellulose.	E16B1A	1		
NANCE & S.A.	E.17	General								

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	Colloidal Propellants (Cast Double-Base) (Cont.)	E13D (Cont.)	Process mechanics.	E13D19	Of new ingredients. Rate of solution of ingredients. Volume changes. Heat transfer problems. Accommodation of curing pressures.	E13D19A E13D19B E13D19C E13D19D E13D19E		
				Large charges.	E13D20	Production problems. Advisory to I.C.I., Summerfield. E.M.R. - I.C.I., Ardeer - Supporting work.	E13D20A E13D20B		
				Experimental 15-inch charge.	E13D21	Development of charge: } (a) Concentric rings. } (b) Star centred. } Development of igniter.	E13D21A E13D21B		
		Pressed Propellants.	E13F	Charges.	E13F1	E.M.R. - I.C.I., Ardeer - Expulsion charges for L.F. rockets. E.M.R. - I.C.I., Ardeer - Large pressed charges for rocket motors.	E13F1A E13F1B		*
						I.C.I. charges (other than propellants for engine starters).	E13F3A		*
		Inhibitors.	E13H	General requirements.	E13H1	Chemical properties of inhibiting materials.	E13H1C		

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Name	No.	Name	No.	Name	No.	Name	No.	PRIORITY	Service	E.R.D.E.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	Inhibitors (Cont.)	E13H (Cont.)	General requirements. (Cont.)	E13H1 (Cont.)	Physical properties of inhibitors. Adhesion to propellant. H.G. and plasticiser migration.	E13H1D E13H1E E13H1F			*
						Materials and techniques.	E13H2 E13H2A E13H2B			*
						Ion coating.				

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
G.W. ROCKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development (Cont.)	E.13 (Cont.)	Colloidal Propellants (Cordites)(Cont.)	E13C (Cont.)	Stability and climatic trials.	E13C7	D.E.G.N. as substitute for nitroglycerine.	E13C7A		*
						Compositions containing potassium perchlorate.	E13C7B		
						Compositions containing pul- boiled nitrocellulose.	E13C7D		
						Charges for 2-inch, 3-inch, and 5-inch rockets (current and new compositions).	E13C7F		
						Engine-starter cartridges - Avon, Ghost, Python, Sapphire.	E13C7G		
		Colloidal Propellants (Cast Double-Base)	E13D	Compatibility with materials.	E13C8	Miscellaneous materials.	E13C8F		
				General research.	E13C11	Effect of thermal history on mechanical properties.	E13C11A		
				Manufacturing techniques.	E13D3	Preparatory operations.	E13D3H		
						Casting.	E13D3J		
						Curing.	E13D3K		
						Final operations.	E13D3L		
						Casting powder shape and size.	E13D3M		
						Ignition.	E13D4	Minimum ignition for low temperatures and pressures.	E13D4A
						Stability and climatic trials.	E13D6	Accelerated (80°C.) cracking trials.	E13D6A
								60°C. cracking trials.	E13D6B
								Low temperature trials.	E13D6C

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.
G.W. ROCKET, TORPEDO, SUBMARINE LPM PROPELLANTS: Other Research and	E.13 (Cont.)	Colloidal Propellants (Cast Double-Base) (Cont.)	E13D (Cont.)	Safety.	E13D7	Electrostatic hazards.	E13D7C		
				Chemical analysis.	E13D9	Casting powder. Finished propellant. Casting liquid.	E13D9A E13D9B		

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.P.
G.W., ROCKET, TORPEDO, SUBMARINE & LPM PROPELLANTS: Other Research and Development.	E.13	All Solid Propellants.	E13A	Mechanical testing.	E13A1	Mechanical properties in relation to use.	E13A1K		
						Development of new methods.	E13A1P		
				Study of stress concentrations.	E13A9	Photo-elastic studies.	E13A9B		
		Plastic Propellant.	E13B	Inspection.	E13A10	X-Ray techniques. Ultrasonics and other methods.	E13A10A E13A10B		
				New ingredients.	E13B2	Alternatives to "polymeths". Alternatives to lecithin + (surfactant). Moderants (rate of burning). Ammonium nitrate. + Degraded natural rubber. Degraded butyl rubber.	E13B2A E13B2B E13B2D E13B2E E13B2F E13B2G		
				Manufacturing techniques.	E13B3	Improvements in processing of P.I.B. compositions.	E13B3D		
				Storage (temperature effects).	E13B4	Climatic trials and temperature cycling of filled motors.	E13B4A		
				Ignition and burning.	E13B7	Effect of particle size and size distribution. Ballistic studies of P.I.B. compositions.	E13B7A E13B7C		
				Chemical analysis.	E13B9	Methods for D.C.I. and D.O.F.(X).	E13B9A		

+ Shared work - p.

TORPEDO, SUBMARINE
& LPM PROPELLANTS:
Other Research and
Development (Cont.)

(Cont.)

Propellants
(Cordites).

E13C

Compositions with
improved mechanical
properties. Extension
of temperature range.

E13C3

Toughness. Resistance to
cracking. With reference
to large webs.

No.

E13C3D

Service

Manufacturing
techniques.

E13C4

Back-pressure and long-
parallel die techniques
of extrusion.
Segmented die

E13C4B

SECRET

PROPELLANTS RESEARCH I.

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>G.W. PROPELLANTS:</u> <u>Dated Work for</u> <u>Services.</u>	E.1	Seaslug	E1A	Boost, cordite.	E1A7	Development of platonised composition.	E1A7A	1	
				Cordite charge for liquid expulsion.	E1A12	Development of platonised composition.	E1A12A	1	
		Test Vehicles when Particular Missile is not Specified.	E1C	Boost, plastic.	E1C6	Supply of filled motors and collaboration with R.O.F.s.	E1C6A	1	
		Red Dean	E1D	Motor, cordite.	E1D1	Development of platonised composition.	E1D1A	1	
		Red Shoes	E1E	Sustainer motor, plastic propellant.	E1E1	Development of slow burning compositions.	E1E1A	1	
		Magpie	E1G	Motor, cordite.	E1G1	Development of platonised medium-fast composition.	E1G1A		
<u>UNGUIDED ROCKET</u> <u>PROPELLANTS:</u> <u>Dated Work for</u> <u>Services.</u>	E.4	3.5-inch HE/AT Rocket.	E4E	Development of M.7. propellant.	E4E1	Factors affecting ballistics. Cutting techniques.	E4E1C E4E1D	1 1	
		Platoon A/T Rocket	E4F	Development of M.7. propellant.	E4F1	Development of stick propellant (Trefoil).	E4F1A	1	

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SECRETPropellants Research I (Contd.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E
High Performance	E4J			Motor, plastic propellant.	E4J1	Development of charge (battery firing).	E4J1A	1	
						slow burning	E4J2A		

SECRET

In terms of work for the individual Services it is roughly:-

<u>Army</u>	<u>Navy</u>	<u>Air</u>
32%	29%	39%

These latter percentages could be rather misleading. The Air figure (39%) and that of Navy (29%) appear high because of the unavoidably arbitrary manner in which the large total G.W. effort and a big slice of 'general research' have to be allocated between all three Services. Apart from G.W. propellants, E.R.D.E.'s contribution to Navy's requirements is small.

A formal Research Programme cannot adequately bring out the time-consuming consultative and advisory services performed by members of the Establishment on behalf of industrial firms, other Establishments, Ordnance Factories, foreign visitors, and so on, both directly and through committees. A considerable amount of testing, mostly of a routine character, also falls to E.R.D.E. as a result of these contacts; this is referred to in the Programme under appropriate code numbers.

Reference sh

stability of ballistics. Attempts are being made to meet the demands for slow-burning 'platonised' compositions in both the medium and high ranges of calorimetric value.

The press-extrusion of large-diameter rocket charges, and of segments of even larger charges, ought to receive more attention at E.R.D.E. than is possible in present circumstances with the small staff available. The situation will be aggravated by the slowness with which the provision of the new cordite development facilities on South Site (Project III) is progressing. They will not be ready before the middle of 1956.

Plastic propellant has become a serious contender for the re-specified 2-inch Aircraft Rocket (unguided); other experimental plastic compositions are under development and test for G.W. 'sustainer' motors.

Difficulties encountered here, and elsewhere, in the use of ammonium nitrate in Composite types of propellant is forcing our work in the direction of basic studies of the pure salt and in association with other salts and matrix materials.

Whilst Cast Double-Base is being investigated with the full effort of the small team engaged upon it, the priority accorded is tending to diminish by reason of the incessant demands from R.A.E./R.P.D. (Westcott) and A.D.E. for experimental propellants of other types. E.R.D.E. has been asked by A.D.E. to look into the development of propellants suitable to the 'gun-assisted rocket' and similar boosted missiles. Unusual physical quantities are called for and special test-methods will have to be devised.

The intention to set up a 'ball powder' plant at R.O.F., Bishopton for the manufacture of small-arms powders will necessitate greater effort by E.R.D.E. in support. This should not be underestimated.

The physico-chemical study of combustion processes in various types of solid systems will be continued. Faint outlines of some useful generalisations are emerging.

The tempo and range of rheological studies have had to be stepped up, and are expected to increase further in view of the stringent requirements of new propellant applications and the advent to Waltham Abbey of the E.R.D.E. Materials Section concerned with ammunition problems (formerly located at Woolwich), and of D.M.X.R.D.'s Materials Group.

The investment in spectroscopic equipment, especially the infra-red recording spectrometers, made two or three years ago is now beginning to pay dividends in the analytical field; especially in regard to the estimation of minor propellant ingredients, the examination of polymeric materials, and the study of reactions in flames.

Progress is being made, and will continue, in linking combustion kinetics with initiation and build up of detonation in liquid explosives, and in the interpretation of 'sensitiveness'.

Picrite manufacture which, in various aspects, still engages the attention of a substantial proportion of the staff of the S.E.I. and S.C.E. Branches, is tending more and more towards the 'lime-cyanamide' and 'direct fusion' route. In spite of unremitting effort no solution to the problem of the high cost of production of diethyl sulphate is in sight and this weighs against the prospects of the Roberts process without diminishing the desirability of exploring its chemical engineering aspects on a scale larger than can readily be undertaken at Waltham Abbey. From the R & D standpoint, the picrite programme initiated immediately after World War II has certainly passed the peak of activity, and

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Chief Superintendent	Dr. C.H. Johnson
Superintendent, Propellants Research I.	Dr. G.H.S. Young
Superintendent, Propellants Research II.	Mr. A. Brewin
Superintendent, Chemical Engineering	Mr. R.G. Ross
Superintendent, Explosives and Intermediates	Dr. A. Lovecy

SECRET

Programme of Research and Development for 1953/54, has four main branches:-

Propellant Research I: Development of solid rocket propellants;

Propellant Research II: physical and chemical properties of solid rocket propellants;

Explosives and Intermediates: laboratory investigation of new processes;

Chemical Engineering: pilot plant work.

Under the heading of 'Progressing and Planning', the main fields of current work are:-

1. 'P' and 'F' headings: namely, Development of New Projects, Unstarted Projects, and Projects in existing Service stores.

2. Design and Development of New Projects, of the types indicated by the 'P' and 'F' headings.

3. The other three against the year.

The progress will be worked out in the 'P' and 'F' headings.

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