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MINISTRY OF SUPPLY

DIRECTORATE OF MATERIALS & EXPLOSIVES
RESEARCH & DEVELOPMENT
EXPLOSIVES RESEARCH & DEVELOPMENT
ESTABLISHMENT WALTHAM ABBEY

Programme of Research and Development
1954-55

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1954

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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

C.H. Johnson

C.H. JOHNSON
C.S., E.R.D.E.

C.S. Bryant

C.S. BRYANT
D.M.X.R.D.

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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

/stability

this has been reckoned with in forward thinking at E.R.D.E. Whether more or less of the Establishment's effort will actually be required in this field over the next couple of years depends very largely on Ministry policy which will determine whether any of the new processes or parts of processes, are to be utilised in the R.O.F.s. In any event, it will be E.R.D.E.'s endeavour to ensure that the 'blue prints' of pigeonholed processes are as complete as possible. An exercise to this end (probably!) has been undertaken, jointly with D.O.F.(X) on the Roberts process, and we are working towards a similar one on Chard's ('lime-cyanamide'). During the current year, at least, there can be little or no diminution of activity; but it will tend to become more narrowly focussed and allied with D.O.F.(X).

With some difficulty a little more effort is being found for problems connected with the use of High Explosives, and the manufacture of R.D.X. and T.N.T. Joint development programmes with D.O.F.(X) are increasing in number.

The projects concerned with mobile units for liquid oxygen manufacture in the field take the form of extra mural contracts with firms. Their priority ratings have lately been reduced.

The proportion of the Establishment's whole effort devoted to G.W. applications for the three Services has tended to increase throughout 1953/54, reaching a figure of nearly 47% during the last quarter, compared with an average of 40% for 1952/53.

4. Staffing

The total strength deployed on the Research Programme on April 1st, 1954, was as follows; corresponding figures on this date last year are given in parenthesis.

D.C.S.O.	1	(1)
S.P.S.O.	5	(6)
Scientific Officers (all other categories)	51	(52)
Experimental Officers (all categories)	88	(85)
Engineers	4	(4)
Assistants (Scientific), all categories	61	(51)

These figures do not include I.S.R.G. or D.M.X.R.D.'s Materials Group whose work does not appear in this Programme.

No attempt has been made to indicate the staffing of individual research and development items, or even the main groups of items. The position is somewhat fluid, and to try to represent it in advance over the course of a year could be very misleading. Moreover, for most of the separate items fractional portions of a person's time are involved. Of course, the number of items listed under a given subject-title provides no clue whatever to the number of staff engaged. An assumption which can be made with certainty is that it is small.

Deployment of staff (S.O. and E.O. categories and Engineers) in the various fields of work can be approximately represented as:-

	2
Ammunition	11
Initiators	5
G.W. Propellants (direct effort)	30
Other Propellants	17
Miscellaneous Service Equipments	4
Basic and Applied Research and Development	33

roughly:-

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RESEARCH PROGRAMME, 1954 - 55.

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

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PROPELLANTS:
Dated Work for
Services.

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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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> Dated Work for Services (cont.)	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> Undated Work for Services.	E.5	Rocket, Signal, Distress, No. 1, Mk. I.	E5G	Motor, propellant, to match Cerlikon.	E5G1	Development of propellant and charge.	E5G1A	2	
<u>UNGUIDED ROCKET</u> <u>PROPELLANTS:</u> Post-Design Work for Services.	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

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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>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. Segmented charges. High-frequency heating before pressing. Automatic rolling of solventless sheet. Reduction in extrusion pressure. Treatment of 'rework'. Factors affecting fires on rolls. Improvement in extrusion accuracy.	E13C4B E13C4C E13C4G E13C4H E13C4J E13C4K E13C4L E13C4M		• • • • • • •
				Rate of burning.	E13C6	Compositions containing + platonisers. Effect of the nature of + nitrocellulose on platonisation. Effect of plasticisers on platonisation. Slow-burning compositions containing cellulose acetate Water-insoluble plasticisers for cellulose acetate. Alternatives to cellulose acetate. Effect of nitric ester variants.	E13C6B E13C6E E13C6F E13C6G E13C6H E13C6J E13C6K		• • • • • •

Stability and climatic trials.

E13D6

temperatures and pressures.
Accelerated (80°C.) cracking trials.
60°C. cracking trials.
Low temperature trials.

E13D6A

E13D6B
E13D6C

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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 conc.	E13D18A E13D18B E13D18C E13D18D E13D18E		*

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Inhibitors.

E13H

General requirements.

E13H1

charges (other than propellants for engine starters).

E13F3A

Chemical properties of inhibiting materials.

E13H1C

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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>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LFM PROPELLANTS:</u> <u>Other Research and</u> <u>Development (Cont.)</u>	E.13 (Cont.)	Inhibitors (Cont.)	E13H (Cont.)	General requirements.	E13H1	Physical properties of inhibitors.	E13H1D					
				(Cont.)	(Cont.)	Adhesion to propellant.	E13H1E					
						N.G. and plasticiser migration.	E13H1F					
						Materials and techniques.	E13H2	Elastic materials (rubber etc.)	E13H2A			
								Potting techniques (polyester resins).	E13H2B			
						Screw extrusion coating.	E13H2D					
						Polystyrene.	E13H2G					
						Specifications (as required).	E13H2H					
				Service to other Establishments.	E13H3	Effect of changes of manufacturing techniques on properties of convolute wound containers.	E13H3D					
				E.M.R. - British Celanese - Development of new cellulosic derivatives and formulations.	E13H5	Preparation and characteristics of cellulose acetates of varying acetyl content.	E13H5A					
				Effect of plasticisers on physical properties.	E13H5B							
				Effect of surface treatment (e.g. saponification, cross-linking).	E13H5C							
		Spin-Stabilised Rocket.	E13J	Development of charge.	E13J1	Cordite.	E13J1A					
						Cast double-base.	E13J1B					
						Plastic propellant.	E13J1C					

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<u>Undated Work</u> <u>for Services.</u>	N.A.T.O.	E15C	Harmonisation of propellants.	E15C3	Use of ball powder. Ad hoc problems.	E15C 3A E15C 3B
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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	S.K.D.F.
<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 pro- pellants for Naval Guns.	E17A8B		
				Stability, climatic and climatic- ballistic trials.	E17A9	Imperfectly sealed S.L. cartridges. Compositions containing sub- stitutes for nitroglycerine. Picrite propellants contain- ing oxamide, D.B.P. or D.E.G.N.	E17A9A E17A9B E17A9C		

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HIGH EXPLOSIVES: Post-Design Work.	E.20	Torpex.	E20C	Stability.	E20C1	Moderation.	E1701D E1701C
		General Fillings	E20D	Compatibility.	E20D1	Depth charges, etc.	E20D1A
		Tetryl.	E20E	Stability.	E20E1	Minol with coating compositions.	E20E1A

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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>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.	E21A1C		
						Carrier creams.	E21A1E		
						Miscellaneous.	E21A1G		
<u>FUZES & INITIATORS:</u> <u>Other Research and Development.</u>	E.25	Chemical Stability of Initiators.	E25C	Mechanism and assessment of deterioration.	E25C1	Mercury fulminate.	E25C1B		
						Substitutes for Compositions A and B.	E25C1C		
						Initiator delay compositions.	E25C1G		
						Effect of moisture.	E25C2	Lead azide.	E25C2A
		Climatic trials.	E25C3	A/C bomb detonators.	E25C3A				
				Correlation of chemical deterioration with effective life.	E25C3B				
		Analysis.	E25C4	Tetracene.	E25C4A				
		Compatibility of Initiators and Delay Systems.	E25D	With metals, plastics, sealing materials, varnishes, etc.	E25D1	Lead azides and substitutes.	E25D1A		•
						Substitutes for Composition A.	E25D1C		•
						Promising new compositions.	E25D1F		
		Physical Properties of Initiators	E25G	Polymorphic forms of lead azide.	E25G3	X-ray crystallographic studies.	E25G3A		

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Grenade igniter.	E28A9	Waterproofing.	E28A9A	
V.T. fuzes.	E28A11	Miscellaneous waterproofing problems.	E28A11A	I

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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 AMMUNITION SEALING & PROTECTION:</u> <u>Other Research and Development.</u>	E.29	Sealing.	E29A	New compositions.	E29A1	Luting serviceable over "Universal" temperature range.	E29A1A		•		
						Improvements to existing self-setting cements.	E29A1B				
						Improved fenestrating varnishes.	E29A1C				
						Miscellaneous problems.	E29A1F				
						Evaluation of synthetic rubber cements.	E29A1G				
		Improved semi-solvent cements.	E29A1H								
		Lutings with improved low-temperature properties.	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.	E29B1A		•
								Internal lacquering of cartridge cases.	E29B1B		
		Hot-melt compositions for H.E. stores.	E29B1D								
		Cartridge-base materials.	E29B2					Alginate fabrics.	E29B2B		
						Terylene fabrics.	E29B2C				
		Plastics.	E29B3		E29B3	Specifications and miscellaneous applications.	E29B3A				
						R.D. Cements on rubbers.	E29B3B				

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Explosives, Initiators and Propellants.	E45C	Study of crystallization problems.	E45B11	Phase diagram studies.	E45B1C
		Methods of analysis.	E45C2	Application of electron microscope and of optical methods.	E45B11A
			E45C3	Application of infra-red spectrophotometer.	E45C2G
					E45C3A

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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 FQ (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.
E17A1CC	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 tinplated.
E25D1B	Silver azide.
E25D2A	Lead azide with substitutes for Composition A.
E25D2B	Lead azide with R.D. 1650.
E28A6A	Waterproofing of safety cap end.

SECRET

Propellants 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 PSDS) - 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.N.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 combustion equations for systems involving consecutive reactions. A routine service to research.	E13A1D		
						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 thermochemical 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.	E13A1E		
				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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esters. Chemical and spectro-chemical studies of the combustion products.
 Effect of lead compounds on the combustion products of liquid nitric esters.
 Chemical and spectrochemical studies.

E13A8B
 E13A8C

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.)	Combustion (Cont.)	E13A8 (Cont.)	Reaction of nitric oxide with formaloxims. The first stage in a synthetic approach to a study of propellant combustion.	E13A8E		
		Plastic Propellant.	E13B	New compositions.	E13B2	Containing alternatives to lecithin. +	E13B2B		*
						Containing ammonium nitrate. +	E13B2E		*
						Studies to find suitable fuel-binding agents for A/N composite propellants.			
Storage: temperature effects.	E13B4	Effect of temperature on cohesion.	E13B4D						
			Effect of temperature on fatigue.	E13B4E					
End ring adhesion. Studies of the effect of end ring geometry, etc., on adhesion of propellant.	E13B4H								
Basic research on plastic systems.	E13B10	Fundamental flow properties. A complete determination of rheological properties at normal and high rates of strain.	E13B10C						
			Thermal conductivity of plastic propellants.	E13B10C					

+ Shared work - p.8

Stability.

E13E7

Trials at T.T.E. on bulk storage of H.T.P. under tropical conditions. Materials and methods of construction of storage vessels.

E13E7A

+ Shared work - p. 9

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.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LHM 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. Sensitiveness of liquid propellant systems.	E15A4A E15A4C		• •
<u>FUZES & INITIATORS</u> <u>Other Research and</u> <u>Development.</u>	E.25	Sensitiveness of Initiators.	E25E	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		•

δ Compare with E25D1B - p.31

Technology.	E4.5M4	Behaviour of colloidal and plastic propellants under high rates of compressive strain.	E4.5M4B
Miscellaneous assessments.	E4.5A5	Routine cal. val. determinations.	E4.5A5A

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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>GENERAL RESEARCH AND DEVELOPMENT:</u> <u>Other Research and 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 propellants.	E4.5C5	Measurement of the electrostatic 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. Development of a test for the sensitiveness of explosives to friction, having no impact component.	E4.5D1A			
							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

SECRET

Sensitiveness of R.D.X. as a function of the size and habit of the crystals: effect of admixture with water/or nitric acid.

E4.5D6C

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>GENERAL RESEARCH AND DEVELOPMENT:</u> <u>Other Research and Development (Cont.)</u>	E.45 (Cont.)	Sensitiveness and Detonability (Cont.)	E4.5D (Cont.)	Sensitiveness of solid explosives and propellants (Cont.)	E4.5D6 (Cont.)	Routine assessment of the sensitiveness of explosives and propellants to impact, friction, electrostatic discharge and thermal effects. Includes provision of data for Safety Certificates.	E4.5D6D		
				Sensitiveness as a function of temperature.	E4.5D7	Effect of temperature on the sensitiveness of liquid and solid explosives.	E4.5D7B		

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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.

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Services.

Igniters, Electric, E22C
(F.85 and Improved
Types for VT
Application).

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-

E22C1A

1

collaboration on production
and specification of lead
styphnate (R.D.1303).
Development of process for
barium styphnate manufacture.

E22B1D

1

E22B1C

1

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.
<u>FUZES & INITIATORS:</u> <u>Dated Work for</u> <u>Services (Cont.)</u>	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	
<u>FUZES & INITIATORS:</u> <u>Post-Design Work</u> <u>for Services.</u>	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	
<u>GENERAL RESEARCH</u> <u>AND DEVELOPMENT:</u> <u>Other Research and</u> <u>Development.</u>	E.45	Propellant Ingredients.	E45B	Picrite manufacturing processes.	E45B2	<u>Ammonium thiocyanate provision:</u> E.M.R. - Dr. Sykes, Swanson - Direct conversion of H ₂ S to CS ₂ . E.M.R. - Prof. D.N. 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.
programs which carry Service

CaO-CO-NH₃ reaction,
 (b) Effect of CO₂, etc., on
 HCN-CaO interaction,
 (c) Mechanism of CaCN₂
 synthesis in relation to
 ammonia-cracking.

E4.5B2Q

Nitrocellulose.

E4.5B3

Continuous disintegration and
 nitration of pulp board.
 Thermal degradation of nitro-

E4.5B3A

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.
<u>GENERAL RESEARCH AND DEVELOPMENT:</u> <u>Other Research and Development (Cont.)</u>	E.45 (Cont.)	Propellant Ingredients (Cont.)	E4.5B (Cont.)	Nitrocellulose (Cont.)	E4.5B5 (Cont.)	Investigations on nitro- cellulose stabilisation chemistry.	E4.5B5F		
						Degradation - measurements on nitrocelluloses from cordite stability trials, etc.	E4.5B5H		
						Fractionation studies for characterisation of nitro- celluloses.	E4.5B5J		
		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		

E4.5B 3D

centrifugal separation of spent acid from nitrocellulose.

E4.5B 3G

Provision of nitrocellulose for rate-of-burning studies.

E4.5B 9A

Provision of guanidine derivatives for stability and user assessments.

(R.D. 1318).

Deferred awaiting progress on previous item.

Inactive until requirements arise again.

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.
<u>G.W. ECKETT,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.13	General.	E13A	Heat transfer.	E13A4	Thermal conductivity of liquid oxygen.	E13A4A		
						Measurement of radiational and convectional heat transfer in rocket motors.	E13A4C		
						Liquid Propellants.	E13E	Corrosion by red fuming nitric acid.	E13E8
Storage tests in cast and welded aluminium alloy closed vessels.	E13E8C								
Manufacturing processes.	E13E9	E.M.R. - Genatosan - Process for concentrating aqueous hydrazine; pilot plant development.	E13E9B						
			E.M.R. - B.O. Co. - Mobile oxygen plant for interceptor fighter boost motor: separator unit.	E13E9E					
			E.M.R. - Howden - Ditto: engine/compressor unit.	E13E9F					
<u>ORDNANCE & S.A.</u> <u>PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.17	Ingredients.	E17D	Picrite processes.	E17D1	<u>Calcium Cyanamide Pilot Plant:</u> Erd-gas separation and recovery	E17D1G E17D1H		
Multi-utilisation of by-products with the 'direct fusion' process.	E17D1S			Investigation of optimum reaction conditions.					

HIGH EXPLOSIVES:
Post-Design Work
for Services.

E.20

R.D.X.

E2CB

Manufacture.

E2CB1

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

E17B1P
E17B1R

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

E2CB1C

Purification.

E2CB2

Joint Programme with
D.O.P. (X) - Continuous
Picrite

E2CB2I

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>COMPRESSED GAS</u> <u>PLANTS:</u> <u>Dated Work for</u> <u>Services.</u>	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. - F.O. Co. Ltd. - Development of prototype.	E30A2A	3	
<u>COMPRESSED GAS</u> <u>PLANTS:</u> <u>Undated Work for</u> <u>Services.</u>	E.31	New Equipments.	E31A	On-site air transportable oxygen plant.	E31A1	E.M.R. - Ricardo & Co. (1927) Ltd. - Development of prototype.	E31A1A	3	
<u>COMPRESSED GAS</u> <u>PLANTS:</u> <u>Other Research and</u> <u>Development.</u>	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		

Items Completed in 1953-54.

E13E8A	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.	Work on phosphate films wound up, work on fluoride films continuing. Limited to ad hoc testing of a few materials - to be reported.
E13E8E	Corrosion of platings and rarer metals by R.F.N.A.	
E17B1E	Calcium cyanamide pilot plant: Operation with pure C.O.	This phase is completed with the establishment of a possible process - items are replaced by E17B1S (p.41)
E17B1F	" " " " : Operation with producer gas.	
E20B1A	R.D.X. Manufacture: Laboratory study on 'icing' of cooling surfaces.	This phase completed - to be reported - E20B1C continues.
E20B1B	" " : Laboratory study of (a) icing, (b) control of grist and acidity.	
E4.5E1A,B,C.	Use of dimensional similarity in analysis of processes.	Preliminary review completed - replaced by E4.5E8A. Omitted for lack of application.
E4.5H1B	Design and provision of equipment for other Branches.	
<u>1953-54 Items Deferred.</u>		
E13A4H	Heat transfer to liquid oxygen at the Critical State.	Lack of staff.
E17B1Q	Pierite processes: concentration of spent acid in a carbon vacuum still.	Deferred in favour of E17B1R.
<u>Item Renumbered.</u>		
E13E9H	Liquid Propellants: manufacture of nitric esters (on request).	This work is now included under E4.5H2A and E4.5H2B.
<u>Item Deferred in 1953-54: Now Reinstated.</u>		
E33A1B	Performance of packed columns in liquid air fractionation.	-

INTERNAL DISTRIBUTION

D.M.X.R.D. (4)
 C.S., E.R.D.E. (2)
 S.P.R.I.
 S.P.R.II.
 S.E.I.
 S.C.E.
 S./I.S.R.G.
 Dr. Roberts
 S.A.O.
 Mr. G.K. Adams
 Mr. Brown
 Mr. Chard
 Dr. Gooding
 Mr. Hewson
 Mr. Hutchison
 Dr. Knight
 Mr. Monro
 Dr. L. Phillips
 Dr. Pryde
 Mr. Taylor
 Mr. Verschoyle
 Dr. Walters
 Dr. Williams
 Mr. H.T. Lester (2)
 Registry (1 + stock)

INTRODUCTION

Format
 Priorities
 Trends
 Staffing

PROPELLANTS RES

G.W. Propell
 Unguided Roc
 G.W., Rocket
 Ordnance &
 High Explos
 Fuzes and I
 Materials c
 General Res

Items Comp
 Items Delo

PROPELLANTS R

G.W., Rock
 Ordnance &
 Fuzes and
 General R

Items Com
 Items Del

EXPLOSIVES

G.W., Ro
 High Exp
 Fuzes an
 General

Items C
 Items D

CHEMICAL E

G.W., F
 Ordnanc
 High E
 Compre
 Genera

Items
 Items

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

1. Format

The Programme of Research like that for 1953/54, has Superintendent's Branch:-

1. Propellant Research of solid rocket
2. Propellant Research of combustion
3. Explosives and laboratory in
4. Chemical Engi

The somewhat stereotyped Programme is taken from to follow. Thus, the or more of five 'P' and specified Service demands and improvements and Development, and D. Wherever possible, work included under one of

All items in this during the year April where a particular item inactive items are completed during 1953/54 Programme, together with

2. Priorities

Inevitably, a variety of the undated kind, ambiguity, to specify affairs were illustrated 1953/54 Programme, though not endorsed of Controller of Munitions Chairman is C.M. the item so marked particular importance and due to receive resources.

3. Trends

Development of S.P.R.I. and S.P.I. phenomena underlying rate-of-burning of tion of lead compounds solved, bearing t

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stability of ballistics. Attempts are being made to meet the demands for 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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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 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' is 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.

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PROPELLANTS RESEARCH I.

SUBJECT	PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
	No	Name	No.	Name	Name	No.	Service	E.R.D.E.
PROPELLANTS: Work for	E.1	Seaslug	E1A7	Boost, cordite.	Development of platonised composition.	E1A7A	1	
			E1A12	Cordite charge for liquid expulsion.	Development of platonised composition.	E1A12A	1	
		E1C	Test Vehicles when Particular Missile is not Specified.	Boost, plastic.	Supply of filled motors and collaboration with R.O.F.s.	E1C6A	1	
		E1D	Red Dean	Motor, cordite.	Development of platonised composition.	E1D1A	1	
		E1E	Red Shoes	Sustainer motor, plastic propellant.	Development of slow burning compositions.	E1E1A	1	
		E1H	Magpie	Motor, cordite.	Development of platonised medium-fast composition.	E1H1A		
							E1E1C E1E1D	1 1
ROCKET ES: Work for	E.4	3.5-inch HE/AT Rocket.	E4E7	Development of M.7. propellant.	Factors affecting ballistics. Cutting techniques.	E4E1A	1	
		Platoon A/T Rocket	E4F	Development of M.7. propellant.	Development of stick propellant (Trefoil).		1	

SECRET

Tab I (Contd.)

SUB-PROJECT	SUB-PROJECT SUB-TITLE		PRIORITY	
	Name	No.	Service	E.R.D.E.
			1	

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>G.W., ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.13	All Solid Propellants.	E13A	Mechanical testing.	E13A1	Mechanical properties in relation to use. Development of new methods.	E13A1K E13A1P						
				Study of stress concentrations.	E13A9	Photo-elastic studies.	E13A9B						
				Inspection.	E13A10	X-Ray techniques. Ultrasonics and other methods.	E13A10A E13A10B		*				
	Plastic Propellant.	E13B	New ingredients.	E13B2	Alternatives to "polymeths". Alternatives to lecithin (surfactant). Moderants (rate of burning). Ammonium nitrate. Degraded natural rubber. Degraded butyl rubber.	E13B2	+ + + + + + +	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 P.C.I. and P.C.P. (X).			

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
			E13C	Compositions with mechanical	E13C3	Toughness. Resistance to cracking. With reference to large webs.	E13C3D		

SECRET

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.
<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)(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, host, Python, Sapphire.	E13C7G		
						Compatibility with materials.	E13C8		
						Miscellaneous materials.	E13C8F		
	General research.	E13C11	Effect of thermal history on mechanical properties.	E13C11A					
	Colloidal Propellants (Cast Double-Base)	E13D	Manufacturing techniques.	E13D3	Preparatory operations.	E13D3H E13D3J E13D3K E13D3L E13D3M			
					Casting.				
Curing.									
Final operations.									
Ignition.	E13D4	Minimum ignition for low temperatures and pressures.	E13D4A						
Stability and climatic trials.	E13D6	Accelerated (80°C.) crumking trials. <small>600C. crumking trials. Low temperatures.</small>	E13D6A						

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.
						Electrostatic hazards.	E13D7C		

Propellants Research I (Cont.)

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> <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		*	
					Climatic trials.	E13F3	I.C.I. charges (other than propellants for engine starters).	E13F3A	*
					Inhibitors.	E13H	General requirements.	E13H1	Chemical properties of inhibiting materials.

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.
				Physical properties of			E13H1D		

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>ARMAMENTS & S.A.</u> <u>PROPELLANTS:</u> <u>Dated work for</u> <u>Services.</u>	E.14	Charges for New Equipments.	E14A	3-inch 70 cal. gun.	E14A1	Development of propellant and charge (with C.S.A.R.)	(E14A1A E14A5A E14A6A E14A8A E14A11A E14A12A	1	
				Light A.A. L.70.	E14A5			1	
				" " -ADE 4.2 mm.	E14A6			1	
				4-inch full calibre.	E14A8			1	
				120 mm. gun for FV.214 (Red Adder).	E14A11			1	
				3-inch gun for armoured car.	E14A12			1	
				30 mm. ADEN gun.	E14A15			E.M.R. - I.C.I., Ardeer - Granular powder for aircraft guns.	E14A15A
Charges for Improved Ammunition.	E14B	Q.F. 17-pr., and 77 mm. A.P.	E14B3	Development of propellant and charge (with C.S.A.R.).	E14B3A	1			
<u>ARMAMENTS & S.A.</u> <u>PROPELLANTS:</u> <u>Dated Work</u> <u>for Services.</u>	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.

SECRET

Propellants Research I (Cont.)

PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
				Suitability of selected	E16B1A	1	

SECRET

Propellants Research I (Cont.)

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

SECRET

Propellants Research I (Cont.)

SUBJECT				SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
					E29A1	Luting serviceable over "universal" temperature range. to existing self-	E29A1A		
							E29A1B		

SECRET

Propellants Research I (Cont.)

SUBJECT	No.	PROJECT Name	No.	SUB-PROJECT Name	No.	SUB-PROJECT SUB-TITLE Name	No.	PRIORITY	
								Service	E.R.D.E.
<u>PROTECTION SEAL-PROTECTION:</u> Research and Development (Cont.)	E.29 (Cont.)	Materials (Cont.)	E29B (Cont.)	Proofing.	E29B4	Metallic oxide treatment of bandolier fabrics. Paper and wood: miscellaneous trials.	E29B4A		
					E29B6		E29B4B		
<u>GENERAL RESEARCH DEVELOPMENT:</u> Research and Development.	E.45	Propellants, General.	E45A	Methods of analysis.	E45A2	Potassium perchlorate propellants. Thermal changes. Rough usage. Elongation at break. Behaviour of colloidal and plastic propellants under high rates of compressive strain	E45A2A		
				Resistance to Service conditions.	E45A3		E45A3A E45A3B		
				Measurement of physical properties at high rates of stress.	E45A4		E45A4A + E45A4B		*
				Propellant Ingredients.	E45B		E45B1 E45B11	E45B1C E45B11A	
Explosives, Initiators and Propellants.	E45C	Study of crystallization problems.	E45C2	Methods of analysis.	E45C2	Application of electron microscope and of optical methods.	E45C2G		
				Methods of analysis.	E45C3		E45C3A		

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Items Completed in 1953/54.

Propellants Research I (Cont.)

Sheet, 3-inch, No. 13 Mk.1/1.

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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.
E4.5A2A	Potassium perchlorate propellants.
E4.5B6A	X-ray determination of crystal structure.

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SECRET

Propellants Research I (Cont.)

Items Deleted or Deferred.

Deleted - requirement cancelled.
Deleted - requirement cannot be met.
Cancelled.

SECRET

Propellants Research I (Cont.)

Items Deleted or Deferred

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

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SECRET

PROPELLANTS RESEARCH II.

SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
No.	Name	No.	Service	E.R.D.E.	
		E151D			

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.J.
<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- pellant. 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		

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.
					E13A8	Reaction of nitric oxide with formaloxime. The first stage approach to a	E13A8E		

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.	
<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.)	Cordites.	E13C	Rates of burning.	E13C6	Development of specific plato- ⁺	E13C6B		*	
						nised propellants for Service	E13C6E			
						use. Research aspects.	E13C6M			
						Effect of the nature of nitro- ⁺	E13C6N		*	
		cellulose on plateau burn-								
		ing rates.								
Effect of chemical nature of										
platonising agent on platon-										
isation.										
Platonisation at low rates of										
burning.										
		Liquid Propellants.	E13E	Proofstand assessment	E13E2	Monopropellants based on ethyl	E13E2C			
				of propellants.		nitrate and isopropyl nitrate.				
				Physical properties.	E13E6	E.M.R. - Prof. W.F.K. Wynne-	E13E6A			
				Jones, University of Durham -						
				Physico-chemical problems of						
				concentrated hydrogen peroxide.						
				Stability.	E13E7	Trials at T.T.E. on bulk	E13E7A			
						storage of H.T.P. under tropi-				
						cal conditions. Materials and				
						methods of construction of				
						storage vessels.				

+ Shared work - p.9

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.
					E13G1	E.M.R. - Monsanto Chemicals,	E13G1A		
						Ltd., - Study of the feasi-			
						ble producing and of the			

Propellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY											
						Name	No.	Service	E.R.D.E.										
<u>FUZES & INITIATORS</u> <u>Other Research and Development (Cont.)</u>	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 Properties 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 contained in small channels.	E25G5A		
<u>GENERAL RESEARCH AND DEVELOPMENT:</u> <u>Other Research and Development.</u>	E.45	Propellants in General.	E45A	Combustion.	E45A1	E.M.R. - Dr. P. Gray, University of Cambridge - Thermal ignition and combustion in the vapour phase of self-combustible compounds, 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. determinations.	E45A5A				

Propellants Research II (Cont.)

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB-TITLE		PRIORITY	
						Name	No.	Service	E.R.D.E.
						Turning of solid and	E45G4A		

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>GENERAL RESEARCH AND DEVELOPMENT:</u> <u>Other Research and Development (Cont.)</u>	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 explosive 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		*

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
							E4.5D6D		

Propellants Research II (Cont.)

Items Completed in 1953/54.

E13A1B	E.M.R. - Prof. C.E.H. Bawn, University of Liverpool - The preparation and isolation of labile molecules.	The Contract has been closed until there is an indication of a fruitful line of work.
E13A1N	E.M.R. - Prof. W.E. Garner, University of Bristol - The preparation of alkyls and hydrides of light metals.	The work has been published. Nothing of immediate Service value was found.
E13A2B	Ignition: factors determining ignitability of cordites.	A report is in preparation.
E13B4C	Effect of temperature on adhesion of plastic propellants.	A report is being written.
E13B8B	E.M.R. - University of Birmingham - Thermal decomposition of inorganic perchlorates.	A second report has been received and the Contract has been closed.
E13B10D	Strength of crystals of solid ingredients of plastic propellants.	A report is in the press.
E13E7D	Stability of liquid hydrazine.	Reported.
E13E9D	E.M.R. - University of Manchester - Studies of the reactions of hydrazine and NH_2 radicals.	The work is being published. Nothing of immediate Service value was found.

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.
<u>G.W. ROCKET,</u> <u>TORPEDO, SUBMARINE</u> <u>& LPM PROPELLANTS:</u> <u>Other Research and</u> <u>Development.</u>	E.13	Cast Double Base Propellants.	E13D	Ingredients.	E13D8	Preparation and characterisa- tion of compounds for use in platonisation studies.	E13D8B		
<u>HIGH EXPLOSIVES:</u> <u>Post-Design Work</u> <u>for Services.</u>	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		
<u>FUZES & INITIATORS:</u> <u>Dated Work for</u> <u>Services.</u>	E.22	Caps, Electric, (30 mm. Aden).	E22B	Study of ingredients of compositions.	E22B1	Collaboration on production and specification of lead styphnate (R.D.1303). Development of process for barium styphnate manufacture.	E22B1C 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	

SUBJECT		PROJECT		SUB-PROJECT		SUB-PROJECT SUB -TITLE		PRIORITY	
Name	No.	Name	No.	Name	No.	Name	No.	Service	E.R.D.E.
<u>INITIATORS:</u>	E.22 (Cont.)	Delay Composi- tions for Fuzes and Detonators, 30 mm.	E22D	Study and development of compositions.	E22D1	(a) Barium styphnate types. (b) Lead dinitroresorcinate types. (c) Lead styphnate types.	E22D1A		
						(a) Pentaerythritol nitrate.	E22E1A		1

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 (Cont.)</u>	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 conditions 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 producing diethyl sulphate.			
						Calcium cyanamide synthesis: Studies of mechanism and kinetics: (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.	E4.5B2F		
							E4.5B2H		
				Nitrocellulose.	E4.5B3	Continuous disintegration and nitration of pulp board. Thermal degradation of nitrocellulose in solution.	E4.5B3A E4.5B3C		

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>	E.45	Propellant	E4.5B	Nitrocellulose (Cont.)	E4.5B3	Investigations on nitro-	E4.5B3F		

Explosives and Intermediates (Cont.)

Items Completed in 1953-54.

E20B1B	Laboratory studies of (a) icing, (b) control of grit 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.
E4.5B2A	<u>Thiocyanate route</u> : integration of stages CS ₂ to guanidine for assessment of prospects.	Completed. Further development awaits policy decisions.
E4.5B2E	Investigations on reactivity and availability of alkylating agents.	Completed.
E4.5B2G	Exploration of routes alternative to alkylation, e.g. sulphamic reaction.	Terminated. Theoretical and exploratory study not encouraging.
E4.5B3D	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).
E4.5B3B	Continuous centrifugal separation of spent acid from nitrocellulose.	Deferred awaiting progress on previous item.
E4.5B3G	Provision of nitrocellulose for rate-of-burning studies.	Inactive until requirements arise again.
E4.5B9A	Provision of guanidine derivatives for stability and user assessments.	Inactive until fresh requirements arise.

Name	No.	Notes	BI.3A	Notes	BI.3B	Notes
	E.13	General.				
Liquid Propell-			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.
						E13E9C
						E13E9D
						E.M.R. - Genatosan - Process

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>Other Research and</u> <u>Development (Cont.)</u>	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 recycling of spent liquor.	E17B1K				
						Spraying and drying pilot plants.	E17B1L				
						<u>Isouron Route:</u> Joint Programme with D.O.F. (X) - Pilot plant development of selected stages.	E17B1N				
						<u>Recovery of nitration spent acid:</u> Review. Vacuum concentration with separation of ammonium salt and improved yield of picrite.	E17B1P E17B1R		*		
<u>HIGH EXPLOSIVES:</u> <u>Post-Design Work</u> <u>for Services.</u>	E.20	R.D.X.	E2CB	Manufacture.	E2CB1	Small pilot plant with acid recirculation, separate fume-off and modified crystalliser.	E2CB1C		*		
						Purification.	E2CB2	Joint Programme with D.O.F. (X) - Continuous recrystallisation from cyclohexanone.	E2CB2B		*
								Pressure boiling.	E2CB2C		

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>	E.30	New Equipments.	E30A	Standard mobile oxygen plant.	E30A1	E.M.R. - B.O. Co. Ltd. - Development of prototype.	E30A1A	3	
				Mobile dissolved	E30A2	E.M.R. - B.O. Co. Ltd. -	E30A2A	3	

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.	E.45	Chemical Engineer- ing 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.	E4.5E7A		
				Studies on continuous reactors.	E4.5E8	Review of knowledge and forma- tion 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.	E4.5H2A		
						For other Establishments.	E4.5H2B		

Produced by ...
Corrosion of Platinum; Operation ...
Calcium cyanamide pilot plant; ...
R.D.X. Manufacture: Laboratory study on 'icing' of cooling surfaces.
" : Laboratory study of (a) icing, (b) control of ...
al similarity in analysis of processes.
Equipment for other Branches.
11-5. Items Deferred.

Lack of staff.
Deferred in favour of ...

still.