

W0195/11,074

SECRET/DISCREET

Copy No. 24

THIS PAPER IS FOR THE PERSONAL INFORMATION OF THE ADDRESSEE. ITS EXISTENCE AND CONTENTS MUST NOT BE DISCLOSED TO ANY OTHER PERSON WITHOUT THE PRIOR APPROVAL OF THE MINISTRY OF SUPPLY, (S.A.C.)

MINISTRY OF SUPPLY

A.C.11078
MCB.148
LFC.118
ManC.87
OrgC.70
PICC.115
XP.31
GEP.62

By Holmes
- 2 FEB 1952

ADVISORY COUNCIL ON SCIENTIFIC RESEARCH
AND TECHNICAL DEVELOPMENT
MUNITIONS CHEMISTRY ADVISORY BOARD
LIQUID FUELS COMMITTEE
MANUFACTURING DEVELOPMENT COMMITTEE
ORGANIC CHEMISTRY COMMITTEE
PHYSICAL AND INORGANIC CHEMISTRY COMMITTEE
CRYSTALLISATION PANEL

A.C.11078
MCB.148
LFC.118
ManC.87
OrgC.70
PICC.115
XP.31
GEP.62

GUN EROSION PANEL
OF THE
WEAPON RESEARCH COMMITTEE

Appendices to
Programme of Research for E.R.D.E. for 1950/51
Communicated by D.M.X.R.D.

MX2/5/2/1

Received 18th August, 1950.

SECRET/DISCREET

A.27624.

Programme of Research for E.R.D.E. for 1950/51

- Appendix A. List of Investigations
- Appendix B. List of Extra-mural Research and Development Contracts

MX2/5/2/1

COPY NO.

24

SECRET DISCREET

MINISTRY OF SUPPLY

DIRECTORATE OF MATERIALS AND EXPLOSIVES
RESEARCH AND DEVELOPMENT

EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT,
WALTHAM ABBEY

Programme of Research for E.R.D.E. for 1950/51

Appendix A. List of Investigations

Appendix B. List of Extra-mural Research and
Development Contracts

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A. LIST OF INVESTIGATIONS

Contents

<u>Part</u>		<u>Page</u>
I	Liquid systems for rockets and other low pressure mechanisms	2
II	Plastic propellants for rockets and other low pressure mechanisms	8
III	Other solid propellants for rockets and low pressure mechanisms	11
IV	Cordites for guns	15
V	Propellants for mortars	20
VI	Propellants for small arms	20
VII	Unorthodox propellant systems	21
VIII	High explosives	22
IX	Initiators	24
X	Materials	26
XI	Chemical engineering	29
XII	Safety investigations	31
XIII	Home Office investigations on industrial explosives	33
XIV	Home Office investigations on compressed hydrocarbons	35
XV	Urgent short-range investigations	37

"Staffing Position" abbreviations

- A - To be continuously staffed.
- B - To be intermittently staffed.
- C - Not to be staffed.

Other abbreviations

- C.I. No. - No. in Ministry of Supply
Classified Index of Research
and Development Effort.

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Proof-stand assessment.	1. Nitric acid with gasoline and "aromatic-free" kerosine.	A	To determine the effect of the chemical and physical properties of the fuel on combustion efficiency.
	2. Nitric acid with benzene, cyclohexane and cyclohexanol.	A	
	3. Mixed acid with kerosine.	A	U.S.A. assessing anhydrous hydrazine, liquid oxygen, liquid ammonia, fluorine, chlorine trifluoride and borohydrides.
	4. Nitric acid with liquid ammonia.	A	
	5. Minimum quantity of W.A.F.1 necessary to ignite non-self-igniting bipropellant.	A	Required by C.E.A.D.
	6. Ethyl nitrate as a monopropellant.	A	Canada assessing nitric acid/nitroparaffin and nitric acid/acetic anhydride. To assess the importance of the mixing process in the combustion chamber.
	7. Comparison of nitric acid/nitrobenzene as bipropellant and monopropellant (Dithekite).	A	
General Assessment.	Appraisalment of all factors, including economics, transport and supply.	A	In collaboration with A.D. Ann. P. (X).
	Chemical and physical properties of fuels and oxidants.	1. Determination of physical properties of monopropellants.	A
2. Thermal conductivity of liquid oxygen as a function of temperature and pressure.		A	

General Programme	Detailed Investigation	Staffing Position	Remarks
Properties of the rocket jet.	<ol style="list-style-type: none"> 1. Radio-attenuation: <ol style="list-style-type: none"> (a) Nitric acid/fuel systems - X band (3 cm.). (b) Fundamental study - K band (1.3 cm.) and Q band (0.8 cm.). 2. Flame-temperature measurement: <ol style="list-style-type: none"> (a) by line inversion; (b) by band intensities. 3. Spectroscopic survey of molecules and radicles in jet and combustion chamber. 4. Development of injection systems for Hydrogen/oxygen motor III. 	<p>A</p> <p>A</p> <p>A</p> <p>B</p> <p>C</p>	<p>Extensive work in U.S.A.</p> <p>E.M.R. contract with Armstrong Whitworth Aircraft Ltd.</p>
Heat transfer.	<ol style="list-style-type: none"> 1. Convictional and radiational heat transfer. 2. Spectroscopic measurement of radiation inside motor. 3. Calculation of emission intensity from products of combustion. 4. Study of boundary layer formation by interferometry. 	<p>A</p> <p>A</p> <p>A</p> <p>B</p>	<p>Delivery of interferometer is expected in 1950.</p>
Manufacture of fuels and oxidants.	<ol style="list-style-type: none"> 1. Possibility of a cheap, non-electrical method of manufacture of H.T.P. 2. Production of anhydrous hydrazine via hydrazine hydrate. 3. Reactions of NH₂ radicles in liquid ammonia: possible formation of hydrazine. 	<p>B</p> <p>A</p>	<p>Under consideration in U.S.A.</p> <p>U.S.A. investigating electrical methods for anhydrous hydrazine. Also work in Canada.</p> <p>E.M.R. contract with Prof. M.G. Evans, Manchester University.</p> <p>Work in Canada.</p>

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Stability, compatibility and storage of liquid propellants. (contd.) Safety in manufacture, handling and operational use. (See also Part XII)	10. Development of a protective vent for H.T.P. transit containers. 1. Sensitiveness of liquid systems to impact, friction and cavity effect. 2. Effect of temperature on detonability. 3. Development of protective devices. 4. Handling risks: (a) Nitric acid with self-igniting fuels, methanol and hydrocarbons. (b) Laboratory trials of nitric acid/liquid ammonia systems. 5. Safety of liquid systems under operational conditions.	A B C A A A	E.M.R. contract with Laporte Chemicals Ltd.; Luton. Required for fore-going Nigerian trials. No immediate work is foreseen. Report in preparation. In collaboration with D.N.O., D.N.C., O.B., R.P.D. etc.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
c) Rheology, cohesion and adhesion.	<ol style="list-style-type: none"> 1. Rheological properties of compositions and ingredients, and widening of temperature range. 2. Interpretation of rheological tests. 3. Cohesion of compositions. 4. Fundamental study of adhesion to metals. 5. Development of improved adhesives. 	<p>A</p> <p>A</p> <p>B</p>	<p>D.S.I.R. extramural research contract with Dr. C. Kemball, Cambridge University.</p> <p>E.M.R. contract with Dr. F.P. Bowden, Cambridge University.</p>
d) Ignition.	<p>Ignition of ammonium perchlorate compositions; effect of temperature.</p>	<p>A</p>	
e) Burning phenomena.	<ol style="list-style-type: none"> 1. Fundamental investigation. 2. Kinetics of thermal decomposition of ammonium perchlorate. 3. Kinetics of thermal decomposition of oxamide. 	<p>A</p>	<p>Expected to commence about August, 1950.</p> <p>E.M.R. contract with Dr. L.L. Bircumshaw, Birmingham University.</p> <p>E.M.R. contract with Dr. L.L. Bircumshaw, Birmingham University.</p>
f) Control of ballistics.	<ol style="list-style-type: none"> 1. Factors affecting ballistics of low-energy-binder compositions. 2. Factors affecting ballistics of P.I.B./Ammonium perchlorate compositions. 3. Clearance trials of composition R.D. 220f. 	<p>A</p> <p>A</p> <p>A</p>	<p>Co-ordinated by the Ordnance Board.</p>

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part III. Other Solid Propellants for Rockets and Low Pressure Mechanisms

Objective requirements: A. Research on cordite and cast propellants for rockets and other low pressure mechanisms so as to improve their performance, serviceability and manufacture and to adapt them to new demands.

C.I. No's. 7.9.3. 23.1. 23.2. 23.3. 23.4. 31.2.4.

B. Research on compressed propellants for low pressure mechanisms.

C.I. No. 24.6.2.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
I (a)	New compositions of higher performance index for rockets.	1. Improvement of F.478/148/K (cal.val.1200). 2. U.K. propellant for U.S. 3.5-in. H.E./A.T. rocket.	A A	
I (b)	New compositions for specific low pressure mechanisms.	1. Propellants for engine-starter cartridges. 2. Cool cordites for liquid expulsion. 3. Improved compressed propellant for liquid ejection.	A A	In collaboration with D. Arm.R.D., A.R.E., I.C.I.Ltd., Rolls Royce et al. For R.A.E./R.P.D. E.M.R. contract with I.C.I. Ltd., (Nobel Division).
I (c)	Control of rate of burning.	1. Effect of composition including source and treatment of nitrocellulose. 2. Pressure index; "platonising" ingredients. 3. Measurements of rate of burning in vented vessel and strand burner.	B A B	Active work in U.S.A.

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
(f) d.) Manufacturing operations. (Contd.)	3. Mechanics of rolling cordite: use of the new research rolling machine for:- (a) fundamental physical and rheological studies; (b) studies for the avoidance of fires during rolling; (c) studies of the effect of selected plasticisers on rate of gelatinisation 4. Fundamentals of die design. 5. Rheology of cordite dough. 6. Die design and extrusion problems for special shapes.	A B B B	Handled as requirements arise.
g.) Surface inhibition.	1. Service life of coated charges. 2. New and improved methods. 3. Interchange of ingredients between coating and basis material; isotony.	B C B	Carried out as required.
h.) Chemical and ballistic stability.	1. Chemical stability and Service life of new compositions. 2. Problems connected with large web-sizes: (a) study of self-heating; (b) reduction of gas evolution and cracking on storage, in particular study of the effect of stabilisers alternative to carbamite. 3. Study of stability and decomposition of nitrocellulose and other nitric esters.	A B B	Carried out as required. E.M.R. contracts with Dr. J.W. Baker, Leeds University, Prof. A.J. Allmand, London University and Dr. S.M. Neale, Manchester College of Technology.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

PART IV. Cordites for guns

Objective Requirements: Research on cordites for guns with particular reference to:-

- (i) reduction of gun-erosion,
- (ii) increase of energy/volume ratio,
- (iii) elimination of flash and/or smoke on firing,
- (iv) improvement of the regularity and stability of ballistics,
- (v) increase of safety in manufacture and use.

C.I. Nos. 11.9. 21.10.9. 25.16. 31.2.4.

General Programme	Detailed Investigations	Staffing Position	Remarks
) Reduction of gun-erosion and development of propellants of maximum force/flame temperature and energy/volume ratios.	1. Relation between flame temperature, gas composition and erosion. 2. Formulation for maximum force/flame temperature and high energy/volume ratios. 3. Effect of free radicles.	A A	Trials carried out in collaboration with A.R.E. Confirmatory trials in collaboration with U.S.A. E.M.R. contract with Prof. A.R. Utbelohde, Queen's University, Belfast.
) Suppression of flash and smoke.	1. Optimum composition for tank guns. 2. Compositions of high nitrogen content. 3. Effect of primers and igniters: venting position in cartridge. 4. Influence of "Trident" flash suppressor on propellant formulation.	A B B A	
) Ignition.	1. Ignition of cool propellants. 2. Means of obtaining a smooth pressure/time relation in burning of cartridges.	A B	In collaboration with A.R.E.; particularly in Q.F. cartridges. In collaboration with A.R.E.

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
(g) Chemical and ballistic stability.	<ol style="list-style-type: none"> 1. Climatic-chemical trials to establish safe life of cordites. 2. Climatic-ballistic trials to establish regularity life. 3. Investigation of factors causing changes in ballistics. 4. Changes in the amount and distribution of volatiles in sealed and unsealed containers. 5. Stability and decomposition of nitro-cellulose and other nitric esters. 	<p>A</p> <p>A</p> <p>A</p> <p>B</p> <p>B</p>	<p>Will include trials of Australian cordites made from mechanically-nitrated wood cellulose, and cordites from N/C programmes.</p> <p>In collaboration with C.S.R. & A.R.E.</p> <p>In collaboration with C.S.R. & A.R.E.</p> <p>E.M.R. contracts with Dr. J.W. Baker, Leeds University, Prof. A.J. Allmand, London University and Dr. S.M. Neale, Manchester College of Technology.</p>
<p>h) Safety in manufacture and use.</p> <p>(See also Part XII)</p>	<ol style="list-style-type: none"> 1. Testing of new compositions and new processes to ensure insensitiveness to impact, friction etc. during both manufacture and use. 2. Reduction of liability to cordite fires in tanks. 3. "Habitability" trials of cordite containing DEGN. 	<p>B</p> <p>A</p> <p>A</p>	<p>Carried out as required.</p> <p>In collaboration with F.V.D.E.</p> <p>In collaboration with Admiralty and M.R.C.</p>
<p>i) Manufacture and manufacturing technique.</p>	<ol style="list-style-type: none"> 1. Manufacture of new compositions, especially cool cordites, and assessment of new and modified ingredients of cordite (alternatives to nitroglycerine, alternative high-nitrogen compounds, picrite). 	<p>A</p>	

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Manufacture of constituent materials. (contd.) Standardisation of propellant charges for guns.	4. Modification of crystal form of picrite. 1. Picrite-based cordite charges for guns for which they are not already available. 2. Interchangeability of picrite-based cordites from Naval and M.O.S. factories. 3. Standardisation with Canada, France and Holland on Naval gun-propellants.	B A A A	Work in hand in U.S.A. In collaboration with O.B., C.S.R. and C.S.A.R. In collaboration with O.B., C.S.R. and C.S.A.R. In collaboration with D.N.O., C.S.A.R. and C.I.N.O.
Analysis, calorimetry and general chemistry.	1. Analytical, calorimetric and chemical services. 2. Climatic trials (see also IV (g) 1 and 2). 3. Calorimetry of cool cordites.	A A A	As required.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part VII. Unorthodox Propellant Systems

Objective Requirement: Research on unorthodox propellant systems for use in rockets, guns, mortars etc.

C.I. No. 21.10.9

General Programme	Detailed Investigations	Staffing Position	Remarks
The application of liquid propellants to guns.	<ol style="list-style-type: none">1. Theoretical assessment of possible systems.2. Ignition and combustion problems.	A B	In collaboration with C.E.A.D. as problems arise. Work in hand in U.S.A.
The application to guns of plastic propellants extruded "in situ".	Trials of external extrusion apparatus for inserting a plastic charge in the breech of a gun.	B	In collaboration with A.D.E. A.D.E. is constructing apparatus for the purpose, and E.R.D.E. will supply suitable plastic compositions when the gun is ready for trial and collaborate on safety aspects of design.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
f) X-ray crystallography.	<ol style="list-style-type: none">1. Possible relationship between crystal structure and sensitiveness of styphnates.2. Variation with temperature of crystal properties of styphnates.	A A	
g) Crystallisation studies.	Fundamental theory of nucleation.		E.M.R. contract with Dr. W.J. Dunning, Bristol University.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
(b) contd.)	Protective materials - special lacquers, varnishes, coatings and paints. (contd.)	3. General: Use of corrosion - inhibiting adjuncts in varnishes and paints of all types; study of the mechanism of corrosion inhibition.	C	
(c)	Paper and textile components.	1. Reinforcement of rolled-paper components. 2. Alternative materials for B.L. cartridge bags.	B B	In collaboration with Industry and Inter-Services Packaging Panel.
(d)	Compatibility problems.	1. Chemical and physical compatibilities of materials intended for contact with, and proximity to, explosives. 2. Corrosion of metals by concentrated nitric acid: (i) corrosion of high strength aluminium alloys by phosphoric-inhibited nitric acid; (ii) closed vessel storage tests; (iii) corrosion-resistant welds in aluminium-magnesium alloys; (iv) assessment of platings on stainless steel for small parts; (v) inhibitors other than phosphoric acid.	B A	In connection with guided weapons. Possible E.M.R. contract with B.N.F.M.R.A.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part XI. Chemical Engineering

- Objective Requirements: A. Research on chemical engineering problems in connection with the manufacture of acids, intermediates, explosives and propellants.
- C.I. No's. 7.9.3 21.10.9. 24.6.2. 31.2.1. 31.2.2.
- B. Oxygen- and nitrogen-producing plant: (apart from breathing equipment) for the Services.
- C.I. No's. 10.3.3. 24.6.2. 31.3.3.

	General Programme	Detailed Investigations	Staffing Position	Remarks
(a)	Basic chemical engineering research in connection with explosives and propellants plant.	1. Study of plastic flow in presses and extrusion plant: (i) resistance to flow at metal surfaces; (ii) application of theory of plastic flow to the design of machines. 2. Application of dimensional similarity to the analysis of performance in unit processes.	A A	
(b)	Pilot plant design and construction.	Pilot plants for picrite manufacturing processes.	A	
(c)	Development of oxygen-producing plant.	1. Mobile liquid oxygen plant for supplying rocket installations. 2. "Air-transportable" oxygen plant. 3. "On site" glider-transportable oxygen plant.	A A A	E.M.R. contract with British Oxygen Co., Ltd. for a basic design. Air Ministry contract S.B.61767/C.B.39b with British Oxygen Co., Ltd. for prototype. E.M.R. contract with Ricardo and Co., Ltd., for a prototype.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part XII. Safety Investigations

Objective Requirement: Research to increase the safety of explosives and propellants in manufacture and use.

C.I. No. 31.2.4.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
(a)	Examination of safety aspects of new propellants and explosives, of new processes of manufacture and of explosive systems under operational conditions.	See items no's. I(1), II(j), III(i), IV(h), IX(e).	A	Carried out as required in collaboration with the other internal groups concerned with the materials and processes, and with the O.B. etc. in relation to operational conditions
(b)	Fundamental studies of the sensitiveness of explosives and propellants.	<ol style="list-style-type: none"> 1. Physical and chemical factors involved in initiation by friction, heat and impact. 2. Initiation by adiabatic compression: cavity sensitiveness in large volumes of liquid. 3. Correlation between rifle bullet tests and other methods of testing the ease of initiation and propagation. 4. Elucidation of the essential factors involved in the phlegmatisation of explosives. 5. Low-melting alloys to prevent initiation by friction. 	<p>A</p> <p>A</p> <p>A</p> <p>B</p> <p>A</p>	<p>Also E.M.R. contract with Dr. F.P. Bowden, Cambridge University.</p>
(c)	Electrical and radiation hazards.	<ol style="list-style-type: none"> 1. Electrostatic: <ol style="list-style-type: none"> (i) sensitiveness of explosives to electrostatic discharges, particularly 	A	

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51APPENDIX APart XIII. Home Office Investigations on Industrial Explosives

Objective Requirements: Research and investigation in connection with explosives submitted by H.M. Chief Inspector of Explosives, including development of methods of examination and assessment.

C.I. No's. 31.2.1. 31.2.4.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
XIII (a)	Industrial Explosives.	1. Control of manufacturers.) 2. Suitability and classification of new compositions.) 3. Definition of new permitted explosives.) 4. Examination of materials from explosives accidents and coal-mine explosions.) 5. Customs importations.)	A	Carried out as required.
XIII (b)	Legal aspects.	1. Examination of samples submitted in connection with offences against the Explosives Acts. 2. Examination of materials submitted in connection with police prosecutions.	A A	Carried out as required. Carried out as required.
XIII (c)	Stability methods.	Investigation into reliability of new methods for estimating stability figure as applied to industrial explosive compositions.	A	(i) "A" staffing dependent on supply of suitable staff in 1950. (ii) Continuation of previous work, in particular the assessment of the "Sealed Tube Method".

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part XIV. Home Office Investigations on Compressed Hydrocarbons

Objective Requirements: Research to develop safety methods applicable to plant and equipment used for chemical synthesis and metallurgical processes both at normal industrial and at high pressures.
Investigation of the causes of explosions in industrial equipment.

C.I. No. 31.2.4.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
IV (a)	High pressure acetylene: safety requirements.	Explosion characteristics following ignition of acetylene with other reactants at pressures up to 21 atms. abs., involving measurements of peak explosion pressures and velocities of detonation.	A	(i) "A" staffing dependent on supply of suitable staff and apparatus in 1950. (ii) Effect of addition of specified reactants over range of temperature to 250°C - carried out in special high-pressure vessel in course of construction. (iii) Explosive effect in steel tubes housed in special explosion tunnel also under consideration.
V (b)	Welding gases: design of safety apparatus.	1. Measurement of peak explosion pressures.) 2. Measurement of velocities of detonation.)	A	(i) "A" staffing dependent on supply of suitable staff in 1950. (ii) Mixtures with oxygen and air to be investigated over explosive range.
V (c)	Dissolved-acetylene cylinders: safety in use.	1. Investigation on process of acetylene decomposition within cylinder. 2. Shock sensitiveness of acetylene in D.A. cylinders.	A A	Continuation of previous work in specially-designed high-pressure vessel on porous-mass fillings for dissolved-acetylene cylinders. "A" staffing dependent on supply of suitable staff in 1950.
V (d)	Explosions in industrial acetylene plant.	Elucidation of causes.	A	Carried out as required.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part XV. Urgent Short-range Investigations

Objective Requirement: Investigations of a short-term nature required when serious difficulties occurring with explosives or ammunition are reported direct to the Establishment for immediate ameliorating action.

To be carried out as required.

APPENDIX-B

Extra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

File Reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
Chem/58	Physico-chemical problems	(a) Decomposition of acetylene (b) Fundamental theory of nucleation (c) Constitution and synthesis of lecithin (d) Thermal decomposition and vapour-phase burning of liquid explosives, including nitric esters.	Bristol University	Prof. W.E. Garner	Mr. J.S. Skelton Mr. G.W.C. Taylor Dr. E. Roberts Mr. L.A. Wiseman Mr. G.K. Adams	
Chem/12 Chem/12	Crystallographic work on explosives	(a) Crystal structure studies on high explosives such as RDX (b) Investigations on the anomalous thermal properties of TNT at temperatures near the melting point.	Birmingham University	Dr. L.W.H. Small	Mr. J.R.C. Duke	
Explosives/4	Kinetics of nitration (nitroguanidine reaction)	Fundamental physico-chemical research on the kinetics of nitration reactions.	Royal Holloway College	Prof. Gwyn Williams	Dr. E. Roberts	
Chem/73	Mechanism of stabilisation of nitrocellulose	Study by electro-kinetic methods of the sulphuric component of nitrocellulose in relation to the chemistry of stabilisation.	College of Technology, Manchester	Dr. S.M. Neale	Dr. L.H. Gerty	

APPENDIX B

Extra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

File Reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
Chem/18	Photolysis of nitric esters and nitro bodies	Elucidation of the structural changes occurring in the thermal decomposition of organic polynitrates.	King's College, London University	Prof. A.J. Allmand	Mr. L.A. Wiseman	
Chem/562	Research on hydrogen peroxide	(a) Stability problems. (b) Vent for aluminium transit containers for H.T.P.	Laporte Chemicals Ltd., Luton	-	Dr. K.A. Cooper	
Chem/21	Free radicles in the attack of metal surfaces	Investigation of the influence of appreciable concentrations of free radicles in the ambient gases in chemical attack on metal surfaces.	Queen's University, Belfast	Prof. A.R. Ubbelohde	Mr. E.G. Lewis	
Plant & eq./3711	Mobile liquid oxygen producing plant for rocket propulsion	Advising on the design of a plant to yield oxygen in sufficient quantities for the demands of aircraft rocket motors and projectiles	British Oxygen Co. Ltd., Morden	-	Dr. G.A. Knight	
/Explve/1	Propellant loads for .27, .28 and .30 ammunition	Research leading to the development of ballistically suitable granular powders for the .27, .28 and .30-inch weapons.	I.C.I. Ltd., (Nobel Div.), Ardeer	-	Mr. K.W. Jones	

SECRET
APPENDIX B

Extra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

File Reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
7/Chem/97	Thermochemistry and kinetics of decomposition of metal alkyls and hydrides	Thermochemistry and energetics of reactions leading to the formation of free radicals and metastable molecules.	Manchester University	Prof. M.G. Evans	Mr. G.K. Adams	
8/Exptl/392	Mobile oxygen-producing plant, 140 cu.ft. per hour	To design, develop and produce one prototype mobile oxygen-producing plant for "on site" generation of oxygen for oxy-welding and cutting.	Ricardo & Co., Ltd., Shoreham-by-Sea	-	Dr. G.A. Knight	
7/Exptl/308	The preparation of labile molecules	Exploration of the possibility of preparing and isolating labile molecules and radioles.	Liverpool University	Prof. C.E.H. Bawn	Mr. L.A. Wiseman Mr. G.K. Adams	
7/Chem/96	The conversion of hydrogen sulphide into carbon disulphide	Investigation of the conversion of hydrogen sulphide to carbon disulphide by the action of carbon dioxide.	University College, Swansea	Prof. C.W. Shoppee	Dr. T.M. Walters	

38G



3
E

1072

7931554

WO 195/11074

Return by (21/02/2013 11:04:20)

8278188 (Peter Blake)

Closure status: Open

S

10/01/2013 11:04:20



PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part I. Liquid Systems for Rockets and other Low Pressure Mechanisms

Objective Requirements: A. Research on the chemistry and operational safety of liquid systems for the production of gas for rocket-propulsion, including their performance and the effect of design factors thereon.

C.I. No's. 7.9.3 24.6.2 31.2.4

B. Research on the chemistry of HTP for special types of ship-propulsion.

C.I. No. 7.9.2

C. Research on the chemistry of liquid systems for the production of gas for mine-clearance by jets, for pressure-operated devices and for other purposes.

C.I. No. 27.2.5

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
I (a)	Theoretical assessment.	<ol style="list-style-type: none"> 1. Metals as fuels. 2. Thermodynamic properties of compounds of fluorine. 3. Chlorine trifluoride as an oxidant. 4. Molecular structure and energetics of organic compounds. 5. High-energy compounds. 6. Possibility of preparing labile molecules. 7. High-temperature properties of oxides, nitrides and carbides. 	<p>A</p> <p>A</p> <p>A</p>	<p>Completion of report.</p> <p>An intensive theoretical study of potential liquid propellants is in hand in U.S.A.</p> <p>E.M.R. contract with Dr. A. D. Springall, Manchester University.</p> <p>E.M.R. contract with Prof. M. G. Evans, Manchester University.</p> <p>E.M.R. contract with Prof. C. E. H. Bawn, Liverpool University.</p>

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Item No.	General Programme	Detailed Investigation	Staffing Position	Remarks
I (d) (contd.)	Chemical and physical properties of fuels and oxidants. (contd.)	3. Viscosity of liquid oxygen. 4. Physico-chemical properties of concentrated hydrogen peroxide. 5. Physical properties of hydrazine and of mixtures containing hydrazine.	B B	E.M.R. contract with Prof. W.F. Jones, Durham University. To be measured as required.
I (e)	Ignition.	1. Nitric acid/kerosine. 2. Ignition of propyl nitrate by spark. 3. Ignition of self-igniting pairs. 4. Effect of atmospheric temperature and pressure. 5. Ignition for intermittent operation. 6. Fundamental study of "blow-plug" system. 7. Mechanism of spark ignition.	A A B A B B	Low priority. E.M.R. contract with Prof. J.M. Liverpool University.
I (f)	Combustion and kinetics.	1. Decomposition of nitric acid vapour. 2. Rate of burning of mixtures of nitric oxide, carbon monoxide and hydrogen. 3. Rate of burning of liquid monopropellants. 4. Rate of burning of vapours of monopropellants, alone and with diluents. 5. Thermal decomposition and vapour-phase burning of liquid explosives. 6. Behaviour of organic fluorine compounds in combustion processes.	A A A A A	Complementary to I(b) 1,2,3,4 E.M.R. contract with Dr. F.H. Bristol University.

SECRET DISCREETPROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51APPENDIX A

Item No.	General Programme	Detailed Investigation	Staffing Position	Remarks
(i) (contd.)	Manufacture of fuels and oxidants (contd.)	4. Mobile plant for production of liquid oxygen for rocket propulsion.	A	E.M.R. contracts with the British Oxygen Co.Ltd., Morden, and Power Jets, Ltd.
(j)	Decomposers for H.T.P.	1. Catalyst stones: cement-based. 2. Metallic catalysts. 3. Theoretical treatment of the chemistry and physics of decomposers. 4. Possibility of developing a thermal decomposer.	A A B B	Liaison with D.A.E.R., Admiralty on porous porcelain-based stones. This theoretical exploration will be abandoned if it fails to show promise.
(k)	Stability, compatibility and storage of liquid propellants.	1. Climatic trial of W.A.F.1. 2. Determination of limiting contamination of hydrogen peroxide consistent with subsequent recovery. 3. Effect of pH, metallic ions and stabilisers on stability of H.T.P. 4. Stability of gaseous and liquid hydrazine. 5. Compatibility of liquid propellants and container materials. 6. Selection of plastic material for H.T.P. bags. 7. Suitability of erosion-reducing additives to fuels. 8. Propellant systems suitable for the temperature ranges specified by the Services. 9. Tropical bulk-storage trial of H.T.P.	A A A C B A A	Required by C.E.A.D. E.M.R. contract with Laporte Chemicals Ltd., Luton. Work in U.S.A. Liaison with Dr. E.J. Bowen, Oxford University, re gaseous hydrazine. Work in U.S.A. Specific requirement awaited from D.G.W.R.D. As required by D.G.W.R.D. Also trials in Nigeria by T.T.E.

SECRET DISCREET

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Part II. Plastic Propellants for Rockets and other low Pressure Mechanisms

Objective Requirements: Research on plastic propellant compositions, including methods of manufacture and filling, assessment of performance and influence of physical conditions on performance.

C.I. No's. 7.9.3. 23.4. 24.6.2. 31.2.4.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
(a)	New compositions of high performance and of wide operating temperature range.	1. Development of compositions with polyisobutylene binders.	A	U.S.A. are working on compositions based on polysulphide-rubber and thermo-setting binders and on nitropolymers. E.M.R. contract with Dr. Malkin, Bristol University E.M.R. contract under consideration.
(b)	Ingredients.	2. Development of compositions based on oxidants alternative to perchlorates.	B	
		3. Reduction of flame temperature without adverse effect on Force Constant.	C	
		4. "Platonised" compositions.	B	
		1. Viscosity of binders.	A	
		2. Control of form and grist-distribution of crystalline ingredients.	A	
		3. Constitution of lecithin.		
		4. Possible substitute for lecithin.		
	5. Economic survey of methods of manufacture of ammonium perchlorate.	A		
	6. Survey of methods of manufacture of oxamide.	A		
	7. Structure of oxamide by means of X-ray crystallography.	A		
	8. Survey of supply position of binders.	B		

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
II (g)	Suppression of flash and smoke.	1. Spectrographic examination of exhaust flames. 2. R.D.X. plastic propellants.	C C	
II (h)	Manufacture and filling.	1. Plant experimentation and development of manufacturing and filling techniques. 2. Manufacture of compositions and filling of experimental rounds for D.G.W.R.D., R.P.D., A.R.E., etc. 3. Liaison in connection with transfer of manufacture of sodium nitrate compositions to D.O.F.(X). 4. Methods of testing filled rounds.	A A A B	
II (i)	Stability, compatibility and storage.	1. Climatic storage and temperature cycling of P.I.B. propellants. 2. Compatibility problems.	A A	
I (j)	Sensitiveness and safety aspects. (See also Part XIII)	1. Sensitiveness examination at all stages of manufacture. 2. Sensitiveness of compositions to impact and friction. 3. Safety of filling under operational conditions.	B B B	As required. As required. As required.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Control of rate of burning. (contd)	4. Maintenance of rate of burning at low pressures; effect of special ingredients.	C	Work in hand in U.S.A.
Improvement of mechanical properties and widening of operating temperature range.	1. Effect of composition on mechanical properties and on their temperature dependence. 2. Assessment of P.V.N. as a constituent.	B A	Also work in Canada.
Methods of producing charges of large diameter.	1. Double-base casting method. (a) Composition and shape of casting materials. (b) Composition of casting solvents. (c) Composition of restrictive containers. (d) Techniques of fabrication of containers and charges. (e) Behaviour of charges. 2. Direct extrusion; factors affecting consolidation and methods of improving consolidation. 3. Methods of building up charges from segments, discs etc.	A A A	Adaptation of U.S. process to suit U.K. conditions. This work is mainly for D.G.W.R.D., and to some extent for R.A.E./R.P.D. and D.Eng.R.D.
Manufacturing operations.	1. Continuous dewatering of cordite paste. 2. Screw-extrusion for gelatinisation and pressing.	C C	Awaiting arrival of plant from Germany.

PROGRAMME OF RESEARCH FOR E.R.D.E. for 1950/51

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
1) Sensitiveness and immunity from risk of detonation. (See also Part XII)	1. Testing of new compositions and new processes to ensure acceptable insensitiveness to impact, friction etc., during both manufacture and use. 2. Study of attack by small arms and fragments.	B B	Carried out as required. Carried out as required in collaboration with O.B. etc.
2) Manufacture of constituent materials.	1. More economical methods of manufacturing nitrocellulose. (a) Continuous nitration of wood cellulose. (b) Manufacturing-scale trials of pulp-boiling. 2. Manufacturing-scale trials of wood cellulose from alternative sources.	B A A	Work on various aspects of nitrocellulose in hand in Canada. Australia is investigating mechanical nitration. In collaboration with O.B. and D.O.F.(X). Also in hand in Australia.
3) Analysis, calorimetry and general chemistry.	1. Analytical, calorimetric and general chemical services. 2. Climatic trials, in particular of cordite made in Australia and cordites from the N/C programmes.	A A	As required. In parallel with ballistic trials by A.R.E.

SECRET DISCREET

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

Page No.16

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Ignition.(contd.)	<ol style="list-style-type: none">3. Specification of gunpowder for efficient ignition of gun cordite.4. Improved alternatives to gunpowder.5. Development of cordite-walled igniters.6. Development of smokeless primers.7. Fundamental studies of ignition.	A B A C C	In collaboration with A.R.E., O.B., I.C.I. etc. Work in U.S.A.
Factors controlling rate of burning.	<ol style="list-style-type: none">1. Ballistic trials of a range of cordites made from picrite of various grists.2. Surface-moderation.3. Behaviour on burning: tests in the Closed Vessel, Partial Burner and Strand Burner.4. Substitutes for carbamate which do not form a complex with picrite.	A C B A	In collaboration with C.S.R. & A.R.E. Apparatus being constructed and installed. Extensive work in progress in U.S.A. on the mechanism of burning, and in Canada on R.D.X. cordites. E.M.R. contract with Prof. W.E. Garner, Bristol University.
Reduction of temperature coefficient of ballistics.	<ol style="list-style-type: none">1. Basic study of erosion of cordites.2. Cordite erosion as a factor in the temperature coefficient of ballistics.	C C	In collaboration with A.R.E.
Ballistic regularity.	<ol style="list-style-type: none">1. Elucidation of reasons for variation of A.C.W. during bulk-production.2. Effect of settling level of granular propellants.	A A	In collaboration with C.S.A.R. & A.R.E.

PROGRAMME OF RESEARCH FOR E. R. D. E. FOR 1950/51

APPENDIX A

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
(i) td.)	Manufacture and manufacturing technique. (Contd.)	2. New processes of manufacture. 3. Mechanics of rolling cordite. (See also III (f)3). 4. Fundamentals of die design and rheology of cordite doughs. (See also III(f)4 and 5). 5. Improvement of loadability of cordite.	C B B B	
(j)	Manufacture of constituent materials.	1. More economical methods of manufacturing nitrocellulose: (a) Continuous nitration of wood cellulose. (b) Manufacturing-scale trials of pulp-boiling. 2. Manufacturing-scale trials of wood cellulose from alternative sources. 3. Processes for manufacture of picrite: (a) Direct fusion of nitrolim with ammonium nitrate: (i) safety studies; (ii) 100 lb./hr. pilot plant. (b) CO/NH ₃ /CaO process for cyanamide: (i) basic studies; (ii) 25 lb./hr. pilot plant. (c) Ammonium thiocyanate process: (i) study of efficiencies; (ii) conversion of H ₂ S to CS ₂ -thermodynamics; (iii) conversion of H ₂ S to CS ₂ by the action of CO ₂ . (d) Nitration of guanidine. (e) Development of continuous methods of drying and grinding picrite.	B A A A A A A A A	Work on various aspects of nitrocellulose in hand in Canada. Australia is investigating mechanical nitration. In collaboration with O.B. and D.O.F. (X). Also in hand in Australia. Urea/ammonium sulphamate process being investigated in U.S.A. Other processes are being investigated in Canada. E.M.R. contract with Prof. D.M. Newitt, London University. E.M.R. contract with Prof. C.W. Shoppee, Swansea University College.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51APPENDIX APart VIII. High Explosives

Objective Requirements: A. Research on the synthesis and manufacture of high explosives and of intermediates used in their preparation.

C.I. No's. 31.2.2. 31.2.4.

B. Research to devise explosives for stranded line charges for minefield clearance.

C.I. No. 27.2.5.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
II (a)	Manufacturing processes for high explosives and ingredients.	1. Continuous nitration of T.N.T.: (i) increased safety in manufacture and application: avoidance of "white compound"; (ii) increased purity of product in order to obtain compatibility with P.E.T.N.; (iii) improvement of manufacturing economics. 2. Fine R.D.X. for Nipolit and other purposes.	A B B A	Assistance to D.O.F.(X) in a jointly-agreed programme of investigations.
II (b)	Synthesis of new explosives.			No work is in hand in the U.K., but extensive investigations are proceeding in U.S.A. and Canada.
II (c)	Study of kinetics of nitration reactions.			E.M.R. contract with Prof. G. Williams, Royal Holloway College; work is now proceeding on nitroguanidine.

APPENDIX A

Part IX. Initiators

Objective Requirement: Research on the synthesis and manufacture of initiators for use in detonators, caps and delay systems.

C.I. No. 22.8

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
IX (a)	Lead azide substitutes compatible with copper.	Silver azide: (a) development of the Woolwich process of manufacture; (b) fundamental study of the Chorley process; (c) possibility of a continuous process of manufacture.	A A B	In collaboration with D.O.F. (X) and C.S.A.R.
IX (b)	Additives to control properties.	Modification of crystal form of beta lead styphnate.	A	
IX (c)	Stability.	1. Kinetic studies of thermal decomposition of initiators. 2. Chemical stability of silver azide and mercury fulminate. 3. Climatic trials to determine the Service life of detonators.	C A A	
IX (d)	Compatibility.	1. Compatibility with explosive and non-explosive materials. 2. Azide problems.	A A	
IX (e)	Sensitiveness and safety.	Safety aspects of solutions of silver salts in ammonia (in connection with manufacture of silver azide).	A	

PROGRAMME OF RESEARCH FOR E.R.D.F. FOR 1950/51APPENDIX APart X. Materials

Objective Requirement: The application of materials of fabrication, sealing and protection in explosive munitions.

C.I. No's. 7.13. 21.10.11. 22.7. 22.8 30.9. 31.2.4. 31.3.

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
(a)	Sealing Materials - lutings, cements etc.	1. Lutings: Development of compositions retaining plasticity over increased temperature ranges. 2. Cements: Development of improved solventless, self-setting cements.	B B	Solvent cements dry to porous masses, generally slightly permeable to moisture.
X (b)	Protective materials - special lacquers, varnishes, coatings and paints.	1. Lacquers and coatings: (i) Development of inert, highly moisture-impermeable lacquers, particularly for use on azide-filled detonators. (ii) Enamel coatings for heat insulation in Q.F. cartridge cases. 2. Varnishes: Development of highly resistant varnishes from materials other than tung oil.	A B	Recent difficulties in handling corroded fuzes have been ascribed to the formation of copper azide by access of moisture and consequent liberation of hydrazoic acid from lead azide, particularly in presence of shellac. An improved lacquer, based on a stable, inert, filmforming material dissolved in strongly hydrophobic solvents, is an urgent requirement.

APPENDIX A

General Programme	Detailed Investigations	Staffing Position	Remarks
Development of oxygen-producing plant (contd.) Research on oxygen-producing plants for Service use.	4. Standard mobile oxygen and nitrogen plant. 1. Fractionating-column packings to give compact air-separation units. 2. Assessment of Piazza column as an air-separation unit. 3. Effect of altitude on compressor performance.	 A A A	W.O. and A.M. requirement not yet placed.

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51

APPENDIX A

	General Programme	Detailed Investigations	Staffing Position	Remarks
c) d.)	Electrical and radiation hazards. (contd.)	<ol style="list-style-type: none">1. Electrostatic: (contd) silver azide and beta lead styphnate; (ii) measurement of charges developed in handling explosives.2. Effect of radio transmitters and gamma radiation.3. Effect of thunderstorms, particularly as regards nitroglycerine wash-houses.	A C C	In collaboration with O.B., A.R.E. etc.
i)	Detonability.	<ol style="list-style-type: none">1. Effect of charge diameter and confinement on velocity of detonation.2. Mechanism of "low-order detonation".	A A	

PROGRAMME OF RESEARCH FOR E.R.D.E. FOR 1950/51APPENDIX A

Item No.	General Programme	Detailed Investigations	Staffing Position	Remarks
XIV (e)	Legal Aspects.	<ol style="list-style-type: none"> 1. Control of manufacturers. 2. (a) Explosions in industrial plant. (b) Examination of samples submitted in connection with offences under the Explosives Acts. 	A	Carried out as required.
XIV(f)	Industrial processes using compressed hydrocarbons.	Assessment of industrial plant and safety apparatus.	A	Carried out as required.

APPENDIX BExtra-mural Research and Development Contracts Relating to the work of the Explosives Research and Development Establishment

Contract No.	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
16	Methods of synthesis and structural factors influencing the properties of nitramines	A study of the decomposition of primary nitramines in alkaline solution and of synthetic approaches for primary nitramines.	Sheffield University	Prof. R.D. Haworth	Dr. T.M. Walters	
60	Thermal decomposition of inorganic perchlorates	A study of the thermal reactions occurring during the burning of plastic propellants containing inorganic perchlorates.	Birmingham University	Dr. L.L. Bircunshaw	Mr. G.K. Adams	
59	Physico-chemical properties of concentrated hydrogen peroxide	Investigation of some physical, electrical and magnetic properties of concentrated hydrogen peroxide.	King's College, Durham University	Prof. W.F.K. Wynne-Jones	Dr. K.A. Cooper	
14	Effects of structure on the stability of organic nitrates	A study of the effects of structural and environmental features on the mechanism and the velocity of hydrolysis of organic nitrates in homogeneous media.	Leeds University	Dr. J.W. Baker	Dr. A. Warren Mr. L.F. Jones	

APPENDIX B

Extra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

Reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
ve/22	Granular powders for 30 m.m. and 20/30 m.m. aircraft guns	Devising ballistically suitable granular powders for the propellant loads of the 30 m.m. and 20/30 m.m. aircraft guns.	I.C.I. Ltd., (Nobel Div.), Ardeer	-	Mr. K.W. Jones	
ve/23	Molecular structure and energetics investigation	Investigation of the molecular structure and molecular energetics of certain organic compounds, including nitro-compounds, fluorinated hydrocarbons, metallic alkyls and hydrazine derivatives.	Manchester University	Dr. A.D. Springall	Mr. L.A. Wiseman Dr. B.G. Cavanagh	
n/25	Oxygen production	Development of ancillary items. Consultation and design of equipment.	Power Jets (R & D) Ltd., London	-	Dr. G.A. Knight	
n/27	Fundamental problems in adhesion	To make a fundamental study of adhesion to metals.	Cambridge University	Dr. C. Kemball	Mr. P.R. Freeman	Controlled by D.S.I.R.
n/87	Fundamental factors affecting adhesion	Development of improved adhesives for Service purposes.	Cambridge University	Dr. F.P. Bowden	Mr. P.R. Freeman Dr. J. Gooding	

APPENDIX BExtra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

File Reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
7/Expl/30	Spark ignition in gases and liquids	Development of an optical technique for studying after-effects of electric sparks which provides repeated exposures at intervals of 10^{-4} to 10^{-5} seconds. Study of the behaviour of the hot gases produced by the spark as a function of time.	Liverpool University	Prof. J.M. Meek	Mr. L.A. Wiseman	
7/Exptl/303	Development of new injection systems for research on L.F. rocket motors	Development of injection systems for Hydrogen-oxygen Motor III.	Armstrong Whitworth Aircraft Ltd., Coventry.	-	Dr. G.H. Young	
7/Chem/98	Studies of the reactions of hydrazine and NH_2 radicles in liquid ammonia	A quantitative study of the energetics of reactions involving hydrazine and NH_2 radicles, and a study of the conditions for combination of NH_2 radicles in liquid ammonia and the possible formation of hydrazine.	Manchester University	Prof. M.G. Evans	Dr. K.A. Cooper	

APPENDIX BExtra-mural Research and Development Contracts relating to the work of the Explosives Research and Development Establishment

File reference	Title	Subject	Location	Supervisor	E.R.D.E. Representative	Remarks
7/Chem/100	Thermal decomposition of crystalline non-ionic compounds of interest in the explosives field	1. Oxamide.	Birmingham University	Dr. L.L. Bircunshaw	Dr. C.G. Lawson Mr. L.A. Wiseman	
Contract SB.61767/C21(b).	Air-transportable liquid oxygen and nitrogen producing plant	Development of prototype.	British Oxygen Co., Ltd., Edmonton	-	Dr. G.A. Knight	