

WASC 2295

PERME

Organisation

PROPELLANTS, EXPLOSIVES AND ROCKET MOTOR ESTABLISHMENT

Westcott, Aylesbury, Buckinghamshire

Waltham Abbey, Essex

A Ministry of Defence R and D establishment within the
Procurement Executive.

1.

RESEARCH AND DEVELOPMENT ON ROCKET PROPULSION, PROPELLANTS AND EXPLOSIVES

Total Staff 1500

Qualified Scientists and Engineers 250 :

Engineers (mechanical, chemical, aeronautical)
Chemists (physical, organic, inorganic)
Mathematicians (pure and applied: computing)
Physicists
Materials Scientists

Activities from FUNDAMENTAL RESEARCH

- D.H. Richards "A one-step alternative to the Grignard Reaction",
J. Chem. Soc. Perkin I 1972, p.1655
- D.E. Jensen "Prediction of soot formation rates: A new
approach", Proc. Roy. Soc. A 1974, 338, p.375

to COMPLETE PROPULSION UNIT DEVELOPMENT

4, 5, 6

PERME FACILITIES

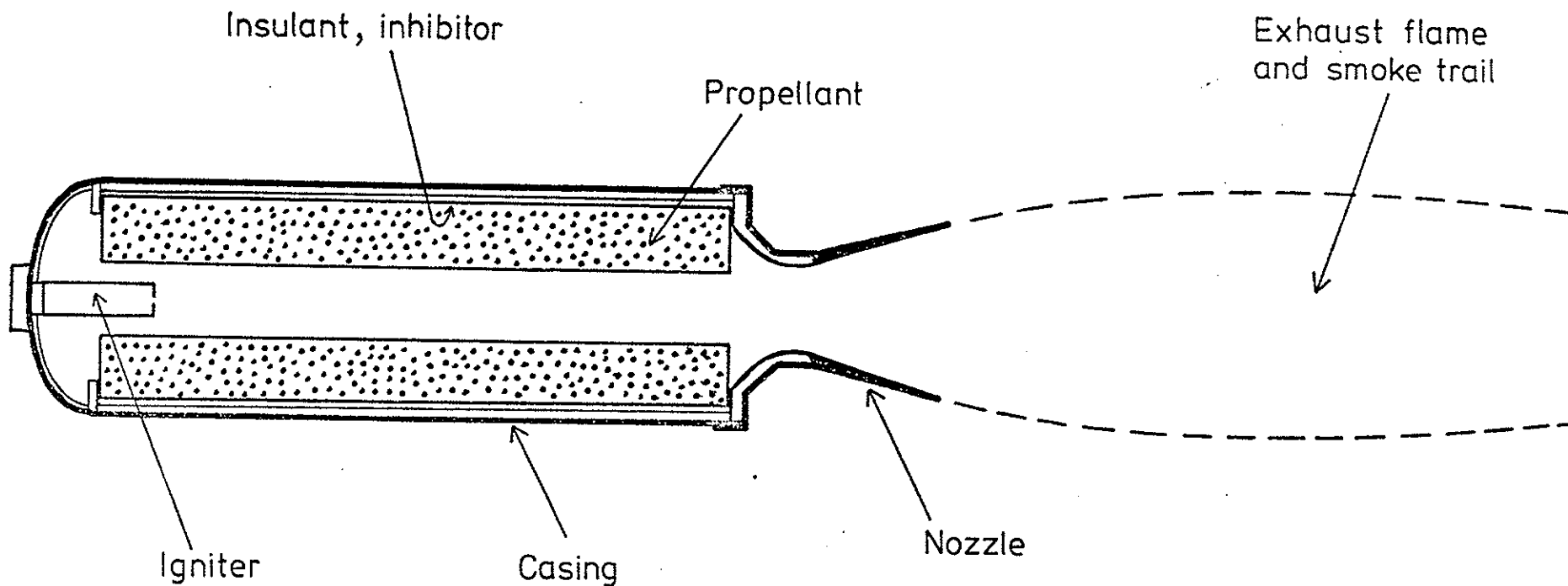
- o Laboratories for pure and applied research
- o Computers (ICL 1904S main-frame and others)
- o Plants for small-scale production of special chemicals, propellants, explosives and materials
- o Extensive chemical analysis facilities
- o Engineering, hardware and instrumentation workshops and drawing offices
- o Test sites for static motor firings: access to flight ranges
- o Component and complete motor assembly and testing shops
- o Environmental and non-destructive and destructive test facilities
- o Comprehensive support services (from libraries to welfare)

PERME WALTHAM ABBEY DIVISIONS

- PROPELLANTS I - Nitrocellulose/nitroglycerine propellants for rockets and guns.
- PROPELLANTS II - Composite propellants (ammonium perchlorate, aluminium, organic binders).
Adhesives and fibre-reinforced structures.
- EXPLOSIVES - Primary explosives; synthesis, initiation, sensitivity and hazards.
- PROCESS RESEARCH - Processing of propellant ingredients, explosives: laboratory to production.
- GENERAL CHEMISTRY - Organic and inorganic: research and analytical techniques.

PERME WESTCOTT DIVISIONS

- S DIVISION - R and D on rocket motors with solid propellants.
Design, development and proof.
- L DIVISION - R and D on rocket engines with liquid propellants.
Design, development and proof.
- C DIVISION - Fundamental and applied research on combustion,
materials science, non-destructive and destructive
testing, organic and inorganic chemistry.



ROCKET MOTOR

GENERAL CHEMISTRY

- o X-ray crystallography
- o Gas chromatography and high-pressure liquid chromatography
- o Flame photometry
- o UV/visible/IR spectrophotometry
- o Calorimetry and gravimetry
- o Mass spectrometry (including GCMS)
- o Nuclear magnetic resonance spectroscopy (various isotopes)
- o Wet chemistry

for

- * analysis of propellants
 - * structural analysis of individual compounds
 - * measurements of polymer configurations
 - * measurement of propellant ageing rates: diffusion and chemical decomposition
 - * study of compatibility of propellant ingredients with other motor components
-

CHEMISTRY AND APPLIED PHYSICS

- o Application of microwave, optical, acoustic, ultra-sonic and holographic techniques to non-destructive testing of rocket motors and components: development of techniques; instrumentation; and analysis.
- o Fluid dynamics and chemical kinetics of combustion; radiative, transmission and electrical properties of flames; numerical analysis and measurement of exhaust flame and smoke.
Missile detection, tracking, guidance, homing.
- o Application of steels, alloys, carbon fibres, plastics, refractories and glasses to construction of motor hardware components.
- o Reaction of propellant ingredients with container materials; inorganic and organic chemistry; diffusion and chemical processes.
- o Numerical and analytical computation of stresses in rocket motor components; internal combustion; total systems analysis.

PROPELLANTS R and D: 1

- o Development of new processing techniques for liquid/solid propellant ingredients: from laboratory to plant
- o Removal of solvent materials from gun propellants
- o Internal ballistics: erosive burning: ignition shock stressing
- o Solid propellant stability and burning characteristics
- o Interdiffusion of solvent and solid propellant materials

PROPELLANTS R and D: 2

- o Plastic propellants (e.g. ammonium perchlorate with polyisobutylene): processing and manufacture. New binders for low-temperature applications.
- o Rubbery propellants (e.g. ammonium perchlorate with hydroxy-terminated polybutadiene). Extrusion into esoteric shapes. Research on basic chemistry and mechanisms of binders and curing.
- o Propellant rheology.

EXPLOSIVES

- o Highly sensitive initiatory explosives (lead azide, heavy metal derivatives of nitro-aromatic compounds, tetrazoles: new compounds).
- o Application of explosives to warheads, grenades, percussion caps.
- o Sensitivity to impact and frictional forces: detonation.
- o Explosions: vulnerability of propellants to fragment attack; influence of propellant grain and casing materials; confined explosions.

PROCESS RESEARCH

- o Synthesis-to-manufacture studies of explosives: from TNT and hexanitrostilbene to new compounds.
Development of new process routes with high yields and low toxicity by-products.
- o Synthesis and production of new composite materials (aligned fibres).
- o Processing of rubbers and plastics for coating propellants.
- o Processing of heat-insulating materials (e.g. polybutadiene rubbers).
- o Development of synthetic routes for new adhesives.
- o Synthesis of block polymers (e.g. from styrenes, tetrahydrofuran; anionic, free radical and cationic mechanisms).

SOLID PROPELLANT ROCKET MOTORS

- o Complete design of rocket motors to deliver required missile performance:
 - charge design (propellant type, weight, shape)
 - structural component design (casing, insulation, inhibition, obturator)
 - nozzle design (shape, material)
 - manoeuvring (thrust vector or aerodynamic control)
 - production engineering
- o Fabrication and testing of solid propellant propulsion units meeting requirements of thrust, strength, durability, manoeuvrability, low smoke
- o Management of motor R and D, and prototype production, in collaboration with scientists and technologists, ordnance factory personnel and service users
- o Integration of advancing component technology into reliable propulsion units for motors with burn times from a few milliseconds to hundreds of seconds
- o Development of gas generators and power cartridges

LIQUID PROPELLANT ROCKET ENGINES

- o Design and development of liquid fuel/oxidiser combinations for missions where accurate control of variable thrust is a prime requirement.

Fuels include kerosene
 amines and hydrazines
 liquid hydrogen

Oxidisers include hydrogen peroxide
 red fuming nitric acid
 liquid oxygen

Monopropellants include isopropyl nitrate
 hydrazine

- o R and D on: fuel and oxidiser flow supply systems;
 combustion mechanisms;
 propellant/container compatibility;
 cryogenic systems;
 gelled fuels.
- o Tailoring of individual components of liquid propellant engines to meet overall performance requirements.

A SEQUENCE IN APPLICATION OF RESEARCH

OBJECTIVE : prevent enemy detection of rocket-powered missile by suppressing exhaust flame and smoke.

- PROGRAMME :
- (1) Fundamental laboratory flame studies of chemical kinetics of free radical reactions.
 - (2) Numerical analysis of interaction of kinetics and fluid dynamics of turbulent exhaust flames from proposed motors.
 - (3) Engineering solution to problem of supplying suppressant to exhaust.
 - (4) Testing under controlled static conditions.
 - (5) Flight test of full design.
 - (6) Incorporation of design into total missile system.

OPPORTUNITIES FOR ENGINEERS

- * Propellant ignition with pyrotechnics: conductive, radiative and convective heat transport.
- * Application of microwave, optical, acoustic, ultrasonic and holographic techniques to non-destructive testing of rocket motors.
- * Design of new liquid propellant engines with precisely controllable variable thrust.
- * Design and development of prototype solid propellant rocket motors with high thrust, long life propellant, light but strong casing and nozzle, high manoeuvrability and low emissions of smoke and flame.
- * Management of rocket motor design and development for individual projects.
- * Design, development, installation and operation of pilot plant for production of new explosives.
- * Pilot plant studies of production of high quality butadiene/styrene polymers.
- * Plant scale processing of composite propellants and their ingredients.
- * Control instrumentation for automation of plant polymer production.

OPPORTUNITIES FOR CHEMISTS

- * Chemical kinetic and diffusion processes controlling reaction between fuels and oxidisers and container materials.
- * Analysis of combustion processes in chambers of liquid propellant rockets.
- * Development of controllable, smoke-free gas generators.
- * Curing and ageing of rubbery propellants.
- * Synthesis of new explosives and intermediate compounds, both organic and inorganic
- * Synthesis of novel block copolymers.

OPPORTUNITIES FOR MATERIALS SCIENTISTS

- * Application of refractories, graphites, glasses and composites to rocket motor cases, nozzles and other components.
- * Adhesion mechanisms and their application.
- * Experimental and theoretical studies of fracture criteria and mechanisms in visco-elastic propellant materials: application to prediction of lifetimes.

OPPORTUNITIES FOR PHYSICISTS AND APPLIED MATHEMATICIANS

- * Research on internal ballistic phenomena, including ignition processes, shocks and erosive burning. Computational analysis of multiphase flow.
- * Computation of rocket exhaust structures: numerical analysis of interacting chemical kinetic and fluid dynamic processes.