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MINISTRY OF DEFENCE
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ADVISORY COUNCIL ON SCIENTIFIC RESEARCH
AND TECHNICAL DEVELOPMENT

SAC.1531
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CHEMICAL ENGINEERING COMMITTEE

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HIGH EXPLOSIVES COMMITTEE

Note on a visit by Members of Council and of the Chemical Engineering and High Explosives Committees to the Explosives Research and Development Establishment, Waltham Abbey, on Tuesday, 9th May 1967.

Received 30th May, 1967.

1. Visitors to the Establishment were as follows:

Council

Professor W.R. Hawthorne	(Chairman)
Professor J.M. Alexander	
Professor F.K. Bannister	
Professor D.G. Evans	
Mr. R. Freeman	
Professor F.A. Goldsworthy	
Professor P. Gray	(also Chairman, High Explosives Committee)
Professor I.N. Sneddon	
Sir James Taylor	
Dr. D.E. Woods	(Secretary)
Mr. T.C.H. Hill	(Assistant Secretary)

Chemical Engineering Committee

Mr. L. Holliday	
Mr. A.W. Leonard	(Assistant Director, Explosives and Chemical Production)
Professor P.N. Rowe	
Mr. L.P. Shortis	
Dr. A.J.V. Underwood	

Polybutadiene propellants (Dr. J.H.C. Vernon)

9. As part of a three-year programme to produce a workable rocket propellant with superior low temperature properties, the use as binder of carboxyterminated polybutadiene is being investigated. This forms part of a castable system producing, on curing, a rubbery propellant. Difficulties have been encountered in finding a suitable curing agent. The tri-functional MAPO produces a flexible rubber at low temperatures but softening takes place at high temperatures on account of decomposition. The most promising solution so far obtained involves the use of a mixture of MAPO and an epoxy system, the thermal degradation softening action of the former being balanced by the continued curing and hardening action of the latter.

Chelate lasers (Dr. A.R. Osborn)

10. Work carried out on the study of acetyl acetone derivatives of europium, known as the europium chelates, was described, together with the assessment of their value as laser materials. It has been found that these substances have an absorbance in the near ultraviolet which is excessive for any realistic Laser application. It is believed that this can be overcome by the synthesis of mixed chelates, in which absorbance is reduced by an order of magnitude, while still maintaining reasonable efficiency. Work along these lines is being continued.

Autoxidation research (Dr. N. Uri)

11. The oxidation of materials by atmospheric oxygen, other than by combustion, presents problems in the technology of many materials, including those in the propellants and in the plastics areas. Aspects of this phenomenon at present being investigated at E.R.D.E. are comparisons of the reaction in the liquid and the solid states, metal catalysts, such as, for example, those employed in the acceleration of epoxy cures, the development of new antioxidants, the theory and application of synergism, and photochemical and gamma-ray induced autoxidation and its inhibition. An outline of American and Russian work on synergism was also given.

12. Visits to the laboratories were then made. Items demonstrated are indicated below.

Composite Materials Group (Dr. C.C. Evans)

13. The theory of the use of fibres in the reinforcement of structural materials was outlined. Whiskers of silicon nitride and silicon carbide possess both good tensile strength and a high modulus. Studies of their growth have been undertaken at E.R.D.E., and it appears that they offer a promising field for rapid production, provided that they can be made in a form suitable for handling. This problem has also been investigated and good progress has been made.

14. The visitors were shown a whisker furnace, its construction and operation being described. The initial whisker material to receive the attention of the Establishment was silicon nitride. On account of the lengthy processing time in the furnace (about three days), production of the material is costly, amounting at present to about £100 per pound. The use of silicon carbide was therefore considered and it was successfully prepared at about one-fifth the cost. It is considered that this can be brought down at least to £5 per pound and possibly less.

15. Separation processes were demonstrated and specimen products were shown. Samples of aluminium alloy rod reinforced with whisker material were also exhibited.

Combustion research (Dr. J. Powling)

22. The general lines along which combustion research on propellants proceeded were described. These include the study of burning surface characteristics, an improved technique for investigation of binder pyrolysis, the enhancement of rate of burning by metal filaments, dimensional scale-up and applied combustion problems.

Miscellaneous items of propellant research

23. A display of annotated exhibits indicated aspects of propellant research being undertaken, apart from those signified in the preceding paragraphs. They included:

Production of combustible cartridge cases

Case bonding of cast double base propellants

Inspection of propellant rounds

Propellant (KU) devised by E.R.D.E. for the Martin Baker Rocket Seat

Platonisation of colloidal propellants

Temperature cycling procedures.

Final remarks

24. At the conclusion of the presentations, THE CHAIRMAN, on behalf of the visitors, thanked Dr. Bellamy and his staff for the most interesting and instructive day that had been arranged. He had welcomed the opportunity to make a visit to E.R.D.E. He was well aware of the expenditure of time and effort such a visit entailed, but he assured Dr. Bellamy and his staff how valuable it was in enabling Council members to understand the many problems involved.

High Explosives Committee

Mr. G.P. Cachia	(Atomic Weapons Research Establishment, Atomic Energy Authority)
Dr. B.L. Evans	
Dr. J.E. Field	
Mr. E.G. Lewis	(Materials and Explosives Research and Development, Ministry of Technology)
Dr. W.L. Murray	(Safety in Mines Research Establishment)
Dr. B.H. Newman	(Royal Armament Research and Development Establishment)
Dr. D.F. Runnicles	(Royal Armament Research and Development Establishment)

2. DR. BELLAMY, the Director, welcomed the visitors to the Establishment. He said that it was very difficult to make a presentation of all the work in progress at E.R.D.E.. He had, however, effected a compromise by arranging for a series of ten-minute talks to be given on some of the current topics of interest; these would be followed by visits to laboratories to see other research being undertaken.

3. Outlining the function of E.R.D.E., DR. BELLAMY said that one of its main activities was research and development of propellants. There were many technological problems to be resolved; these included prevention of cracking and slumping, tailoring for special purposes and devising compositions to withstand low temperatures. On the high explosives side, work was in progress to compound new fillings of enhanced performance for underwater weapons. A new facility was being constructed for this research.

4. In the materials area, effort was being deployed on building up data on polymers which were required in engineering design. An example of this was in the production of parachute cords, where it was required to improve the strength of the fabrication materials at high rates of shear. Another aspect of the work on polymers was the search for compositions having better mechanical properties at high temperatures. The Establishment was also engaged in the development of 'whiskers' of silicon nitride and silicon carbide for reinforcing structural materials. In this context, the production and application of asbestos fibres were also being studied.

5. DR. BELLAMY said that a two to three man effort was deployed on laser materials research. The Establishment was very well equipped for investigating the chemical structure of substances by physical means.

6. The short presentations outlined in paragraphs 7 to 11 were then given.

Sonic boom simulation (Dr. J.A. Hicks)

7. The simulation of the sonic boom of an aircraft by means of detonating a series of parallel line charges was described; only 3½ lbs of explosive are required. A Mark II simulant was now being developed by the Establishment which employed one pound of explosive charge. Applications of this technique outside the aircraft area were in the general physiological investigation of ear response, in buildings research, in the study of snow avalanches and in the simulation of blast take-off of missiles at launch.

Head to head links in vinyl polymers (Dr. D.H. Richards)

8. This digest described the synthesis of vinyl polymers forming head to head and tail to tail links to produce materials of improved thermal stability. Starting with a conventional monomer, it is possible to produce by the method described polymers of completely different structure. The synthesis of head to head poly α-methyl styrene has been achieved employing the reaction of two di-anions with iodine, a one hundred per cent linkage being obtained. This has been confirmed by nuclear magnetic resonance studies, spectroscopic investigation and viscosity determinations. Work is now in progress on the production of tail to tail poly α-methyl styrene.

High Energy Explosives Facility (Mr. E.G. Whitbread)

16. Reference has already been made to this installation (paragraph 3). Its design has been based on an earlier pilot scale model, and the new facility is at present in the course of construction. When complete, it will enable research and development on composite high energy explosives to be carried out under remote control. This will include manufacture, preparation of samples for assessment, and, by means of a five inch gauge railway, transport of rounds to firing chambers and to test and disposal grounds. All operations are directed from a central control console. Batches up to an equivalent of ten pounds of Torpex can be prepared. This capacity represents the smallest size of plant which can be readily scaled-up if that is required.

17. In the development of better underwater explosives, it is hoped to achieve a 70 per cent improvement by 1969 with the possibility of a one hundred per cent enhancement to follow. Work on the pilot plant has been based on the ammonium perchlorate/aluminium system. The relative merits of two binder systems are being evaluated, polyurethane plasticised with nitroglycerine and polyurethane incorporated with lithium perchlorate.

Work of the Chemical Engineering Branch (Mr. R.G. Ross)

18. Work in this Branch falls into three categories, process development, unit operation assessment and equipment research. Examples of investigations undertaken include the drying of liquid explosives, polyester manufacture, the processing of hazardous materials, fibre alignment and composites development, and crystallisation studies.

19. The visitors saw three demonstrations. These were the study of dynamic torque in mixer blades and clearance assessment, the alignment of fibres by extrusion in an alginic acid gelled filament, and a pilot plant for asbestos fibre alignment into felts for their subsequent incorporation into resin composites.

Current work on colloidal propellants (Dr. W.G. Williams)

20. This presentation outlined the very wide area covered by the Establishment in the development and examination of colloidal propellants. Facilities exist for making any such composition and for assessing its properties. Capacity ranges from propellants for small arms and mortars, having a burning time of a few milliseconds, to gun and rocket propellants with burning times of a hundred milliseconds to thirty seconds for sustainer motors. Charges for liquid expulsion could be required to burn for up to one hundred seconds. Examination procedures include those for assessing safety, temperature dependence and storage life. Ultrasonic and X-ray techniques are used to inspect finished rounds. No similar facility for taking such a wide and overall view of the colloidal propellants exists anywhere else in the world. The Establishment led the rest of Western Europe in propellant technology.

Composite propellants (Mr. P.R. Freeman)

21. The history of the development of plastic propellants was outlined, from their inception as simple oxidant/fuel mixtures to their high sophistication of the present day. Plastic propellant can be used straight from the incorporator, and batches of different mixes can be blended to yield a product having the required physical and ballistic properties. Burning rates up to over one inch per second can be obtained, and high rates can be achieved by the incorporation of metal filaments or ferrocenes. Performances up to 250 seconds are obtainable. Disadvantages of smoke production on burning, and of poor mechanical and low temperature properties have led to the development of elastomer propellants. Specimens of both types of composite propellant were on show.