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On Her Majesty's Service

Nursing Mirror
article 14-9-1956

WASC 398

MINISTRY OF AVIATION

NOTES PREPARED FOR VISITORS

ON

12TH JULY 1966

EXPLOSIVES RESEARCH AND
DEVELOPMENT ESTABLISHMENT

A SHORT ACCOUNT OF E.R.D.E.

History

The Explosives Research and Development Establishment occupies a site rich in history. Within its boundaries stood the oldest gunpowder factory in Britain, boasting four hundred years of continuous operation. Of many significant happenings during these centuries one of the most important and durable was the outright purchase of the mills by the Government in 1787. Following the acquisition much money was spent on repair, modernisation, and expansion, and gunpowder manufacture was resumed on a large scale just in time for the Napoleonic wars.

From that time onwards the production of gunpowder was continuous until brought to an abrupt end by a German bomb during the winter of 1940/41. By then, however, other parts of the factory were engaged in making cordite and high explosives and continued to do so until 1945, when the premises were handed over for their present research purposes. The newcomers were faced with the considerable task of converting an out of date explosives factory into a modern research establishment. Metalled roads were non-existent apart from the approach to the Main Gate along Powdermill Lane (which is as ancient as the factory itself), all internal transport being by means of a network of canals and narrow gauge railways. During the last twenty years roads and services have been provided and the great majority of the buildings have been converted - with both success and economy - to their present purposes. Some new buildings have been added, and visitors may observe a few to which only temporary improvements have so far been possible.

/Present

Present Functions

The Establishment now occupies two sites each of about 250 acres in extent, with one lying to the north and one to the south of Waltham Abbey. In all a total of some 250 buildings are in use, ranging from laboratories to explosives processing buildings, firing chambers, machine shops and offices. Of the total personnel of about 900, some 80 are university graduates or have professional qualifications, about 120 have High National Certificates or equivalent, about an equal number are possessed of a manual skill and about 100 are trained in explosives processing.

E.R.D.E. is a centre of chemical research and development with interests centred upon explosives, solid and liquid propellants, and related compositions. To a lesser extent the Establishment is active in the field of non-metallic materials, mainly those used in aircraft or defence equipment. As the only research organisation (with very minor exceptions) in the United Kingdom engaged in the field of propellants and explosives E.R.D.E. serves all fighting services. Much continuing research and testing is necessary to provide a sound basis for advice upon matters of production, use, and safety, and a good deal of this work is required equally whether the weapon is British or, like Polaris, purchased from abroad. Close working arrangements exist with the Establishments concerned with weapon design, chiefly the Rocket Propulsion Establishment and the Royal Armament Research and Development Establishment, and with the Royal Ordnance Factories responsible for munitions production.

To maintain perspective it should be mentioned that the following notes upon current activities have been prepared not so much to convey a complete and balanced picture of the Establishment but rather to select items thought to be of most interest to today's visitors.

/Solid

Solid Propellants

The essential requirements of a solid propellant are that it should burn at a precisely predetermined rate for a precise time with a standard thrust, and that it should retain its characteristics for an indefinte period - or at least for a long and specifiable time during which one can be confident that there will be no deterioration which could give rise to dangerously high burning rates or inaccurate ballistics.

New formulations are continuously being devised to meet the changing requirements of the weapon designers in respect of ballistics, mechanical properties, resistance to extremes of temperature, absence of smoke, and etc. Processes for full scale production are also developed, and new compositions in quantities ranging from a few pounds to many tons are supplied to the weapon design Establishments for trial. The propellant processing plants available in E.R.D.E. range in size from laboratory to full production scale and, in aggregate provide a facility unique in the Free World.

Recent work includes collaboration with the Martin-Baker Aircraft Co., in the development of an aircraft ejector seat suitable for use within a few feet of the ground. Ejector seats made by Martin-Baker are sold in many foreign countries including the U.S.A. Improvements have also been made in the process for the manufacture of combustible cartridge cases, which should now give a better and cheaper product than its American competitor. Export sales are hoped for.

Liquid Propellants

Under this heading activity centres mainly on the study of heat transfer characteristics, under the conditions encountered in liquid rocket propellant engines, of fluids of interest as rocket fuels. Recent measurements have a civil fall-out inasmuch as the basic data obtained is also relevant to calculations on heat transfer in high pressure steam boilers.

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The precision engineered apparatus built here for the work is unparallel in Europe and is from time to time made use of by British firms and by such bodies as the Central Electricity Research Laboratory.

Explosives

Military explosives, with very few exceptions, are mixtures of chemical ingredients, each of which contributes in its own particular way to produce the required set of properties. The point may be illustrated by the classical example of gunpowder, where good results in the gun were greatly dependent upon the careful attention given to the quality of the charcoal ingredient. In modern explosive compositions the ingredients are usually quite elaborate compounds and many have distinctive functions, e.g. to control sensitiveness or to secure adequate stability in adverse storage conditions; thus by the careful choice of ingredients the utility of explosives compounds may be extended to meet more exacting requirements.

It is therefore necessary to study in depth the connection between the chemical constitution and the useful properties of the various substances in order to understand both the reasons for their usefulness and their limitations. Compounds thought likely to confer specific benefits are synthesised and research is carried on into the chemical details of methods of manufacture.

Unfortunately it is probable that a marked increase in performance can now only be obtained by the use of ingredients which increase the explosion hazard during the process of manufacture. It has therefore been necessary to construct a new building in which raw materials will be processed into explosive compositions, and fired under predetermined conditions to give technical data, with the operatives exercising control from behind safe cover.

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The remotely controlled plant for this building is being designed, and will be partly built, in E.R.D.E. and will also be largely installed by the Establishment staff.

Another way in which the effectiveness of an explosive compound may be increased is by the optimum exploitation of the mechanism of detonation. For use in under-water weapons an attempt is being made to tailor the shock wave by changes in the composition of the compound, so as to achieve the most damaging pressure - time profile. This work is being carried out in close collaboration with the Naval Construction Research Establishment.

Two recent examples of calls made by outside bodies upon the specialist explosive knowledge of E.R.D.E. may be given. The first is the development of special techniques to employ the chemical energy of explosives to pump high energy lasers, in collaboration with the Royal Aircraft Establishment. The second is the development of special explosive charges to reproduce air blast waveforms of specified form, e.g. rocket motor take-off blast. This provides an inexpensive means of checking the effect of the blast upon static ground equipment.

Initiating Compositions

Small quantities of initiating compositions, all of which are highly sensitive, are required in all systems using explosives or solid propellants. E.R.D.E. has achieved notable success in the improvement of these compositions and initiators developed here are currently being made in the U.S.A., Canada, Sweden, and Pakistan, in some cases on a patent royalty basis. Recent research has been directed to the improvement of the high temperature performance and to longer safe installed lives. New compositions, going a long way towards achieving these ends, have been developed and are now undergoing practical Service trials.

/Polymeric

Polymeric Materials

In the polymer field research activities are directed towards obtaining a better understanding of the behaviour of such substances as plastics, rubbers, adhesives, and fibrous substances.

One important target is the improvement of the resistance of materials such as rubber, polyethylene, and proofed fabrics to the deterioration caused by heat, air, and light. Recent months have seen the successful development of a simple process which should substantially improve the ageing characteristics of nylon, and which is the subject of patent application.

E.R.D.E. acts as consultant to the Military Equipment Experimental Establishment and the Fighting Vehicles Research and Development Establishment, amongst others, on the choice and use of rubbers and plastics. These materials are examined here to gather data on such mechanical properties as their elasticity, ultimate strength, tensile properties under biaxial stress, and rate of response to high speed stress. Applied work to solve ad hoc design problems is carried out, a recent example being the development of conducting rubbers for tank tracks to eliminate radio interference.

The programme of work of the Tropical Research Unit, a joint venture with Australia, is another responsibility. The Unit carries out long term trials involving exposure to tropical conditions of both metallic and non-metallic equipment.

/Composite

Composite Materials

Recent advances in basic materials science has shewn that while the improvement of classical engineering materials is within sight of its natural limitations, there are entirely new possibilities in the development of unorthodox structural materials. In particular we now understand in principle how to get toughness and high strength from any solid substance almost irrespective of its chemical nature. The techniques available at present usually involve the manufacture of strong fibres which are then bonded together with a matrix of some other substance to form a reinforced or two-phase material of superior mechanical properties.

Suitable fibres are being grown in furnaces at E.R.D.E. and emerge in the form of short whiskers, which derive their high mechanical strength from the perfection of their surface structure. One use to which whiskers are being put is the reinforcement of an aluminium alloy, to produce a material which is superior to the original in the respect that it retains useful strength and stiffness up to 300°C. Attention is also being directed to the reinforcement of nickel alloys by alumina fibres for use in the extra high temperature environment of aero-engines. Specimen turbine blades made from the reinforced alloy are now under test at the National Gas Turbine Establishment.

Whiskers come from the furnace as a tangled felt and before use must be cleaned, graded by length, arranged parallel to one another, and spun into threads. Automatic processes for these purposes which have been developed at E.R.D.E. (and patented) have aroused great interest in the U.S.A., and there have been a number of enquiries for licences.

/These

These grading and orienting techniques have been found suitable for asbestos, which although cheap and potentially useful, has in the past found its use as a reinforcing agent handicapped by handling difficulties. The Establishment is now treating asbestos by the processes used for the handling of whiskers and is developing an asbestos reinforced plastic which, weight for weight, is stronger and stiffer than light metal alloys.

Chemical Engineering

Chemical Engineering is concerned with means and equipment for processing chemicals on a production scale. E.R.D.E. develops not only methods of quantity production of, but also the special plant required for, explosives, propellants, initiators, pyrotechnics, certain plastics, and chemicals which may be required as ingredients for them. (When methods have been established the task of production is taken over by the appropriate Royal Ordnance Factory.) Research to this end carried out on basic "unit operations" produces knowledge which may be applicable, for example, equally to sugar as to an explosive. Most of the technological knowledge acquired is therefore just as useful in the civil as in the defence field.

Other chemical engineering research is aimed at improving the performance and safety of explosives and propellant processing equipment, particularly mixing machines which are used not only for propellant pastes but also in the chemical and bakery industries. Attention is also directed to the design and improvement of methods of remote control of machines. In addition the chemical engineering facilities are used to make quantities of novel or unusual chemicals both for E.R.D.E. and for other Government Establishments.

/Chemical

Chemical Analysis

As might be expected from what has already been written there is a continuous need for accurate and comprehensive chemical analysis, and modern equipment is in use for this purpose. The analysts also develop new physical-chemical techniques of identification and analysis, which, although aimed primarily at the particular problems of E.R.D.E., are of universal use in the world of chemistry. Much attention is directed to the safety and stability of propellants and explosives in various conditions of long term storage and to the compatibility of these not only with each other but also with the other materials with which they will be brought into contact. Unsafe reaction between chemicals must, of course, be avoided.

From time to time special apparatus is devised to permit novel chemical or physical examination. A recent example is the construction of a thermo coupled device with over 2,000 junctions per square inch, with sensitivity sufficient to detect heat emission at a rate down to 0.5 calories per day.

Miscellaneous Research Activities

To support propellant research a lively interest in the chemistry of flames and combustion must be maintained and E.R.D.E. is a recognised authority in this field both at home and abroad.

A small group under the personal leadership of the Director of the Establishment is engaged on a number of research topics. Many of these are essentially probing investigations with the object of deciding whether or not a particular field merits a more elaborate study. Although unspectacular to the non-scientist such work is very necessary if expensive but fruitless research is to be avoided.

/Engineering

Engineering Work

The Engineering Branch employs professional engineers, technicians, and sizeable numbers of skilled and non-skilled manual workers. It is equipped with civil and mechanical design offices and with a number of workshops containing modern general purpose tools.

There are two main functions. Firstly direct support is afforded to scientific work. Professional advice is given, special purpose apparatus designed, and manufacture is either undertaken in the Establishment's own workshops or is arranged under contract. Secondly, the branch is responsible for all maintenance and servicing - of the grounds and buildings, of explosives and non-explosives plant, and of services such as electricity, water, sewerage, heating, ventilation, steam, compressed air and refrigeration.

New buildings are constructed under contracts let by the Ministry of Public Buildings and Works against requirements drawn up in E.R.D.E. but the provision and installation of special purpose plant is undertaken by the Establishment.

Some idea of the scale of engineering activity may be gauged from the fact that the branch employs more than one-quarter of the total personnel and accounts for nearly one-fifth of all expenditure.

Supporting Services

The Establishment is self-contained inasmuch as all necessary supporting services are provided from within its own resources. Direct support to scientific work is given by a comprehensive library of both published and unpublished material (shortly to move into the new accommodation temporarily in use as exhibition rooms), by a small but highly skilled glass technology section, and by an electronics and instrumentation section.

/An

An Administrative branch looks after recruitment, personnel, finance, pay, and stores procurement (some 6,000 orders are placed each year). Typing, transport, storage and internal postage are amongst the services provided.

All aspects of safety are covered by the Safety Section and the Establishment runs its own medical, ambulance, fire and police services.

Patents

During the course of its work the Establishment frequently develops ideas of value outside the Government service. These normally become the subject of patents which are exploited for the benefit of the taxpayer by the National Research Development Corporation. During the last year twelve patent applications have been made covering such diverse subjects as:

Ear Defender with peak limited sound transmission.

Improvements in the manufacture of urea.

A single shaft de-aerating machine.

An improved line pipette.