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The A.R.E. of the Ministry of Supply has been celebrating its 50th year Jubilee in a distinguished gathering of its members, Ministry of Supply associates and leading academicians and industrial scientists.

It is the fashion now-a-days to refer to scientists, and particularly Government Research men, as Boffins or Back-room-boys, and in this way to dismiss them out of mind to their back rooms where, presumably, they are safely locked away. This is a singularly foolish form of escapism from responsibility on the part of the public and unfortunately fails to understand the humanity of these men and their personal crusade for the safety of their fellow countrymen.

The Armament Research and associated Establishments exist to provide the fighting Services with the most efficient armaments for the country's defence, and this Jubilee seems a fitting opportunity to make their scope and achievements better known to the public.

During the Boer War, British ammunition proved far from satisfactory in the field and as a result of public concern, an Explosives Committee, headed by Lord Rayleigh and with Sir Andrew Noble, Sir William Crooks, Mr. R.B. Haldane, Q.C.,M. and Sir W.C. Robert-Austen as members, was appointed in 1900. It almost immediately recommended that an Experimental Establishment should be set up to investigate Service munitions problems.

The Chemical Research Department, as the new establishment was christened, was built in 1903 adjacent to Woolwich Arsenal and staffed by only half-a-dozen young scientists. Nevertheless they set out on the task of overhauling Service munitions.

In 1907 the Establishment became the plain Research Department and by 1914 numbered some 20 scientists. ~~This small group in the years before the First World War laid the foundations on which the modern design of armaments has been built.~~

Shortly before World War I the Proof and Experimental Establishment, with a history of ballistics research back to the 17th century, and a Metallurgical Section had been added to the Department. During the last War a Pyrotechnics Section was founded ~~which rapidly grew, particularly in the intervar years into an important and widely used unit.~~

During the first World War the scientific staff increased to 1260, including many women scientists. Conditions of employment at that time did not compete with industry and after the war most of this staff returned to their industrial occupations, ~~reducing the Department~~.

Around 1921 however, thanks to the efforts of Dr. Robertson, later Sir Robert Robertson, the Director of Explosives Research in the Department, at that time conditions of employment were placed on a more attractive ~~satisfactory~~ basis and the staff settled down as a permanent team of enthusiastic workers at an authorised peacetime strength of 100 (150?) scientists and about 1000 other grades. The scope of the work steadily widened up to second World War, and the staff was increased to just around 1000 in 1939 expanding to 3000 in 1942.

Shortly before the outbreak of this war with the growing menace in Germany, the first Sister Establishment,-the Projectiles Development Establishment at Aberporth - was detached from the Research Department to deal with the rapidly expanding and specialised research on anti-aircraft rockets as a quicker and cheaper way of combating invading aircraft. This Sister Establishment was to develop the rockets later used in the anti-aircraft defence of Britain, the attack on the Normandy beaches, and aircraft attack on tanks and submarines. After the war this Establishment ~~became~~ was re-absorbed in to the A.R.E. which the R.D. had by then become.

Some time Shortly before Munich the Heads of the Department made plans for the coming war then definitely accepted as inevitable. As a result, on the outbreak, small units of the Department's staff moved into some of the Ordnance Factories and Universities, strategically selected to serve areas from Inchterf near Glasgow to Pendine in South Wales, ~~while the remaining Department as a whole concentrated out of Woolwich,~~ in all, to some 30 stations. The plan was that each unit should be the liaison between the Department and the Ordnance Factories, Universities and Firms engaged in war work in its area. The plan worked unexpectedly well and some of these groups are still functioning in this way in their original locations - in these cases Ordnance Factories.

During the war the Research Department was changed to the Armament Research

Department, and shortly after the war, to the Armament Research Establishment, its present title. This change was due mainly to the setting up by various Service Branches of other Research Stations to deal with their own highly specialised problems. These Stations did not lighten the burden of the A.R.E. as might be thought; on the contrary the expanding fields of development in the Stations referred back to this Establishment more problems than ever.

After the war the fall away of staff was not as great as in 1918-1919 and one difficulty has been the collecting together at one site the widely distributed staff. Not more than two-thirds have yet been returned to the London area.

Two sister establishments have been hived off since the war. The first the Explosives Research and Development Establishment at Waltham Abbey, resulted from a decision to separate the purely chemical from the explosive work. The second resulted from a decision to entrust the production of the first atom bomb to the A.R.E. Approximately two-thirds of its facilities and more experienced staff were diverted to this end and not till the manufacture of the first weapon was well in hand was it decided to start a new Establishment for this work at a new site. This is now in hand and is proving severe to the A.R.E. not only because of the demands on its organisation, stores, etc., but also because of the heavy transfers of trained staff to the new work. However an effective beginning has now been made in building up the residue into a new Armament Research Establishment and bringing them as far as practicable onto one site suitably staffed and housed, and with modern equipment.

A revealing comparison can be made between the position of the services armaments at the beginning of the last war and that of the First World War. Although in 1914 the R.D. had been in existence for some years, the very small staff, limited facilities and the chaotic condition of the post Boer War armaments had prevented an altogether satisfactory preparation for the war, and some time was lost in 1914 and 1915 in bringing the Services munitions into line. At the same time much had by then been done, and in time the Services were equipped up to date. In the inter-war period however, the staff, more permanently established and organised, greatly increased

with better facilities and experience, had advanced the art of armaments far beyond its existing status, and was able to meet the outbreak of the war with improvements already worked out and awaiting adoption, improvements which were to provide the Services in many directions with equipment partially superior to those of the enemy. It is significant that some few years before the war Ordnance Factories had been built or were building to provide new explosives and propellants for the coming war, and the outbreak saw a preparedness in this field that perhaps would surprise the public if it were fully known. It is a tribute indeed to the foresight of the Establishment, the Services, and the Authorities, and a commentary on the fable of the effete Briton, not to mention the Civil Servant. It could be claimed that during the war the design and manufacture of munitions in this country were superior to that in any other country, and it certainly is true that the processes then and now being used in the Ordnance Factories practically all originated in the old Research Department.

From this historical outline it will be of interest to turn briefly to some of the Establishment's outstanding achievements. highlights.

In the course of these 50 years the old Department in addition to the vast work in detail covered has many spectacular achievements to its credit. Many have become fundamental for explosive design, manufacture and application not only in this country but in some cases throughout the world. Of these a few are mentioned here, chosen because of their more ready understanding by the layman with untechnical readers.

Prior to 1914, the small staff had studied the use of T.N.T. as a substitute for lyddite, which it was foreseen would not meet the demands of a new war. At the commencement of the war a new process for its manufacture, which was in fact the key to its production in the large quantities required, was worked out in a pilot plant in the Department at Waltham Abbey and transferred by the Department to the M.O.M. factories, with their eventual large production, all employing the R.D. process and staffs trained on the pilot plant. Later, amatol, a mixture of T.N.T. and ammonium nitrate, in plentiful supply, was developed in the Department to enable this production, large as it was by the standards of those times, to meet the rapidly expanding demand. "Amatol won the war", said the Director of Artillery in 1918.

Up to this ~~point~~ the war there had been a period of formulation of new principles for guns and ammunition and out of this arose a new system for fuzing shell - a milestone in our armaments development - and equally important, the evolution of the booster principle ~~of~~ (the gaine) to ensure a ~~certain~~ sure explosive train from fuze to filling, and to control detonation and fragmentation. For this the use of tetryl was closely studied and a process for its manufacture was devised and installed in the M.O.M. explosive factories.

~~The battle of Jutland revealed the lack of armour penetrating power of the British Naval shell but this was speedily corrected by the Department by means of a special filling and delay fuze.~~

Shortly after this war the R.D. gave attention to an explosive then only a chemical curiosity, but later called R.D.X. in this country. Its use had been precluded so far by the danger of its preparation and handling. The R.D. in the course of the following 10 years scored two truely remarkable bullseyes:- the evolution to a large pilot plant scale of a safe process of manufacture - later scaled up to large production in the Ordnance Factories without major alteration - and the devising of safe means for its effective use in shell, bombs, (block busters etc.), depth charges, torpedoes and demolition compositions. This work placed in the hands of all three Services explosives of a new order of high power and blast, quickly realised and widely used in World War II, and strikingly demonstrated in the sinking of the Bismark and Tirpitz and the destruction of the Möhne Dam.

During this war T.N.T. production reached a new peak, only made possible by a new continuous process which originated in the R.D. way back in World War I.

Propellants have developed out of all recognition since the pre 1914 days and in this the R.D. has played no small part. ~~Prior to World War I the SMP Cordite compositions was altered to reduce the heavy wear on guns.~~ During the war a special new propellant was worked out quickly and introduced into the Services to meet the insufficient supply of acetone. During that war and some years after, the expensive cotton cellulose base for the nitrocellulose was replaced first by cotton waste, then by wood cellulose with a six figure stirling

saving per annum to the country.

After War I a major change was made by the R.D. by the introduction of a solventless cordite, quicker to manufacture, more accurate in dimensions composition and energy thus dispensing with the costly and time consuming proofing for weight charge - a saving of supreme importance in the last war. More important this cordite, eliminated the risk of spontaneous ignition to which, using the old cordite the loss of some battleships and magazines had already been attributed. This again dispensed with costly testing for stability and also practically doubled the storage life of cordite with a corresponding reduction in overall cost to the country. The new cordite was, as became later clear, more amenable to new devices and designs for special purposes.

In Flashless Cordite the Department made one of its most daring and successful ventures, and one in which it is practically the sole inventor throughout. Conceived from fundamental principles, boldly breaking away from the old conventions and developed to the manufacturing scale through its many problems, it has now become standard throughout the Services. The elimination of flash, which not only gave away position on sea and land, but seriously handicapped rapid fire at moving targets by temporarily blinding the gun crews, is a milestone in propellants development. Compared to this, other countries approaches to the problem were elementary, and nowhere else has consistent flashlessness been obtained with anything but relatively small calibre guns.

Another invention of the Establishment of a similar level of originality and importance, is propellants for rockets along two lines; one a modified conventional composition and the other a new idea of a cheap plastic mixture. These were worked out mainly during the war and saw active service in antiaircraft defence around the London area. These propellants obviate guns, are more manoeuvreable to fire, have a higher ceiling and the plastic type is quicker and cheaper to manufacture. The plastic propellant has still difficulties to overcome which, in view of its economic attraction, are being strenuously tackled.

The achievements activities of the Metallurgical Branch make impressive reading and only a selection can be mentioned.

During World War I the properties of gun steels, and of brass for cartridge

cases were overhauled and important improvements introduced. The Branch led a team with the steel makers in producing satisfactory shell, ~~These particular activities here~~ continued since then through the second war to the present date in an ~~increasing~~ increasing search for better shell, cartridge cases, etc., and special-

⊗ An important discovery was a means of putting hard wear resisting metal coatings on steel providing a means of repair of overworn and overmachined components of a wide variety of war equipment thus saving remaking. This work also led to the lining of the gun barrels by electrodeposition

Many results have proved of everyday benefit to the country as well as to the Services. For instance the study of aluminium bronzes and the introduction of aluminium brass condenser tubes, the development of ternary lead alloys with greatly increased resistance to cracking, now widely used for cable sheathing and water pipes; methods of improving the casting of brass ingots, and research on the structure and properties of electro-deposited metals, paving the way for the lining of gun barrels by electro-deposition. The Woolwich School of Electro-deposition Research is known throughout the metallurgical world.

detonation, and performance. Some of this Branches work has already been mentioned e.g. amatol, R.D.X. compositions, etc. Others no less outstanding are the pre war evolution of the giant bombs (12000 and 22,000 pounders) the development and exploitation of aluminium powder as a power and blast enhancing addition to explosives, and the devise of the hollow charge which can make a flame penetrate a foot of armour igniting explosives etc. in the tank. The first hollow charge weapons used by any belligerent during the war were grenades developed by this Branch. The German Panzerfaust and the American Bazooka are derived from this weapon. The full scope of this principle has probably even now not yet been fully achieved.

The Pyrotechnic Group has developed from zero since World War I to a varied organisation of star shell, lights, signals smokes incendiaries etc. One marked success was a special incendiary filling for shell for aircraft guns which by setting fire to the petrol tanks destroyed a great number of enemy aircraft, and was a factor in

the Battle of Britain. This filling has been imitated everywhere and it has not yet been superseded.

The highlights of the Ballistic Group are not so evident to the non expert, involving as they are with abstruse mathematics. Nevertheless they are none the less significant achievements which have influenced the formulation of propellants and design of guns and contributed in a major way to the regularity of these weapons.

The newly formed Ballistics Branch undertook a complete and extensive overhaul of ballistic theory and of the factors which make for the highest possible accuracy in gunnery. They also devised a means of using cordite for such unusual affairs as lifting hydraulic jacks, engine starters, and catapulting pilots out of aircraft or even launching aircraft with catapults. Flame throwing weapons also owe much to their research. All this work placed the science of ballistics on a firmer footing than hitherto and as a byo product resulted in a range of recording instruments including two and ten stage counters which have an increasing application in Industry in later years.

If it be urged that the atom bomb has outmoded all this type of work, the Korean war alone is a reminder that the so-called minor, albeit very significant wars will still have to be decided by a war of attrition and European satellites in favour of superior manpower and this will be only possible if the technical quality of our munitions expressed in fire power exceeds that of our enemies by a very wide margin. Or if the stage be reached when nuclear weapons will determine the major direction of war it will still remain to be seen how far the possession of adequate supporting fire power will still be essential. Present indications are that the A.R.D. will for a long time to come continue to play as important a part in the build up of armaments and remain as essential a feature in the organisation for war that it has been in the past.

Requirement As to recruitment of the entrants into the A.R.D., and its sister Establishments come from the Universities via the G.C. Commission and an unusually high standard of academic qualification and individual ability are demanded for their exacting work and conditions. That these men find their life in the Establishments both congenial and satisfying must be deduced from the fact that resignations are very rare indeed. There is ample scope for the best of our

scientists to make this their career and help in carrying out this vital ~~practical~~ task.

~~Organisation.~~ Not only does the Establishment work in close collaboration with its Sister Establishments, the R.R.D.E., the A.D.E., etc. but with the numerous special Service Establishments and Research Stations already mentioned. All this takes place nominally through its Paternal Head the Chief Scientist and his Directors, although naturally a considerable latitude for direct action prevails. Collaboration with the Explosive and Filling Ordnance Factories with Armament, Explosive and other industrial firms, and not least with the Universities, is necessarily close and live. Funds and facilities for the last two are organised by the M.O.S. through a system of E.M.R. Contracts. This collaboration calls for progressing and consultation between the scientific staffs, down to working level, of the Establishment and the Organisations concerned, both at Home and Away. Mention must here be made of the Scientific Advisory Council, a body of leading University and Industrial men organised by the M.O.S. to assist through a series of joint committees the A.R.E. (and other Ests.), to undertake where advantageous, E.M.R. contracts and at the same time to ensure that the problems of the A.R.E. ~~Which of course all are of vital National~~ which after all are of national importance, are receiving the best attention available.

But, one may ask, how does the A.R.E. get its orders and finally pay off dividends. This would be difficult to make plain in a few words. A vast amount is done in a practical direct way with the other Establishments, Ordnance Factories and Industry. But the main to and fro proceedings are by collaboration with the Ordnance Board, and a special, broadly controlling body consisting of Chiefs of the Services and Heads of the Ordnance Factories and of the Research and Development Establishments. At these, existing deficiencies and new requirements are brought to notice by the Services; problems, safety and new developments and implementations are discussed and recommended by the Establishment and general policy laid down. Behind all this, and conditioning much of it, looms the Treasury with a proper tight grip on the country's purse strings.

As can be surmised the Establishment's sailing is by no means always plain and sunny, but nevertheless with a bold course set, shrewd navigation, and lots of goodwill it usually manages to make landfall with a very welcome and valuable cargo aboard.