ADMIRALTY RESEARCH AND DEVELOPMENT ORGANIZATION

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On the Board of Admiralty, the Third Sea Lord (*Controller*) bears responsibility for providing the Navy with its ships and all their equipment ; he is assisted in the field of research and development by the *Deputy Controller, Research and Development.* Under the *Controller* come (i) a number of technical departments each having responsibility for research, development and production within a defined field, and (ii) the *Chief of the Royal Naval Scientific Service* and his four departments which have broad responsibility for research and development throughout the whole field of Naval interest. This organization is illustrated in the table opposite.

Departments (A) are those having responsibility for research, development and production within limited fields. The *Director of Naval Construction,* for example, is concerned with the field of warship construction, while the *Director of Radio Equipment* is concerned with all Naval radar, radio and communication equipment. The Directors of these departments are in most cases Naval Officers, but in some cases (e.g., *Director of Naval Construction* and *Director of Electrical Engineering*) they are professional engineers.

Departments (B) are headed by civilian scientists and carry broad responsibility for the application of science and scientific method to the research and development of work of the Navy as a whole.

Many departments (A) have one or more experimental establishments where investigations are directed towards the development of weapons and equipment for the supply of which the department is responsible. The research and development staffs of these establishments are mainly scientists belonging to the R.N.S.S.

Besides the experimental establishments of the departments (A), there are establishments and facilities for conducting research on problems which are common to two or more such departments ; attention here is also paid to fundamental research and long term investigation having no immediate application to weapons and equipment. These establishments and facilities come under the control of the civilian scientific departments (B).

Experimental Establishments working under Departments (A)

(*a*) As long as there exists a Navy it will need warships, and the means to make and keep them efficient fighting units. Responsibility for the design of warships rests with the *Director of Naval Construction* (D.N.C.).

The D.N.C. requires an establishment where he can determine the best hull shapes for warships from the point of view of water resistance, manœuvring and turning characteristics, stability in heavy seas or when damaged in action, and absence of serious vibration. He needs also to design and develop ships' propellers of high efficiency. For this work he maintains the *Admiralty Experiment Works* (A.E.W.), with towing tank and cavitation tunnel facilities for experiments with model ships, and allied hydro-dynamical investigations.

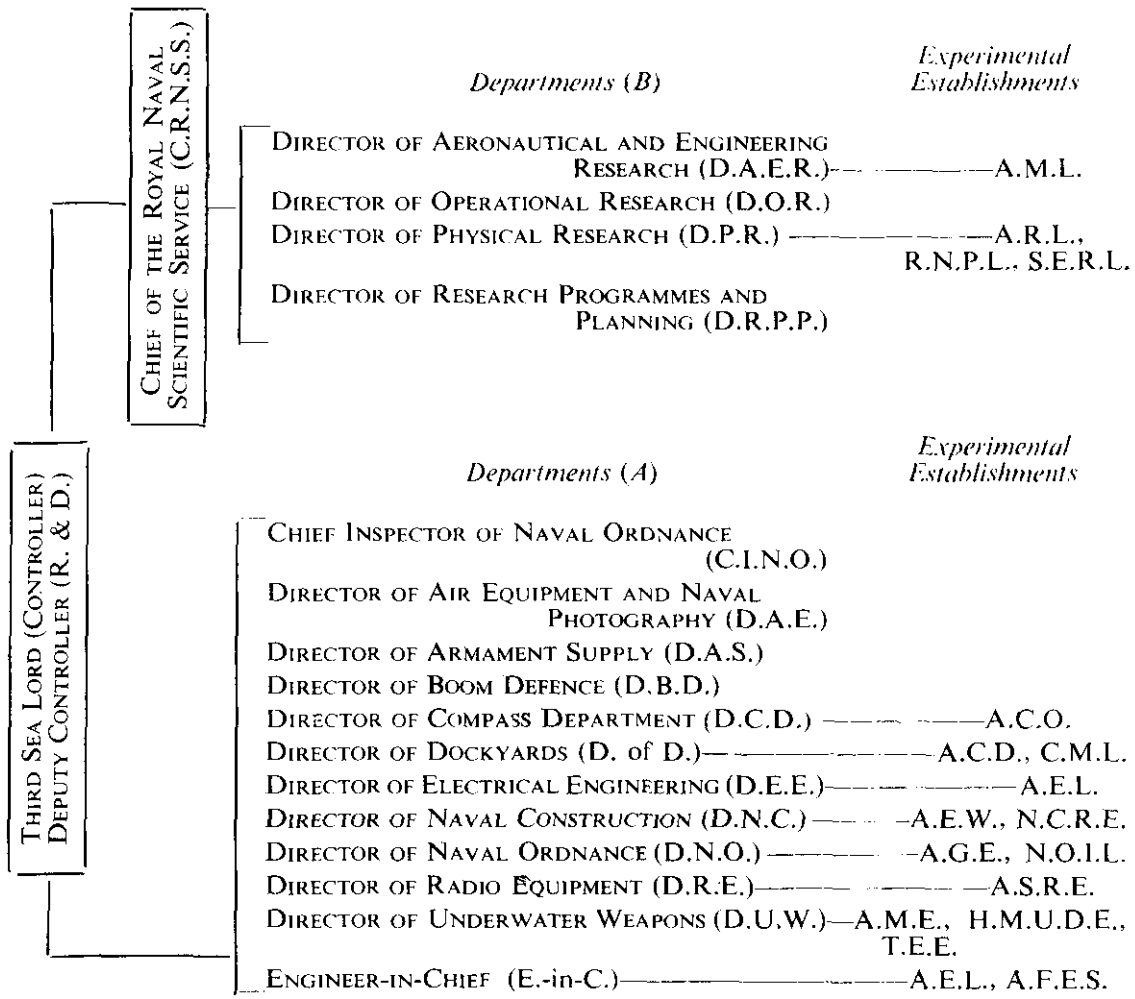
Warships must also be designed to withstand attacks from above-water and under-water weapons. In order to determine the best techniques of ship

construction to withstand such explosive and shock effects, the D.N.C. maintains the *Naval Construction Research Establishment* (N.C.R.E.). The problems dealt with here have always been difficult, but now, with the advent of the atomic bomb, they have become more formidable and basically important than ever before.

N.C.R.E. is not only concerned with the design of warships to withstand shock effects, however. It has also to determine the most efficient and economical methods of straightforward construction, and must investigate such problems as the relative merits of welding and riveting, the applications of prefabrication, and the use of light alloys.

Investigation at N.C.R.E. of the damaging effects of anti-ship weapons is, of course, as much needed by the designer of such weapons as by the ship designer, and the Establishment provides information on the explosive and damaging efficiency of weapons for the *Director of Underwater Weapons*, referred to later.

(*b*) The warship needs engines to propel it, and their provision is the responsibility of the *Engineer-in-Chief* (E.-in-C.).



E.-in-C. has two establishments. The first, the *Admiralty Fuel Experimental Station* (A.F.E.S.), has been devoted mainly to improving methods of burning oil in warships' boiler furnaces. The second establishment, known as the *Admiralty Engineering Laboratory* (A.E.L.), was originally devoted solely to the testing and development of engines for submarines, which have always been a matter of particular concern to the Navy. More recently the Establishment

has also carried out development and testing of commercially-produced internal combustion engines for use in small craft.

(*c*) Besides the power needed to propel itself, a warship needs a supply of power for illumination and for operating the mass of specialized and intricate weapons and devices it carries. Most of this secondary power is electrical and a separate department, under the *Director of Electrical Engineering* (D.E.E.), bears responsibility for its provision. The problems of electrical supply in warships are far from being straightforward adaptations of normal electrical supply techniques ; there is the underlying requirement that supplies shall still be available even though the ship has been shaken and torn by internal and external explosions, with perhaps some compartments flooded. Interruption of main and branch circuits, moreover, must not produce fire risks.

Modern developments in radar and radio communications, and in the power control of guns, have greatly increased the complexity of shipboard electricity supply. Other special Naval electrical problems are encountered in the design of submarine batteries, of degaussing equipment, and of cable and equipment for sweeping magnetic mines.

For investigation of all such problems within his field, D.E.E. maintains an Electrical Engineering Section within the Admiralty Engineering Laboratory, previously mentioned.

(*d*) The warship, of course, needs armament, both for attack and for self-defence ; this armament can be considered in two parts—above-water weapons and under-water weapons.

The *Director of Naval Ordnance* (D.N.O.) is responsible for providing up-to-date above-water weapons, from the big 16 in. guns of the battleship to the machine guns of little ships and merchantmen. No special Naval Establishment is required for the development of the guns themselves, shell and fuzes, since most of this kind of work is undertaken for all three fighting services by the Ministry of Supply. The Navy, however, encounters problems of special difficulty in the mounting and power control of its weapons, since the warship at sea is far from being a steady platform.

These problems involve close study of fire-control in all its aspects, and the development of special equipment. Before the Second World War, a certain amount of the research necessary for this purpose was carried out in the Fire-Control Section of the *Admiralty Research Laboratory* (A.R.L.) both for the Army and for the Navy, but for the great bulk of development work we relied on commercial organizations. This excessive reliance on outside organizations proved unsatisfactory and it became clear during the war that the Services must expand their own facilities to cover more of this difficult field themselves. The *Admiralty Gunnery Establishment* (A.G.E.) was therefore brought into being under the D.N.O. and made responsible for research, design and development in the fields of fire-control, including power control of mountings, for both Army and Navy.

(*e*) The title of the *Director of Under-water Weapons* (D.U.W.) well explains his field of responsibility. The D.U.W. conducts research and development of torpedoes at the *Torpedo Experimental Establishment* (T.E.E.), and on mines, depth charges and other anti-submarine weapons at the *Admiralty Mining Establishment* (A.M.E.).

T.E.E. is concerned not only with the torpedoes used by surface ships and submarines, but also the torpedoes dropped by Naval and R.A.F. aircraft. The normal torpedo of the future must travel at much higher speed under water than the present-day weapon, and must be able to withstand dropping from very high speed aircraft ; other torpedoes will be fitted with target-seeking

devices or be capable of continuous guidance in direction from their parent craft. The scientific and technical problems involved in these developments are very considerable.

At A.M.E. research is applied to both mining and minesweeping. The primary task is to develop forms of mine against which no ship can reasonably hope to immunise itself, and which no sweeper can sweep without great risk to itself. For development of such mines there are available many permutations and combinations of the well-known ship characteristics of magnetic, acoustic and pressure fields, apart from new characteristics to be explored.

The D.U.W. also controls *H.M. Under-water Detection Establishment* (H.M.U.D.E.), where research and development is applied to the problems of detection and location of submarines. The development by this establishment of the under-water echo-detection apparatus known as ASDIC, and of hydrophones for detecting submarine noises, necessarily involves investigation of the acoustic properties of the sea, ships and submarines.

Research into all forms of under-water detection and alarm apparatus for harbour defences is also a commitment of H.M.U.D.E. ; this became important as a result of the employment of the midget submarine, human torpedo and other " sneak-craft " in the last war.

(*f*) Detection of above-water targets for the Naval gunner is now largely a radar problem, and it is radar which not only picks up the aircraft or ship target in the first place, but also helps to direct the gunfire continuously at the target.

The *Director of Radio Equipment* (D.R.E.) is responsible for research and development in all radar equipment for warships, and also for all radio communication and signalling equipment. This research and development is carried out under the D.R.E.'s direction at the *Admiralty Signal and Radar Establishment* (A.S.R.E.).

Radar technique has diverse and important applications to warships and sea warfare, involving technical problems peculiar to ships in general and in most cases peculiar to specific classes of warships or specific individual warships. Radar is needed in a battleship to give warning of the approach of other warships and of aircraft, to determine the precise position and course of hostile ships and aircraft, and as a component of the ship's armament to assist in the control and direction of fire against visible or invisible targets. In an aircraft carrier radar is needed for control and direction of fighter aircraft ; in a destroyer a special radar set is needed for the detection of submarines. The provision of radar in a submarine brings its own special difficulties. Many of the problems encountered in the design and development of naval radar sets arise from the circumstance that so many different sets have to be accommodated, together with many wireless telegraphy transmitters, in the limited metallic confines of a warship in such a way that each can function efficiently without interference with another. Not only is there a shortage of accommodation for aerials—one cannot erect masts here and there all over the ship—but in many applications the aerials need to be stabilized against roll, pitch and yaw. The problems of aerial design and elimination of interference are much more difficult than any encountered on land. The A.S.R.E. is the specialist electronic circuit laboratory of the Navy serving every other laboratory and establishment with advice and much equipment in this important field.

Much attention is being given to the development of radio and radar aids for navigation of ships, especially in conditions of bad visibility. In the mercantile field, the A.S.R.E. acts as technical adviser to the Ministry of Transport.

(*g*) While wireless and radar are lending increasing assistance to the Captain in navigating his ship, the main instrument of direction is, of course, still the compass. The *Director of Compass Department* (D.C.D.) maintains the *Admiralty Compass Observatory* (A.C.O.) where work on the development and design of magnetic and gyro-compasses is undertaken for the Navy, the Merchant Navy, and to a large extent for the Army and Royal Air Force as well.

Experimental Establishments working under Departments (B)

The research and development in the establishments listed under (*a*) to (*g*) of the preceding section is directed towards clearly defined objectives ; it is mainly applied research needed for the improvement and evolution of specific types of weapon and equipment. In addition, however, it is essential to conduct a programme of research of a more fundamental exploratory character which in the long run may yield invaluable new data or point the way to entirely novel departures in design and use of weapons and equipment. Provision is made for fundamental research by the *Chief of the Royal Naval Scientific Service* in the establishments under his direct control. These establishments may thus be concerned in investigating subjects of such wide interest to the Navy as to spread beyond the confines of any single Admiralty technical department, or in undertaking various lines of research for which no separate provision is made in the Admiralty organization.

Among the laboratories of the C.R.N.S.S. are the following :—

Admiralty Research Laboratory (A.R.L.)

This laboratory is primarily devoted to fundamental physical, chemical and engineering research. Two of its groups have Inter-Service responsibilities within their fields. The Optics Group is responsible for research on optical instruments and vision problems for both Army and Navy, while the Infra-Red Group* conducts research in infra-red waves and their applications for all three Services. Basic studies of electromagnetic and acoustic phenomena carried out at A.R.L. between the wars proved invaluable in the last war in enabling counter-measures to new enemy weapons to be quickly devised. The organization as a whole is kept very elastic so that new lines of research can readily be fitted into the programme of A.R.L. as the need arises. Thus an Oceanographical Group was created to meet the need for gaining further basic knowledge about the inter-relation between sea-waves and weather conditions. The valuable work which it has already done in this field will be integrated with that of the recently (1949) formed National Institute of Oceanography.

Services Electronics Research Laboratory (S.E.R.L.)

This establishment was set up in 1946 to meet the needs of all three Services for investigation and development of the specialized types of radio valve required in Service wireless, radar and electronic equipment. It collected into one place various activities which had previously been carried out elsewhere, and was a recognition of the new importance of electronic devices in modern military equipment.

In the case of many designs of valve which eventually become standardized for Service use in large quantities, it is essential in the early stages to have the facilities of a Service valve laboratory where modifications can be made, faults diagnosed, and revised specifications and tests suggested by experts in both the electronics of the valve and its Service applications. Agreement of all Services in the control and direction of this Inter-Service Laboratory by the

* This Group will be moved during the early part of 1950 to the Services Electronics Research Laboratory.

Admiralty is an acknowledgement of the Admiralty's initiative, both pre-war and in wartime, and great experience in the conduct and co-ordination of this class of research and experimental development.

Admiralty Materials Laboratory (A.M.L.)

The efficient design of ships, weapons and equipment demands an expert knowledge of the properties of structural materials, and continuous cognizance of the various types of new materials that become available, e.g., plastics, silicones, light alloys. The diversity of choice of materials is now so great that the designer of equipment cannot hope himself to be an expert on them all, but needs the advice of expert consultants. Outstations for such research have existed for some time in the *Bragg Laboratory* of the *Naval Ordnance Inspection Laboratory* (N.O.I.L.), which is the main metallurgical centre, and the *Admiralty Chemical Department* (A.C.D.) and *Central Metallurgical Laboratory* (C.M.L.), where chemical and corrosion problems are dealt with, but it was felt that a central laboratory to deal with more fundamental physical and chemical research on materials was lacking, and this was set up in 1947.

Royal Naval Physiological Laboratory (R.N.P.L.)

This laboratory came into being during the war to meet the growing needs for investigation of uniquely naval physiological problems, such as those connected with living conditions in submarines and the endurance of divers and swimmers. It is now recognized that without physiological research to elucidate the conditions which promote maximum human efficiency in operation of weapons and equipment, much of the technical ingenuity applied to the design of modern fighting equipment would be wasted. Very close liaison and collaboration is maintained between the R.N.P.L., the Medical Research Council and other specialists in physiological research.

Conclusion

This outline of the Research and Development organization of the Navy and its main research and development establishments is necessarily incomplete. Among the less material though none the less important matters are those in the scientific intelligence field, the numerous problems of combined operations, and liaison with activities elsewhere of great importance to the Navy, such as with the Ministry of Supply on Atomic Energy and Fleet Air Arm equipment.

The R.N.S.S. organization which has been described came into force after the war as a recognition of the growing importance of science to the modern Navy and the need for increased strength in the "scientific arm." The C.R.N.S.S. himself is responsible for advising on the recruitment and the most efficient use of the Navy's scientific manpower.

In addition to the Admiralty's own organization the fullest possible use is made of outside effort in the Universities and Industry in various fields of scientific research and on special development projects, and a number of outside experts in the academic and industrial worlds act as consultants. In this way the research and development resources of the country are enlisted to ensure that the Navy is provided with a comprehensive and up-to-date scientific service.