THE METALLURGICAL LABORATORIES ATTACHED TO H.M. DOCKYARDS

by

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The several metallurgical laboratories which are attached to the Engineering Departments comprise the Central Metallurgical Laboratory at Emsworth, together with smaller metallurgical laboratories located in the Dockyards at Portsmouth, Devonport, Chatham, Rosyth and Malta. The activities of the C.M.L. at Emsworth are devoted principally to research, development and general investigatory work, whilst the smaller laboratories in the Dockyards deal mainly with routine control and day to day problems of an " ad hoc " nature. Scientific Staff, metallurgists, engineers, physical chemists, physicists and biologists, senior and junior, number in all about 50 forming part of D.S.R's Scientific and Technical Pool and include members of the Royal Naval Scientific Service. Some 75 per cent. of this number work at C.M.L. whilst each Yard laboratory is staffed by not more than three men.

The scope of activities is set out diagramatically in Fig. 1 and in the following a brief account is given of the more specific items :

SCOPE OF ACTIVITIES

Activities of the organisation may be classed into the following categories :—

(*a*) Routine control work associated with metallurgical operations in the Engineering Departments, including the production of steel, cast iron and non-ferrous alloys in the foundries, moulding sand control, casting operations ; supervision of physical and mechanical testing as required, heat treatment and check of pyrometric gear ; occasional checks of welding technique and of welders ; other miscellaneous work dealing with incidental routine operations in foundries, boiler shop, factory, coppersmiths shop, etc.

(*b*) Development work of a metallurgical nature of particular interest to E. in C. and D.N.C., and other Departments including the production and testing of alternative alloys, melting procedure and foundry materials ; comparative trials of new metallurgical materials and operations ; factors relating to the economy of materials in short supply ; testing of new welding techniques, including metallic arc, carbon arc, flame, atomic hydrogen, automatic and other more specialised methods; brazing and soldering; hot and cold fabrication methods, crack and flaw detection by gamma-ray, magnetic, luminescent and other methods, pickling, degreasing and cleaning, furnaces and refractories, metal spraying, electroplating, etc.

(*c*) Metallurgical examination of service failures occupy a very prominent part of activities and range over most items to be found in the Engineering and Constructive Departments in H.M. Ships. During the past six years, these investigations have totalled well over 2,000 and have revealed a most valuable and interesting overall picture of the engineering and allied arts, involving defective material and design, faulty operation and, by no means

METALLURGICAL LABORATORY ORGANISATION—H.M. DOCKYARDS
CENTRAL METALLURGICAL LABORATORY (EMSWORTH)

ACTIVITIES

ROUTINE	DEVELOPMENT	ADVICE	SERVICE FAILURES	CORROSION
—Chemical and metallographical tests	—foundry materials and processes	—records	—Inspection of components in situ	—Inspection of components in situ
—physical and mechanical tests	—welding and joining methods	—technical information	—laboratory investigations	—laboratory investigations
—tests of foundry materials	—fabrication methods	—liaison with Admiralty and Service Depts. Ships' Officers, etc.	—reports	—field trials
—tests of fuels and refractories	—heat treatments	—liaison with research organisations committees, etc.	—enunciation of specific problems for further research	—tests on protective and anti-fouling compositions
—production processes	—furnaces and refractories			—development of improved protective methods
—pyrometry	—metal cleaning			—anti-fouling enunciation and specific problems for further research work of Admiralty Corrosion Committee
—flaw detection	—machining problems			
—electroplating	—miscellaneous			
—miscellaneous				

Fig. 1

ROUTINE LABORATORIES

These smaller metallurgical laboratories are located in H.M. Dockyards at Portsmouth, Devonport, Chatham, Rosyth and Malta. Another has just been started at the R.N. Aircraft Repair Yard, Fleetlands. Work engaged upon is mainly of a routine nature and concerns current production work (see Routine column in above table) together with a limited amount of general investigatory work The several routine laboratories operate with the central laboratory as a unit.

last, our lack of fundamental information and data. This work is one of the most fruitful sources for the enunciation of specific objectives for further research.

(*d*) Corrosion investigations, antifouling and the work of the Admiralty Corrosion Committee (A.F.O. 2923/43) together with the three Sub-Committees dealing respectively with hull, boiler and non-ferrous corrosion problems constitute about 50 per cent. of the activities of the C.M.L. Since its inception in 1943, the A.C.C. has issued over 200 reports, the main of the investigatory work having been carried out by C.M.L. staff. In addition to purely laboratory studies, investigations include inspections of ships and components in dock, panel and other small scale trials in the sea and general " field " work. Engineer Officers

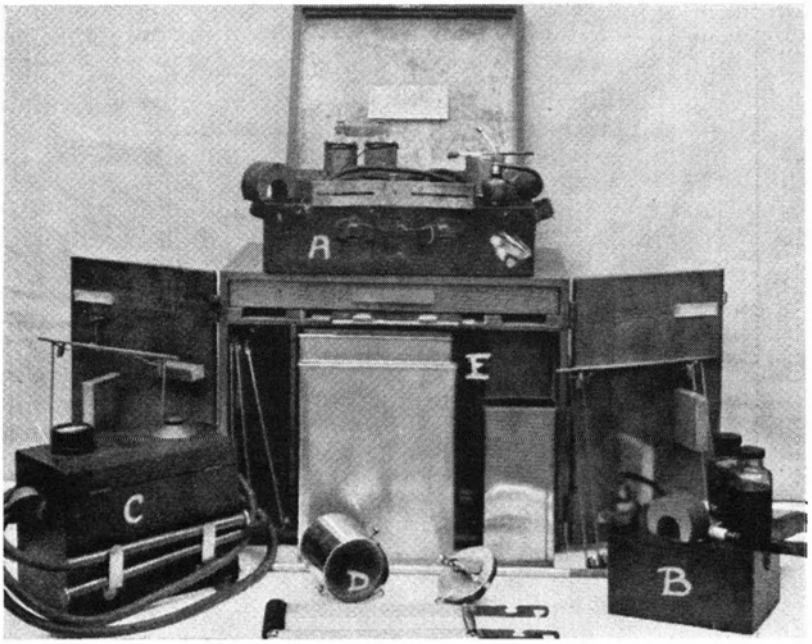

FIG. 2.—PORTABLE FLAW DETECTION EQUIPMENT INCLUDING :—
A.—" PORTMOUTH " TYPE MAGNETIC CRACK DETECTION SET
B.—SMALL MAGNETIC CRACK DETECTION SET
C.—FLASH MAGNETISATION CRACK DETECTION SET
D.—220 M.G. RADIUM SOURCE (CONTAINER)
E.—PORTABLE DEVELOPING CABINET

will be familiar with BR.1254 which deals with corrosion of components in sea water cooling systems and it is of interest to note that the A.C.C's activities will result in the preparation of other more practical handbooks, including three dealing with boiler corrosion and deterioration problems.

(*e*) General advice and assistance in metallurgical and allied problems referred by naval and other establishments having engineering interests. These range from a simple telephone enquiry which can be answered on the spot, to more elaborate problems requiring a fair amount of laboratory work in addition to the compilation of technical data and advice.

RESEARCH

Longer term investigatory or research work in progress at C.M.L. Emsworth merits separate reference and the following brief particulars of some of the items on hand may be taken as indicative both of the work and of the trend of developments :—

(i) *Welding.*—Most of this work is devoted to investigations mainly of a development nature and includes metallurgical advice and assistance in the application of new welding techniques, such as automatic welding, stud welding, carbon arc welding, etc. The testing of new types of metallic arc electrodes, particularly for special jobs such as grade " A " welds, underwater welds, deep penetration, repair of H.T. brass propellers, cast iron and other alloys are also matters of concern.

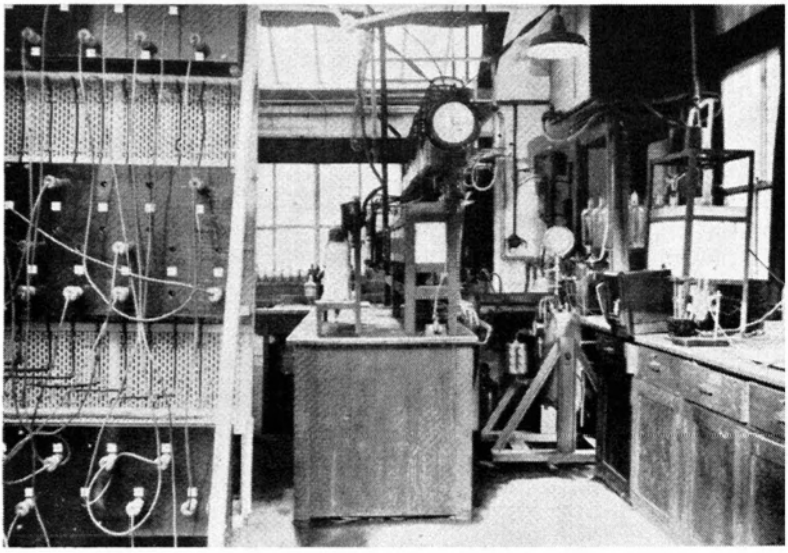

FIG. 3.—PORTION OF BOILER CORROSION LABORATORY C.M.L.

(ii) *Flaw Detection.*—Both the development and application of methods suitable for use in Yards and in ships have received very full attention. The two chief techniques employed are magnetic crack detection and gamma-ray. Many engineer officers will be familiar with the " Portsmouth " type portable magnetic crack detecting outfit which was evolved in the C.M.L. and comprises a strong electromagnet for use both with 110 and 220 v.D.C., a large permanent magnet of Alnico alloy, together with a spray for the magnetic ink. As a consequence of the loss of the laboratory's X-ray set in a Portsmouth blitz and the lack of other equipment, a large gamma-ray source comprising 220 mg. radium was obtained in 1941 and this has been widely used for the survey of defects in castings, cracks and other flaws. The ready portability of this unit, which includes the radium capsule and a hand case carrying the developing materials for the films has been a great asset. The laboratory has thus organised a flaw detection service which has been rushed, at a few hours' notice, to most of the ports in this country. Fig. 2 illustrates the portable equipment used.

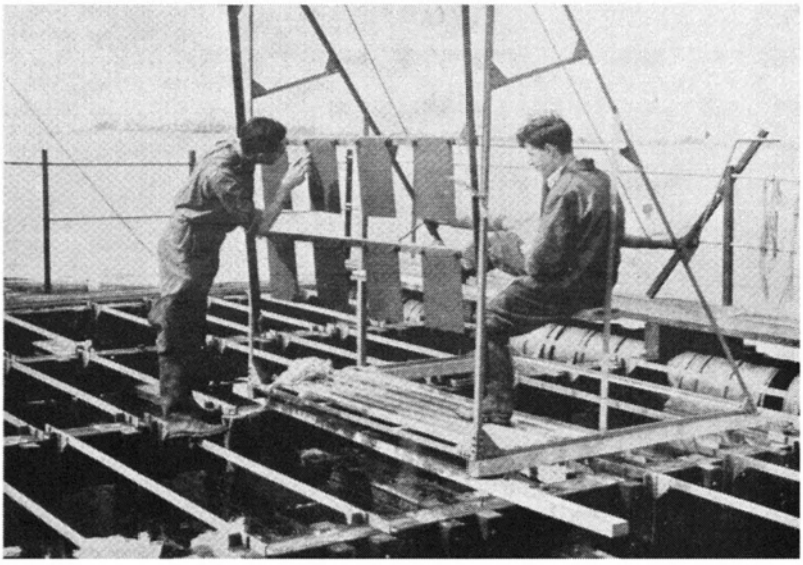

FIG. 4.—EXPOSURE RAFT, CHICHESTER HARBOUR, SHOWING A SUSPENSION FRAME CARRYING TEST PANELS HOISTED FOR INSPECTION

(iii) *Corrosion and Deterioration in Boilers.*—This matter which has been of very considerable concern to E. in C. has resulted in the investigation of several hundred service failures and the starting up of a fair volume of fundamental research. The field covered is a wide one and includes investigation of soft and hard scab pitting, crazy cracking, conditions determining the bursting of tubes, effect of oil fuel and other deposits on thermal conductivity, conditions governing the formation of high temperature scale, cracking in boiler drums, caustic embrittlement and other matters. Factors involved in the successful conditioning of boiler waters by means of boiler compound have been elucidated and developed. These several items have been summarised in three booklets issued by E. in C. and have become " popularised " by lectures in the Home Ports. A portion of the boiler corrosion laboratory at C.M.L. Emsworth is shown in Fig. 3.

(iv) *Corrosion in Salt Water Cooling Systems.*—This problem became priority 1 soon after the outbreak of the War, in view of the many failures in copper piping, bellows pieces and other components of condenser systems, consequent on the use of higher water speeds in ships of newer construction and the more arduous operating conditions. The elucidation of the trouble is now, of course, more or less historical, but the development of remedial measures has required a much more prolonged effort. Briefly, the trouble arises when sea water containing entrained air bubbles and moving at speeds above about 6 ft./second causes impingement attack of copper, resulting ultimately in localised perforation. Other factors are involved, such as the proximity of the copper to gunmetal which causes galvanic stimulus of the attack. The main lines of defence which have been developed, apart from reduction of water speed and turbulent flow, include the use of alternative alloys, notably the B.N-F. alloy (Cu 94%,

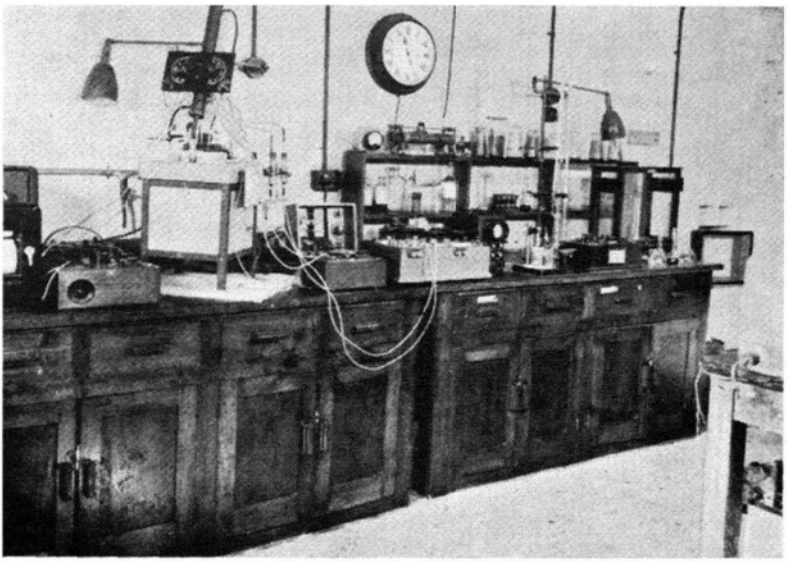

FIG. 5.—PORTION OF CORROSION LABORATORY, C.M.L.

Ni 5%, Fe 1%), and various high duty protective paints, such as Detel, Debecote and Tretol. Engineer Officers will find an interesting and useful account of this work and the developments arising in B.R. 1254 previously mentioned, which was issued in 1945.

(v) *Hull Corrosion and Fouling.*—The objectives of these longer term investigations are to seek out the causes of abnormal corrosion of under-water plating, rudders and propeller shafts which occur from time to time and to improve the performance of protective and antifouling ships bottom compositions. Such researches yield dividends slowly but surely in avoiding costs of replacements, longer periods out of dock and economy in fuel consumption by ensuring cleaner bottoms for longer periods. Factors for study have included the all important initial preparation of the plating and the evaluation of the protective and antifouling compositions which are available. Various laboratory and small scale testing techniques have been developed for sorting out the many compositions prior to selecting the more promising ones for trial on ships. A raft (See Fig. 4) from which small panels can be exposed in the sea is located in the Chichester Harbour, where fouling organisms are plentiful, whilst other exposure sites include a large salt water tank and a series of racks at ½ tide level. More fundamental work is also in progress to elucidate the mechanism of failure of protective compositions, the causes of blistering and related phenomena. On the biological side, an intensive study is being made of the marine organisms responsible for fouling with particular reference to factors relating to their repulsion by toxic surfaces. The rates at which the poisons are leached from anti-fouling paints and which determine their toxicity and efficiency are also being examined. Fig. 5 shows a portion of the corrosion laboratory at C.M.L.

(vi) *Non-Ductile Fracture of Mild Steels*

Service experience has indicated that fracture in a non-ductile manner may occur in certain circumstances in mild steels which, under normal test, show excellent toughness and ductility. Examples which have occurred include boiler drums, chain cable, bolts, parts of ships' structures, etc. Such catastrophic failures are fortunately reasonably rare, but their occasional occurrence is a matter for some concern, especially in connection with all welded structures, where the instantaneous fracture can be propagated over long distances. Two quite distinct factors appear to be involved ; the relative capacity of the steel to become embrittled by plastic strain and the liability of the steel to a cleavage type of fracture. It has become apparent that a number of characteristics, apart from chemical composition of the steel, are involved and much fundamental investigation is required to elucidate the problem. The physical mechanical testing laboratory at Portsmouth Yard is illustrated in Fig. 6.

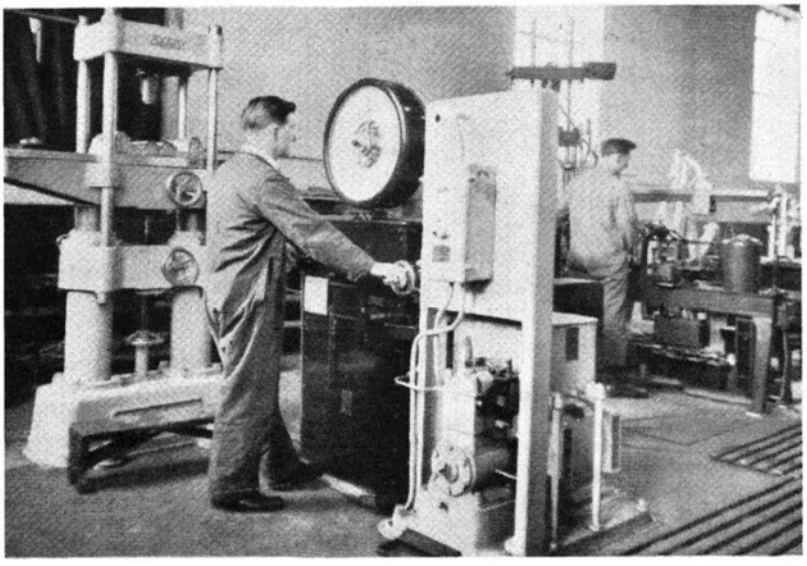

FIG. 6.—MECHANICAL TESTING LABORATORY, PORTSMOUTH YARD

Additional to the foregoing, there are several other major investigations in progress or contemplated. These include, corrosion investigations on light alloys to be used in ships' structures, elucidation of the functioning of zinc protectors, electrolytic pickling for the cleaning of oil tanks, corrosion in hydraulic systems by leather washers, corrosion fatigue, stress corrosion cracking of H.T. brass, creep of high duty alloys for gas turbines. With the availability of further scientific staff and larger laboratory facilities, it is hoped considerably to extend the scope of these and other researches. In addition, it will be possible to devote time and energy to the more fundamental elucidation of many problems which so far have been investigated in an " ad hoc " manner. Brief surveys of some of these activities have been brought to note in previous

issues of " Engineering Papers " and it is hoped to maintain a constant contribution of items of particular interest to engineers.

It will be appreciated that the enunciation, investigation and ultimate solution of any problem is essentially the result of a " combined operation " in which both the practical engineer and the scientist must fully co-operate. Such liaison can only be established and maintained by each having knowledge and confidence in the other and it is hoped that Engineer Officers will freely bring their problems, great and small, as occasion demands, to the scientist for discussion. The future holds much in store in the metallurgical world, which is of very immediate interest in naval engineering and which is of concern, not only in the development of new machinery and equipment, but also in using more efficiently and economically the materials we already possess.