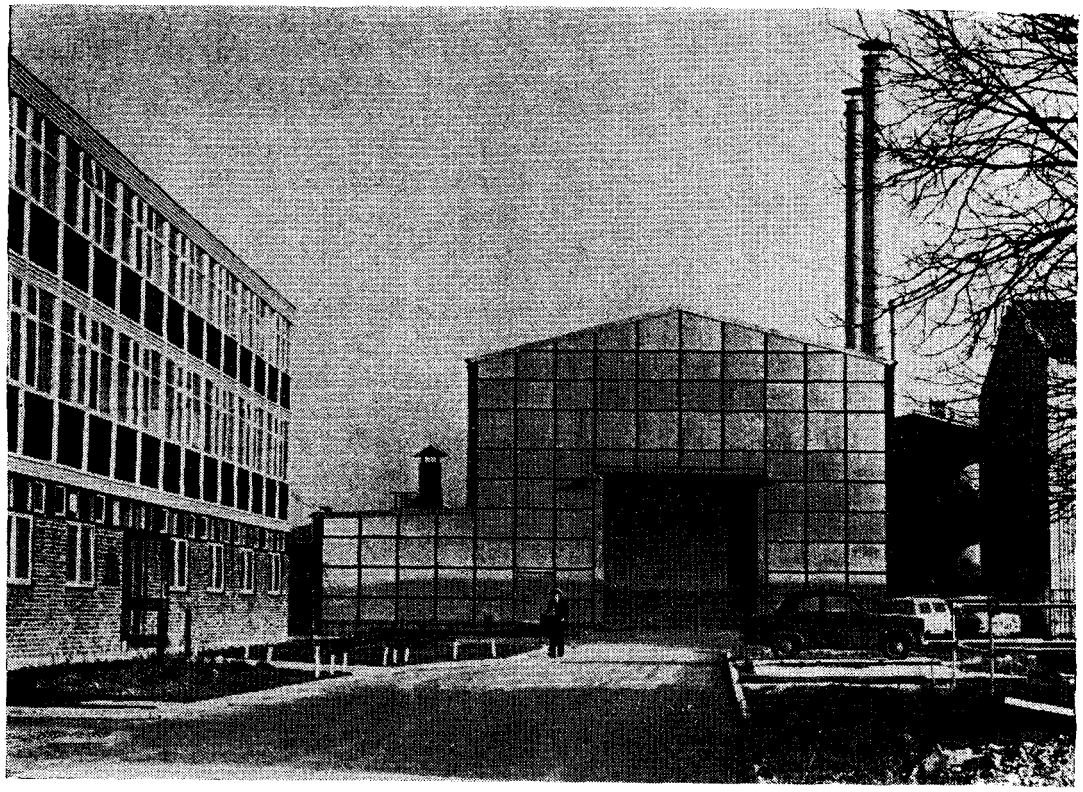


FIG. 1—NEW OFFICE BLOCK AND AMTH BUILDING

THE ADMIRALTY MARINE ENGINEERING ESTABLISHMENT

HASLAR

BY

COMMANDER V. EVANS, M.A., R.N.

INTRODUCTION

It is unlikely that anyone who knew the Admiralty Fuel Experimental Station, even only five or six years ago, would recognize the present Admiralty Marine Engineering Establishment as its descendant. (FIG. 1.). Certainly the area of land to the north of Haslar Hospital and to the west of the Gunboat Yard is very different from the allotments and blackberry bushes among which the Admiralty Liquid Fuel Experimental Establishment was set up in 1902. The Constructors were the first to establish themselves on the site by building, in 1887, what is now No. 1 Ship Tank of the Admiralty Experiment Works. (1).

The two Establishments have grown side by side, although in the case of the A.M.E.E. the biggest expansion has been during the last five years. Now the A.M.E.E. occupies most of the central portion of the site, bounded on three sides by the A.E.W. The fourth boundary is on Haslar Creek, from which the cooling water supplies are obtained. This creek empties at low tide and the lack of water for the condensers must have imposed severe restrictions on operating in the early days. The present condensers, one from H.M.S. *King George V* and one from H.M.S. *Implacable*, take their water from a fairly extensive area of impounded water. Even this does not allow entirely free operation because

the total possible output of the Establishment's boilers is over 500,000 pounds of steam per hour—about four times the capacity of the ponds over the low-tide period.

The Admiralty Fuel Experimental Station was largely engaged in work on boilers and the burning of liquid fuels. But the availability of steam in large quantities and at the right conditions made the introduction of a limited amount of machinery testing inevitable. It is this aspect of the work of the Establishment which is the subject of the more recent expansions. In any case the setting up of the Admiralty Oil Laboratory in 1951 had taken away all the work on fuels except that associated with combustion. The change in emphasis was finally acknowledged by the introduction of the present title of the Establishment in November, 1966.

With over sixty years of Research and Development on boilers it is not possible to do justice in this article to the many achievements of the past. By necessity the descriptions which follow must be of a somewhat general nature.

ADMINISTRATION

The Establishment is directed by a Superintendent, who is a Captain, R.N. and who is responsible to the Director General Ships for fulfilling the programme of experimental and development work. He is also responsible to the Commander-in-Chief, Portsmouth, for local administration as a Civil Establishment within the Portsmouth Command.

For the purposes of internal administration the Establishment is divided into three sections:

(*i*) Testing and Trials Groups under the Chief Test Engineer, who is also the Deputy Superintendent

(*ii*) Scientific Support Groups under the general direction of a Principal Scientific Officer, Royal Naval Scientific Service

(*iii*) Station Services and Workshops under the Senior Engineer.

In addition to the A.M.E.E. proper, the Superintendent is responsible for the local administration of two other units accommodated in the Main Office Block, viz:

(*a*) The Machinery Controls Trials Unit under the Officer-in-Charge M.T.U.—a Commander R.N.

(*b*) The Machinery Controls Trials Team under the Officer-in-Charge M.C.T.T.—a Lieutenant-Commander R.N.

PERSONNEL

The expansion of the Establishment has, of course, been reflected in an increase in the number of men employed, which is now double the figure for 1961. It is interesting to observe the differing types of professional staff who have been appointed in order to obtain the most suitable officers for the very wide range of testing and research that is undertaken.

The present complement including M.T.U. and M.C.T.T. is:

14 Naval officers
15 R.N.S.S. officers
3 R.N.E.S. officers
20 Production Pool officers
4 Retired officers, R.N.
30 Naval ratings
120 Other civilian staff

THE WORK OF THE ESTABLISHMENT

Although the A.M.E.E. is designated a Research and Development Establishment and is financed from the Research Vote, the major part of the work of the Establishment lies in the field of Evaluation and Development. It is a basic principle of Ministry of Defence policy to use commercial machinery and plant where possible; it is in proving this possibility and making recommendations for improvement that the A.M.E.E. is concerned.

Provided that the machine or plant fulfils its expectations both on trial and subsequently in service, the task is comparatively simple. If it does not, the problem is a very different one requiring expertise which is often beyond the capacity of the manufacturer. In order to provide such expertise it is necessary for the professional staff at the A.M.E.E. to obtain a much wider knowledge of their subjects than would be expected of purely test engineers. A certain amount of such knowledge comes naturally as a result of experience in testing but, nevertheless, it is believed that some fundamental work should be carried out, even in fields where its immediate requirement is not apparent.

Notwithstanding the requirement to make the maximum use of commercial equipment, it frequently occurs that no such equipment is available. In this event it is incumbent on the Research and Development Establishments to make good the deficiency. So far as the A.M.E.E. is concerned this is most apparent in the case of combustion equipment. The search for suitable commercial oil burners and air registers has been continuous but largely unavailing; only one commercial air register has proved to be suitable for use with the very small furnaces of naval boilers—the Babcock and Wilcox 'Iowa' Register fitted in some of the *Daring* Class.

The Admiralty Suspended Flame Register was designed and developed at Haslar to cover this deficiency during the post-war years, and has since been widely adopted, under licence, by commercial manufacturers. The pressure jet burners currently in use were a combined venture with the manufacturer (2) (3). Now design is well advanced with a new generation of air registers which it is hoped to introduce into the later Y.160 *Leanders*, together with a new design of twin-fluid atomizer.

In general, the programme of trials is sponsored by the appropriate specialist sections in the Ship Department. The need for a trial may arise from their own work, or because of reports received from sea. Trials of a more fundamental nature may be inserted by the A.M.E.E. or by the Scientific Advisers to the Director General Ships. Whatever method is adopted the trials programme is a full one, demanding close liaison with the sponsors to determine priorities, methods, and to discuss progress as the trial proceeds.

The Boiler Groups

Y.100 *Whitby* Class Boiler

Y.102 *Devonshire* Class Boiler (FIGS. 2 and 3)

Steam Gunboat Boiler

Refractories Laboratories

Atomizer Testing

Air Test Rig and Tunnel Furnaces

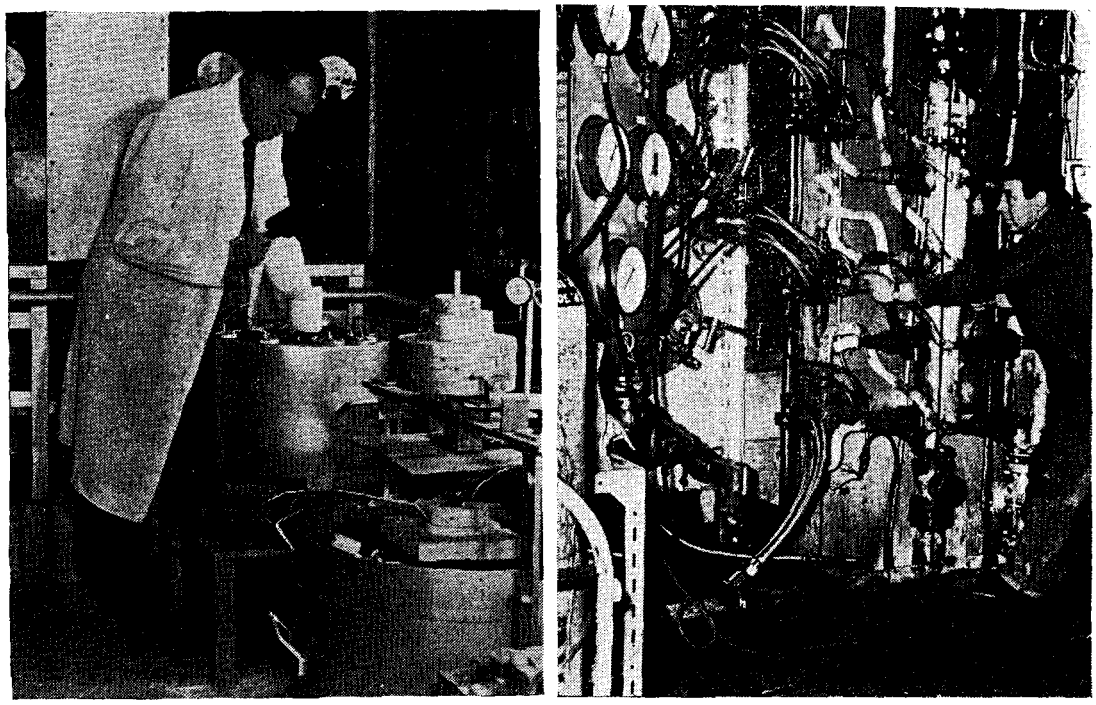
Each of the boiler groups, named above, is manned by a team of professional and industrial staff, with their own particular responsibilities. For example, the Y.100 boiler group are responsible for the development of combustion equipment, Y.102 for automatic boiler controls, and the Steam Gunboat boiler is used for fundamental combustion and heat transfer work. But, of

FIG. 2—Y.102 CONTROL ROOM

FIG. 3—RATING AT WORK IN Y.102 BOILER ROOM

course, it does not end there; trials may be applicable to the particular facility rather than its specialized designation, or require wider resources than can be given by any one group. Such is the interchange between the various boiler groups that it is preferable to describe the work in terms of a combined effort, rather than attempt to define each group separately.

The development of new designs of combustion equipment has been mentioned earlier; this has required the use of most of the facilities within the boiler groups. Much work has been done on boiler circulation and on lighting up procedures, involving all the boilers. A good example of this broad based effort has been in trials involving the burning of distillate fuels. Some of the reasoning behind the desire to burn Diesel oil has been described elsewhere (4), and the earliest trials were carried out on the tunnel furnaces and Y.100 boiler to find out if any obvious difficulties would be revealed. One problem that had been stated lay in an anticipation of trouble with the fuel pumps in those ships operating spill burner systems with a fuel supply pressure of 1000 lb/sq in. Accordingly, once the practicability of burning Diesel oil with the Simplex burners of the Y.100 type had been established, the Y.102 boiler group were invited to investigate the effect on the automatic control system. There was very little trouble in using the existing arrangements, with the normal spill atomizer (2850/850), and it was the opinion of the trials staff that the fuel pump did not suffer from excessive wear. Nonetheless, a further trial was conducted with a larger size of atomizer (3750/850) operating at the lower end of its range and hence at lower pressures. Control settings were established requiring very little modification to the system, using fuel supply pressures below 600 lb/sq in. However, as had been feared, the combustion performance of the larger atomizer was far from satisfactory at the bottom end of the power range. This was investigated further on a tunnel furnace, revealing that combustion problems are likely when burning below about 300 pounds per hour with this atomizer in Y.102 or Y.111 registers.



REFRACTORIES TEST LABORATORY Y.102 BOILER

FIG. 4—SOME TESTS ARE MORE SCIENTIFIC THAN OTHERS

The effort was then diverted to the effect on the patterns of heat transfer due to the differing emissivity of distillate flames, requiring changed damper settings on the controlled superheat boilers. For these trials the fundamental group took over both Y.100 and Y.102 boilers, fitting them with water cooled probes, and establishing the heat transfer pattern with Diesel and avcat compared to that obtaining in practice when burning furnace fuel oil.

Interspersed among the various elements of the distillate fuel trials were many other individual trials. The Y.102 Group, for example, have carried out a searching examination into boiler feed regulation, with particular emphasis on the three-element regulator fitted in the latest classes of ships. The initial evaluation of this regulator had been carried out on the Y.102 boiler in its automatic mode, and it had appeared to be satisfactory in service. However, the introduction of a variant of this regulator in the Y.124 Assault ships, and the Y.136 *Leanders* had apparently led to the loss of an observable water level on rapid change of power. The Y.102 boiler was modified to simulate both the Y.124 and the Y.136 arrangements, and extensive trials carried out without revealing any critical differences in behaviour from the original system. It was not possible to lose the water level so long as the installation was in automatic control, so the trials were repeated simulating the hand control applicable to the two classes under investigation. This established that with the much more rapid changes in power possible the water level could be lost irrespective of the settings imposed on the regulation system. In fact, it was observed that the extreme variations in level which were the reason for the trial could be caused almost entirely by over-rapid alterations to the steam off-take. Recommended limitations on the rate of throttle opening, together with proposed settings for the regulators on the various boilers, have been forwarded to the sponsor section.

The two support groups—those dealing with atomizers and refractory materials—were set up originally for the purpose of production control testing of items before going into service. Although their main task still lies in this

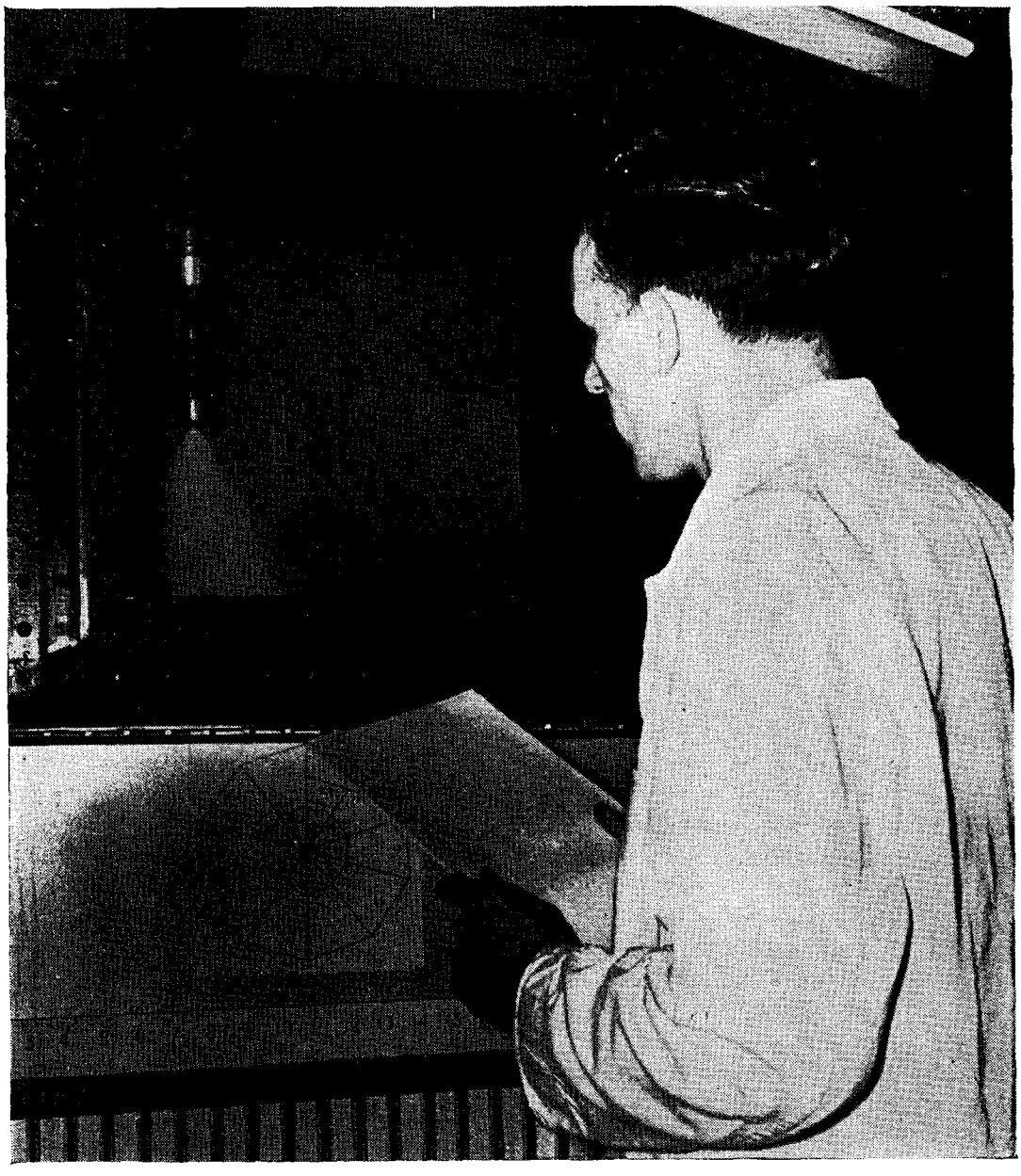


FIG. 5—ATOMIZER ON TEST IN THE ATOMIZER TEST RIG

requirement, both groups carry out a certain amount of research. The Refractories Group also accepts any chemical or metallurgical problems that may arise, and is responsible for feed water chemistry so far as it affects the Establishment (FIG. 4). Efforts to introduce recalibration of atomizers as a routine for H.M. ships have not yet been successful, but much has been done by private arrangement. In 1963, the group were reporting the testing of 500 atomizers; the figure for 1967 was over 5,000 (FIG. 5).

The Auxiliary Machinery Test Group

Testing of auxiliary machinery and individual components, such as valves, has been carried out by the boiler groups for some years. The dependence of such trials on the operation of the boilers imposed severe limitations on the amount of running that could be achieved, and, in 1960, Y-A.R.D. were instructed to prepare a specification for an independent Auxiliary Machinery Test House. This has now been in full operation since June, 1967 (FIG. 6). Before

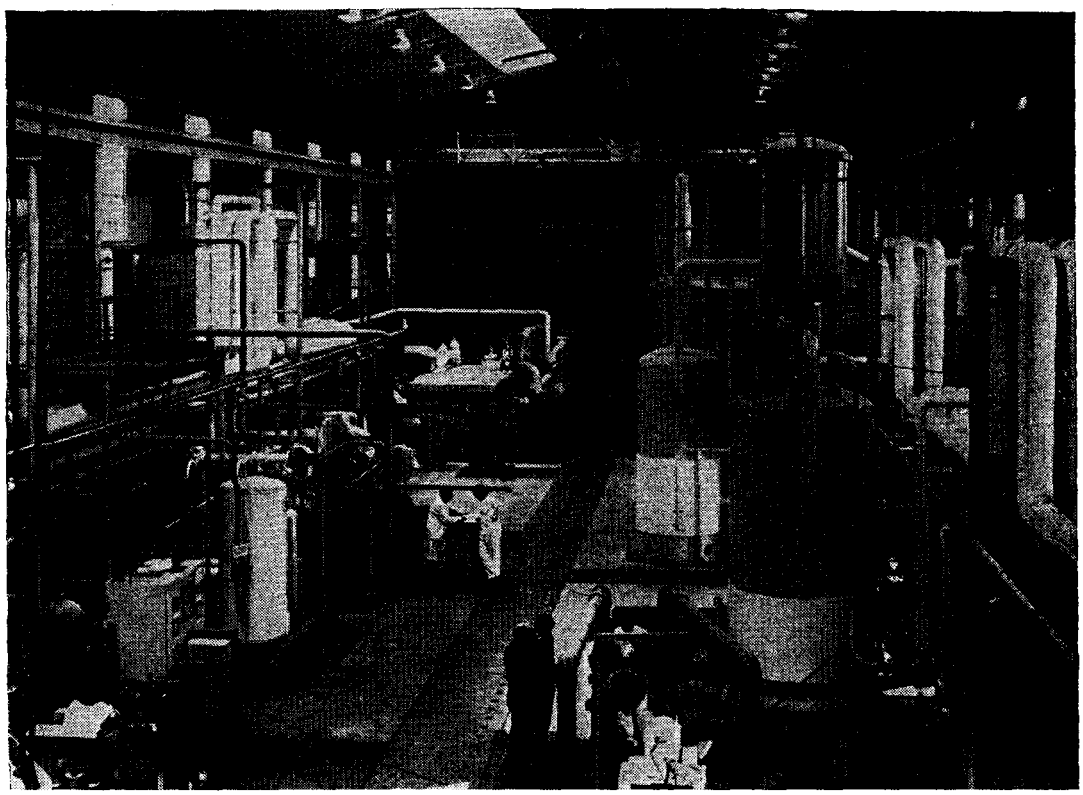


FIG. 6—AMTH—GENERAL VIEW

the commencement of running in the A.M.T.H. a small nucleus of a test group had been set up, conducting trials of fuel pumps on an electrically operated rig, and on a turbo blower in Y.102 boiler house. The Experimental Officer, R.N.S.S., who established this group and used his experience to assist in setting up the present test organization, is now engaged in investigating gny matters of a more fundamental nature that arise in the course of routine auxiliary machinery testing. It is intended that the number of scientific staff so engaged shall be increased.

The operation of the Auxiliary Machinery Test House, which is on a twenty-four hour basis, is directed by one of the Naval Project Officers, assisted by an officer of the Royal Naval Engineering Service. The conduct of the trials is under the direct control of Production Pool Officers.

The Objective

The objective in the A.M.T.H. is clearly associated with endurance and performance testing of commercial products, rather than development. It is stated as being to:

(*i*) Prove the suitability of a machine's design prior to fitting in ships, consulting with the makers and such other organizations as the Ship Maintenance Authority when necessary.

(*ii*) Establish reliable data on the useful life of machinery components, and the effects of wear on performance, and to assess methods of non-destructive examination, e.g., the relation between noise and vibration signatures and the wear in components.

Method of Testing

The method of testing is established by consultation between A.M.E.E., the sponsoring section and, where necessary, the manufacturer. Where not

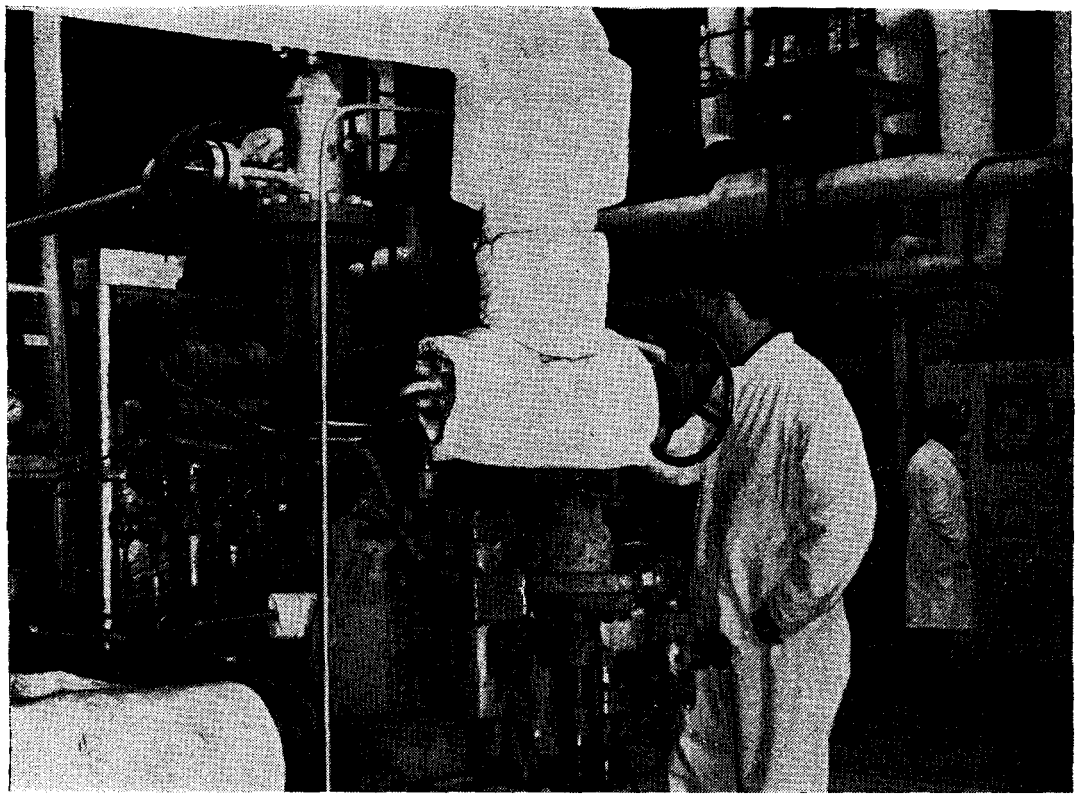


FIG. 7—Y.160 FEED PUMP ON 10,000 HOURS ENDURANCE TEST

previously carried out by the manufacturer in association with officers from the A.M.E.E., units are stripped down on receipt for examination and dimensional checking, when any faulty workmanship can be discovered before the trial is commenced.

The normal trials programme consists of a long period of endurance running at various specified conditions, interspersed at suitable intervals with checks on the output performance, response to changes in control signals, noise and vibration signatures, etc., as well as inspection and dimensional checking of parts liable to wear (FIG. 7). Selected variables are monitored continuously by a data logger in the control room, which includes an alarm scanning system.

When desired by the Ship Maintenance Authority a suitable period is allocated for the conduct of a maintenance evaluation exercise. Once established the proposed routine maintenance schedule is followed throughout the trial.

The services that are available at the test rigs in the A.M.T.H. are too numerous to list here, but were designed to accommodate all foreseeable ship conditions, using either steam or electric prime movers. It is sufficient to remark that two new station boilers have been built, with an output of 180,000 pounds of steam per hour at up to 1,200 lb/sq in. and 950 degrees F.

Test Rigs

The test rigs that were available are shown in FIG. 8. Although this shows the official functions for which the rigs were designed there is sufficient flexibility to allow for differing usage in accordance with the current requirement. For example, two H.P. air compressors are installed in the turbo-generator test rigs, and a submarine feed pump is in the extraction pump rig. The area designated Miscellaneous Test Rigs, and any other spare floor space is rapidly being used up with additional items such as an L.P. air compressor, an SSBN electrolyser, and a bellows test rig. A list of the permanent rigs together with their capabilities is given in TABLE I.

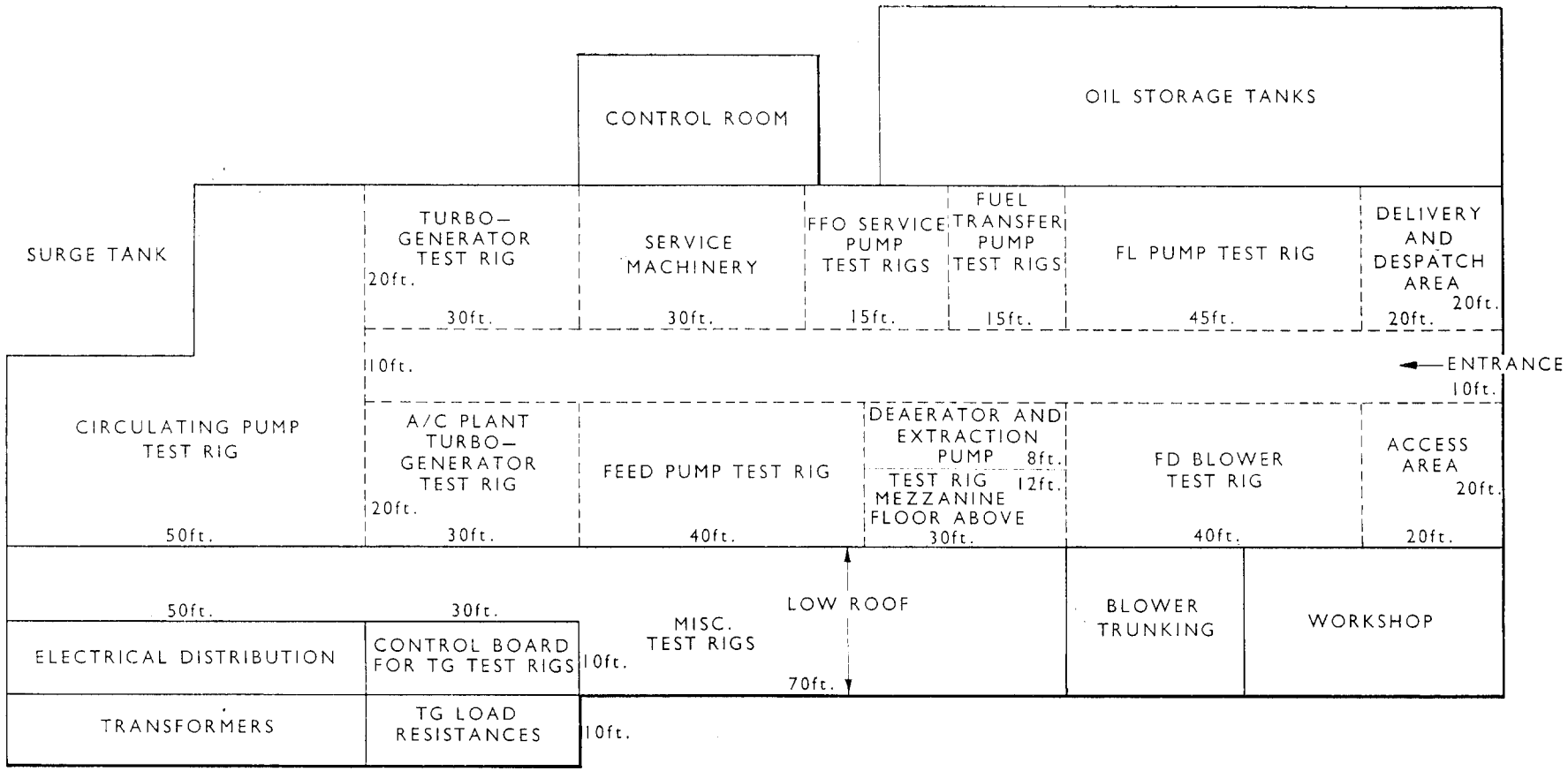


FIG. 8—AMTH—PLAN OF TEST RIG LAYOUT

TABLE I—AUXILIARY MACHINERY TEST HOUSE—TEST RIGS

Equipment for Test	*Maximum Capability of Test Rig*	*Standing Equipment as Part of Rig*
Main Circulating Pumps Fire Pumps Eductors	60,000 g.p.m.; 30 lb/sq in. head 1,100 g.p.m.; 160 lb/sq in. head 1,500 g.p.m.; 80 ft head	Surge Tank
Turbo Generators	2,000 kW—self condensing 500 kW—back pressure	4 load resistances—500 kW each External Cooling Tower
Condensate Extraction Pumps Deaerator Extraction Pumps	840,000 lb/hr; 60 lb/sq in. head 840,000 lb/hr; 35 lb/sq in. head	Vacuum Tank Air Ejector Deaerator Pressure Vessel
Feed Pumps	840,000 lb/hr; 1,400 lb/sq in. head	Reservoir Expansion Tank Cooler
F.F.O. Service Pumps	50,000 lb/hr at 1,000 lb/sq in.	Heaters Coolers Filters
F.F.O. Transfer Pumps Dieso Transfer Pumps Avcat Transfer Pumps	250 ton/hr at 200 lb/sq in. 350 ton/hr at 200 lb/sq in. 350 ton/hr at 200 lb/sq in.	Coolers Strainers
Forced Lubrication Oil Pumps	2,000 g.p.m. at 75 lb/sq in.	Heater Cooler. Exhaust Fan Renovating System
Forced Draught Blowers	110,000 c.f.m.: 120 in. wg head	Air Trunking and Silencers
Chilled Water Plant (alternative use for second T/G Rig)	3,000,000 BTU/hr	Chilled Water Header Tank Calorifier
High Lift Pumps	Maximum Suction Lift: 20 ft	Adjustable Platform Pond (under)

Relief and Safety Valve Test Facility

Any verbal description of the relief and safety valve test facility is inadequate for conveying an appreciation of its dimensions or its importance to the Ministry of Defence (FIG. 9). For security reasons it is not possible to state the pressures and flow rates of which it is capable. Perhaps it will be sufficient to state that the original estimate for the rig installation alone was £110,000, and that this has since been extended further.

The facility was originally conceived as a means of proving that the safety requirements were being met by the steam and water relief valves in the primary circuits of the nuclear submarines. Two test stations were designed for this purpose, but a further two stations were added to the design to permit testing of conventional safety and relief valves. Each of the four stations is provided with steam or water at the conditions appropriate to its designed use.

The pressure of meeting the submarine building programme has been such that the facility has been heavily loaded ever since commencing testing in July, 1965. It is a regular employer of overtime running, and the analysis of the test results occupies a considerable number of professional man-hours.

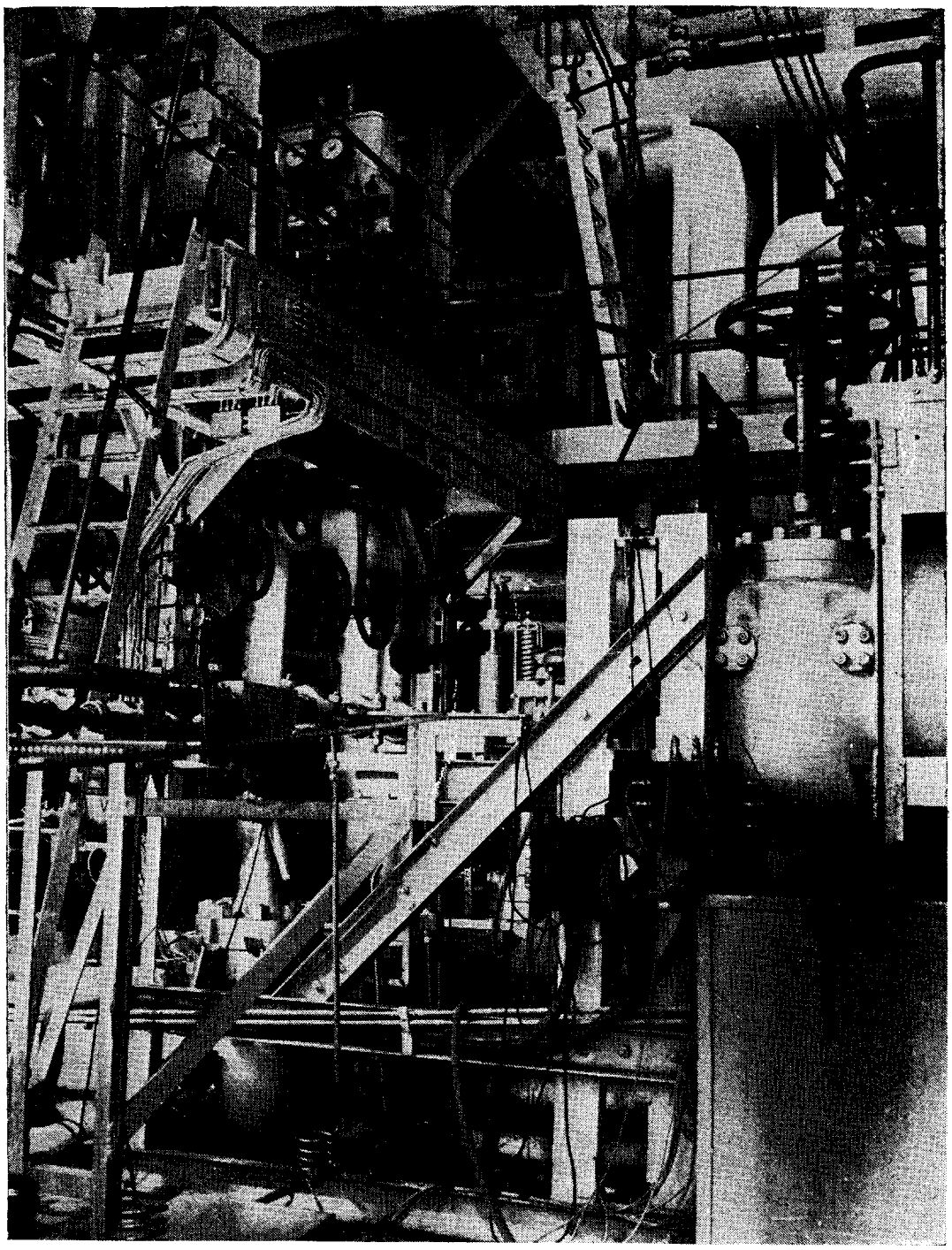


FIG. 9—RELIEF AND SAFETY VALVE TEST FACILITY

An increase in the pressure has been applied by the suitability of the facility for testing components for the nuclear programme other than those for which it was designed. A steady stream of items such as emergency coolers, hull valves, and a quench tank have been added to the relief valve testing programme. It is not surprising that very little non-nuclear testing has been possible, but it is worth noting that it has been practicable to adapt one of the stations to study the behaviour of a steam reducing valve.

Fire Test Ground

The Fire Test Ground was established at Haslar for convenience, rather than

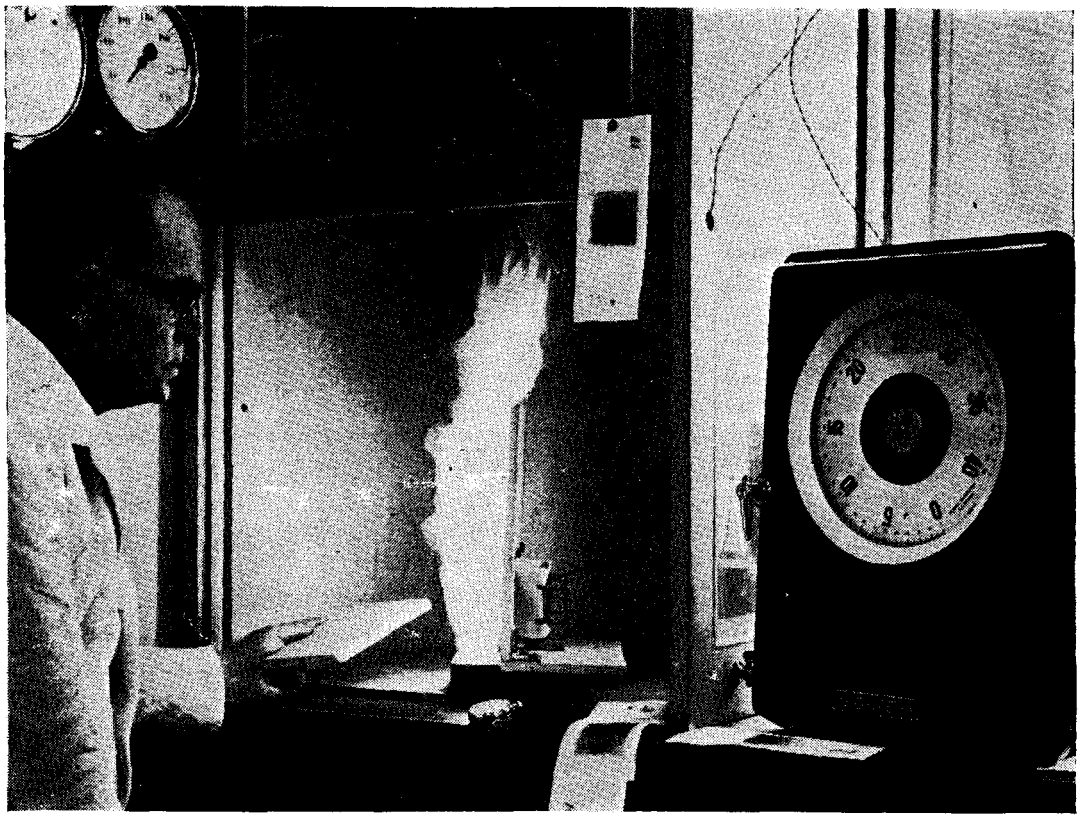


FIG. 10—TESTING THE FIRE RESISTANCE OF FEARNOUGHT IN THE FIRE TEST GROUND

because the work was appropriate to the staff of the Admiralty Fuel Experimental Station. Nonetheless it is a valuable facility, and is, in fact, one which is much appreciated by visitors to the Establishment.

It consists of a small laboratory, an open concreted area, and a section of a ship's hull. Trials are carried out on many types of fire-fighting equipment to assess suitability for use in the Royal Navy, and to prove that the relevant British Standards are met (FIG. 10).

Much work is done on the fire resistance of materials such as glass reinforced plastic for use in the hulls of coastal minesweepers, or the various classes of lagging and insulating materials. The mock ship is also a suitable facility for carrying out tests on components like smoke filtration units for use within the gas-tight citadel.

The Trials Teams

The Machinery Trials Unit, which was transferred to Haslar in July, 1966, was formed in 1964 by combining the machinery trials staffs of Commander-in-Chief Portsmouth and Commander-in-Chief Plymouth. Its purpose is to supervise, on behalf of D.M.E., trials in new construction surface ships and in ships modernized, converted or refitted by dockyards. It also carries out formal machinery installation inspections in such ships (5). The M.T.U. comprises two teams, each directed by a Commander, as well as a support organization. The programme for 1968 is a very full one; probably sufficient to employ three teams rather than the two available.

The Machinery Controls Trials Team has been associated with Haslar since its inception. Ostensibly there are two teams which can be made available to H.M. ships on request to the Ministry of Defence (6). One of these is a permanent team, with the officer-in-charge working from the Ship Department; the other is provided by the staff normally allocated to the Y.102 boiler at the A.M.E.E.

Both the M.C.T.T. and the M.T.U. are controlled directly from the Ship Department, and come under the Superintendent, A.M.E.E., for local administrative purposes only. However the provision of staff from A.M.E.E. test groups for attending ships to advise or carry out trials is within the Establishment's own control. Opportunities for such visits are welcomed except in so far as they are disruptive of the normal test programme. They are accepted readily if appropriate staff can be made available.

PUBLICATION AND LIAISON

One of the difficulties of Defence Research is the limitation imposed by the security requirement on free interchange of results and ideas with other research workers in the same field. Additionally, where commercial equipment is involved a 'Commercial-in-Confidence' classification may be applicable. In consequence the majority of the official reports rendered as a result of trials at A.M.E.E. have a restricted distribution, although efforts are currently being made to facilitate wider publication through the Naval Scientific and Technical Information Centre.

Fortunately, the nature of the fundamental work by the boiler groups is rarely of a sensitive nature, except perhaps in some of the detail. Some basic research is carried out by the Universities under contract, with A.M.E.E. officers appointed to carry out liaison; a fairly free interchange of ideas is conducted verbally with other organizations, such as the Central Electricity Generating Board and the Oil Companies; and the Principal Scientific Officer represents the Ministry of Defence on the Oil and Gas Panel of the International Flame Research Foundation at Ijmuiden in Holland.

In addition to the official reports from the Establishment a number of papers have been presented by Establishment officers, as personal efforts. The most recent has been a full day symposium under the auspices of the Institute of Marine Engineers and the Institute of Fuel at which papers concerning work on behalf of the Ministry of Defence on Combustion Research and Register Design were presented by the Universities and the Establishment.

THE FUTURE

Cuts in the expenditure on Defence Research are probable. It would appear likely that any effect on the A.M.E.E. would be felt mostly by the boiler groups. In any case, discussions are already taking place to decide for how long the Ministry of Defence should continue to support fundamental research into the generation of steam by plant using liquid fuel.

So long as boilers are retained in service a requirement will remain for some test facilities, but the extent to which fundamental problems should be tackled is less certain. Unless an entirely new concept of boiler design is envisaged the research worker has very little outlet for his ideas.

A belief in a requirement for fundamental research in support of the test facilities generally has already been stated. It is expected that this will continue to grow in respect of auxiliary machinery and valve testing. In anticipation of some diversification away from boiler work, the fundamental heat transfer group is now devoting some of its time to the study of heat transfer in condensers and heat exchangers, and to the problems of two-phase flow associated with relief valve design and steam separation in the nuclear power plants.

Whatever happens in the future many boiler problems will remain unsolved. The last word can best be left with *The Times* of 12th December, 1967, in which the dramatic critic described the characters of a play as: ' . . . a household bursting with sex like a marine boiler'. Maybe this is still one more topic which would repay investigation.

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