GAS TURBINE TRAINING IN THE ROYAL NAVY

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ABSTRACT

Officers' and ratings' career training is described, with emphasis on gas turbine aspects, and also preparation for specific ships. Methods of validating the training, to ensure it meets the needs of the Fleet, are outlined.

Introduction

Gas turbines have been an accepted source of main propulsion in the Royal Navy since they were first introduced into the Fleet in the late 1950s. These early marine gas turbines were large, low-powered machines, and it was not until 1968 that the first ship went to sea with gas turbines derived directly from their aero equivalents. Since then, the Royal Navy has introduced into service four classes of major surface combatants propelled solely by such gas turbines, amounting to some 70% of today's surface fleet. As the numbers of these ships have slowly increased, so the older largely steam driven ships have been phased out. The Royal Navy has therefore been faced, over a number of years, with an ever-increasing requirement to train men to operate and maintain gas turbines.

Clearly, training in the operation and maintenance of gas turbines is only one aspect of the overall training given in the Marine Engineering specialization.

Unlike other forms of main propulsion, such as diesel or steam plants, the amount of maintenance that it is possible to carry out *in situ* on a modern marinized gas turbine is limited. The emphasis during gas turbine training is therefore placed on their 'setting to work' requirements, on their operating procedures and parameters, on fault diagnosis techniques for the control systems, and on engine health monitoring practices. For major defect rectification or routine major engine overhaul, the gas turbine is removed from the ship, replaced by an overhauled unit and then is itself overhauled in a shore facility.

SHORE TRAINING

Officers

Undergraduate Training

Engineer Officers are trained at the Royal Naval Engineering College at Manadon, near Plymouth. A three year full-time engineering degree course is offered which provides a fundamental engineering education and a basis for the subsequent specialist training in all branches of naval engineering, be it air, weapon or marine.

For officers who pursue the marine engineering specialization a number of foundation courses are given, including the study of heat transfer and fluid mechanics. In the final year of the course the application of these foundation courses is pursued which includes the theoretical treatment of simple and compound gas turbine cycles. The subject is then further developed with an appreciation of gas turbine characteristics, component matching and off-design performance.

The Marine Engineering Application Course

After graduating at the end of the course, the young officers are sent to the Fleet for periods of up to one year to gain experience in the wider aspects of the Navy and to consolidate their first degree education. They then return to the Royal Naval Engineering College, where they undertake a further course, known as the Marine Engineering Application Course, which is designed to prepare them for their first job at sea as an Assistant Marine Engineer Officer in a frigate or a destroyer, or as a Section Officer in a larger ship. This one year course develops the largely theoretical knowledge gained during the earlier degree course and imparts an appreciation of the principles of design, construction and operation of marine engineering equipments and systems. Gas turbine technology is a major element of this course and comprises the following elements:

(*a*) *Phase One*. A short introductory course which is given to acquaint the students with the operation of the College's Tyne module and its auxiliary systems. It also gives them their first 'hands on' experience of operating a gas turbine from a machinery control room.

(*b*) *Phase Two*. In this Phase, the students receive a series of lectures on the practical aspects of gas turbine technology. Introductory lectures are given on the development of gas generators since World War II and a résumé of thermodynamic cycles, along with a brief on the reasons why the Royal navy has adopted the policy of an 'all gas turbine' surface fleet. The course develops with a detailed account of the component design of compressors, turbines, combustion chambers and auxiliary systems. Finally, operational aspects, such as stop/start procedures, engine health monitoring and ship administration are given to acquaint the student with the overall management of a gas turbine propulsion plant.

The students are shown how to prepare and start a gas turbine, operate it up to full power and carry out basic fault diagnosis with the on-engine fuel control system. They also examine, in detail, sectionalized components withdrawn from naval service and familiarize themselves with the propulsion plant by tracing the fuel, lubrication and other systems.

Additionally, this phase of the course includes a visit to Rolls-Royce to acquaint students with the latest technology used in the design and manufacture of main propulsion gas turbines.

(*c*) *Phase Three.* For the final phase of their application course, the officers return to sea in a dedicated sea training ship to gain their operating certificates and administrative qualifications.

The Master's Degree Course

Since 1918, the Navy has provided a course for a small number of selected officers to prepare them for appointments associated with the design, development and procurement of marine engineering equipments for the Fleet. This course, known as the Advanced Marine Engineering Course and run at the Royal Naval Engineering College, aims to provide these officers with a post-graduate education suited to their subsequent employment in the Sea Systems Controllerate at the Ministry of Defence and for certain jobs in research establishments. The course, which leads to the award of a Master's Degree is also available for offiers of NATO, foreign and Commonwealth navies and for members of the defence industries engaged in marine systems development and in project management with the Ministry of Defence.

All students on this 15-month course will already have a good honours degree in mechanical or electrical engineering and also have accumulated at least two years of practical marine engineering experience.

The gas turbine specialist option includes a Fluid Flow and Performance module which is designed to extend and develop the students' knowledge and appreciation of theoretical analysis and empirical methods used in marine gas turbine design. The performance assessment of gas turbines in general, and of marine propulsion plants in particular, is studied to give a sound knowledge of current marine gas turbine technology and of prospects for future developments. The subject is enhanced by further studies into the principles of combustion, and the theoretical and practical approaches to design.

Visits to Rolls-Royce are included to enable students to discuss detailed aspects of engine design and performance with senior engineers on the design, manufacture and production staffs.

Artificers

The Navy's skilled technicians (artificers) typically join the Navy straight from school. They then embark on an apprenticeship which lasts for 3 years and 8 months and culminates in the award of a National Diploma and a Skills Test Certificate.

The course starts at H.M.S. *Raleigh,* a shore establishment near Plymouth, where the new recruits complete a term of basic naval training. They are then sent to H.M.S. *Sultan,* where they undertake the major part of their specialist training before proceeding to sea to gain their operating certificates.

For ten terms, the trainee technicians undertake a fully integrated electro-mechanical training. Initially, the emphasis is placed on instruction in the classroom to give the trainees the foundation skills in mathematics, thermodynamics, electrotechnology and other related subjects that they will need later in their training. The course then develops into a study of the design, construction and principles of operation of the whole range of equipments which they will meet in their later careers. Also, they develop their maintenance skills both in the workshops and in practical periods where they strip, examine, reassemble and then operate a variety of typical equipments found at sea.

During this apprenticeship, the trainees study the construction of a gas turbine, component by component (FIG. 1), and look into the requirements for, and the operation of, the various air, lubrication, fuel, control, fire fighting, and electrical systems. Whilst this instruction is based on twin spool,

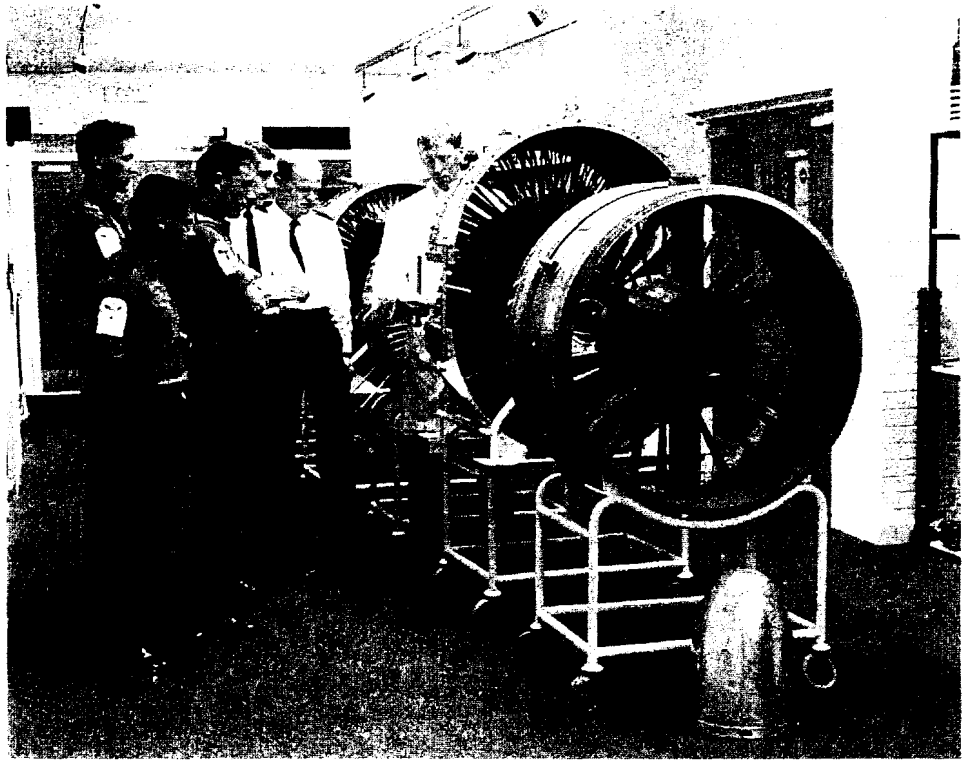

FIG. 1—TRAINEES EXAMINING SECTIONED GAS TURBINES IN THE DISPLAY AREA, RAPER BLOCK, H.M.S. 'SULTAN'

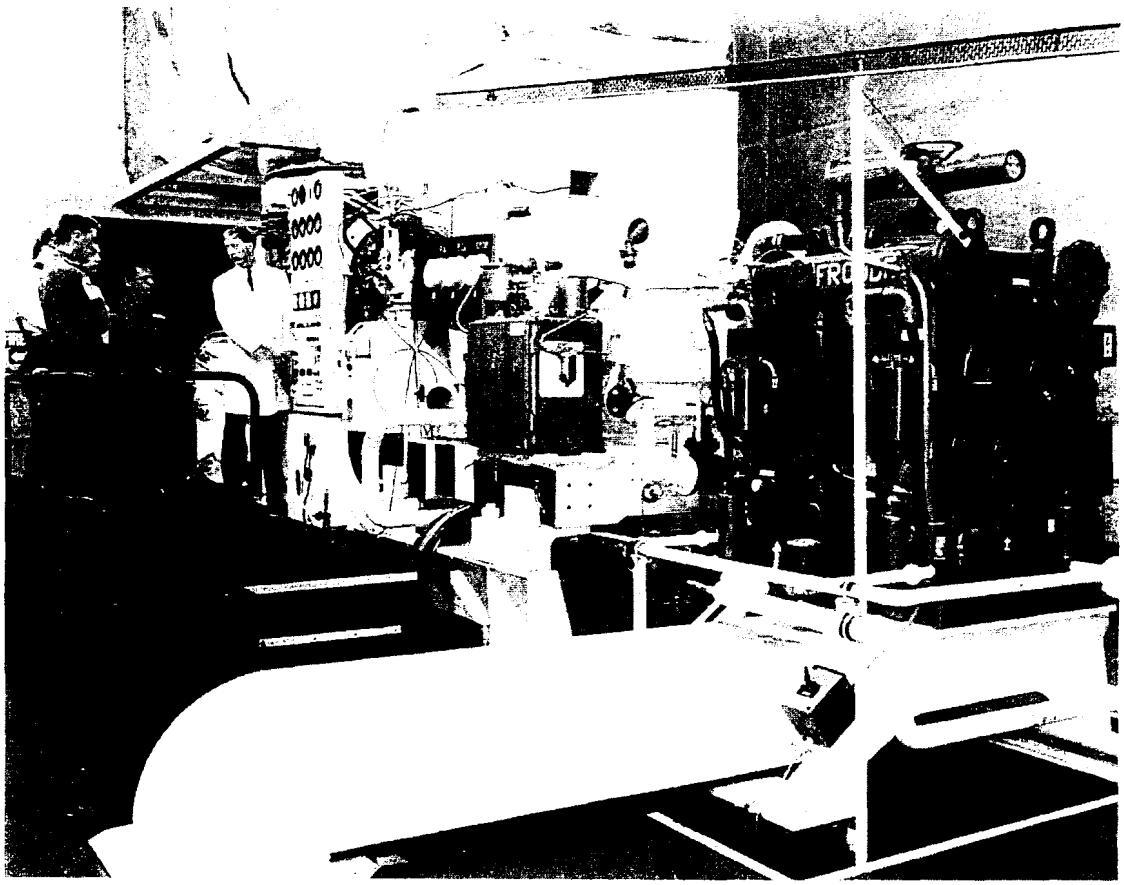

FIG. 2—TYNE MODULE IN RAPER BLOCK

triple shaft gas turbines, H.M.S. *Sultan* has a comprehensive training facility made up of an installation of each of the Navy's three operational gas turbine (Olympus, Tyne and Spey, FIGS. 2 and 3), all of which are capable of being operated up to full power. The trainees are therefore able to carry out the various operator tasks associated with setting to work, operating and watchkeeping on an operational engine and to study the different engine health monitoring techniques used at sea. Additionally, the trainees undertake various maintenance routines on non-operational engines and practice non-destructive engine health monitoring techniques, such as endoscope inspections.

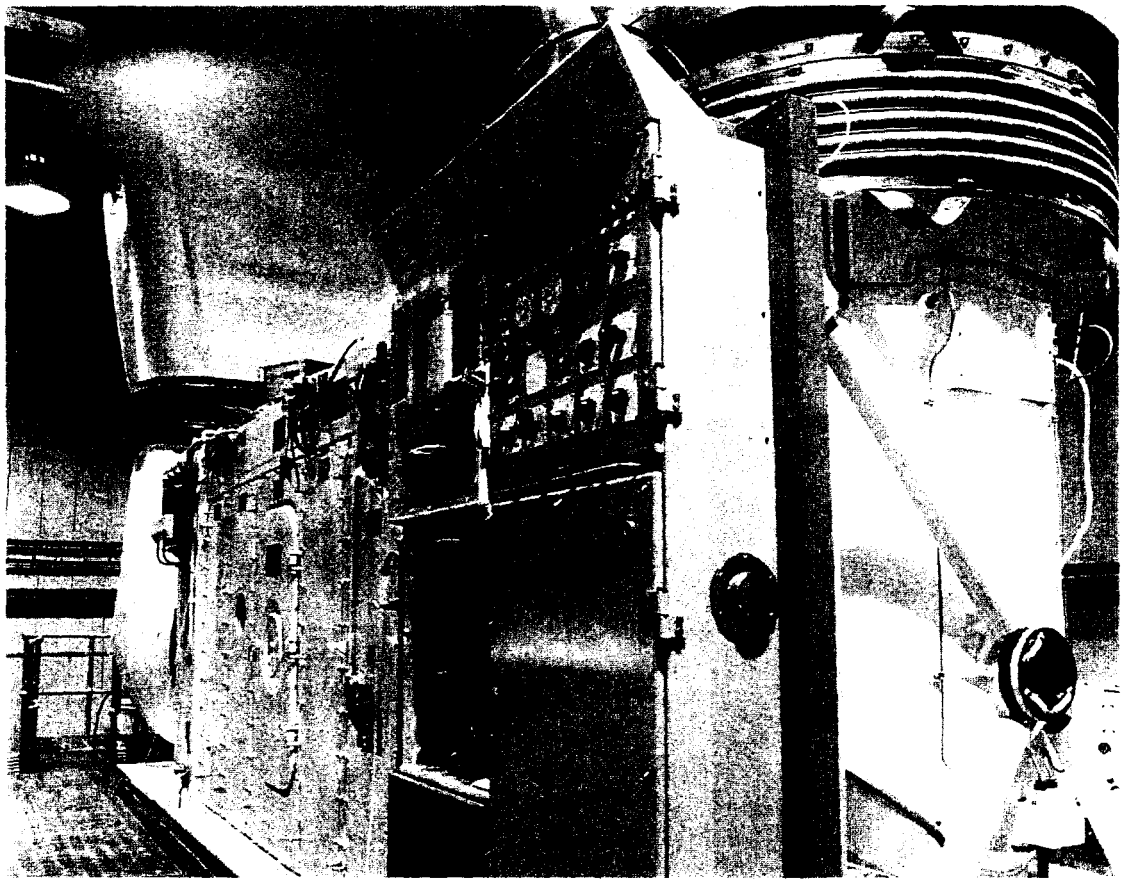

FIG. 3—SPEY GAS TURBINE IN H.M.S. 'SULTAN'

Mechanics

During their initial career training, mechanics are given only rudimentary instruction on gas turbines. This begins with a very brief look at the principles of operation of a gas turbine and an opportunity to witness an engine being run. The course then develops to discuss the basic start cycle and the installed safety devices and trips. Finally, they are shown how to carry out the routines that will be part of their duties when at sea, such as assisting with compressor washing and engine inhibiting, and the actions to be taken in the event of a fire.

At a later stage in their early careers, the mechanics undertake a further course at H.M.S. *Sultan* in which they study gas turbine operating procedures in more depth. It is at this stage that those trainees who show a particular aptitude are selected for training as artificers.

Pre-joining and Team Training

Because the general career training cannot be geared towards any specific class of ship, further courses, known collectively as Pre-Joining Training, provide familiarity with the particular ships in which they are about to serve. Additionally, the facilities at *Sultan* are available for use by personnel who have already joined their ships, a particular function which is known as Team Training.

Pre-Joining Training

Pre-Joining Training is undertaken primarily by officers and artificers, and a typical course, which might last four weeks, will introduce them to the full range of machinery they will meet on board their next ship.

Gas turbine instruction on these courses is biased towards the operating requirements of the engines and always involves the actual running of a machine. Considerable emphasis is also placed on operating procedures and, to assist with instruction in this area, H.M.S. *Sultan* has a comprehensive fit of computer-based simulators (FIGS. 4 and 5). These simulators allow personnel to familiarize themselves with the control consoles they will meet at sea and to practice the various machinery operating procedures. The instructors are able to simulate a variety of faults in the main and auxiliary machinery and then monitor the responses of the personnel under instruction.

Team Training

The simulators are also extensively used by the personnel from operational ships who use them to provide realistic training for their watchkeeping teams whilst their ships are alongside. Personnel undertaking this Team Training typically spend a day in the facility gaining confidence in their equipment

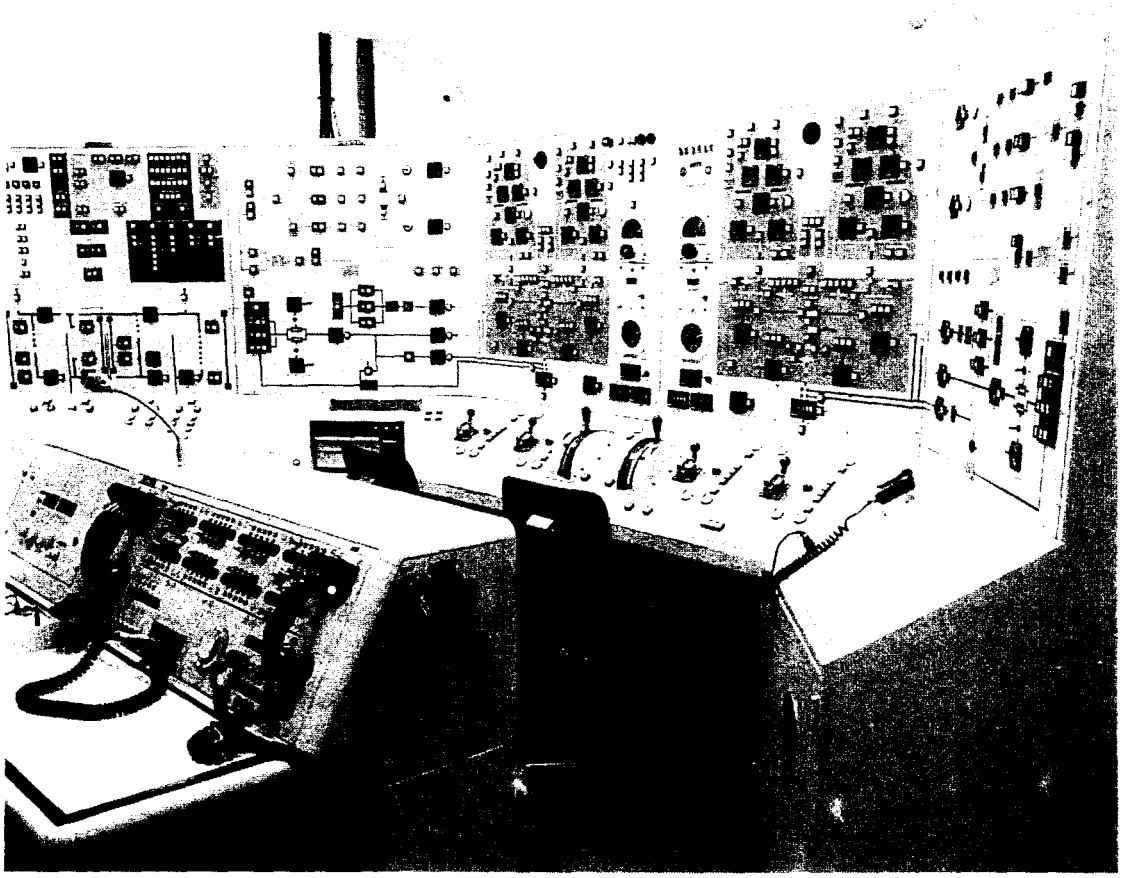

FIG. 4—CVSG CONTROL SIMULATOR IN PARSONS BLOCK, H.M.S. 'SULTAN'

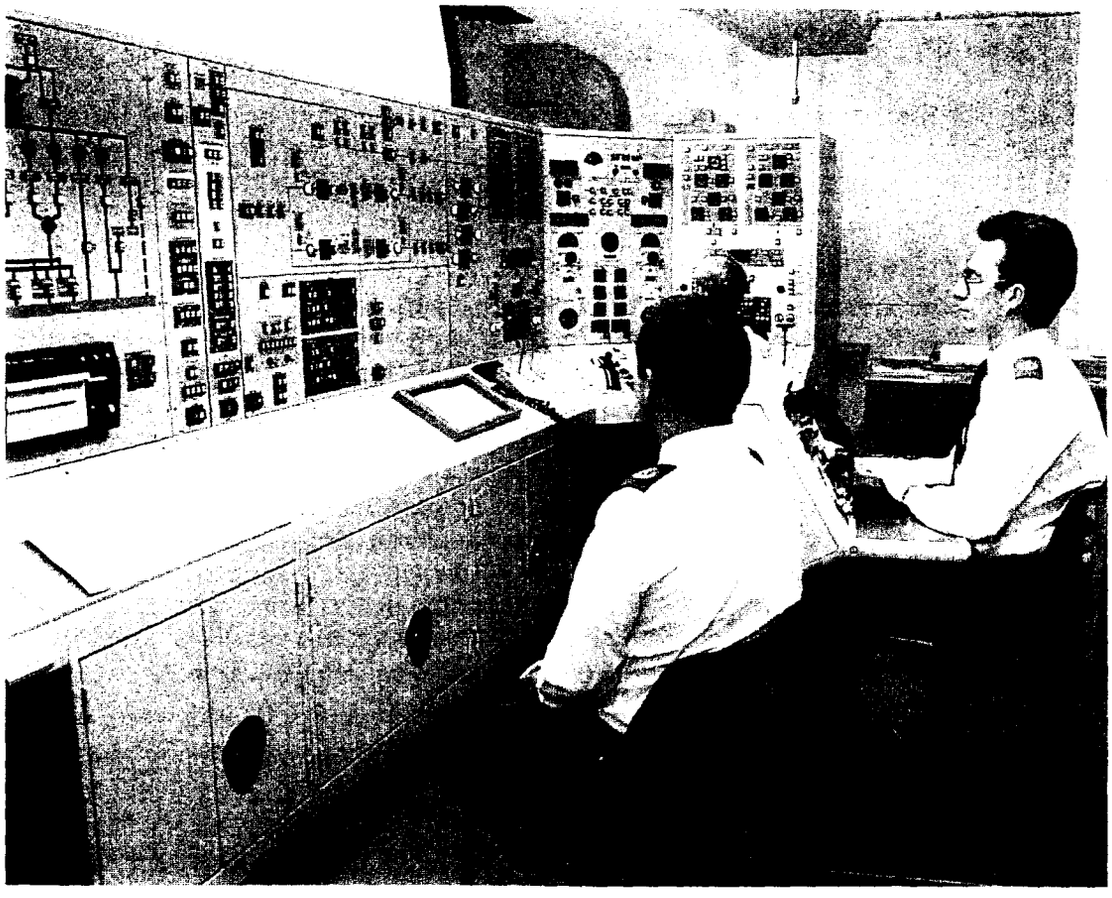

FIG. 5—TYPE 22 CONTROL ROOM SIMULATOR AT H.M.S. 'SULTAN'

and their own ability to handle it. The opportunity to train in this way is particularly important for the personnel of ships which are about to return to sea following a refit or extended maintenance period.

Courses for the Supporting Services

Training is also provided for the uniformed and civilian personnel who work in the Naval Bases and Royal Dockyards. A two-day course is provided to describe the procedures for removing a gas turbine from a ship and replacing it with a reconditioned engine. This course goes into detail of removal routes, pre-installation checks on the replacement engine and the necessary preservation routines for the outgoing engine. A further one-week course is provided for civilian employees to introduce them to the operating parameters and procedures for gas turbines.

Numbers Under Training Ashore

As a summary of the gas turbine training given in the various shore establishments, it is helpful to look at TABLE I which shows the numbers of trainees who, in 1987, completed the courses already discussed.

TABLE I—*Numbers completing courses in 1987*

Officers	Degree Course	10
	Application Course	14
	M.Sc. Course	4
Technician Mechanics All Ranks	Apprenticeship	215
	Basic Training	715
	Pre Joining Training	260
	Team Training	360

SEA TRAINING

Training at sea has two distinct aims: on the one hand it is necessary for the inexperienced personnel who have just completed their initial training ashore to gain their gas turbine operating qualifications; and on the other hand there is a need for team training to ensure that the engineering personnel on board are, at all times, welded together as an effective team.

Operator Qualifications

The major thrust of training at sea is directed towards the gaining of qualifications in the form of operator certificates which in turn lead to promotion and better pay. Whilst officers, artificers and mechanics can all qualify to operate gas turbines, for simplicity in this article the artificer is taken as the example.

Artificer Operator Qualifications

Once on board, the artificer's training is directed towards reinforcing his basic engineering skills by giving him practical experience in maintaining and repairing a wide range of equipments. Running in parallel with this daywork activity, the young technician will also keep watch, where he will be understudying an experienced watchkeeper in his duties. During his time on watch, he has to familiarize himself with the operation, purpose and layout of all of the equipment and systems for which the watch is responsible. Particular emphasis is placed on the correct procedures to be carried out in the event of the failure of a gas turbine or some other emergency such as a fire. This phase of his training culminates in him being examined for the award of his Gas Turbine Watchkeeping Certificate. Once over this hurdle, he is qualified to operate the ship's gas turbines and associated machinery systems either from his position in the Ship Control Centre or from the Local Control panels in the machinery spaces.

However, this does not qualify him to take charge of the watch. For this, he has to serve a further two years during which he gains in experience and consolidates his earlier training. He then takes another examination which, on this occasion, is directed towards assessing his knowledge of his broader responsibilities as a fully qualified technician as well as looking in detail at his proficiency as a maintainer and as a diagnostician. With this examination behind him, the artificer is considered to have completed his training and may take charge of the watch of any ship with gas turbine propulsion.

Officers' Qualifications

The young officer in his first gas turbine ship is expected to demonstrate the same level of expertise as the technicians with regard to watchkeeping skills. Whilst he is not formally examined at this stage, he will be expected to prove his competency to his Marine Engineer Officer, he will also be expected to master the management skills associated with a gas turbine propulsion plant, in particular with regard to managing operating cycles and planning the various maintenance procedures required, from routine inspections through to engine replacements.

Team Training

The second aim of training at sea is to provide team training in the procedures to be followed in the event of a machinery failure or other incident. Depending on the skill and experience of the watch concerned, this training can take the form of instruction, touch drills, or actually carrying out the procedures. Regulations specify that these drills are to be practised

four times each week when at sea, with each drill period lasting for two hours. This ensures that each of the four watches is exercised at weekly intervals.

The drills are planned and closely monitored by the more experienced members of the engineering staff on board. The procedure followed is that the supervising staff fully brief the watch as to which drill is about to be exercised, initiate the drill, and then discuss with the watch any lessons to be learned from it. Typical drills might include the actions to be taken following the detection of a fire in a gas turbine module, or the failure of a running gas turbine.

VALIDATION OF THE TRAINING

Considerable effort is made to ensure that the personnel at sea have the necessary knowledge and skills to fulfil their tasks. This validation of the training given both ashore and afloat is a continuous process which involves feedback from the ships at sea and their administrative authorities, and assessing the content of the courses given.

At the most basic level, this objective is achieved by examination and by holding discussions at the end of each course to gauge the reaction of the trainees. This ensures that the instruction is pitched at the right level and maximizes retention. In addition, young officers are formally invited to comment on the relevance of their initial training in the light of their experience in their first ship.

Feedback is also obtained directly from sea by a team of a warrant officer and chief petty officer known as the Training Feedback Team. It is their job to visit ships and Fleet Maintenance Groups to talk to engineering managers to obtain their views on the quality of the training their men have received. They also talk to the ex-trainees themselves to assess the relevance of the course they completed when compared with the job they are now doing. On their return to H.M.S. *Sultan*, the Training Feedback Team analyse their findings, and these are then fed back into the continuous process of revision and update of the content of the courses.

The instructors themselves are another very important source of information, since throughout the training process the majority of the instruction is given by uniformed naval personnel. As many of these men will have only recently returned from sea, they are well versed in the latest problems in the Fleet and are also ideally positioned to ensure that the training organization is alerted.

The introduction of new equipments into the Fleet always provides the training establishments with a challenge. When it is a major piece of equipment fundamental to the capability of the ship, such as a gas turbine, every effort is made to obtain a representative machine for training purposes. Alternatively, it is sometimes feasible to opt for a simulated machine or system—although such arrangements clearly have their limitations if maintenance practices are to be taught.