NAVAL SHIP SYSTEMS ENGINEERING STATION PHILADELPHIA

BY

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Introduction

The regular reader may be forgiven for questioning the validity of publishing an article on a United States Naval Establishment in this *Journal*. Nevertheless, based on the volume of exchange information which flows between the two nations and the significant role that the Naval Ship Systems Engineering Station (NAVSSES) fulfils in establishing much of that information, the article should prove relevant and of value to a wide audience.

The aim of this article is to outline the organization and tasks of NAVSSES and to discuss some of the work that is in progress or is planned for the immediate future. As part of the agreement between the two governments to exchange personnel in areas of common interest and also in recognition of the engineering role of NAVSSES, an exchange post for a Royal Navy officer was established at NAVSSES in 1984 and the nature of this job will be discussed in detail later in the article.

U.S.N. Administrative Organization

To understand fully the function of NAVSSES it is first necessary to appreciate where the establishment fits into the overall naval structure. Any organization which exists to support a 600 ship fleet is necessarily large and complex, and the numerous authorities and agencies involved in the warship and equipment procurement process is at first sight bewildering. For this reason the organizational details which follow have been simplified. The administrative organization of the Navy begins with the Secretary of Defense and then goes through the Secretary of the Navy and the Chief of Naval Operations (CNO), a four star post. The primary task of the CNO is to support his operational commanders but amongst other things he is responsible for the procurement of warships, their systems and equipments, and research and development (FIG. 1).

One of his subordinate Commands is the Naval Sea Systems Command (NAVSEA) which is headed by a three star admiral, some of whose responsibilities are illustrated in FIG. 2. The headquarters for the Ship Design and Engineering Directorate is located in Washington and broadly fulfils the same role as the Royal Navy's DGME and CNA organizations. NAVSSES, one of its agencies, is located in Philadelphia and can best be likened to a number of Admiralty Research and Test Establishments combined under one roof, although NAVSSES does play a more significant fleet support role. Direct fleet engineering support is provided principally by the Naval Sea Centres based in Norfolk and San Diego and they have similar responsibilities to those of the Royal Navy's Fleet CSO(E) organization.

NAVSSES Tasks

The primary tasks of the establishment are to serve as the Navy's principal centre for the test and evaluation (T&E) of hull, mechanical and electrical (HM&E) ship systems and to provide in-service engineering (ISE) support

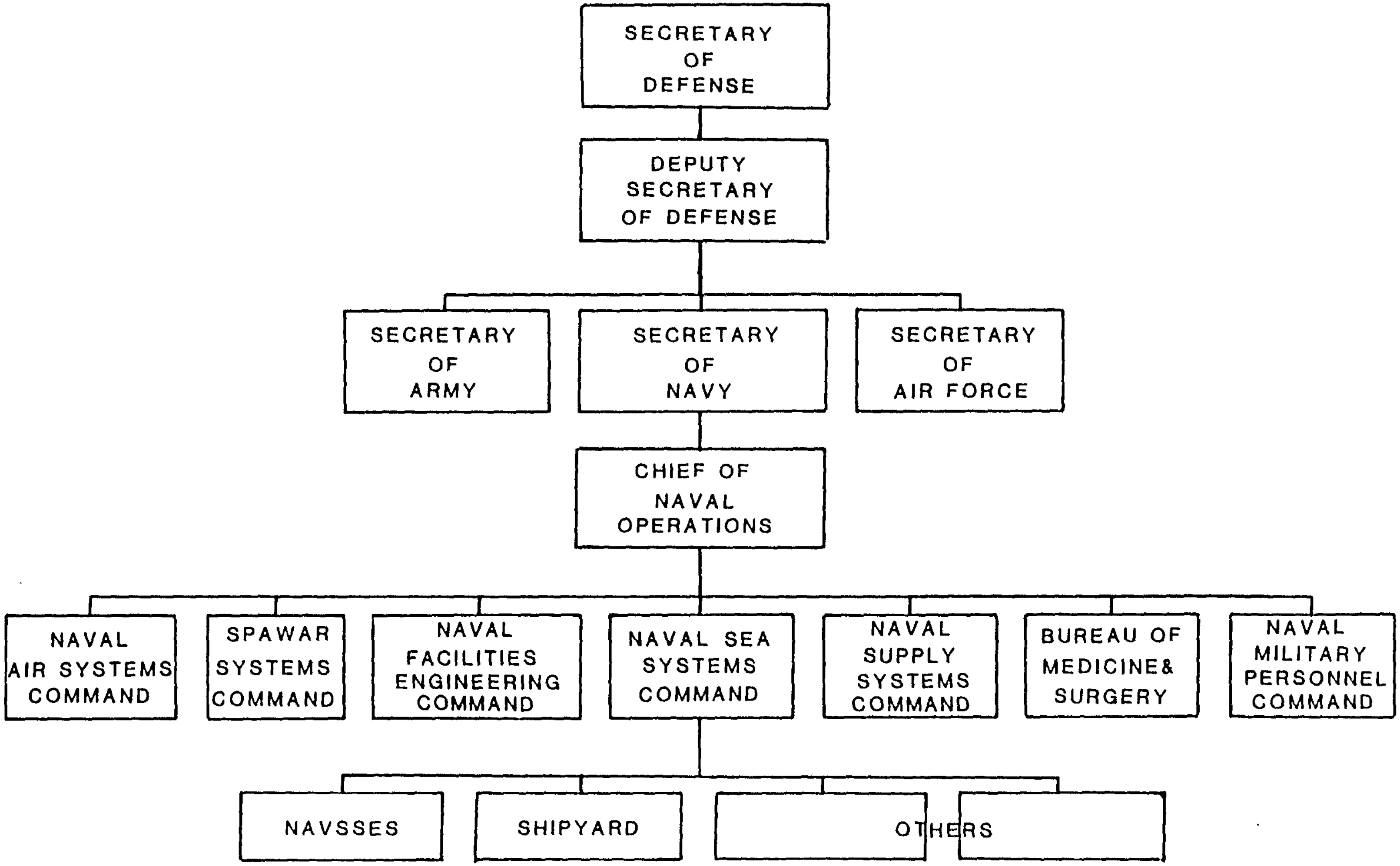

FIG. 1—CHIEF OF NAVAL OPERATIONS ADMINISTRATIVE ORGANIZATION

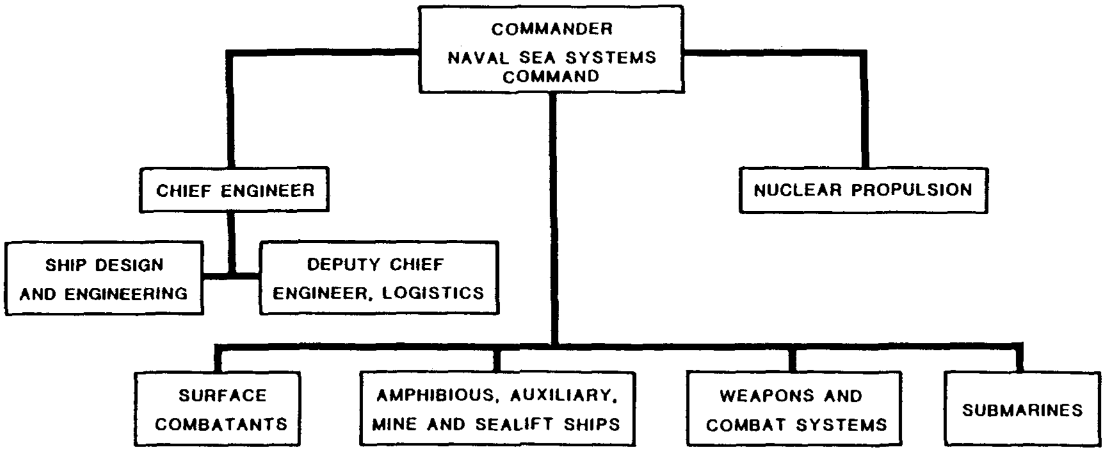

FIG. 2—NAVAL SEA SYSTEMS COMMAND ORGANIZATION

for these systems and other equipments. The majority of this work is performed for NAVSSES's primary customers, the Naval Sea Systems Command (NAVSEA), the Space and Naval Warfare Systems Command (SPAWARS), and the various Fleet Commands. The Life Cycle Reference Chart (FIG. 3) puts these tasks in better perspective and clarifies the responsibilities that the Commands have for ship systems.

NAVSSES's tasks can be grouped under three headings.

Ship Systems Test and Evaluation Centre

The tasks of the Ship Systems Test and Evaluation Centre are to:

(*a*) Conduct test and evaluation programmes required to demonstrate and determine the acceptance, suitability and approval of ship systems, equipments and components for naval service.

(*b*) Provide for the test and evaluation of ship systems in the research and development process.

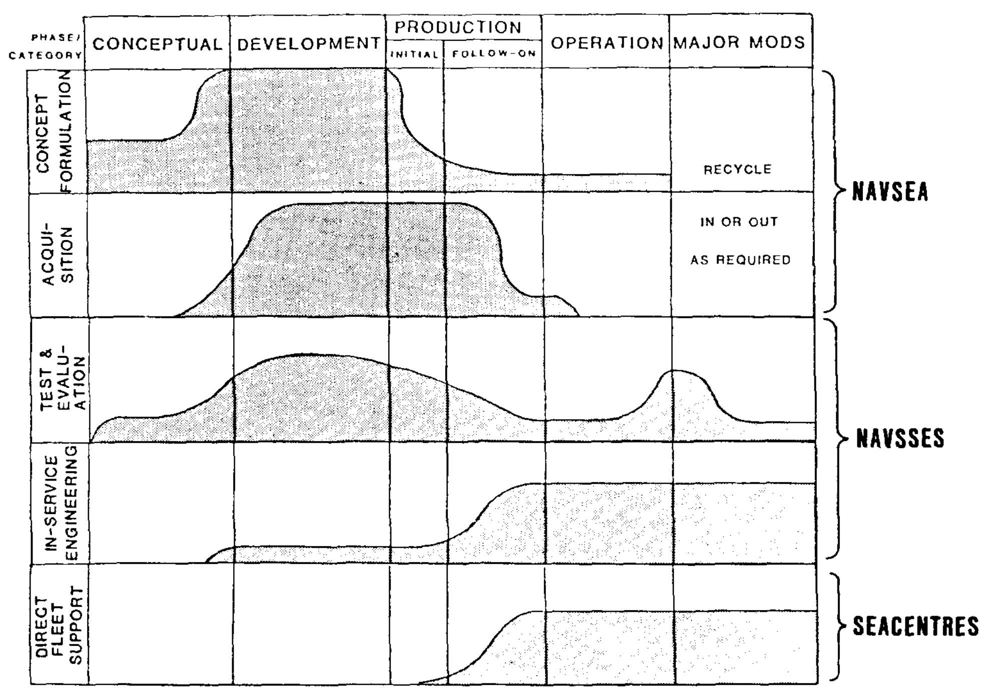

FIG. 3—LIFE CYCLE REFERENCE CHART

(*c*) Participate in the Total Ship Test Programme as the Ship Systems Test Director.

(*d*) Provide engineering and facilities assistance to vendors for the testing and evaluation of ship systems intended for naval shipyard installation.

Ship Systems In-Service Engineering Support

Comprehensive in-service engineering support is provided for HM&E ship systems and related fuels, materials and instrumentation in operational ships and repair and maintenance facilities. These responsibilities include development of design changes and, upon approval, implementing follow-on actions, safety reviews, test support, technical documentation, performance and maintenance data analysis, maintenance and installation engineering, training support, logistic support, repair standards and procedures. This is a very broad statement which clearly represents an enormous task and therefore of the three functional areas of ISE in which NAVSSES is involved—data management, integrated logistic support and equipment engineering—the key is effective data management so that system and equipment problems in the fleet can be identified in the first place. Management by exception then becomes the method of execution.

Submarine Antenna and Periscope Systems Support

This consists of:

(*a*) Similar in-service engineering support of submarine antenna and periscope systems.

(*b*) R&D and T&E programmes for submarine antenna and periscope systems.

Examples of current and future work in some of these catagories will be discussed later.

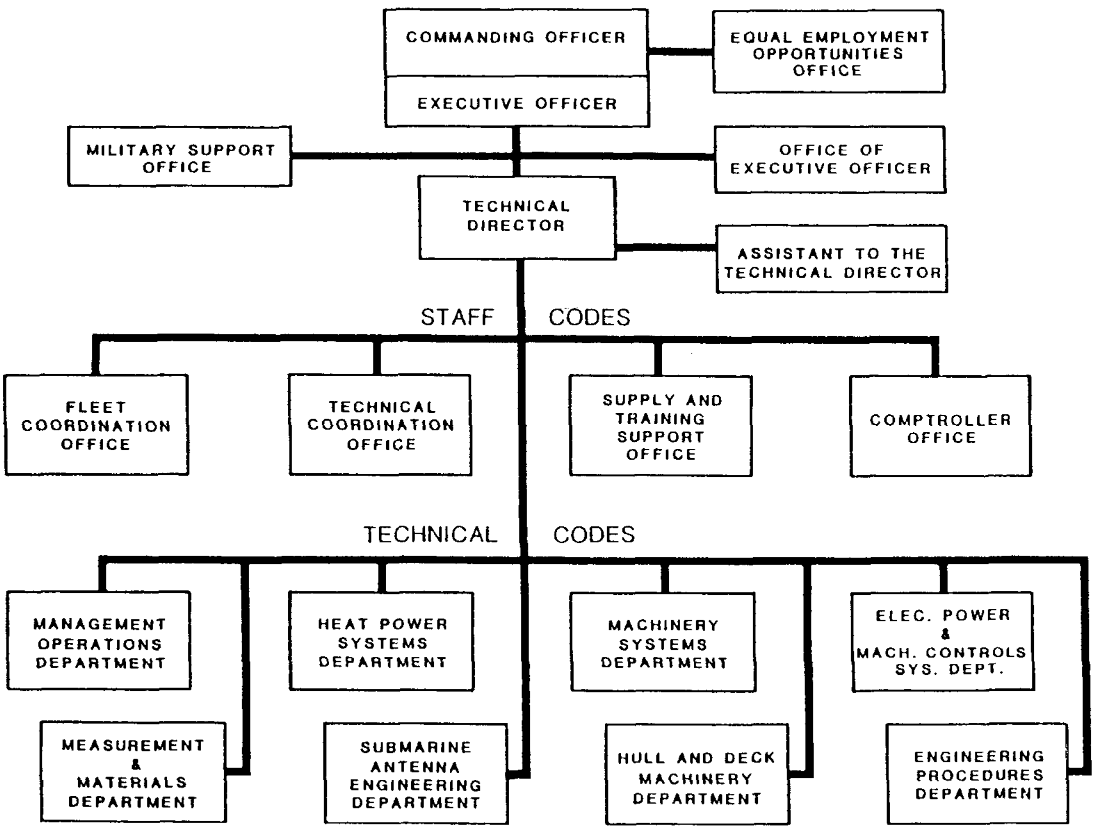

FIG. 4—NAVSSES ORGANIZATION

NAVSSES Organization

NAVSSES is located in the U.S. Naval Base at Philadelphia and adjacent to the naval shipyard. The station is designated a major Command in the U.S.N. and the staff of 1550 personnel is headed by a senior captain. The various tasks of NAVSSES are accomplished by the staff and technical departments (FIG. 4) who are directly responsible to the Technical Director, a senior civilian government service officer, with the R.N. exchange officer acting as his assistant. The technical departments at NAVSSES are organized along system lines to reflect this approach to the work and a matrix management *modus operandi* has been adopted which allows the expertise of the various departments to be utilized by one another without being hampered by traditional chains of command. In essence this avoids micro-management and encourages delegation.

The majority of people employed at NAVSSES are civilian, although there is a strong corps of uniformed personnel of various ranks and rates. Current proportions of staff are shown in FIG. 5.

Whilst most of the staff are employed at Headquarters in Philadelphia, field representatives are stationed at locations around the United States and abroad to provide more immediate ISE support. In many areas the establishment is self-sufficient but where in-house expertise, facilities, services and capacity are not sufficient then work is contracted out. The legal aspects of seeking competitive tenders, sole source procurement and the general contracting business are involved and, whilst a separate authority exists to deal with the procurement process, the detailed preparation of contract documents is entirely in the hands of the cognizant technical departments within NAVSSES. All activities are run on a commercial basis and strict financial accountability and control are exercised. All funding is provided from the charges made to 'customers'. In fiscal year (FY) 1986 it amounted to $178M, and the projected figure for FY 87 is $200M of which about $84M will be for work contracted out.

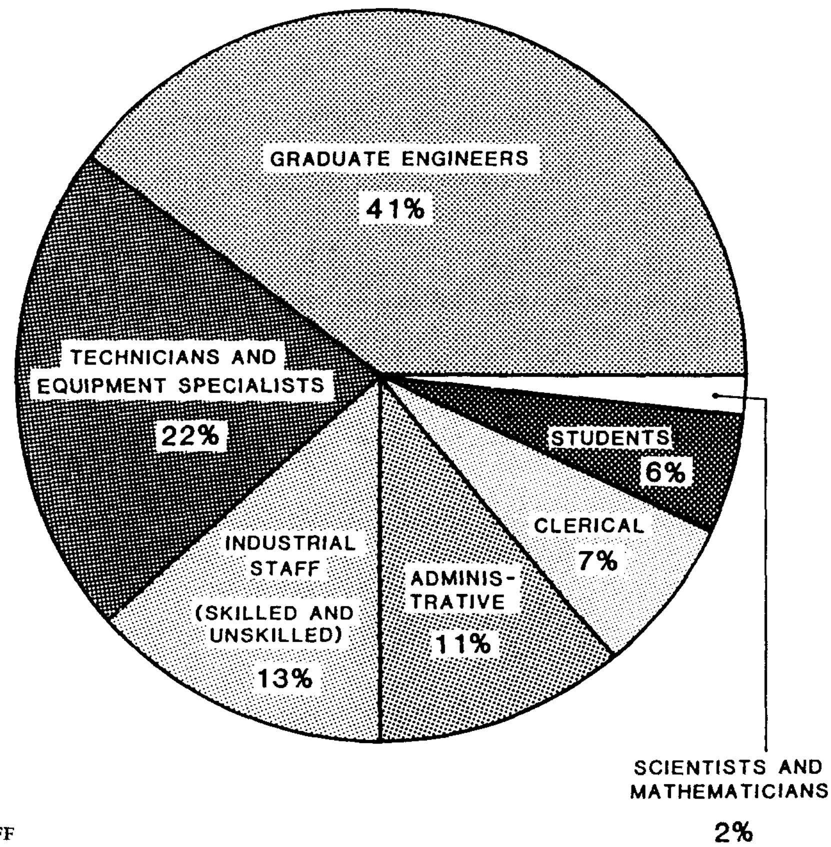

FIG. 5—NAVSSES STAFF

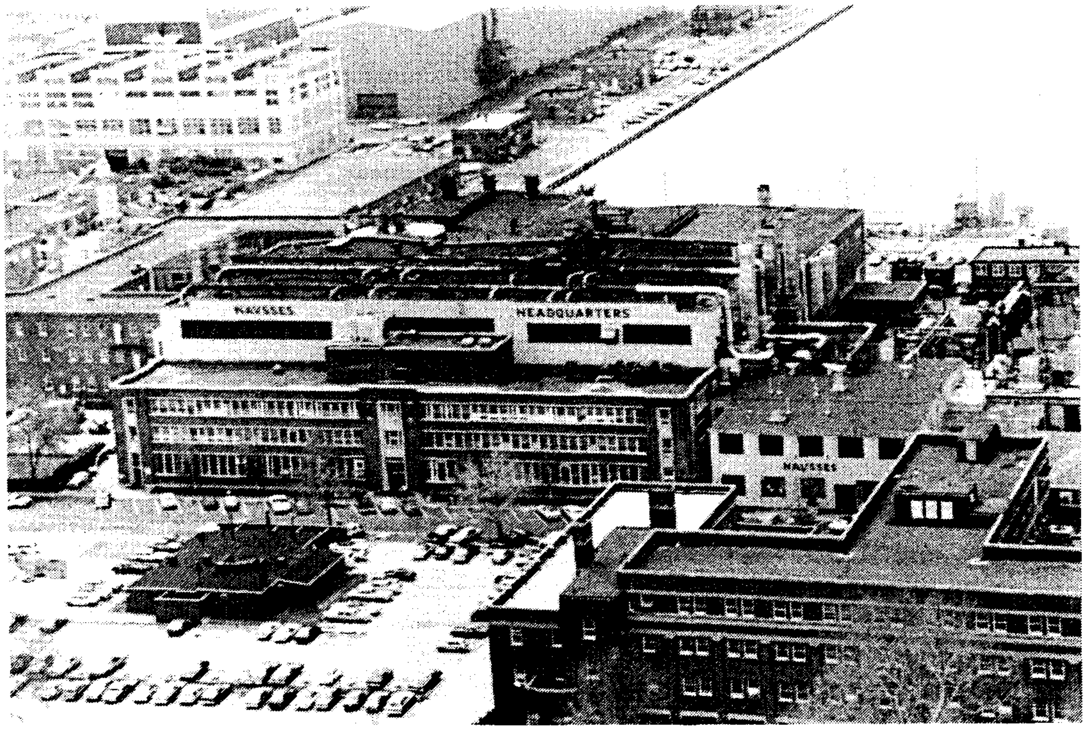

FIG. 6—NAVSSES HEADQUARTERS COMPLEX

Facilities

NAVSSES occupies some fifty sites on the base and most of this space is devoted to test facilities, FIG. 6 shows the headquarters building.

It is beyond the scope of this article to describe every facility but suffice it to say that they range in terms of size from destroyer and submarine main propulsion plants to instrument calibration rigs, and in terms of diverse technology from fibre optics to boiler water treatment. In addition to the many test sites the establishment also boasts sophisticated laboratories and equipment to support work in such fields as materials technology, fire detection, gear metrology, electronic equipment calibration, shock and vibration, marine coatings, emission and X ray spectroscopy and radar absorbent materials. Before discussing particular test programmes, a distinction needs to be drawn between the three fundamental types of test site used at NAVSSES:

(*a*) Test Site (TS)—a facility which is designed and built to test system components or equipments.

(*b*) Land Based Test Site (LBTS)—a facility which serves as a multi-purpose test and evaluation platform where a total system is tested but shipboard space, maintainability and configuration constraints are not fully reproduced.

(*c*) Land Based Enginering Site (LBES)—as (*b*) above but the facility fully replicates shipboard operation, space, maintainability and configuration restrictions.

Additionally NAVSSES administers a FORREST SHERMAN Class destroyer as a floating test platform. These test facilities are used not only for traditional test and evaluation purposes but also for crew training, validation of maintenance practices, evaluation of future system changes and alterations, and validation and verification of technical documentation.

FIGS. 7 and 8 show the test sites housed in two NAVSSES buildings.

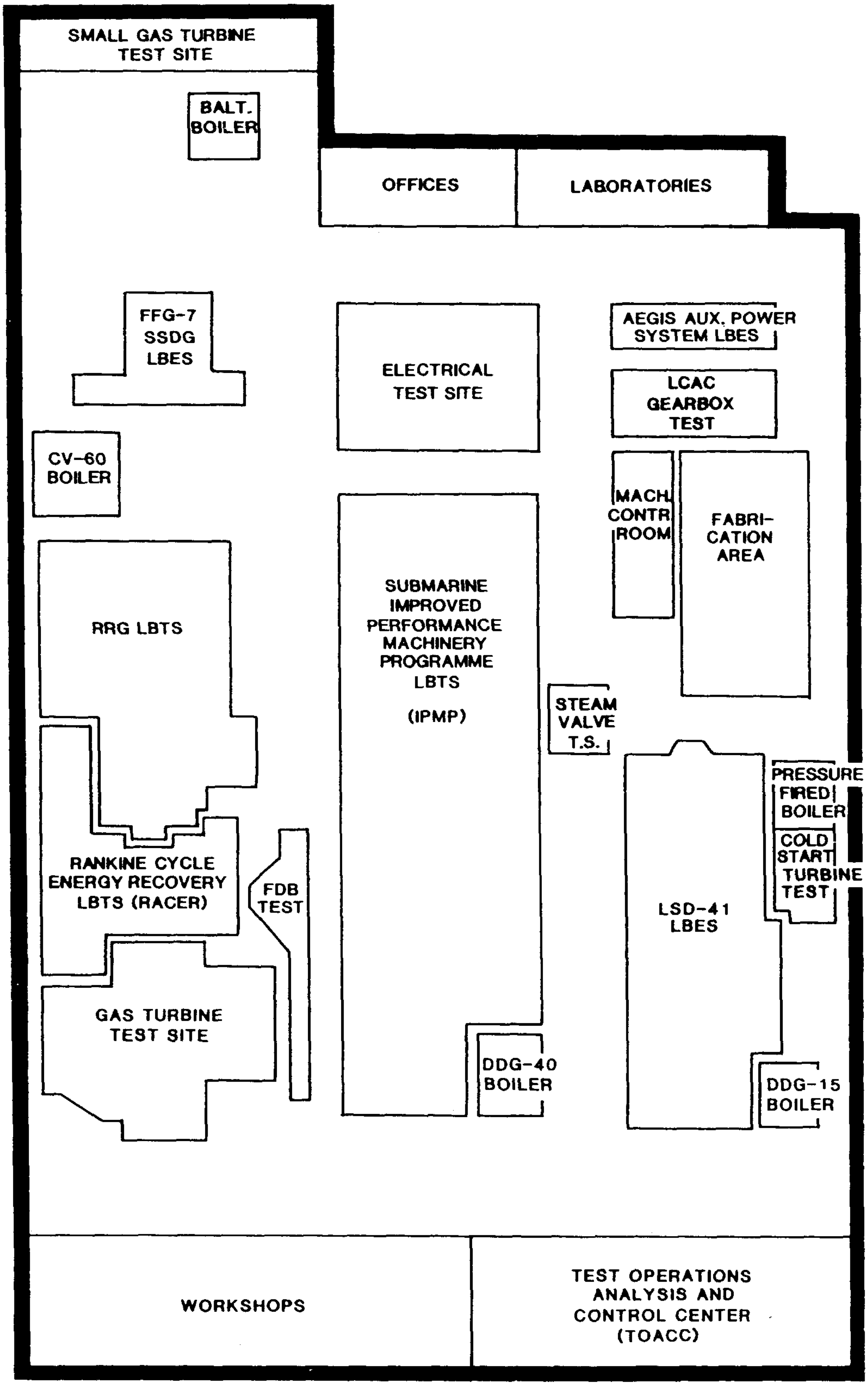

FIG. 7—TEST SITES IN BUILDING 633
for key see TABLE I

TABLE I—*Key to Major Test Facilities in Building 633* (FIG. 7)

Small Gas Turbine Test Site	Two test cells and control room currently being used to test AGT 1500 gas turbine, the main engine of the M1 battle tank.
Various boilers	Used to provide steam for testing of steam plant propulsion systems and components.
FFG 7 Ship Service DG LBES	16 cylinder 1MW Stewart and Stevenson modified Detroit diesel generator fitted in FFG 7 Class ships, currently being used to evaluate engine and generator modifications.
Electrical Test Site	Site for testing motor starters, controllers, 60/400 Hz motor generators, switchboard breakers, etc.
AEGIS Auxiliary Power System-LBES	Allison K17 gas turbine and generator, waste heat boiler and associated domestic steam systems. As fitted on CG 47 (AEGIS) Class ships.
LCAC Gearbox Test Site	Facility for back-to-back testing of Landing Craft Air Cushion gearboxes.
RRG LBTS	Reverse Reduction Gear. Two LM 2500 gas turbines, reduction gearbox fitted with Franco Tosi coupling, auxiliary systems and propulsion controls.
IPMP LBTS	Submarine Improved Performance Machinery Programme. Security classification prevents further discussion.
RACER LBTS	Rankine Cycle Energy Recovery. LM 2500 gas turbine, water brake, waste heat boiler, steam turbine and condenser.
LSD 41 LBES	Two-Colt Pielstick 16 cylinder 500 bhp diesel engines, gearbox, water brake, associated systems and controls. Duplicates one half of LSD 41 Class propulsion system.

TABLE II—*Key to Major Test Facilities in Building 77* (FIG. 8)

Electric Drive Propulsion System LBTS	Gas Turbine/Electric drive propulsion system.
Gas Turbine Propulsion System LBES	Propulsion System for the next generation DDG.
Electrical Test Site	Site for testing small to medium motor-driven hull and deck machinery and shipboard electrical power generation, distribution and control equipments.
Seawater Flow Test Site	Site to evaluate flow characteristics of SSN 21 seawater cooling systems.
Volumetric Flow Calibration Site	Flow facility consisting of volumetric provers and various diameter test pipe sections for the accurate calibration of flow measuring instrumentation used in the Fleet.
Standard Cargo and Weapons Elevator LBES	6 deck elevator machinery, hatch, door and associated components test facility.
Halon Drench Test Site	Enclosure containing oil fire trays and a BTM system.
Air Compressor Test Site	Facility consisting of a number of controlled environmental cells for testing HP and LP air compressor systems.
Acoustic Test Chamber	Evaluation of hydraulic pump airborne, fluid-borne and structure-borne noise.

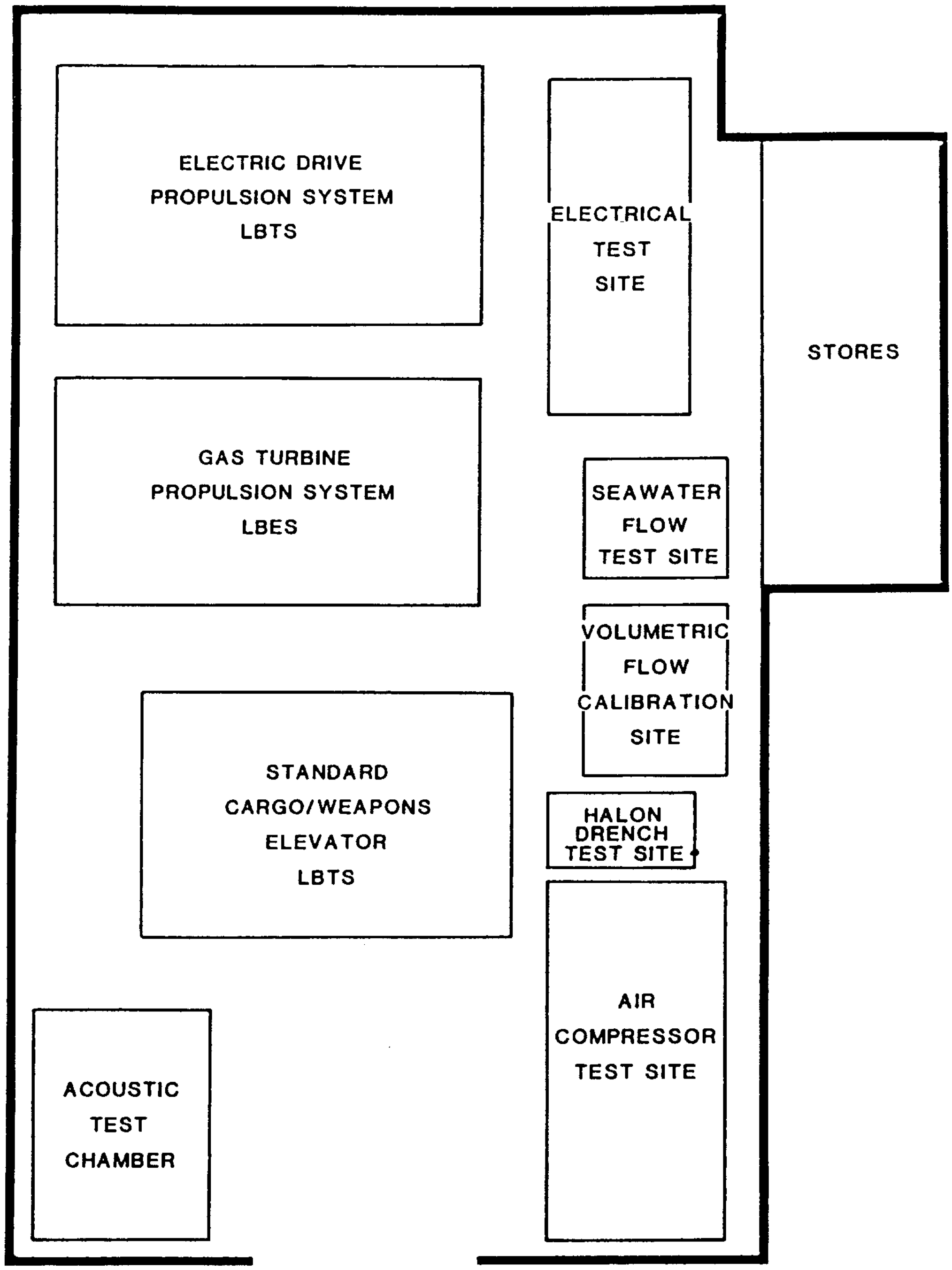

FIG. 8—TEST SITES IN BUILDING 77
for key see TABLE II

Test Programme Management

Test and evaluation activities are designated programmes or projects according to their degree of visibility, dollar value and complexity, and each has a designated manager. Managers of major test programmes have a team drawn from the various technical departments within NAVSSES—typically, a design, construction and test manager who are dedicated to the programme but have a dual technical reporting relationshp in that they also report to the director of their parent department. Management is kept up-to-date on programme and project progress through weekly status reports which are transmitted via the Management Information System. The latter is a computerized menu-driven system which provides easy access to a wide range of management and technical related information and reports. Test operations have been greatly enhanced recently by the addition of a centralized data acquisition and process facility, the Test Operations Analysis and Control Centre (TOACC). The TOACC is used to acquire, process, display, record and store test data from any selected test facility. Surveillance, operation and analysis of data are conducted by the test managers from four large consoles (FIG. 9) which are also equipped with visual and audio communications with the sites.

TOACC is linked to the establishment's central computer complex thus enabling vast amounts of data to be stored and recalled later, e.g. for trend analysis or comparison with ship operating profile data.

FIG. 9—PART OF TEST OPERATIONS ANALYSIS AND CONTROL CENTRE

Current Test Programmes

In the U.K., NAVSSES is probably most widely known for its recent work on Rankine Cycle Energy Recovery (RACER) and the Reverse Reduction Gear (RRG) which incorporates the Franco-Tosi coupling, and therefore these are appropriate subjects on which to start.

RACER

Detailed descriptions of the system have been published[1,2] and what follows is a summary of the present status of the programme. The system (FIG. 10) uses a heat recovery steam generator (HRSG) to recover waste exhaust heat from General Electric LM 2500 gas turbines. Superheated steam (900°F and 335 p.s.i.g) is produced by the generator, a once-through boiler, and is expanded in a turbine to produce additional propulsion power in the order of 8000 h.p. at 10 000 r.p.m.

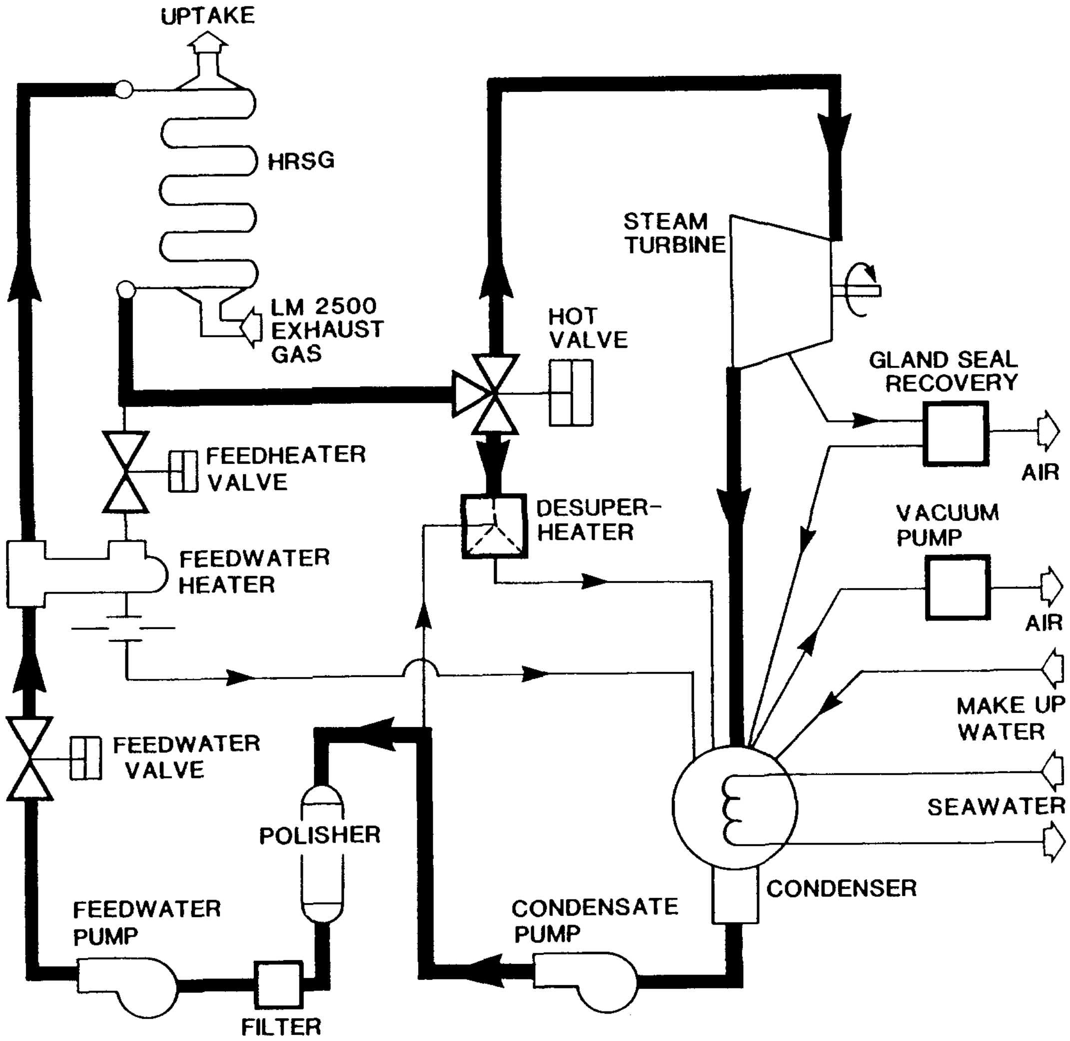

FIG. 10—RACER SYSTEM
HRSG: heat recovery steam generator

Extensive testing at NAVSSES' LBTS (FIG. 11) highlighted a number of design shortcomings, and although many of these have been resolved some key problems remain. In particular:

(*a*) *HRSG output.* In an effort to reduce HRSG noise when dry fired (boiler empty) some gas baffles were removed to allow exhaust gas to by-pass the generator and, whilst this proved successful, the removal of the baffles resulted in a reduced HRSG output.

(*b*) *HRSG steam outlet temperature.* Control of steam outlet temperature has not been reliably achieved during certain upward and downward load transients with the result that the system shuts down when the steam temperature is outside the specified range.

(*c*) *Steam turbine performance/gland seal damage.* The turbine and condenser are an integral unit with the compact turbine designed for operation at various steam pressures. No throttle valve or nozzles are used; instead a valve (the hot steam valve) directs steam to the turbine during normal operations or by-passes it to the condenser via a desuperheater during start-ups and shut-downs. It would appear that some distortion is being caused either by heating during by-pass operations or rapid cooling by the condensate from the desuperheater following system shutdown. The net result is misalignment of bearing bracket, seal housing and turbine casing and this in turn has led to excessive rubbing of turbine gland and interstage seals and a degradation in turbine performance. During certain modes of operation excessive turbine exhaust temperatures have been experienced and turbine vibration has increased to the designated trip point.

The programme above all else has demonstrated the value to the Navy of thorough system testing. Much has been learned from the test process and the knowledge gained has been used to design better system components and, given the resources and time, there can be little doubt that a reliable integrated system could be developed for shipboard use.

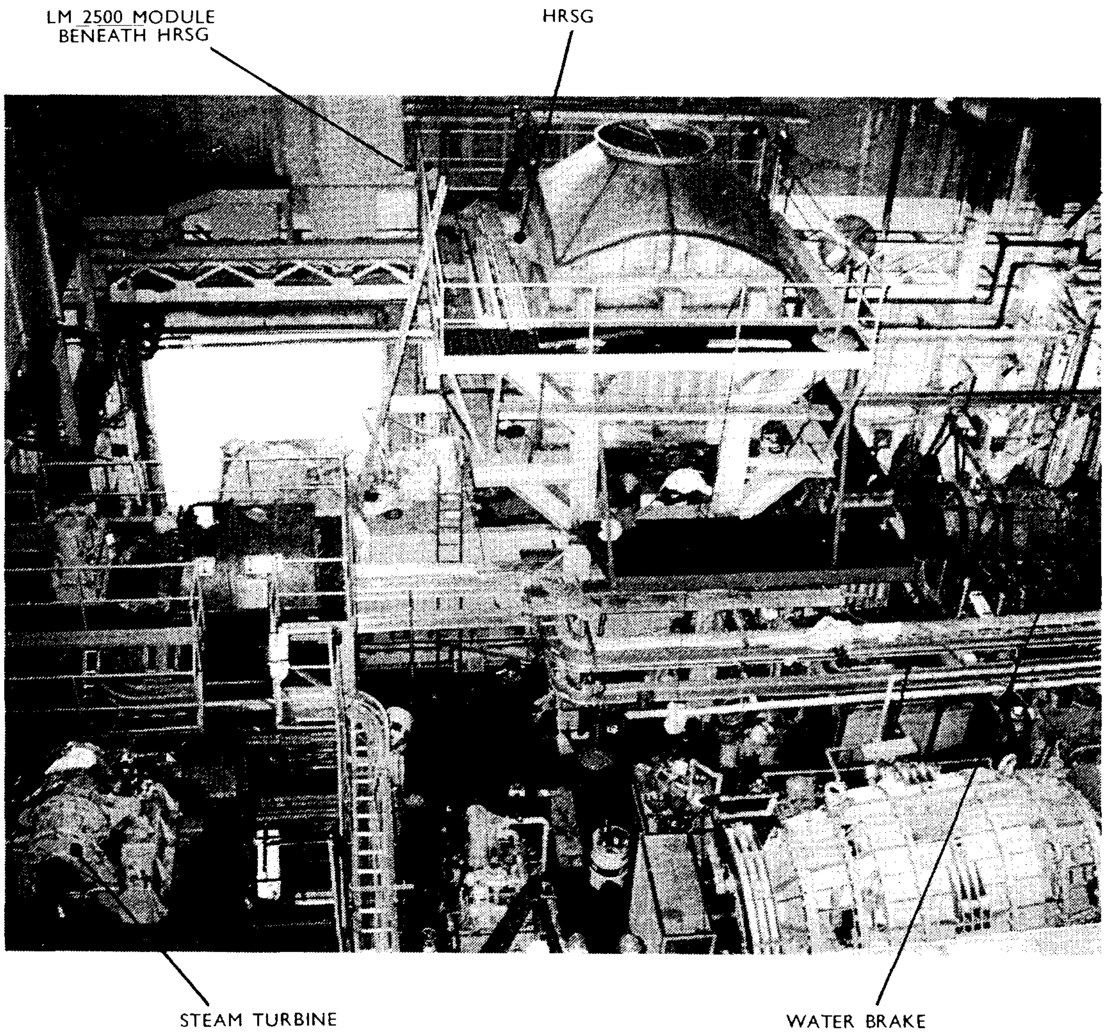

FIG. 11—RACER LAND BASED TEST SITE

Reverse Reduction Gear (RRG)

The Reverse Reduction Gear uses a Franco-Tosi reversing element to achieve astern operation with the gas turbine prime mover, thus obviating the need for a CPP system or a more conventional reversing gearbox. The coupling is being tested on what was the FFG 7 main propulsion plant LBTS at NAVSSES (FIG. 12), the essential elements of which are two LM 2500 gas turbines, a Western reduction gearbox, associated systems and controls. In the test configuration the Franco-Tosi coupling has been mounted external to the gearbox and a flywheel added to simulate down-stream inertia.

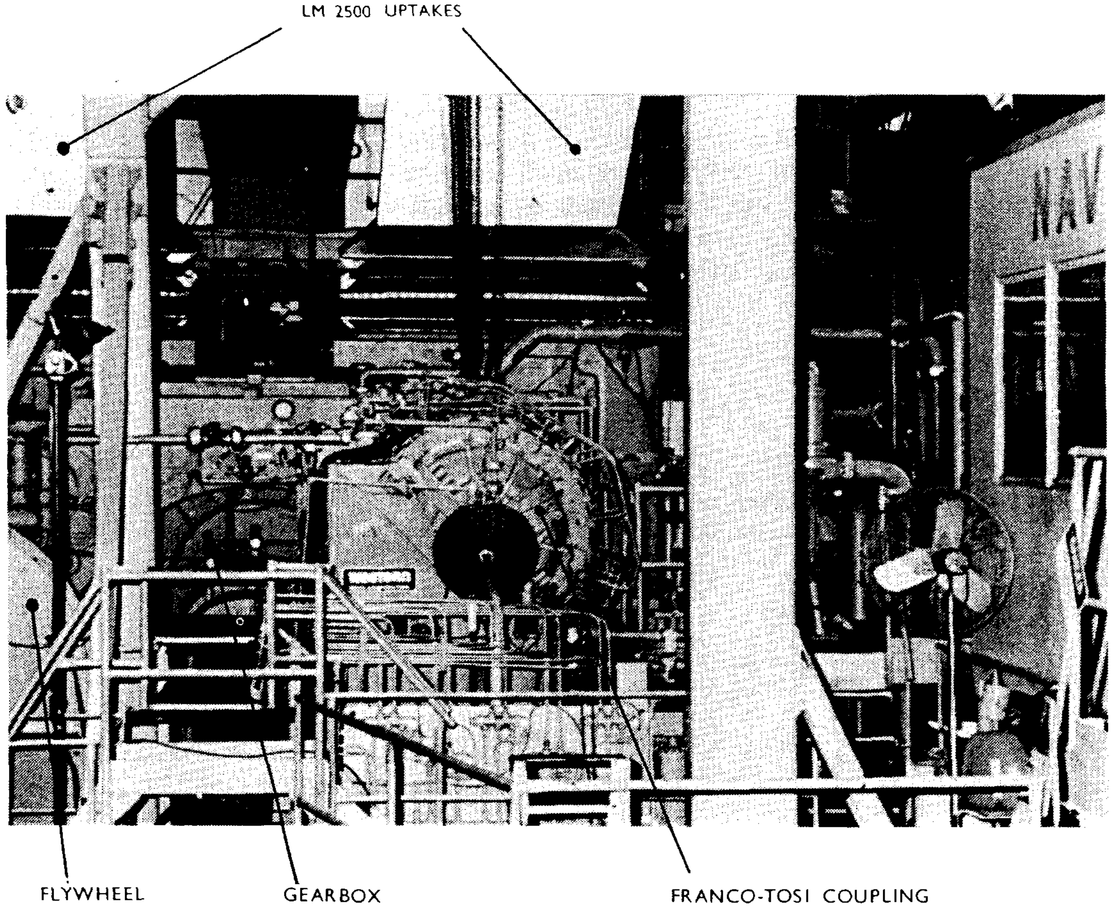

FIG. 12—REVERSE REDUCTION GEAR LBTS

FIGS. 13 and 14 show the reverse gear arrangement and a cross-section of the Franco-Tosi coupling. The coupling has stator vanes around the periphery which are moved radially into or out of the fluid circuit between the driving turbine and driven impeller to change the direction of rotation of the coupling output shaft. An SSS clutch is used in conjunction with the fluid coupling to by-pass the fluid drive to the propeller shaft during cruising or full ahead operations. Thus in the direct drive mode the power turbine input directly drives the main reduction gear high speed pinion and the propeller is driven through the locked train. In the manoeuvring ahead mode (FIG. 13) the power turbine drives the forward coupling rotor through the manoeuvring drive gearbox. The coupling is filled with hydraulic oil, thus providing the medium to drive the aft rotor of the coupling in the same direction as the forward rotor. The aft rotor drives the high speed gear and the propeller is driven in the ahead direction through the locked train. Manoeuvring astern (FIG. 14) is the same as manoeuvring ahead except that 26 hydraulic coupling

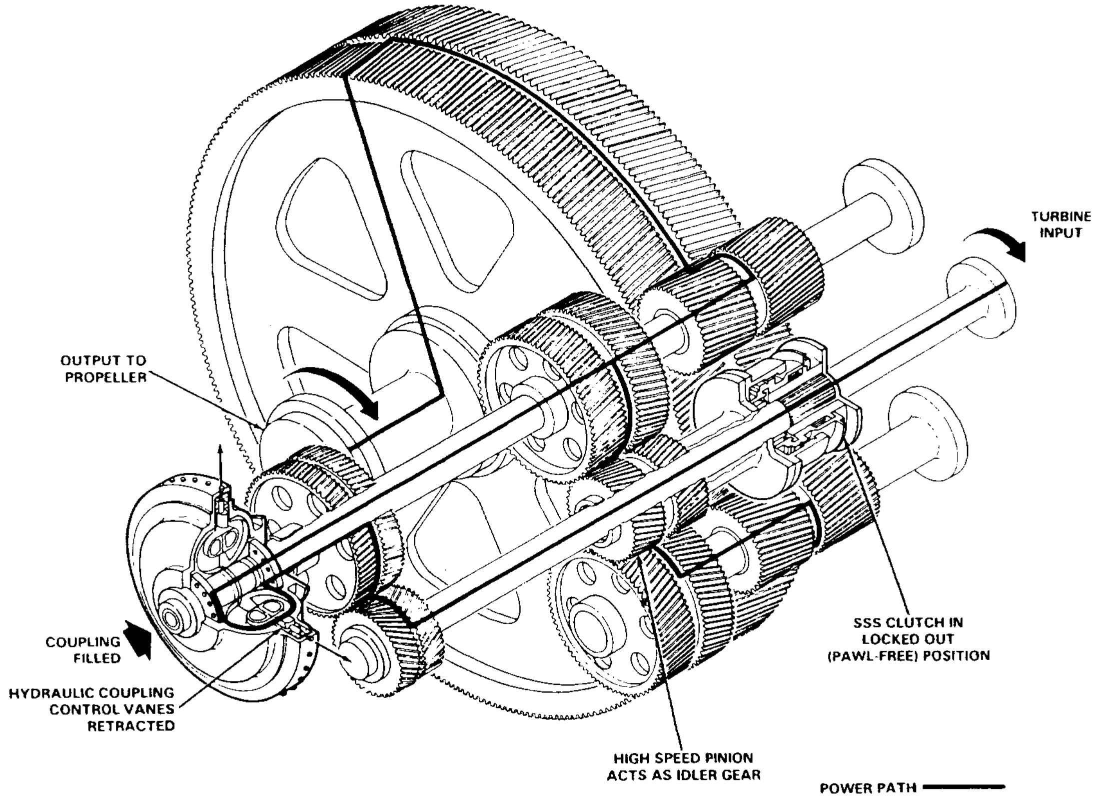

FIG. 13—REVERSE REDUCTION GEAR WITH FRANCO-TOSI COUPLING: MANOEUVRING AHEAD OPERATION

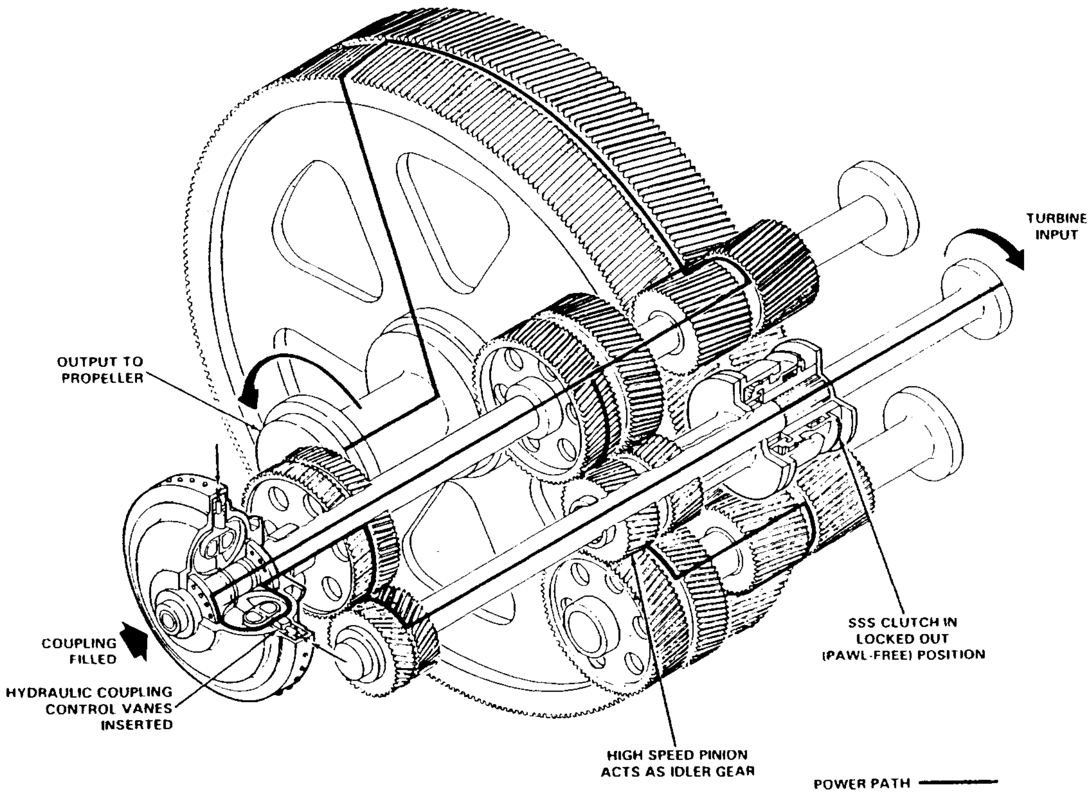

FIG. 14—REVERSE REDUCTION GEAR WITH FRANCO-TOSI COUPLING: MANOEUVRING ASTERN OPERATION

control vanes are inserted into the coupling, reversing the direction of fluid flow and thereby turning the aft rotor in the opposite direction to the forward rotor. Consequently the propeller is driven in the astern direction.

Testing began in March 1984 and the more significant results of the first two years of the test programme, which involved a number of different or modified rotors, are summarized below:

Type 79 Coupling—Testing stopped in June 1984 due to fatigue cracking of the output rotor vanes caused by high alternating stresses. A new coupling (Type 84) was manufactured following redesign of the rotor vanes and the insertable stator vanes. The output rotor was instrumented with strain gauges and pressure transducers to measure actual stress levels.

Type 84 coupling —Testing commenced in May 1985, but results showed that the astern efficiency was considerably lower than the predicted values and indeed than the measured values of the 79 rotor. The output rotor was subsequently modified at the exit regions and the coupling designated the Type 84A.

Type 84A —Testing took place in August 1985, but, no improvement in astern efficiency was recorded. The decision was then taken to test the Type 79A coupling, which consisted of the original 79 input rotor and a prototype output rotor.

Type 79A —Testing conducted in February 1986 indicated that astern efficiency was still lower than predicted by approximately 10%.

Type 79B —This coupling consisted of the original 79 input rotor but combined with an output rotor manufactured by Tooling Specialists, Inc. and not Franco-Tosi.

Analysis of the results from these latter stages of the test programme led to the decision to incorporate the coupling into the gearbox of the new AOE 6 class fast combat support ship. Testing continues with the aim of compiling more data to predict performance through the whole range of operational requirements.

LSD 41 Propulsion System

The propulsion plant for this new class of landing ship has been tested at NAVSSES where a facility was built which exactly duplicates the ship's starboard propulsion system and includes two Colt Pielstick PC 2.5 16 cylinder, 8500 bhp diesel engines, reduction gearbox and associated couplings, clutches and brakes. An integral part of facility is the propulsion control system which includes local, remote and bridge consoles, local propeller pitch controls, and the entire package of propulsion support systems (FIG. 15). The primary objective of the facility was to conduct installation, operational and maintenance tests of the system to achieve approval for service and is a prime example of the need to test an integrated system even though the engines themselves are commercially proven.

The return for investing in this LBES began in the early stages of the programme when it was discovered that the engine's internal alignment information was incorrect because of modifications carried out to meet the Navy's shock requirements. To have resolved this problem once installed on the lead ship of the class would have proved an extremely costly and time-consuming process. From the construction to the completion of the operational testing phases of the propulsion system some three hundred and thirty reports (similar to S2022s) have been generated which have impacted and had direct applicability to the ship; some were design related, many related to technical documentation and some addressed material and operational problems. The first two ships of the class are now at sea and benefiting from the thoroughness of the testing programme. However the story does not end there and the LBES will continue to be operated so that problems encountered at sea may be duplicated ashore and solutions developed, evaluated and approved. It is noteworthy that during the testing of this system, various maintenance demonstrations and evaluations have been performed by NAVSSES's enlisted personnel. These operations, which included the removal and reinstallation of a complete piston and cylinder liner assembly, served to validate the guidance to ship's companies for conducting such work at sea. The facility has been and will continue to be used for training crews about to join their ships.

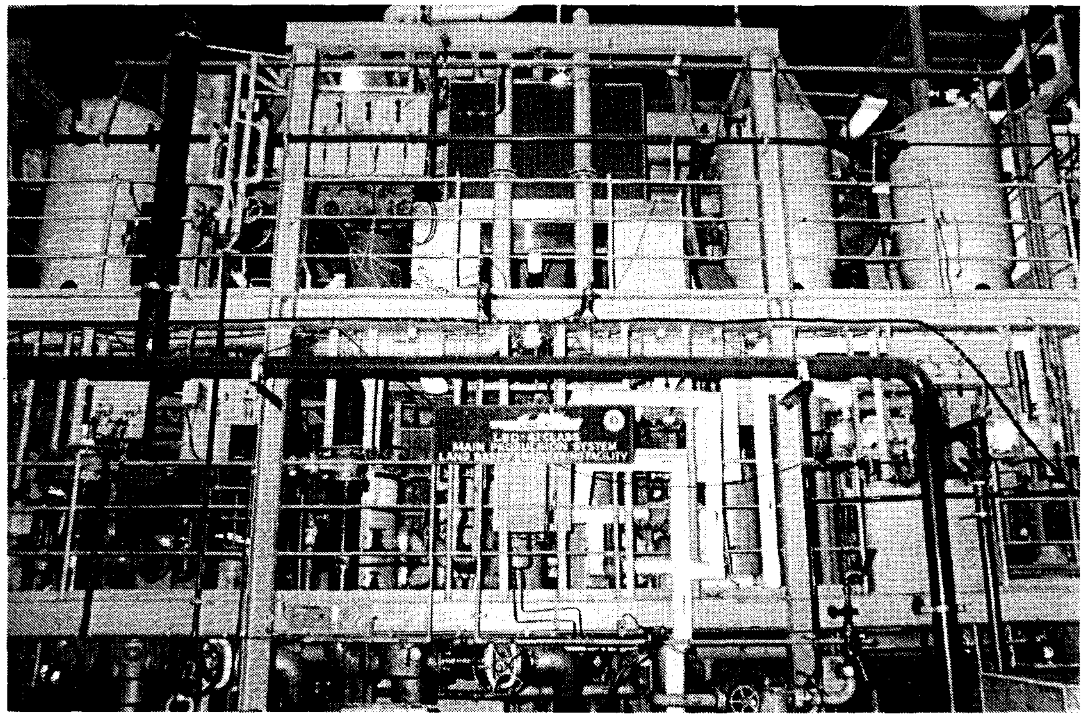

FIG. 15—LSD 41 LBES: VIEW SHOWING FORWARD 'BULKHEAD'

Standard Cargo/Weapons Elevator

An example of a major test programme that was initiated because of problems experienced in the Fleet is the Standard Cargo/Weapons Elevator Programme. There are some 700 cargo/weapons elevators at sea representing 21 different load-carrying capacities ranging from 1000 to 18 000 lb. Many of these elevator systems and components have been developed by different vendors and not necessarily to common specifications; and added to this are the numerous modifications that have been incorporated with inadequate testing and poor supporting documentation. The end result is an enormous logistic and maintenance support burden and a poor reliability record. In an effort to standardize designs and meet declared reliability, maintainability and safety standards, NAVSSES has just completed construction of a LBES which is capable of testing elevator systems and components under simulated shipboard conditions. The LBES (FIG. 16) stands 52 feet high, has 6 deck levels, and has a vertical carrying capacity of 12 000 lb. The hoist machinery is located on the third deck in a machinery room which is equipped with environmental controls. Machinery removal routes and maintenance access considerations are all important features of the design. The hydraulic power unit is housed in a compartment at ground level which replicates the typical shipboard configuration and space constraints and is instrumented to record airborne and structure-borne noise. An interesting feature of the test site design which maximizes the use of the tower is that different doors and hatches can be fitted at each deck level so the requirements of vessels from auxiliary ships to carriers can be met. In addition, the effectiveness of hatch seals can be proved by the built-in ability to flood the main deck level.

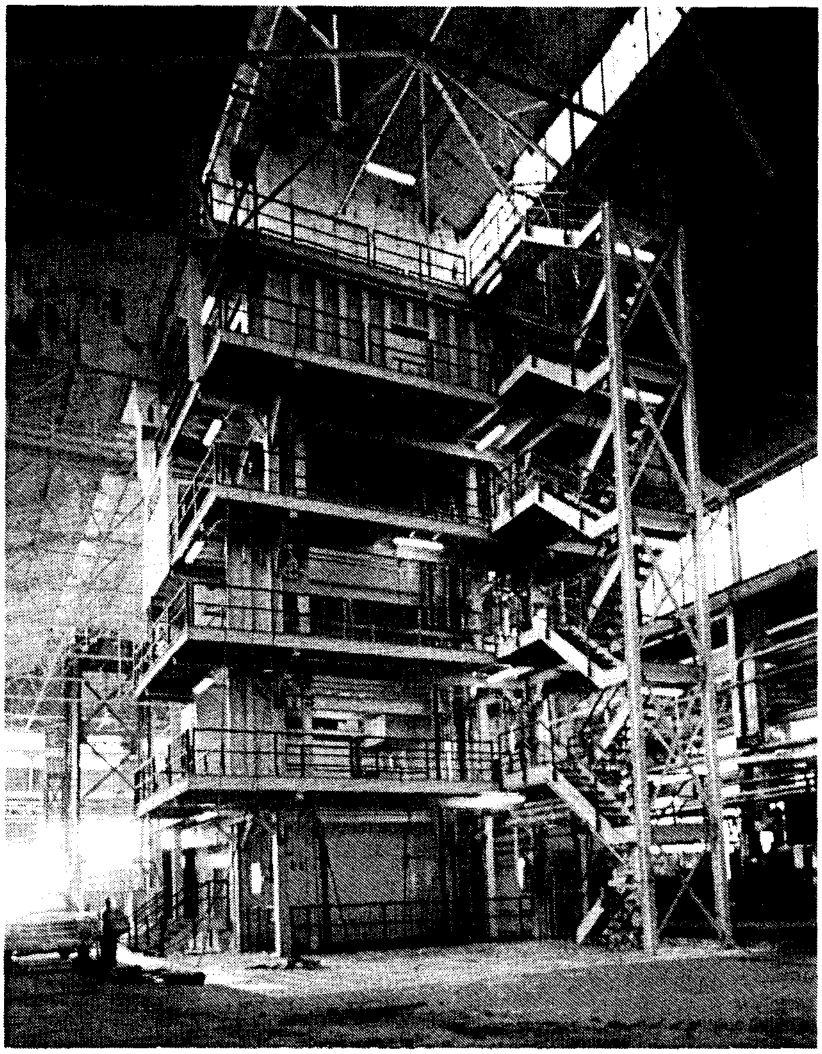

FIG. 16—STANDARD CARGO/WEAPONS ELEVATOR LBES

Initial testing will focus on the elevator needs of the future AOE 6 and AO(J) Class auxiliary ships. However the development and testing of components and sub-systems such as hoist machinery, motor controllers, logic controllers, sensors, hydraulic power unit, hatches and doors, platform construction and safety devices is aimed at improving the hardware and supporting documentation for elevator systems in all classes of ship.

Electric Propulsion Drive

This article would not be complete without discussing future work. A land based test site is currently being prepared at NAVSSES to test a 25 000 shp electric propulsion drive system. This installation represents one half of the propulsion plant proposed for a future twin shaft SWATH or conventional monohull warship. Although detailed design work for the final ship propulsion system, and therefore also the LBTS installation, is not complete, an earlier feasibility programme has resulted in the essential system components and configuration being defined.

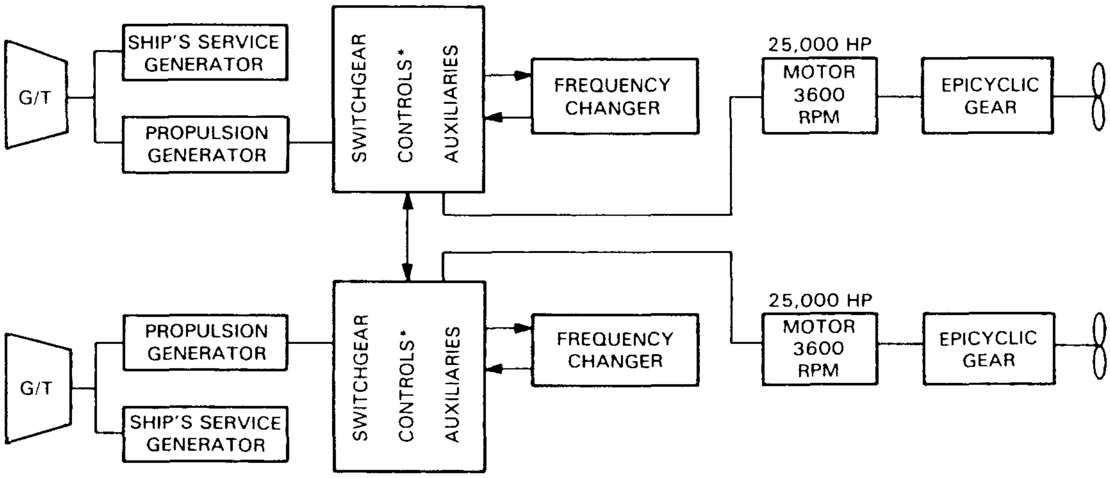

FIG. 17—ELECTRIC PROPULSION LBTS
*indicates twin shaft control

FIG. 17 shows the proposed shipboard installation. The prime movers will be two LM 2500 gas turbines and in the cruise mode one engine will be shut down and the power for both drive motors will be supplied from the remaining propulsion generator. It has yet to be decided whether a ship's service generator will be gear driven from each gas turbine output shaft or indeed whether ship's service electrical power will be taken directly from the propulsion generators. The LBTS will replicate one half of the propulsion plant with the option of the second half being added at a later date. A high speed water brake will be used on the site until the epicyclic gear is ready for testing (with another water brake). The LBTS should be in operation about 1989 and in the meantime seemingly endless tons of concrete are being delivered to the site as the foundations take shape and supporting services are installed.

Future Gas Turbine Propulsion Systems

Arguably one of the most exciting programmes at NAVSSES is one which will combine a number of existing programmes to support and test propulsion systems of future classes of ship. It is designated the Gas Turbine Ship Land Based Engineering Site (GTSLBES) and, although the DDG 51 will be the first class to benefit from the programme, this LBES has broader and longer term aims and therefore uses a generic title. NAVSSES will thus have an engineering site which is not dedicated to one partcular class of ship but will be flexible enough to incorporate and test systems, subsystems and components for specific classes as the need arises.

The LBES will replicate one machinery space of a gas turbine ship and initially will include:

(*a*) upgraded LM 2500 gas turbines which incorporate integrated electronic controls;

(*b*) a high power density (HPD) gearbox;

(*c*) a totally digital ship propulsion control system;

(*d*) a gas turbine driven ship's service generator;

(*e*) machinery control room including electrical switchboard.

Adjacent to the GTSLBES will be the Electric Propulsion and the AEGIS Auxiliary Power Systems sites, the ship's service generators of which will be fed to the GTS switchboard so that electrical power generating and main propulsion machinery can be fully integrated.

As a result of other current and future test programmes it is planned subsequently to incorporate into the GTSLBES:

(*a*) intercooled regenerative gas turbines;

(*b*) RRG in conjunction with the HPD gearbox;

(*c*) Fibre optic sensors and transmission system (it is unlikely that a 'pure' fibre optics machinery control system will have been developed by that time).

Clearly this is a major programme involving significant capital investment and will be the first time that all the subsystems will be tested in a single integrated system environment where component interactions can be evaluated before installation in the lead ships.

In Service Engineering Support

This article has tended to dwell on the test and evaluation role of NAVSSES but a significant proportion of the station's time and resources are spent on support of the Fleet and this is undoubtedly a growth area for the establishment. Responsibilities in this area have been outlined earlier and the support effort is provided by the technical desks within NAVSSES or from field representatives. The establishment is an action addressee on HM&E CASREP (OPDEF) signals and will respond by signal or, has happens frequently, by sending specialists to the ship.

A particularly noteworthy area of ISE support is the U.S. Navy's successful Machinery Alteration (MACHALT) Programme. Similar to a Modification, a MACHALT is a change to a shipboard HM or E system or equipment to improve its performance or reliability where the change is contained within the individual system or equipment boundary. It is a kit concept which enables changes to be accomplished expediently and without shipyard support, unlike the SHIPALT (A&A) process which deals with more major changes. The concept was developed to package not only the material requirements for the change but also all the associated technical and logistic support documentation. NAVSSES is involved in the development, preparation, validation, distribution and installation of all MACHALTS. A timescale of three years is allotted from final approval to installation in all applicable ships and, considering the number of ships in any particular class, or number of different ships fitted with a common equipment, this is an ambitious undertaking but one which is being accomplished.

The end result, the kit, is literally a box containing everything needed to achieve and support the change as illustrated in FIG. 18. The kit is delivered on board and installed by NAVSSES field representatives using ship's company or base support where necessary. Following successful installation, the equipment or system is tested; if applicable the ship's company is trained;

the supporting stores, maintenance and technical documentation changes are incorporated; supporting spare parts are put in naval stores; and finally a modification state plate is attached to the equipment involved. The information loop is closed by NAVSSES who inform relevant Fleet agencies of the completion of the MACHALT installation.

The MACHALT programme has had a significant impact on the Fleet and has proved a relatively rapid, cost-effective and reliable method of instituting changes. It is particularly popular amongst ship's companies who are no longer saddled with an equipment they cannot totally support.

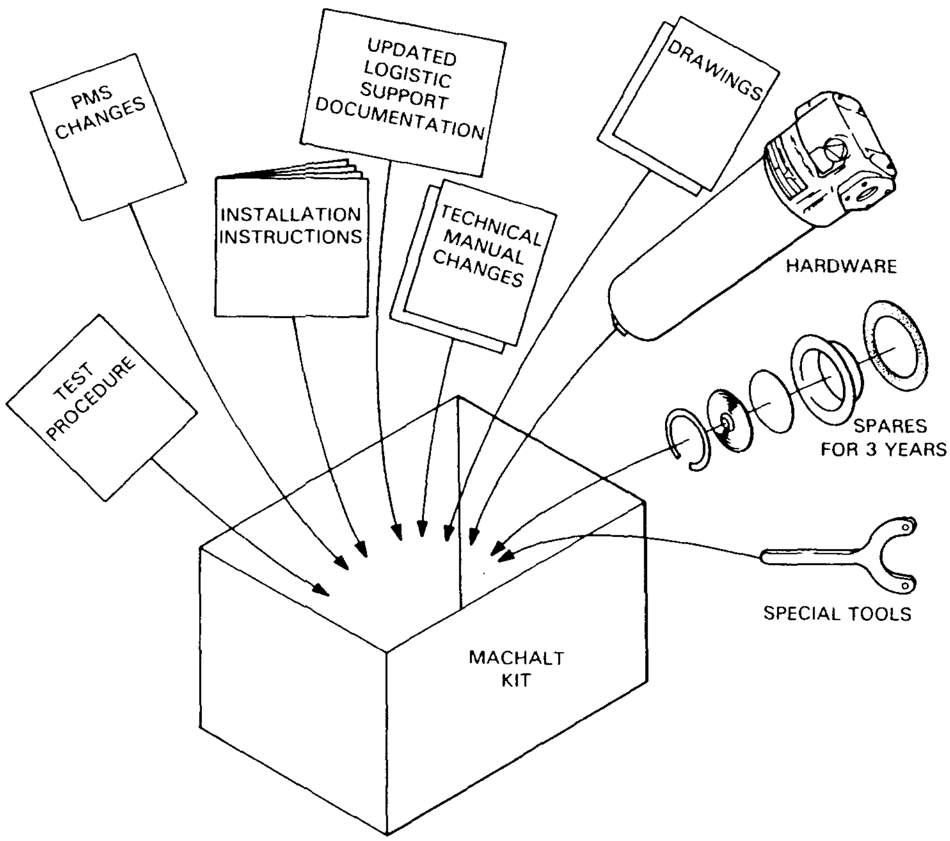

FIG. 18—MACHINERY ALTERATION KIT

Role of the R.N. Exchange Officer

The exchange officer is employed as assistant to the Technical Director of NAVSSES and is assigned tasks to review, analyse, investigate and oversee technical and engineering projects. In pursuance of this task the job certainly offers variety and the opportunity to get to grips with a diverse range of subjects, the majority of which are very relevant to the direction in which the Royal Navy is headed. The job also has the attraction of not being totally desk-bound; a proportion of each working day is usually spent on site reviewing work, test and installation progress. Visits are made to headquarters in Washington, to NAVSSES field activities around the country and to U.S. Naval ships and establishments. The exchange officer also has a direct and significant role to play in the systems test process. Prior to the commencement of each test programme, however large or small, the test team have to present their programme to the Mission Readiness Panel (MRP). This for want of a better phrase is the final quality assurance audit to ensure that it is safe to commence testing and no own goals are scored.

The panel is chaired by the exchange officer and reviews safety matters, installation, controls and instrumentation, operator training and qualifications, engineering practices and standards, and operating and test procedures. Successful completion of the MRP permits the test programme to commence. It should perhaps be emphasized that the exchange officer is in the employ of the U.S. Government and is not permitted to communicate information directly to his parent service, which is why NAVSSES headed notepaper never crosses the desks of Foxhill. Information relating to the work being conducted at NAVSSES is channelled through CNBS's office in Washington to ensure that there is compliance with the various exchange of information agreements.

Conclusion

The value of the systems concept and the need for thorough systems testing have become an integral part of the warship design and procurement process and the days when the engineering community at large made the mistake of combining proven equipments and components in the belief that they would constitute a reliable system have hopefully long gone. The manner in which NAVSSES is organized and executes its business is a reflection of its conviction in the systems approach, i.e. the hardware is merely a subsystem and the total system in this context must include documentation, logistic support, engineering procedures and practices, training and human engineering. NAVSSES presents a healthy environment in which to work; it is a growing organization which is committed both to the U.S. Navy's strong drive for innovation and also to ensuring that HM&E systems are made more reliable, affordable and able to meet the needs of the weapons platform and I commend the job to my prospective successors.

As a final note and 'food for thought' the CNO has challenged ship designers and engineers to remove the bridge from future surface warships or limit its size to that of a 747 cockpit.

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