ISLAND CLASS OFFSHORE PATROL VESSELS

MACHINERY INSTALLATION

BY

COMMANDER G. C. BURNAN, M.SC., C.ENG., M.I.MECH.E., M.I.MAR.E., R.N., AND LIEUTENANT-COMMANDER C. L. W. PAGE, C.ENG., M.I.MECH.E., R.N.

Introduction

During the early 1970's, the enormous potential of the North Sea as a producer of natural gas and oil became increasingly apparent, and more companies took up options to search for gas and oil in the areas that had been allocated by Government agreement. In addition, the influx of foreign trawlers into the rich fishing grounds round our coasts increased the work load of Captain, Fishery Protection.

In these circumstances, the Naval Staff were directed to investigate the resources available, at present and in the future, to ensure adequate 'policing' of the gas and oil installations and fishery protection areas in the probable Exclusive Economic Zone. This investigation was carried out as part of a broad study known as 'Offshore Tapestry'.

Director General Ships became actively involved in mid 1973 when the Naval Staff directed that a survey should be carried out of suitable vessels then on the open market, either for sale or for charter, which could be made available within a short time 'to evaluate the requirement'. Such a vessel had to have good sea-keeping qualities, have a maximum speed of at least 16 knots, and be easily convertible to and from the protection role. All negotiations were carried out through the auspices of the Admiralty Broker, the Ministry of Defence link with the commercial shipping world.

At this time there was no limit on British trawlers' fishing areas, and modern large stern-freezer and other trawlers could make large catches and command high prices for them on return. As a result the trawlers available for Offshore Tapestry were:

(*a*) either too old, having been proved uneconomic by their owners,

(*b*) or priced at a very high level to reflect their loss of earnings whilst under R.N. control.

Nevertheless, a DGS 'cloak-and-dagger' inspection team visited ten ships of various sizes and conditions selected from over twenty offered.

The sophistication of modern trawler design became apparent during this investigation: bridge control of main engines, CP propeller systems, and generators with automatic run up, paralleling and switching in of stand-by generators, and complex multi-temperature freezing installations being specified by the owners' marine superintendents. In the stern-freezer trawlers, the machinery installation and layout is very often determined by the fish handling, preparation and freezing areas, and in most cases results in the machinery spaces being sited far forward and generally below the accommodation spaces, sometimes resulting in habitability problems. To offset the capital investment involved, trawler owners expect a very high usage factor from their vessels; this is achieved by short turn-round times and the reliability of the installed equipment. However, the effect of this policy is shown by the overall appearance of the vessels, particularly in the hull and superstructure where deep-set rust soon makes its mark.

Despite a widespread belief to the contrary, it was difficult to find such trawlers with a maximum speed of 16 knots. Furthermore, very extensive and expensive stripping and refitting of accommodation and work spaces would have been necessary to rid the selected vessel of the pungent and all-pervading aroma of fish. These factors together with the others already mentioned led the team to the conclusion that the trawler option was not to be recommended, and that other designs of ships should be investigated.

Following an inspection of *Jura* by Naval Staff and DGS representatives, the Department of Agriculture and Fisheries for Scotland offered their newly completed protection vessel to the Ministry of Defence on loan until protection forces could be reinforced. This offer was accepted by the Ministry; additionally, it was decided to bring forward H.M.S. *Reward* from reserve, and finally to place a contract with Hall Russell and Company of Aberdeen for five protection vessels. To reduce the design and building time to a minimum, the design of these vessels was to be substantially 'as *Jura*' and only modifications to:

(*a*) meet the NSR,

(*b*) improve safety and resistance to damage,

(*c*) ease maintenance and support problems,

would be considered.

The 'Jura' Design

The following description of the *Jura* installation forms the background from which the necessary changes were undertaken to equip the 'Island' Class for a R.N. role.

Jura was completed by Hall Russell and Company in mid 1973, the machinery design being based on a Y-ARD study for the Department of Agriculture and Fisheries, Scotland, for a fishery protection vessel.

General Particulars

General arrangement	— Similar to 'Island' Class (see FIG. 1)
Length overall	— 59·5m (195ft)
Displacement (Deep)	— 1250 tonnes
Fuel capacity	— 257 tonnes
Speed: Max. both engines	— $16\frac{1}{2}$ knots
Max. one engine	— 15 knots

Brief Description

The main propulsion machinery comprised two British Polar diesel engines, each rated at 1512 kW at 750 rev/min driving through a twin-input reduction gearbox to a single controllable-pitch propeller.

The gearbox was of Barclay Curle manufacture with a ratio of 3:1 and capable of:

(*a*) transmitting the maximum output of both engines ahead and astern;

(*b*) transmitting the maximum output of one engine continuously and indefinitely with the other shut down;

(*c*) being trailed indefinitely with the gearbox lubricating oil pump running.

Shafting, which was to Lloyds rules, was divided into tailshaft and intermediate shaft to facilitate removal from the ship. A manually operated band type brake was fitted to the intermediate shaft coupling.

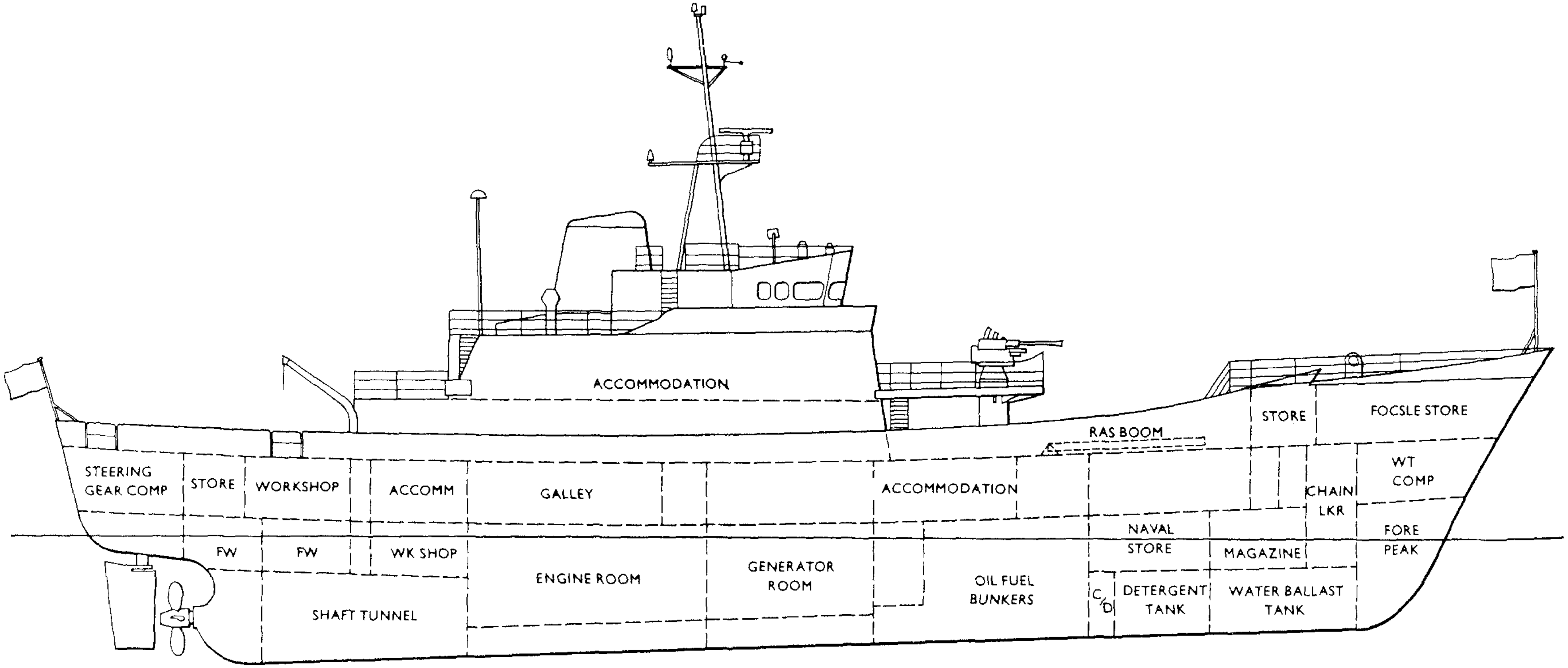

FIG. 1—'ISLAND' CLASS—GENERAL ARRANGEMENT

An Escher Wyss four-bladed controllable-pitch propeller absorbing the maximum shaft power at 251 rev/min was fitted. Rotation was anti-clockwise viewed from astern. Two hydraulic pumps were fitted for working or stand-by duty as required.

Hydraulic steering of K and L manufacture was provided, controlled by telemotor from the bridge and powered by two motor-driven hydraulic pumps, one of which was stand-by in auto. Hand hydraulic steering using the wheel on the bridge was available in the event of power failure to the steering motors.

Three main generators of Paxman 6RPHCZ design each with an output of 200kW, 415V, 50Hz at 1200 rev/min arranged for parallel operation were fitted. All main generators were situated in one compartment forward of the engine room, with access from the engine room through a watertight door.

Pneumatic control of the machinery was available from the bridge and the bridge wings by combinator, and from the machinery control room. Pitch and engine speed could be varied independently from the MCR, and from the bridge main control position on removal of the ganging pin. Emergency control of the propeller pitch was provided in the shaft tunnel at the CPP distribution box.

Compressed air at 27 bars was provided by two motor-driven Hamworthy air compressors. Air was supplied for:

(*a*) Main and auxiliary engine starting,
(*b*) Control systems,
(*c*) Workshop,
(*d*) Weed clearing.

A fully-automatic refrigeration system was provided with two compressor units (one as stand by).

Summary of Changes in 'Jura' Machinery Design for the OPV Role

The changes can be considered as divided into the three categories referred to at the end of the 'Introduction' to this article.

Changes to meet the NSR

A diving air system was installed for the re-charging of three Aquarius and ICABA breathing sets. Space was found in the forepeak for the compressor, bottle, and associated charging panel.

No evaporators are fitted, and as the crew of the OPVs would exceed that of *Jura* the fresh-water capacity was increased to 90 tonnes. The fresh-water pumping and calorifier heating capacity were also increased.

Changes to Improve Safety/Resistance to Damage

The Royal Navy has an aversion to its ships sinking, thus all warships are internally subdivided to some degree. *Jura*, being a commercial ship, does not meet DGS criteria for surviving after collision damage, in that she could sink if her largest compartment were flooded. The largest compartment is, of course, the engine-room, which in *Jura* includes the shaft tunnel. 'One compartment standard', i.e. the ship surviving with one compartment flooded, was achieved in the 'Island' Class by forming a watertight bulkhead at the after end of the engine room, and sealing off the watertight door to the generator room. This necessitated a separate access to the workshop, generator room, and shaft tunnel.

In the event of loss of all main generators (because of fire or for any other reason), *Jura* loses all propulsive power because most of the essential services for the main propulsion machinery are supplied by electric pumps, including the gearbox lubricating-oil pump and the CP propeller pumps. A secondary generator was therefore fitted in the engine room of the 'Island' Class to provide power for essential propulsion and safety services should main generator power be lost. As a further safeguard, the lubricating oil header tank (installed to provide, in the event of pump failure, emergency lubrication of the gearbox until the shaft could be stopped) was increased in size.

The *Jura* design, based on Lloyds rules, included two fire pumps in the machinery spaces, with a diesel-driven fire pump in the forepeak. There was a requirement to increase the pumping capacity of the 'Island' Class because of the addition of a magazine, and the need to separate the fire pumps to provide integrity of supply in the damaged condition. Three 10 hp pumps therefore replaced the two 8 hp pumps in *Jura*. These were sited in the generator room, the engine room, and the shaft tunnel respectively. The commercial diesel-driven pump was discarded, and a Spate pump was supplied for emergency use.

In line with Ship Department policy, the fire-fighting arrangements throughout the ship were reviewed to bring them up to the latest R.N. standards. As a result the existing one-shot CO_2 drench system fitted for the machinery spaces in *Jura* was replaced by a two-shot BCF system. A forced exhaust system was added and special low level suctions were provided for the removal of BCF gas after it had been used to extinguish a fire. Remote stops for all fans were fitted. In addition, foam tubes were provided for the engine room and generator room to combat bilge fires. The fire-detection system in *Jura* protects the generator room only. For the 'Island' Class, a Minerva automatic fire-detection system was installed to serve the following spaces:

(*a*) Engine room,
(*b*) Generator room,
(*c*) Magazine,
(*d*) Magazine adjacent compartments.

Audible alarms were specified for the wheelhouse, MCR, and the accommodation. The associated alarm panels were sited in the wheelhouse and MCR.

To avoid unnecessary damage caused by minor collisions, some re-siting of machinery, tanks, pipes, and cables was required to keep the internal hull plating of the machinery spaces clear of such items in the vicinity of the waterline.

Other minor changes included the provision of:

(*a*) a split fuel oil system, so that generators and main-engine supplies were separate;
(*b*) double-skinned high-pressure fuel pipes for the main engines;
(*c*) a mechanical means of locking the controllable-pitch propeller in the ahead pitch position should the hydraulic system fail; a shaft brake was added to hold the shaft during this evolution;
(*d*) a block and tackle system for emergency steering.

Changes to Reduce Maintenance and Support Problems

It was decided to change *Jura*'s British Polar main engines to Ruston 12RK3CMs, giving a slight increase in engine power. A flexible coupling was introduced between the engines and the gearbox to facilitate alignment.

Discussion with the civilian operators of *Jura* indicated that the turbocharged Paxman 6RPHCZ generators were overpowered for their duty, with the result that problems of light-load running had been experienced. It was therefore decided that the non-turbo-charged Paxman 6RPHZ would be substituted in the 'Island' Class design. In conjunction with this change, the frequency of the electrical distribution system was changed from 50Hz to the normal R.N. frequency of 60Hz. The mountings of the generators for the 'Island' Class were also changed to the R.N. type mounts, in order to minimize noise and improve habitability in the accommodation spaces above the generator room.

The design of the Escher Wyss controllable-pitch propeller fitted in *Jura* had been improved by the manufacturer. The improved design was therefore adopted for the 'Island' Class. Additionally, in order to reduce cavitation in the single engine condition, the propeller blades were re-designed and the shaft speed reduced, necessitating a small reduction in the gearbox reduction ratio.

Other minor changes in the *Jura* design included:

(*a*) the deletion of the fuel oil and lubricating oil separators, the lubricating oil transfer pump, and the lathe in the workshop;
(*b*) provision of a small R.N. type laundry;
(*c*) the alteration of materials for heat exchangers to bring them into line with R.N. practice;
(*d*) the deletion of the permanently-fitted shaft torsionmeter;
(*e*) the re-siting of the hydraulic module for the CP propeller;
(*f*) the improvement of the oily bilge system;
(*g*) the supply of lifting and transporting arrangements for the main and auxiliary machinery;
(*h*) provision of sump heaters for the main engines.

'ISLAND' CLASS

Standards of Machinery Installation

The 'Island' Class were to be built to good commercial standards to meet Lloyds and Department of Trade regulations, and the acceptance of these factors by the Ministry of Defence was essential in order that the ships could be designed and built to a very tight time schedule. Certain aspects of the 'Island' Class machinery design therefore do not meet the relevant R.N. requirements for warships. Notably, most of the pipe systems, valves, and machinery mounts are to purely commercial standards. Removal routes have only been planned for the largest items of machinery.

Build Programme

Work began on the first vessel of the Class in August 1975 with the following programme of acceptance dates:

H.M.S. *Jersey*	September 1976
H.M.S. *Orkney*	January 1977
H.M.S. *Shetland*	May 1977
H.M.S. *Guernsey*	August 1977
H.M.S. *Lindisfarne*	December 1977

The first two ships have been accepted on time and the remaining three are on schedule.

Machinery Installation: General Particulars (FIGS. 2 and 3)

Two Ruston 12RK3CM diesel engines each rated at 1634kW at 750 rev/min provide the propulsion power. Although these engines have a very wide

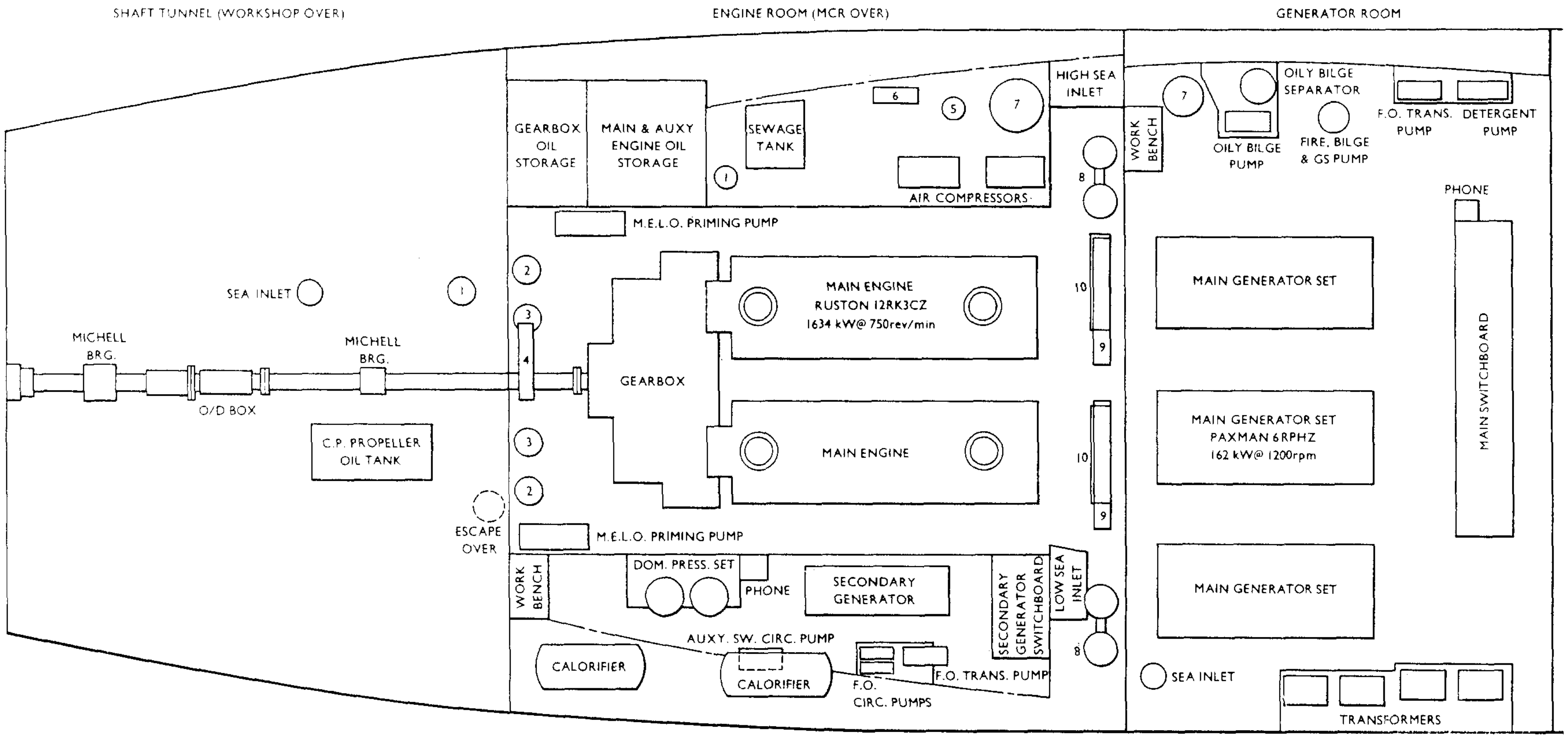

FIG. 2—'ISLAND' CLASS MACHINERY SPACES—GENERAL ARRANGEMENT PLAN

Key:

(1) Fire, Bilge, and G.S. pumps
(2) Gearbox L.O. pumps
(3) Gearbox L.O. strainers
(4) Gearbox L.O. cooler
(5) Control air receiver
(6) Compressor control panel
(7) Starting air receivers
(8) M.E.L.O. filters
(9) M.E.L.O. coolers
(10) M.E. heat exchangers

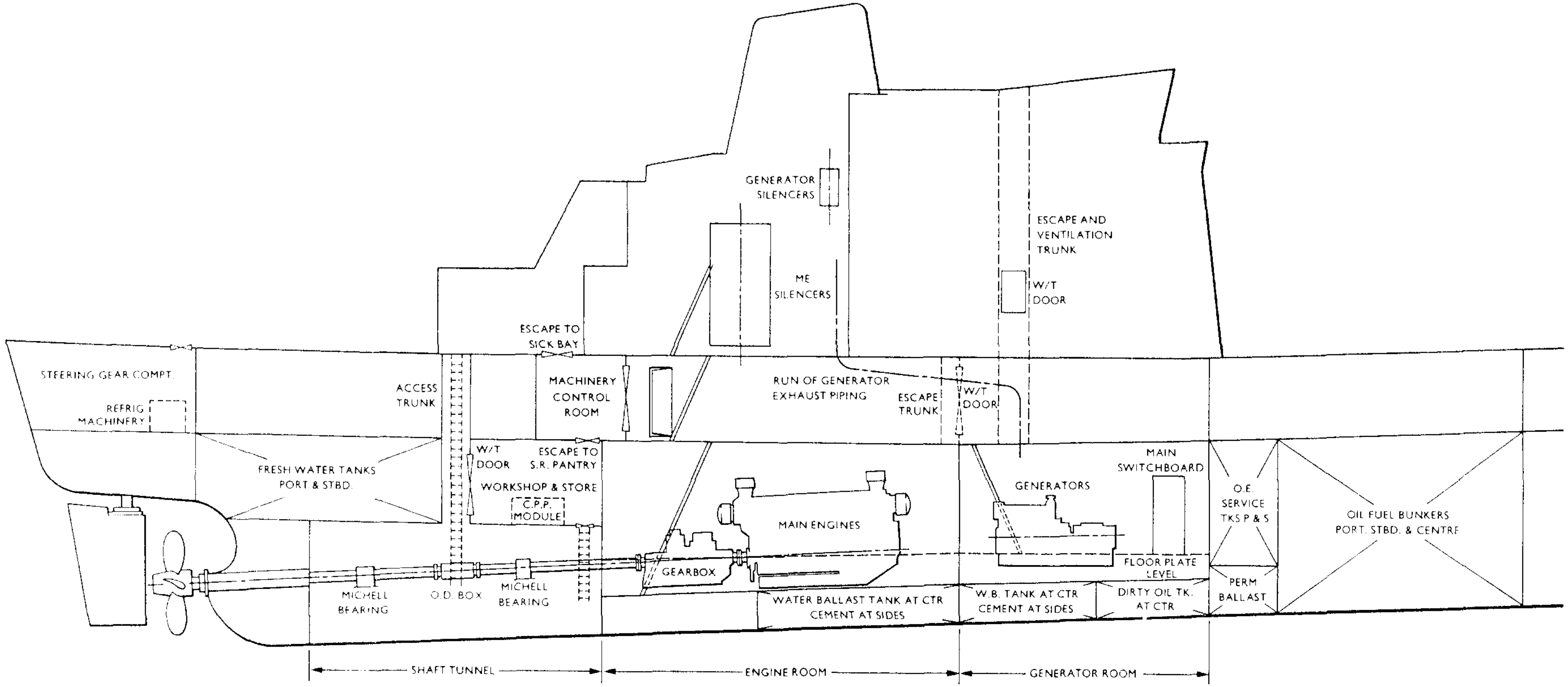

FIG. 3—'ISLAND' CLASS MACHINERY SPACES—GENERAL ARRANGEMENT PROFILE

background of applications in rail traction and marine use, this is their first installation in a R.N. ship. The engines are to be refitted *in situ*, with a light overhaul every 10 000 hours (heads, fuel pumps, piston rings, etc.) and a major overhaul every 20 000 hours. They are conservatively rated by commercial standards; the total weight of each is about 20 tonnes.

The Barclay Curle gearbox, very similar to *Jura*'s, is a single-reduction unit with ratio of 3·26 : 1. Lubrication is provided by two electrically-driven lubricating-oil pumps, which also provide oil for the hydraulic clutches. Electrically-powered turning gear is fitted.

Shafting is to Lloyds rules, supported inboard by two Michell-type bearings. Simplex 'Compact' oil seals are fitted at the inner and outer ends of the stern tube supplied from a 150 l gravity oil tank.

The Escher Wyss CP propeller absorbs a maximum of 3150 shaft kW at 225 rev/min. In this condition the propeller pitch is 23·5°. Maximum speed is over 16 knots on two engines, and over $14\frac{1}{2}$ knots on one engine.

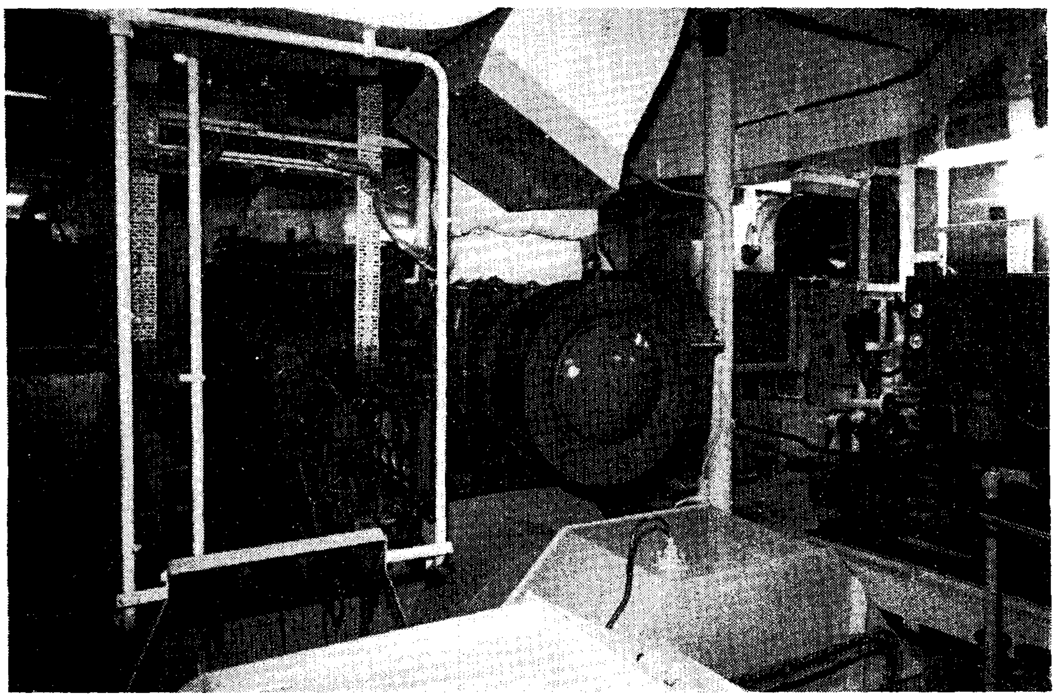

FIG. 4—H.M.S. 'JERSEY' ENGINE ROOM SHOWING STARBOARD MAIN ENGINE AND GEARBOX IN FOREGROUND

Main electrical power is provided by three Paxman 6RPHZ generators rated at 162kW at 1200 rev/min, 440V, 60Hz. Each generator set weighs over $5\frac{1}{2}$ tonnes; similar engines are fitted in other MOD(N) vessels under the charge of the Director of Marine Services. Secondary power is catered for by an air-cooled FODEN FD4 diesel engine in the engine room; this produces 50kW at 1800 rev/min, and is capable of being started by hand. Among the services supplied by this secondary generator are:

Gearbox lubricating-oil pumps
Auxiliary circulating-water pump
Machinery-space ventilation fans
Fire pumps
Air compressors
CP propeller pumps
Machinery alarms

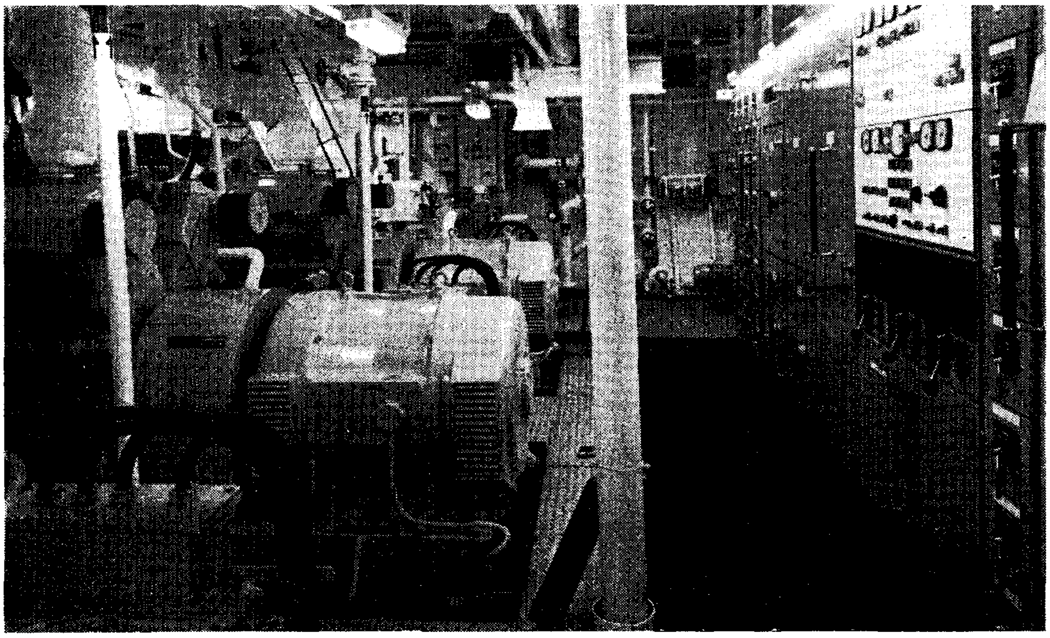

FIG. 5—H.M.S. 'JERSEY' GENERATOR ROOM SHOWING SWITCHBOARD AND TWO MAIN GENERATORS

The main supply is 440V, 3-phase, 60Hz, unearthed, to Lloyds standards. The main switchboard is installed in the generator room. Transformed supplies at 230V are used for heating, lighting, and certain low-power and galley equipments. 115V supplies are used for all other small power requirements, and portable apparatus sockets. Preferential tripping is incorporated for certain high-power, low-priority equipments. A shore-supply box is installed capable of receiving a supply from port or starboard.

The MCR is situated at the after end of the engine room at 2 deck level (FIG. 3). Main machinery control is similar to *Jura*. Normal control of machinery is from the bridge by combinator, by which engine revolutions

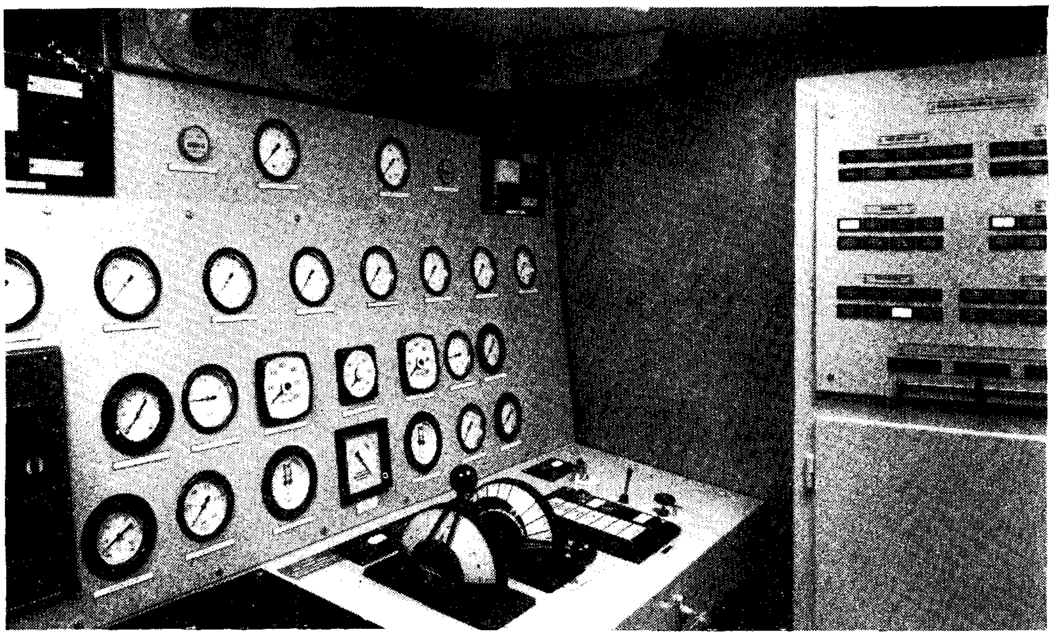

FIG. 6—MACHINERY CONTROL ROOM SHOWING SEPARATE PITCH AND REVOLUTION CONTROL LEVERS

and propeller pitch are changed together, ahead or astern. Separate control of pitch and engine speed is available from the bridge and the MCR. To prevent overloading of the propulsion system, automatic protection devices are built in to:

(*a*) restrict the maximum ahead and astern pitch when operating on one engine;

(*b*) shed pitch from the propeller in the event of a sudden overload.

A control panel and separate automatic alarm panel are situated in the MCR, containing a comprehensive list of machinery gauges and alarms. A window in the MCR allows the watchkeeper a view of the engine room. The MCR provides an area of relative quiet in the noise of the engine room which is shattering at full power.

Safety devices/interlocks are fitted to the propulsion system to:

(*a*) prevent engagement of main-engine clutches when:
 (*i*) the shaft brake is engaged;
 (*ii*) the turning gear is engaged;
 (*iii*) the main engines are not running;

(*b*) declutch the engines automatically in the event of loss of:
 (*i*) gearbox oil pressure;
 (*ii*) main-engine oil pressure;

(*c*) prevent starting of the main engines without lubricating oil to the main gearbox;

(*d*) stop the main engines on:
 (*i*) overspeed;
 (*ii*) loss of main engine lubricating-oil pressure;
 (*iii*) operation of emergency stop pushes (one for each engine in the MCR, and one for both on the bridge).

The engineers' workshop is sited aft of the MCR and is accessible from the shaft tunnel trunking. The following equipment is installed:

(*a*) Pillar drill (1 inch capacity),

(*b*) Bench grinder,

(*c*) Injector test set,

(*d*) Work bench and vice.

A lockable cage for ready-use gear is provided on the starboard side.

The steering gear, refrigeration machinery, and compressed-air systems are basically as *Jura*.

The diesel fuel bunker tanks, sited forward of the generator room, provide sufficient fuel for several thousand miles steaming at economical speed. The daily service tanks are built in to the bunkers, one to serve the main engines and one for the auxiliary engines. Two Weir Imo transfer pumps are fitted, each capable of drawing from fuel bunkers and discharging to service tanks and fuel bunkers; the system can be cross-connected. Two Mono circulating pumps maintain a full header tank in the uptakes for the main engines, the tanks being arranged to provide gravity feed to the main engines, and are of sufficient capacity to provide fuel for at least three hours at full power. Main engine fuel consumption can be accurately measured by permanently-fitted calibrated fuel snap tanks. Fuel for the secondary generator is provided from a 200 l header tank, whereas the main generators take their supply direct from the service tank.

The lubricating-oil systems for the main and auxiliary engines operate on the wet sump principle, the temperatures being controlled by thermostatically-controlled coolers. Each main engine has a motor-driven stand-by pump arranged for automatic starting in order to provide lubrication in the event of the engine-driven pump failing. This provides sufficient time for the appropriate hydraulic coupling to be emptied and thereby to declutch the defective engine. One storage tank with a capacity of 6000 l for all main and auxiliary engines is situated in the casing.

The gearbox has its own self-contained lubricating system, utilizing two motor-driven 'Triro' pumps (one stand-by) drawing through filters from a sump tank of capacity 3400 l, and discharging to the gearbox oil cooler. The stand-by pump cuts in automatically on failure of the running pump. A lubricating-oil storage tank of 3000 l is fitted in the uptakes.

Also in the uptakes are a stern-tube header tank containing 150 litres and a CP propeller header tank of 70 litres. In addition three secondary oil tanks of 180 litres each are sited in the engineers' workshop.

The oily-bilge system is fitted, comprising a 'Comet' oily-bilge pump capable of taking suction from the bilge, main-engine, and gearbox sumps and from the dirty-oil tank, and discharging to a manually-operated Simplex oily-water separator, to a deck connection, or to the dirty-oil tank. Emergency bilge suction is available from the auxiliary circulating-water pump or from the three general service and fire pumps.

Support

The ships are to be administered by Captain, Fishery Protection and will be based at Rosyth as tenders to H.M.S. *Cochrane*.

Upkeep

Upkeep is based on current naval practice (with the exception of certain commercial type equipments). The planned maintenance system is similar to that of coastal minesweepers and minehunters, documentation for bi-monthly and above routines being held ashore. The vessels will operate a cycle of three weeks on patrol followed by a limited support period of five working days or a base maintenance period of ten working days. The refit interval is four years with an intermediate docking after two years. A major refit is scheduled after twelve years.

Documentation

Maintenance schedules have been produced in the 'E2' format for all equipments. A full range of makers' handbooks has been provided and allocated BR numbers. Other drawings, specifications, and test documentation will be to commercial standards. Lists of drawings and technical publications have been supplied by the shipbuilder in D787 format. No master record has been prepared, but a SS and E list (recorded on computer file) has been provided.

Spare Gear

Spare gear, including onboard, base, refit, and depot spares, has been listed by the shipbuilder, and volumes have been issued to ships and other interested authorities; each item is identified by Adrefno and makers' part number. Separate provision has been made for the SPDC to stock base (back-up) and refit spares appropriate to the Class.

Operating Experience to Date (Feb. 1977)

Contractor's sea trial for the first two vessels of the Class were completed in September 1976 and January 1977 respectively. Trials were conducted by the shipbuilder to a modified machinery trials unit (MTU) format, supervised by the MTU and the PNO Clyde. Both sets of trials included some time in severe weather conditions demonstrating that:

FIG. 7—H.M.S. 'JERSEY' ON TRIALS

(*a*) the ships could operate in rough seas;
(*b*) the automatic pitch-shedding devices functioned correctly;
(*c*) the ships are decidedly lively.

All the naval staff requirements for speed were met. Over 16 knots was achieved on trials by *Jersey* and *Orkney*. It is interesting to note that the cruising speed of the ship at one-third power on one engine is over 11 knots, and at full power on one engine is over 14½ knots. Only in conditions of navigational hazard or where the small extra speed given by full power is required, need both engines be run. Likewise, one generator is enough to supply all the ship's normal load.

Manoeuvring in the open sea is adequate both ahead and astern; a recent trial revealed that the vessels will steer astern at up to 11½ knots. Handling in confined waters is constrained by the single-shaft, single-rudder configuration, and requires care.

Improvements in Class Resulting from Experience to Date

Improvements resulting from operating experience have been limited to those which affect personnel and machinery safety.

On the machinery side, this has entailed the fitting of vents, isolating valves, and by-passes to various items of machinery to maintain integrity of certain services. Additionally the CP propeller module proved to be so noisy at sea that working conditions in the workshop were very unpleasant; measures are in hand to clad the module with an insulating cover. Finally, the need became apparent to provide a means of verbal communication between the CP propeller emergency control position in the shaft tunnel and the machinery control room/bridge; the existing telegraph proved unsatisfactory on its own. A telephone and handset are now provided. Retrospective action to incorporate these changes in the two ships already accepted is under consideration.

One hull modification of interest that has been completed in *Orkney* and subsequent vessels is the provision of larger bilge keels to improve rough weather seakeeping. First experience with the ships has shown this change to be very desirable.