THE TYPE 22 FRIGATE

PHILOSOPHY OF THE MARINE ENGINEERING DESIGN

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Introduction

With the shipbuilder (Yarrow Shipbuilders Ltd.) involvement in the detailed installation design started in July 1972, and the eighteen month-long task of preparation of marine engineering contributions to the Building Specification and guidance drawings complete early in 1973, it is of interest to outline the Type 22 design as it currently stands.

The first draft Naval Staff Requirement (NSR) for this *Leander* Class replacement ASW escort vessel was circulated in early 1969, and the ship design passed from the Forward Design Group to the Ship Sections in the Directorate of Warship Design in January 1971.

The Sketch Design received Board approval early in 1972. The first long lead items were ordered in September 1972. The last Defence White Paper anticipated that 1973 would see commitment to build the first of class.

There is no machinery shore prototype trials facility.

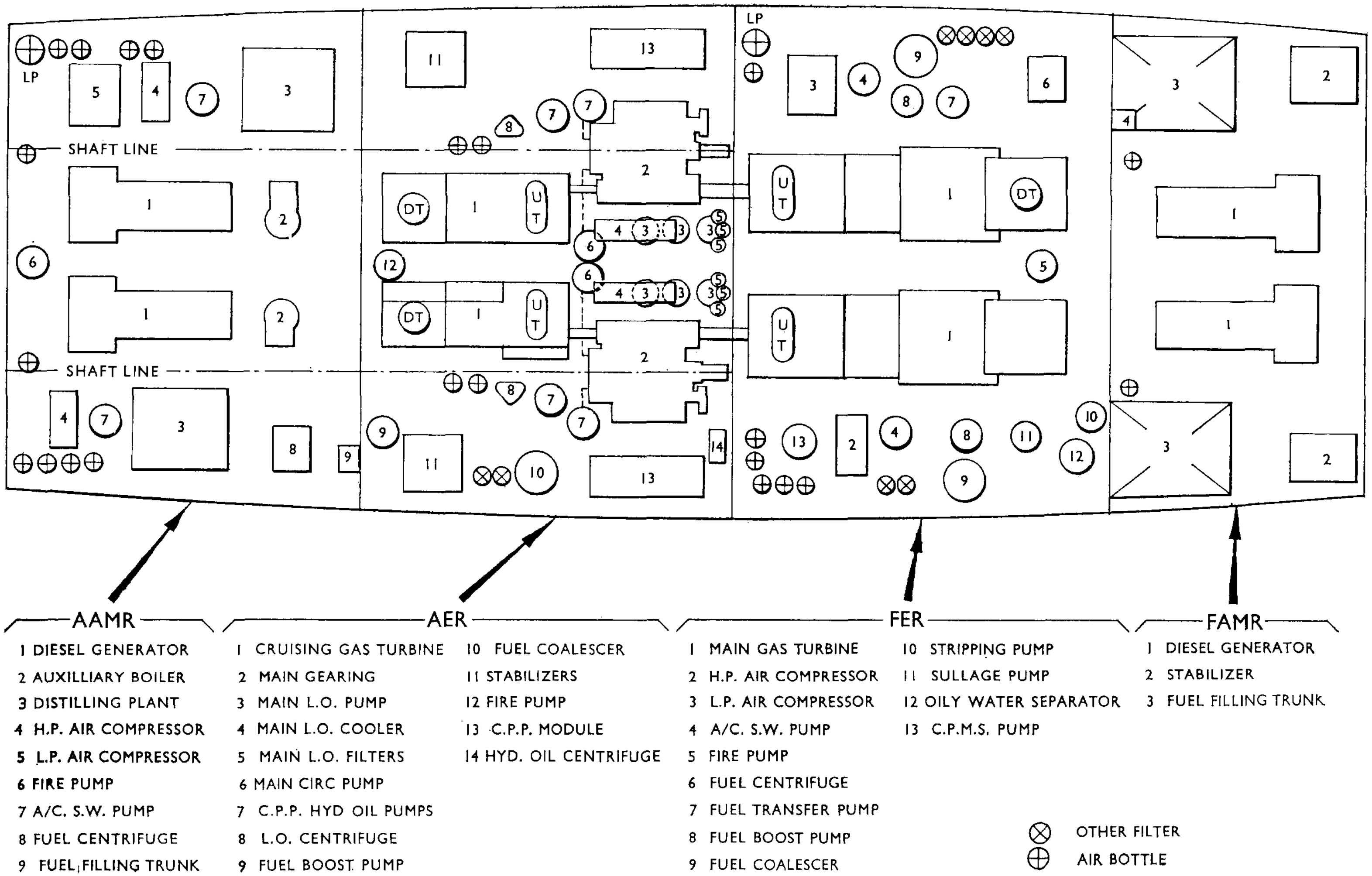
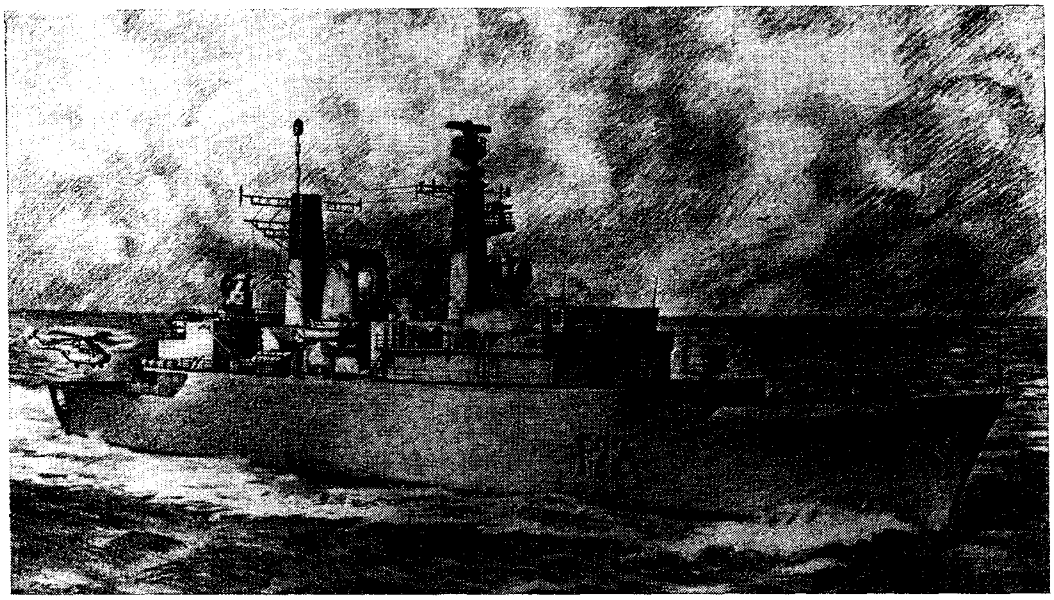


FIG. 1—LAYOUT OF PRINCIPAL MACHINERY



ARTIST'S IMPRESSION OF TYPE 22 FRIGATE

Restraints on Design

No radical changes in performance and operating patterns from recent equivalent-sized warships were called for with the Type 22 frigate. Gas turbine propulsion on two shafts and auxiliary machinery from the SYMES range wherever practicable were requirements. Since most of the Type 42 equipment had been nominated for the SYMES range, it will be little surprise to learn that, as the ship has grown to comparable proportions with the Type 42 destroyer, the machinery installation has evolved to be similar to Type 42 design. See TABLE I. Perhaps the most significant step post-Feasibility Study was from a 3-room to a 4-room configuration for the principal machinery. See FIG. 1. This provided sufficient separation of watertight bulkheads between pairs of generators to obviate fitting a Diesel Generator OMS.

The areas of difference between the Type 42 and the Type 22 NSR.s which most affect marine engineering design are:

(*a*) Reduction of two senior rating and six junior rating in the ME complement (about 20 per cent).

(*b*) Very stringent underwater noise targets.

(*c*) Revised blast criteria.

Thus the Type 22 ME project team (the authors) have sanctioned departures from Type 42 arrangements only where one of the following could be demonstrated:

(*a*) Fullest implementation of upkeep by exchange (U by E) with improvement of machinery removal routes and accessibility.

(*b*) Significant improvement to noise signature.

(*c*) Reduced complexity or greater standardization.

(*d*) Reduced effort required from ship's staff to meet maintenance and watchkeeping tasks.

(*e*) Improved NBCD and fire-fighting capabilities.

Inherent in the above is an attempt at the same time to improve reliability and maintainability.

Mention of restraint would not be complete without referring to cost. Marine Engineering investment in the Type 42 shows a substantial increase in capital outlay over previous DD/FF designs (for example, about a 40 per cent increase in cost/tonne of machinery over Improved *Leander* Class on current quoted prices). Thus to those who are interested only in the purchase price of a ship of the Type 22 Class, change from Type 42 is only welcome if reduction in cost of equipment and installation will result.

Avoidance of change also helps to keep those additional costs associated with the first of class ship relatively low. On through-life costs, commonality of repair and servicing facilities, spares, hand-books, training, etc. for the Type 22 and the Type 42 is obviously advantageous.

Space and Upkeep by Exchange Implications

Finalization of the 1/6 scale model of the Type 42 machinery spaces was in time to influence the Type 22 design.

The need to improve on the Type 42 in avoiding congestion and the expectation of having to fit bulky noise attenuation measures led to the following changes for the Type 22:

(*a*) Reduction of the number of systems in the principal machinery spaces; for example, the removal of air-conditioning plants to separate compartments on No. 2 deck.

(*b*) Additional length over the four principal machinery rooms (the beam is comparable).

(*c*) Simplification and improved layout of systems, e.g. C.P. propeller hydraulics moved outboard.

Provision for ease of removal of equipment swallows up any space advantage which may have been expected of gas turbine machinery. Including intakes and uptakes, the marine engineering installation occupies over one third of the internal volume of the Type 22 design. This compares with little over one fifth for the *Leander* Class, the difference being only in part attributable to a 25 per cent increase in generating capacity/tonne deep displacement, and a 75 per cent increase in air-conditioning capacity/tonne deep displacement.

The shafts, which have been kept parallel, are located as far apart as is consistent with the hull form aft. This arose principally:

(*a*) because the change from two passageways outboard as in the Type 42 to one on the centre-line on No. 2 deck in the Type 22 made it desirable to increase the gap between the Olympus volutes

(*b*) to improve access between the sets of main gearing compared with the Type 42.

Greater separation of Diesel generators has made it possible to remove one without interferring with the integrity of the other.

The removal routes from the Auxiliary Machinery Rooms (AMR) thus became useful open flats in the centre passageway, rather than lost spaces in removal trunks as in the Type 42 (See FIG. 2).

It was recognized that the use of a gas turbine intake as a main removal route for auxiliaries from an engine room (when the gas turbine was not being removed) could not only involve hazard to the propulsion engine but also make excessive work in silencer removal, etc. This led to the definition of normal 'out-of-refit' removal routes for the smaller auxiliaries via machinery space hatches into the centre passageway, from whence the after AMR route above No. 2 deck is used to remove these U by E items from the ship.

Availability during the design and development phase of a 1/10 scale model at Y-ARD and the development of techniques for quickly incorporating changes therein has permitted better appraisals of rearrangements in layout than on any previous design. The aim of making the best use of the space so secured has been pursued *inter alia* by:

(*a*) achieving better identification of maintenance envelopes of equipments;

(*b*) endeavouring to provide overhead handling arrangements for the removal of equipments, the rails and pulley blocks of which, it is hoped, can be permanently installed.

Times in hand for dockyard ministration were required to be shorter for the Type 22 than for the Type 42. This drive towards increased ship availability in order to make the future fleet really cost effective justifies the capital and design investment for the provision of removal routes.

The base-assisted maintenance periods will have to include change of gas turbine change units and of auxiliaries, and the top overhauls of Diesel generators. The replacement of Diesel generators should only have to be undertaken during D.E.D. or refit periods.

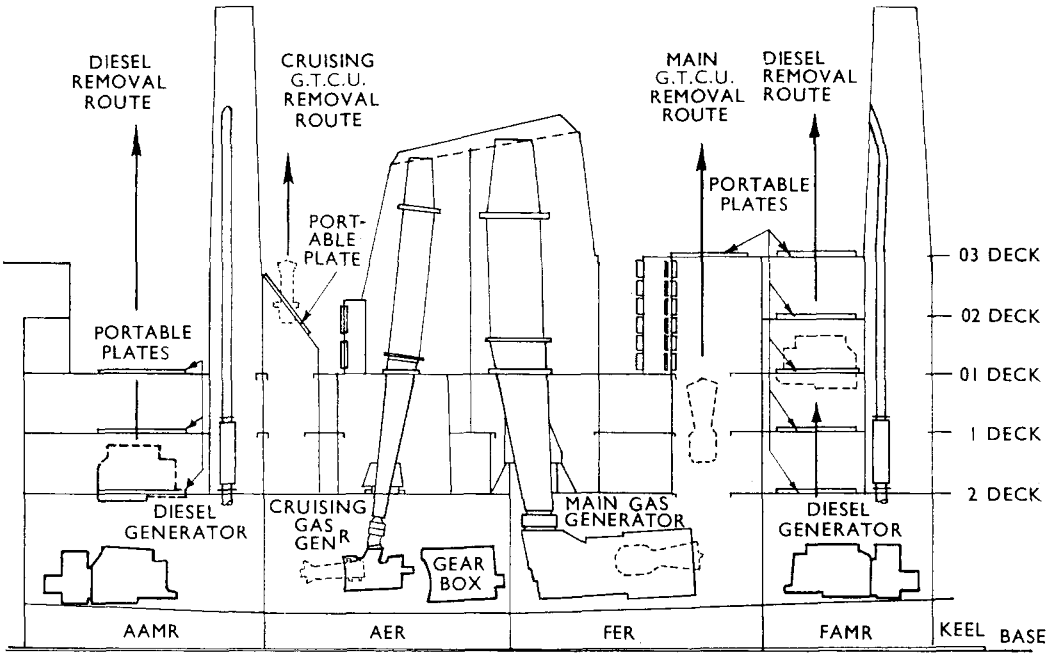


FIG. 2—REMOVAL ROUTES FROM MAIN MACHINERY SPACES

Major Changes from the Type 42 System Design Philosophy

Configuration

The double-bottom fuel and lubricating oil tanks form a flat deck to the principal machinery spaces, the bilge suctions of which are taken from gulleys at the side edges of the outboard tanks (See FIG. 3). The double-bottom tanks under the AMR.s are shallower than in the Type 42, thus contributing to increased deckhead height in these spaces. A return to the use of ventilation trunks instead of having a false deckhead forming a ventilation channel, as in the Type 42, also contributes to the improvement of deckhead height, and at the same time eases maintenance and preservation, simplifies overhead support, and helps removal routes.

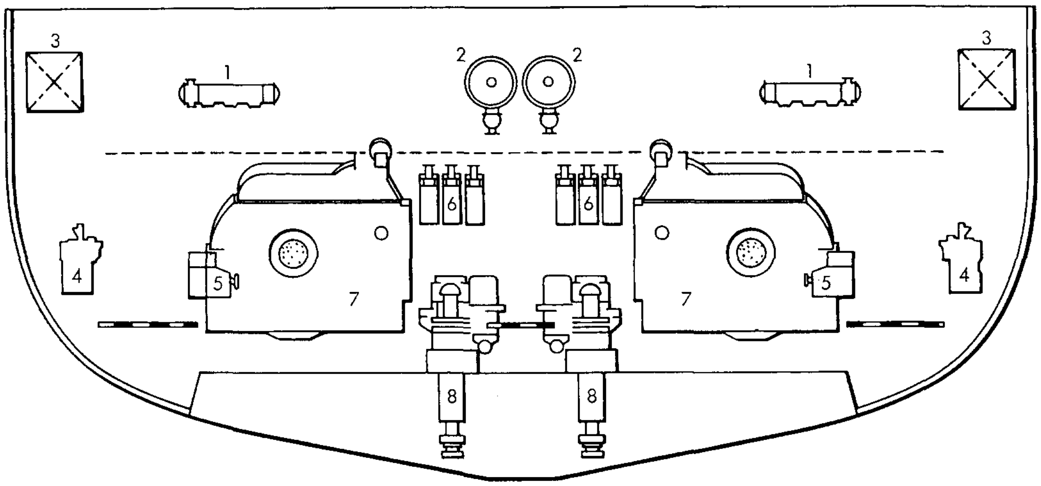


FIG. 3—SECTION THROUGH AER
Key: (1) Special service air cooler.
(2) Main L.O. cooler.
(3) CPP oil header tank (OM33).
(4) Resonance changer pumping unit.
(5) G/D CPP hydraulic oil pump.
(6) L.O. filter.
(7) Main gearcase.
(8) L.O. pumps.

The main engines are further removed from the main gearing to help installation layout in these areas and, at the forward end, to permit an improved design of uptake diffuser to be fitted to the Olympus volute.

Olympus

Comparison of model test results of three options on uptake design with model and full-scale test results for the Type 42 configuration have produced a design which should reduce for the Type 22 frigate the peak gas velocities close to the surface of the silencer splitters.

The problem of high peak to mean flow patterns emerging from the Olympus TM3B volute was referred to in Captain Archer's article on the CAH propulsion system (*Journal of Naval Engineering*, Volume 21, No. 1, page 67).

Full-scale testing of a prototype Type 22 uptake at Messrs Rolls-Royce, Ansty, due to start before the end of 1973, will show whether splitter design has really advanced sufficiently to permit use of gas velocities closer to 300 ft/sec than the 200 ft/sec mentioned by Captain Archer.

During these trials, the Olympus will be run on rubber mounts for the first time. Though not the mounts proposed for the Type 22, they could indicate whether rubber is a viable alternative to the expensive Constant Position Mounting System fitted in Type 42.

Lubricating Oil System

Current shaft-driven pump designs mean that the attainment of the required output down to the lowest speeds involves excessive output at the higher speeds with the attendant risk of oil aeration. The Type 42 solution was to accept the cut-in of a boost supply at lower speeds. It was the questionable reliability of the latter that led to the adoption for the Type 22 of a three pump arrangement per shaft; two motor-driven and one air-driven, the latter capable of sustaining lubricating oil pressure for a minimum of about fifteen minutes.

The failure mode effect analysis study which clinched the above decision included investigation of the integrity of electrical supplies to the motor-driven pumps. The conclusion drawn was that the electrical distribution system proposed for the Type 22 is a marked improvement over the Type 42 system.

It should be noted that the expectations given in Cdr. Chapman's article (*Journal of Naval Engineering*, Volume 18, No. 2, pages 183–4) with regard to the lubricating oil system of the Type 42 were subsequently amended. The minimum shaft r.p.m. necessary in order that, with total failure of electrical power and with no air-driven lubricating oil pump fitted, the ship could be stopped or continue to run proved to be above the 88 r.p.m. mentioned. The plateau for constant r.p.m. for slow-speed running had to be dropped well below the 98 r.p.m. mentioned. Hence the requirement for cut-in of the motor-driven pump as boost supply as mentioned above. The Type 42 now has an air turbine fitted above the electric motor of the back-up pump.

Run-down tests of this Type 42 pump before the end of 1973 will show whether the figures (less than two seconds) being used in the Type 22 design for the time interval from sensing loss of the running motor-driven pump to having the stand-by pump (motor-driven or air-driven) run up will be adequate to maintain minimum pressure at bearings. The most sensitive of these is the oil-directed type of thrust bearing on the Olympus power turbine pedestal.

Trials will take place early in 1974 to ensure that sufficient heat will have been dissipated from a shut down Olympus while the air turbine pump is running, following a loss of electric supply to motor-driven pumps, to prevent subsequent overheating damage to pedestal bearings.

Main Gearing

The elimination of shaft-driven lubricating oil pumps gave options on which of the three auxiliary drives available round the as-Type 42 gearbox would best suit the system layout for the main circulating sea-water and CPP pumps.

An improved design of clutch is fitted in the Olympus and Tyne drives. Hydraulic locking in engagement replaces the bulky sleeve of previous designs —a potential balancing problem in the sensitive high speed line. Lighter Metastream flexible couplings are introduced for the same reason.

Simplified arrangements to permit disconnected running of the gas turbines will make this an easier operation than with the Type 42.

The inclusion of seals should mean that the watertightness requirements will be met and, perhaps more significant, that oil leaking out of the gear box and collecting and overheating in the Metastream coupling covers will be avoided. The latter has been a problem in many ships, not least H.M.S. *Exmouth* (*Journal of Naval Engineering*, Volume 21, No. 1, page 139).

Flexible connections

Reliability studies have high-lighted system sensitivity to catastrophic failure of flexible pipes, particularly bellows, so that their liberal use, as at one time advocated (*Journal of Naval Engineering*, Volume 18, No. 2, page 182) as an aid to rapid repair by replacement in the Type 42, is no longer in vogue. A design of bellows within a bellows to indicate and contain a failure of the inner pressurized bellows is being developed.

Fuel System

The limits of contamination of the fuel specified by D.G. Ships as acceptable at the Tyne/Olympus engines are:

(*a*) Sodium — 0·3 ppm

(*b*) Free water — 10 ppm

(*c*) Filtration standard — 98 per cent efficiency at a mean particle size of 5 microns.

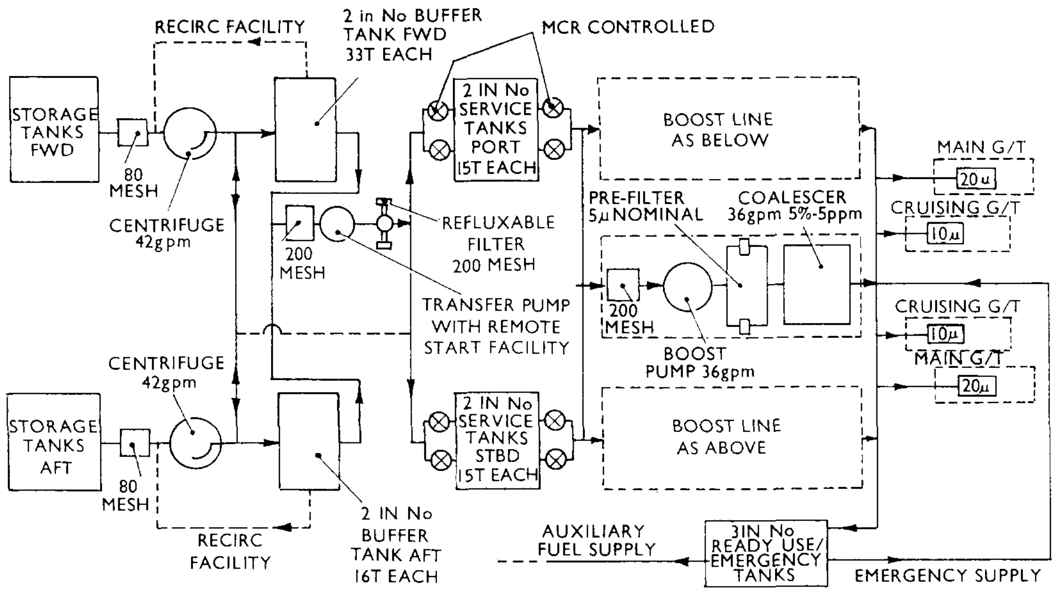


FIG. 4—FUEL SYSTEM

To achieve this high standard of cleanliness, a two-stage clean-up system has been developed (See FIG. 4).

Unlike the Type 42 where, for stability reasons, some water-compensated tanks are used, none are needed in the Type 22 current design. The centrifuges, which can individually keep pace with both Olympus engines at full power, will remove the bulk of the contamination in the first stage process. This should ensure good life of second-stage filters and coalescers (a problem in H.M.S. *Exmouth* which has no centrifuge).

Again unlike the Type 42, it has been possible to conform to the General Marine Engineering Specification on the size of fuel service tanks. These are deep tanks in the forward AMR, independent of shipside structure, and account for an appreciable part of the extra space in the principal machinery rooms mentioned already.

Auxiliary Circulating Water System

As forecast in Cdr. Lockyer's article on the Type 42 (*Journal of Naval Engineering*, Volume 19, No. 3, page 430) the fresh water/salt water auxiliary cooling system of the Type 42 has been rejected in favour of a simple high-pressure salt-water firemain-fed arrangement. It has been possible to effect this change because:

(*a*) there is a closer quality control of selected materials;

(*b*) detailed designs are developed to avoid turbulence

(*c*) rigid checking of assembly techniques is now employed.

In the event, all the complexity of the Type 42 system has failed to avoid having to put salt water into the fresh water system to give adequate cooling under tropical conditions.

Compressed Air Systems

As the demand for L.P. air has increased, so the advantage of having only one type of compressor (H.P., reducing for L.P.) as Type 42 has diminished. Reliability figures from the Fleet have shown that overworking H.P. air compressors results in unacceptably high failure rates which can even hazard ship availability. The Type 22, therefore, has a mix of both L.P. and H.P. compressors.

Sullage System

The sullage system has been designed to pass all tank strippings and bilge suctions through an oily water separator so that ship's staff should be relieved of worry over discharge overboard violating international standards for oil pollution. Fuel and most lubricating-oil centrifuges are new-design self-cleaning types, reducing the tasks of the ships' staff.

Fire-fighting

A machinery space water-spray system has been developed in place of the CO_2 system of the Type 42. The main advantage seen for this system is that fire-fighters can remain in the compartment with the spray on. It also overcomes the problem of CO_2 being a 'one-shot' system which leaves the ship vulnerable to re-ignition fires.

Closed Down Ventilation System

Although a closed down ventilation system is not specified in the NSR, a low-cost system has been devised to allow the machinery to operate (probably indefinitely) in the closed-down state. However, availability of the necessary chilled water is almost certainly dependent on all four air-conditioning plants being serviceable, and thus it has not been possible to eliminate the requirement for a ventilated-suit system.

Machinery Controls

The machinery control system philosophy is as in the Type 42, the hardware being rearranged in a design of Machinery and Electrical Control Console Assembly (MECCA) to suit the configuration of the Type 22 Ship Control Centre (SCC). Servo-manual control of propeller pitch and engine throttles from the SCC is being specified as an override to the normal controls, thus reducing the chances of needing to adopt local control with consequent requirement of additional watchkeepers.

Dynamic data recording is planned; this will provide the post-mortem playback facility to assist fault diagnosis evidenced as being necessary by H.M.S. *Exmouth's* newsletter (*Journal of Naval Engineering*, Volume 20, No. 1, page 84). It is expected that this will comprise magnetic-tape storage of dynamic response of pre-selected performance parameters with playback possible on a multi-channel pen recorder.

Automatic Surveillance and Data Logging

Console design is proceeding on the basis of providing the machinery control watchkeepers based in the SCC with an increased number of indications of departure from normal performance on main, auxiliary, and ship-service machinery by use of the Decca Integrated Ship Instrumentation System (ISIS).

Local scanners multiplex up to 40 channels every 0·6 seconds, passing the data up a single line to the remote control position. In the central processor the value of each parameter is compared with pre-set high and low values. Departure through these levels lights a warning lamp and gives an audible alarm.

The current value of any channel is available on demand from a digital display. Values of all parameters can be printed out on a typewriter at any pre-set frequency. Time and value at departure from, and return to, normal are automatically printed out, giving a further valuable post-mortem record to assist fault diagnosis. The amount of manual data logging required of the watch (1 MEA(P), 1 POMEM, 1 LMEM, and 1 MEM) will thus be greatly reduced, and trials and more frequent recording of the performance of an item of machinery being 'nursed' will be facilitated.

Sufficient directly-wired instrumentation will, however, be retained to permit remote control of machinery in the event of loss of Decca ISIS, albeit only for a short duration until additional watchkeepers can be summoned.

Decca ISIS was evaluated in H.M.S. *Hecate* and H.M.S. *Vulcan* and is being fitted in the latest nuclear submarines; it is increasingly appreciated that some form of automatic surveillance is essential for unmanned machinery spaces with such complexity of machinery. The fitting of Decca ISIS is proposed for the CAH. Its fitting in the Type 22 is regarded as the biggest single step towards making the NSR-imposed marine engineering complement viable.

Early Shipbuilder Involvement

It is hoped that by having the shipbuilder involved at as early a stage as possible in the design, before the order date for the first-of-class ship, that time can be saved in the build phase. The intention with the Type 22 to make the shipbuilder's large-scale model of the machinery spaces earlier than with previous classes has been met, so that detailed production drawings should be available in good time to ensure that the ship is built to that model. Particular attention is being paid to pipework installation and to ensuring that no violation of removal routes occurs during building.

Flexibility to Incorporate Initial Type 21 and Type 42 Sea Experience

In many respects the Type 22 is following too closely behind the Type 21 and the Type 42, in that accusation can be laid that change is all based on conjecture. On the other hand it is unlikely that useful feedback would be available merely from the planned first-of-class evaluation period between acceptance and operational date. There could be a danger of paying too much attention to problems which might only be teething troubles.

The Type 42 design was achieved in a tight timescale. However, with new main propulsion machinery, there may have been little to gain by more thought.

The Type 22 has been able to benefit from:

(*a*) considerable running in H.M.S. *Exmouth*, including the solving of many teething troubles;

(*b*) prototype evaluation of Type 21 and Type 42 machinery;

(*c*) lessons learned in converting Type 21, Type 42, and Type 82 ideas into hardware;

(*d*) evolution of ideas surrounding the new propulsion machinery.

A number of proposed changes are being regarded as 'for-but-not-necessarily-with' alternative outfits, for example, several noise attenuation measures. Experience with Type 21-01 and Type 42-01 can probably be awaited before a decision whether to fit has to be made.

At least the Type 22 can boast of having more space in hand at this stage than is usual; an essential if there is to be any flexibility for the rectification of mistakes. To put this space in perspective before anyone asks—there is no room for a spare gas turbine change unit however desirable this may seem!

Conclusion

The marine engineering of the Type 22 frigate contains little which is novel but plenty which is currently still unproven.

It is confidently expected that, because it is an evolution of previous design with strict restraint on changes, the end product when it goes to sea will be at least as good as the Type 21 and the Type 42 will by then have become.

There can be no substitute for sea experience of Olympus and Tyne, and significant alterations may be shown to be necessary for batch two ships of each class.

TABLE I—*Comparison of Equipments*

Equipment	*Type* 42		*Type* 22		*Maker*
	No. Off	*Location*	*No. Off*	*Location*	
Main Gas Turbine	2	FER	2	FER	Rolls-Royce (SYMES App.)
Cruising Gas Turbine	2	AER	2	AER	Rolls-Royce (SYMES App.)
Main Gearing	2	AER	2	AER	David Brown (SYMES Nom.)
Resonance Changer Unit	2	AER	2	AER	Michell
CPP G/D Hyd. Oil Pump	2	AER	2	AER	Dowty Rotol (SYMES Nom.)
CPP M/D Hyd. Oil Pump	2	AER	2	AER	Dowty Rotol (SYMES Nom.)
CPP Hyd. Oil Transfer Pump	2	AER	2	AER	Plenty
M/D Lub. Oil Pump	2	AER	4	AER	Weir (SYMES Nom.)
G/D Lub. Oil Pump	2	AER	—		
ATD Lub. Oil Pump	—		2	AER	Weir (SYMES Nom.)
Main Lub. Oil Cooler	2	AER	2	AER	Serck (SYMES App.)
Main Lub. Oil Filters	6	AER	6	AER	Vokes (SYMES Nom.)
OEP 69 Main Lub. Oil Centrifuge	2	AER	2	AER	Alfa Laval (MAPX204) (SYMES Nom.)
OM 33 Hyd. Oil Centrifuge	1	AER	1	AER	Alfa Laval (B1419) (SYMES Nom.)
OMD 113 Oil Transfer Pump	1	AER	1	AER	Weir (SYMES Nom.)
Feed Transfer Pump	—	·	1	AAMR	Worthington Simpson (SYMES Nom.)
G/D SW Circ. Pump	2	AER	2	AER	Hamworthy (SYMES Nom.)
Fire Pump	1	FER	1	FER	Hamworthy (SYMES Nom.)
	1	AER	1	AER	
	2	OMS	1	AAMR	
			1	OMS	
Oily Water Separator	—		1	FER	Alexander Esplen 'Comyn' (SYMES Nom.)
Sullage Pump	—		1	FER	Plenty (SYMES Nom.)
H.P. Air Compressor	1	FAMR	1	FER	Reavell (40 c.f.m.) (SYMES Est.)
	1	FER	2	AAMR	
	1	AER			
L.P. Air Compressor			1	FER	Williams & James (150 c.f.m.) (SYMES App.)
			1	AAMR	
Aux. Blr. Air Compressor	2	AAMR	1	AAMR	Hymatic (SYMES Nom.)
Diesel-driven Air Compressor	1	AAMR			
Special Service Air Cooler	2	AER	2	AER	Serck
Auxiliary Boiler	2	AAMR	2	AAMR	Stone Platt (SYMES Nom.)
Fuel/Filter Water Separator	2	FER	2	FER	Broom
	1	AER	1	AER	
Fuel Pre-Filter	4	FER	4	FER	(No decision yet)
	2	AER	2	AER	
Fuel Boost Pump	2	FER	2	FER	Weir (SYMES Nom.)
	1	AER	1	AER	

Equipment	Type 42		Type 22		Maker
	No. Off	Location	No. Off	Location	
Fuel Transfer Pump	1 1	FER AER	1	FER	Weir (SYMES Nom.)
Fuel Centrifuge	2 1	FER AER	1 1	FER AAMR	Alfa Laval (MAPX 210)
Stripping Pump	1	FER	1	FER	Plenty (SYMES Nom.)
Stabilizer	2 2	FER AER	2 2	FAMR AER	Denny-Brown (SYMES Nom.)
Diesel Generator	2 2	FAMR AAMR	2 2	FAMR AAMR	Paxman (SYMES Est.)
Distilling Equipment	2	AAMR	2	AAMR	Caird & Raynor (SYMES Nom.)
Air Conditioning Plant	2 2	FAMR AAMR	4	OMS	H.T.I. (SYMES Nom.)
A/C Plant SW Circ. Pump	2 2	FAMR AAMR	2 2	FER AAMR	Hamworthy (SYMES Nom.)
A/C Plant Chilled Water Pump	2 2	FAMR AAMR	4	OMS	Hamworthy (SYMES Nom.)
FW/SW Circulating Pump	1	FER		—	
CPMS Hyd. Oil Pump	2	FER	1	FER	Serck