

TYPE 23 FRIGATE

THE ENGINEERING DEVELOPMENT

BY

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(*Sea Systems Controllerate*)

Introduction

In the wake of the Falklands conflict the Secretary of State for Defence announced in the House of Commons:

I have recently endorsed the general configuration for the Type 23 Frigate . . . We intend to place an order as soon as possible in 1984 so that we can have the Type 23 in service by 1988 . . . Our aim is eventually to achieve an order rate of three new Type 23s per year—and this is provided for in our forward financial plans.

The Secretary of State continued his statement by describing the Type 23 as a:

general purpose frigate—suited to operations outside the NATO area, but fully able to conduct anti-submarine warfare operations in the harsh and operationally difficult environment of the North Atlantic. The Type 23 will therefore be equipped with the most advanced hull-mounted sonar as well as the latest towed array for detecting submarines. The most important feature of the Type 23 for anti-submarine warfare will be a specially designed platform for a new helicopter—the Sea King replacement. This will be heavier than the existing Sea King, but it will be very much more agile, enabling it to operate safely from small ships in foul weather. It will have a much greater load carrying capability and will carry Sting Ray torpedoes as well as advanced sonics. Other armaments will include two separate trackers for the Sea Wolf point defence missile system incorporating the latest improvements now under development, an anti-ship missile capability, self-defence torpedo capability against submarine attack and a light gun. For quietness to maximize detection ranges on her sonar, her main propulsion will be diesel-electric, supplemented by two of the new Spey marine gas turbines for high speed boost. We are determined to keep the cost of the Type 23 down but it must be designed to meet essential needs in full. The cost will be around £90 million at September 1981 prices, against around £135 million for the Type 22. I believe that in terms of fighting power it will offer excellent value for money. The Type 23 will have a ship's company of about 150 officers and men against up to 250 for the Type 22.

An artist's impression of the ship is shown in FIG. 1.

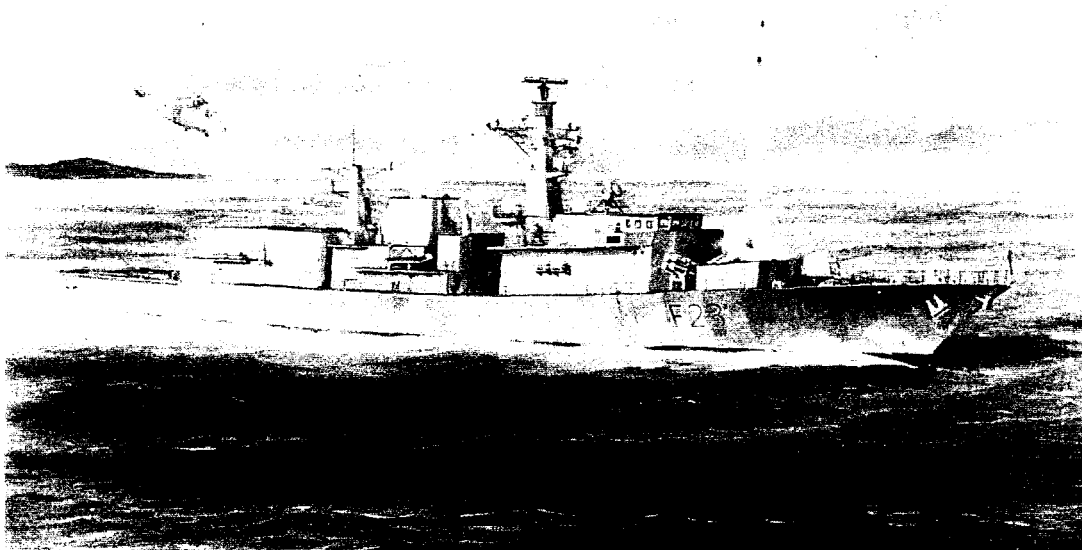


FIG. 1—ARTIST'S IMPRESSION OF TYPE 23 FRIGATE

Naval Staff Requirements

To enable the Secretary of State to make such a comprehensive statement on the design of a new warship a considerable amount of ship design work had to be undertaken against the background of a Naval Staff Target from which has since evolved an approved set of Naval Staff Requirements (NSR) for the Type 23. It is not yet possible to reveal precise details from the NSR, but three particular requirements have had a fundamental effect on the selection of the propulsion machinery. These are:

- (a) Predicted operating profile.
- (b) High endurance.
- (c) Low noise.

Predicted Operating Profile

In order to optimize the performance of the towed array when seeking submarines at long range, the ship must operate at speeds at which hydrodynamic noise and propeller cavitation are minimal. In general, the slower the forward speed the better the array performs. Thus when the Type 23 operates on surveillance duties, a large part of the mission will be spent at relatively low speeds. It is possible to plot the various speeds at which ships operate against the length of time spent at each speed for a given length of mission, and produce usage profiles for various types of mission. In FIG. 2 a typical General Purpose Frigate profile is compared with a possible profile for the towed array surveillance role. It can be seen by examination of the 15-knot line that, whereas the GP Frigate is likely to spend 60% of its time at sea at speeds in excess of 15 knots, the towed array frigate may expect to operate for only half this time at these higher speeds. More significantly, the towed array frigate is thus likely to operate for around 70% of its mission at speeds less than 15 knots.

It is important to note the relatively small propulsive power requirement necessary for a frigate to achieve 15 knots. FIG. 3 illustrates a typical power-speed curve and clearly a mere 3 MW is sufficient to produce a speed of around 15 knots, which in a two-shaft installation equates to only 1.5 MW per shaft.

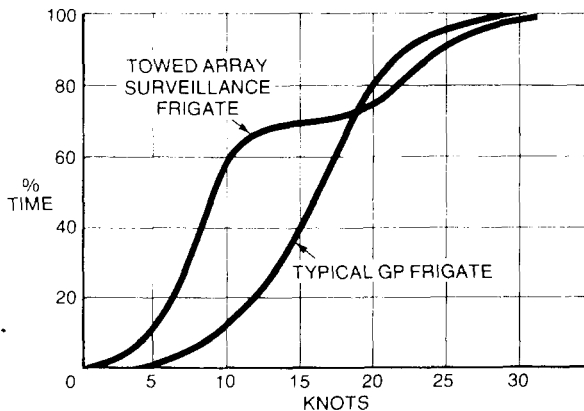


FIG. 2—PREDICTED OPERATING PROFILES FOR FRIGATES

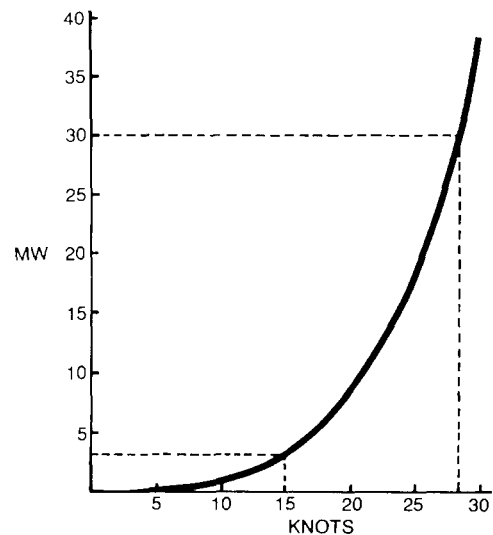


FIG. 3—TYPICAL POWER/SPEED CURVE FOR A FRIGATE

If a conventional Tyne gas turbine 'cruise' fit were fitted in the Type 23, one Tyne engine would provide sufficient power for 70% of a surveillance mission. However, for a large part of this type of mission powers of only 2 MW or less may be necessary; consequently a Tyne fit would almost always be running at less than its optimum efficiency and ship endurance would suffer. In addition, if single-shaft operation is adopted in a twin-shaft installation to improve gas turbine efficiency at low speeds, the noise performance is likely to be poor due to the mismatch between the driven and trailing propellers.

Clearly, if a towed array frigate is to have the capability of transferring quickly to a new area of search and perhaps keeping watch ahead of a fast-moving Task Group or convoy, a relatively high top speed is important. The case for an extremely flexible cruise and boost propulsion machinery fit, capable of prolonged low speeds and high top speeds has never been stronger.

Selection of CODLAG Machinery

There are many varied machinery options a designer can conjure with to give satisfactory cruise/boost performance over the speed ranges postulated. In the event Combined Diesel-Electric and Gas Turbine Machinery (CODLAG) was selected.

The selection of the boost engines was relatively easy. Taking into account the relatively short times to be spent at high speeds, high power/weight prime movers such as gas turbines were the obvious choice for the boost condition. FIG. 3 shows that in order to match current frigate/destroyer top speeds a total power of around 30 MW is adequate. The Spey engine (SM1A), with a rating of 12.75 MW, nearing the completion of its MOD-sponsored development by Rolls-Royce Ltd, was clearly the prime contender and was ultimately selected; although the ageing Olympus was not discarded lightly in view of its lower unit cost.

The requirement for around only 1.5 MW per shaft of propulsive power for slow speed operations allowed many possibilities to be considered for cruise engines. Perhaps the simplest and cheapest of all the options reviewed was the use of direct drive low speed diesel engines. Higher speed diesel engines with geared drives were also strong contenders. However, as soon as the likely noise signatures were assessed—together with the cost, weight, and space of suitable noise reduction measures such as flexible shaft drives—direct drive diesel propulsion became unattractive. Hydraulic drives and even outboard motors were considered, but eventually the ability of diesel-electric propulsion machinery to meet all the staff requirements won the day. Although diesel-electric drives may seem novel to the surface fleet, submarines have used this system successfully for many years, and be it known that the 6000 tons cruiser-minelayer H.M.S. *Adventure* went to sea in 1927 with two 1.6 MW d.c. electric motors for cruise propulsion. (That these motors were subsequently removed on the grounds that they contributed little to overall efficiency, added considerably to weight, and occupied much valuable space, does not require emphasis at this stage of the design of the Type 23!).

Returning to the NSR and the requirement for high endurance, FIG. 4 illustrates the potential of a CODLAG machinery fit. With usable fuel similar to that of a LEANDER Class frigate—that is rather less than is embarked in a Type 22—the potential advantages of diesel-electric propulsion are easily deduced. This is particularly important for a ship that may wish to operate for long periods many miles from the nearest tanker. The three curves drawn

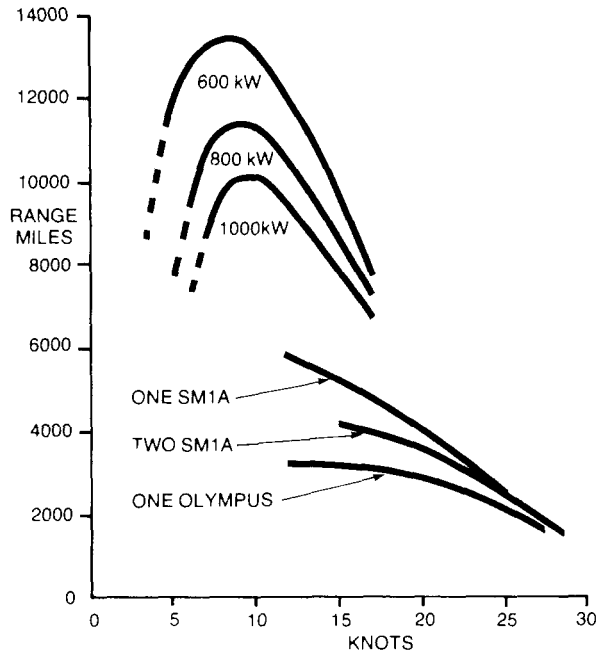


FIG. 4—ENDURANCE FOR VARIOUS AUXILIARY LOADS AND GAS TURBINE FITS IN A TYPICAL 3000 TONNE CODLAG SHIP WITH 400 TONNES OF FUEL

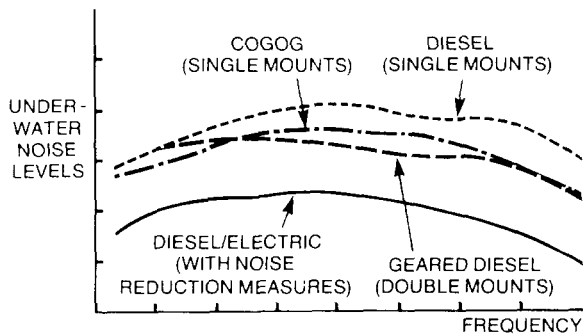


FIG. 5—RADIATED UNDERWATER NOISE LEVELS DUE TO PROPULSION MACHINERY

machinery. As may be expected the singly mounted diesel engines produce the highest radiated noise levels. Typical COGOG ships (e.g. Type 42) and even double-mounted geared diesel engines are better, but the noise generated by the main gearboxes is significant and was considered likely to degrade the performance of towed array sonars. The noise levels possible from a diesel-electric propulsion system, with careful attention paid to noise reduction techniques, clearly give it the best potential of the four installations considered. It should be noted that much of the gain attributable to the diesel-electric fit is due to the elimination of gearbox tonals and presupposes that the electric motor is mounted directly on the propeller shaft with the elements of the gearbox stationary when 'quiet' propulsion is required.

Motor and Gearbox Arrangement

Having established some of the advantages of diesel-electric drives for cruise propulsion and gas turbines for boost, a suitable transmission system

in the range 5–17 knots illustrate the effect of a ship's auxiliary load on range. For speeds in excess of 15 knots the range achievable by one and two SM1A gas turbines is shown. The case against the Olympus is immediately apparent for, in spite of its lower unit cost, the gain of 2000 miles in range at 16 knots is clearly worth having in terms of enhanced operational value and reduced through-life operating costs.

Underwater Noise

As noise reduction measures applied to submarines become more effective, the primary task of the ASW Frigate—to locate submarines—becomes more difficult. The limitations of hull-mounted sonars due to hydrodynamic noise have been well-known for a long time, hence the development of the towed array sonars towed at slow speeds many metres astern in undisturbed waters. In spite of the length of tow, the performance of the array can be severely degraded if the ship's radiated noise level in the astern aspect is allowed to exceed definable limits.

When ships move through the water at speeds below cavitation inception speed, the radiated noise is dominated by that generated by the main and auxiliary machinery. FIG. 5 indicates the relative noise levels produced by warships with four different types of propulsion

had to be derived. The principal requirements of this system centred around the need to be able to operate the electric motor independently from the gearbox and yet utilize the normal well-proven facilities for gas turbine boost.

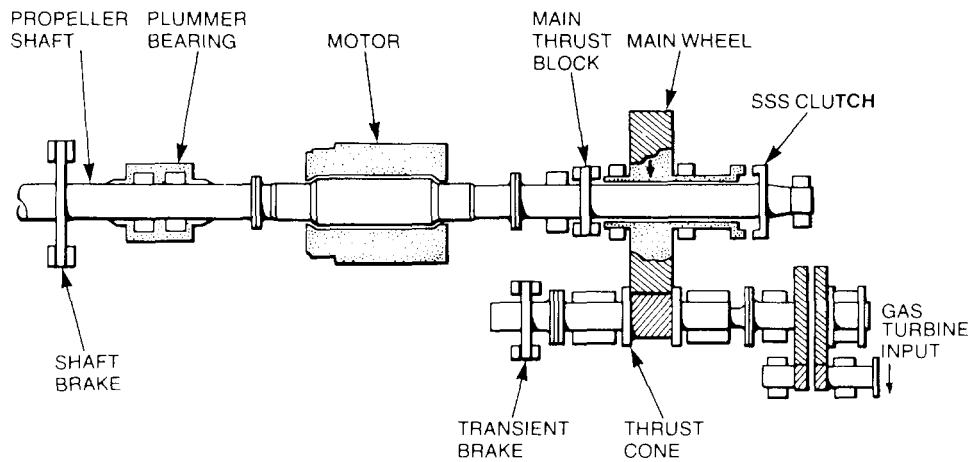


FIG. 6—SCHEMATIC ARRANGEMENT OF MOTOR AND GEARBOX (PORT SHAFT)

A schematic arrangement of the motor and gearbox is shown in FIG. 6. The drive from the gas turbine is transmitted through the primary and secondary gears to a conventional synchronising self-shifting (SSS) clutch mounted forward of the main wheel. The main wheel, with single helical teeth, is located axially by means of thrust cones mounted on the secondary pinion. When the gas turbine is driving, power is transmitted via the SSS clutch, through the centre of the main wheel via a quill shaft, and hence to the main propeller shaft on to which is mounted the main electric motor. When the gas turbine is shut down for quiet operations, the SSS clutch will be disengaged and locked out (as drawn). The motor can then drive the propeller shaft with all the gears in the gearbox stationary. An additional bonus with regard to low noise is the ability to shut down the main forced lubricating oil pumps when in motor drive. The main thrust block, sited within the gearcase to minimize installation volume, is lubricated by a separate small shaft-driven pump when in motor drive. As motor power can be used in conjunction with the gas turbine for maximum ship speed the propulsion system has been dubbed **CODLAG**, rather than **CODLOG**.

It can be seen that the gearbox has no reversing capability. The electric motor is capable of driving the propeller ahead or astern so it has been possible to return to fixed pitch propellers once again. The ability of the Type 23 to crash-stop from full power ahead has been assessed using computer simulations. These simulations have shown that, while the Type 23 will not match the rapid response of the COGOG ships, stopping distances will be similar to those achieved in LEANDER Class frigates.

Electric Power Generation and Distribution

There are many ways in which the propulsion motors and the ship's main electrical supply system could be supplied with power. There are some advantages in generating power for the propulsion motors with dedicated generators and using separate generating sets for the ship's main supply system. This is because the optimum voltage for the motors is higher than the traditional 440 volts used in main supply systems. Higher voltages also

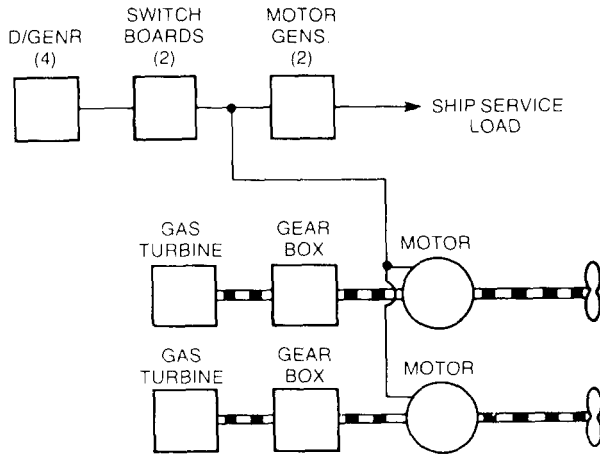


FIG. 7—DIAGRAMMATIC ARRANGEMENT OF CODLAG PROPULSION PLANT

allow breaker size to be reduced. However, as a result of in-depth feasibility studies it was shown that an integrated electrical system offers flexibility of operation and allows the available power to be optimized. The CODLAG system adopted in the Type 23 therefore utilizes an integrated electrical system comprising 4×1.3 MW, 600 volt a.c. generators with two switchboards. The diagrammatic arrangement of this system is shown in FIG. 7.

The generators will normally run in parallel and will be capable of being started remotely and paralleled automatically. Automatic

load-shedding facilities are fitted to safeguard the system in the event of a generator failure. The 600 volt a.c. supplies are fed directly from the switchboard to the thyristor converters (a.c./d.c.) which control power to the direct current motors as indicated in FIG. 8. The 440 volts main supply system is fed by two motor-generator sets (600V/440V). Motor-generator sets were selected in lieu of transformers because the chopping of the power supply waveform by the thyristors may give rise to power supply distortions outside normal DEF-STAN limits and electromagnetic interference. At least two of the four main generators will also be capable of generating at 440 volts—achieved by manually changing the setting of the automatic voltage regulator. This facility has been provided in the design for use in the unlikely event of both motor-generators being unserviceable at the same time.

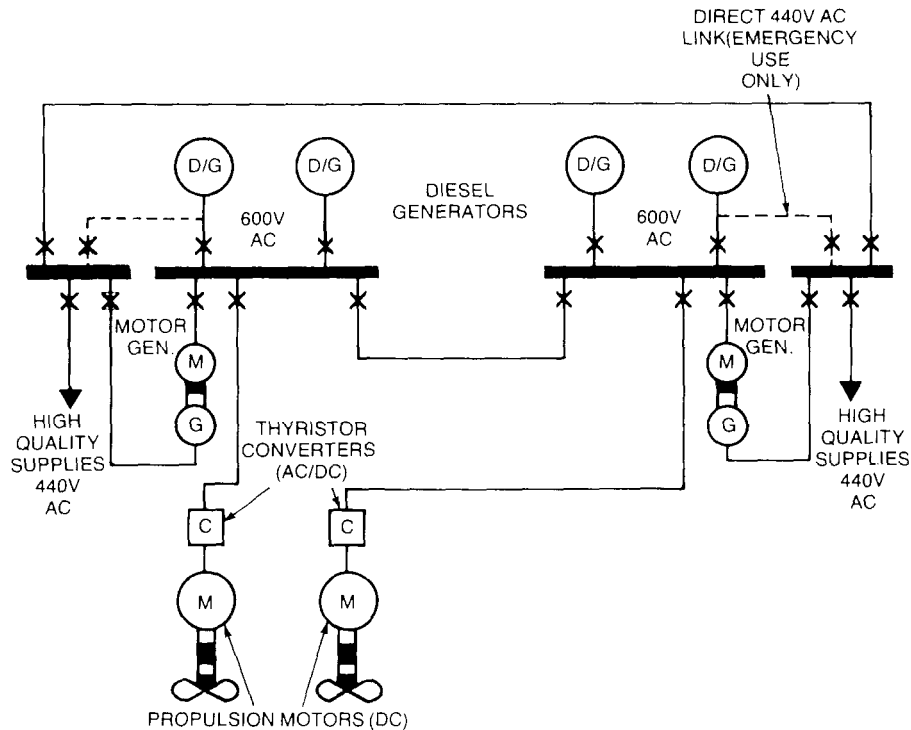


FIG. 8—ELECTRICAL POWER GENERATOR AND DISTRIBUTION

The four prime movers for the generators are 12-cylinder versions of the GEC Diesels Ltd (Paxman) Valenta engine. These engines were selected as being capable of meeting the predicted maximum activity load and the demands of the propulsion motors with a level of redundancy that allows a ship mission to be accomplished should one engine fail. Although these engines have not previously been used by the Royal Navy for power generation, they have a good record of service in an air-cooled version with British Rail in the 125 Passenger Train. They are of the same family as the 16-cylinder version used in the INVINCIBLE Class. The four generating sets are arranged in two pairs, two on the upper deck and two mounted below the water-line. The sets below the water-line are mounted inside hoods to reduce noise levels to an acceptable level.

The ship service loads have been predicted under various operating modes, and the normal hotel load is rather higher than in previous ships of this size. This is mainly because the Type 23 is a 'no steam/all electric' ship. Reverse Osmosis desalination plant is fitted in lieu of conventional evaporators, thereby removing the principal reason for fitting auxiliary boilers in earlier frigate designs. Under normal operating conditions at sea when in motor drive it will be possible to maintain continuous adequate loads on at least two diesel engines. As the ship's speed increases, additional generating sets can be started to meet the demands of the propulsion motors. The advantage of integrating the electrical systems, and thus allowing the loading of the diesel engines to be optimized according to ship's speed, is readily apparent.

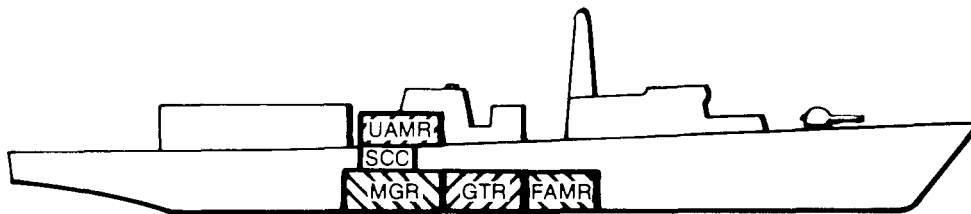


FIG. 9—RELATIVE POSITION OF MACHINERY COMPARTMENTS

SCC	Ship Control Centre
FAMR	Forward Auxiliary Machinery Room
GTR	Gas Turbine Room
MGR	Motor Gear Room
UAMR	Upper Auxiliary Machinery Room

Machinery Layout

The relative positions of the four principal machinery compartments are shown in FIG. 9, together with the location of the Ship Control Centre (SCC). The two auxiliary machinery rooms contain the diesel generators and their associated motor generator sets, the air compressors, and the fuel treatment equipment. The arrangement of machinery in the Gas Turbine Room and the Motor Gear Room is shown in some detail in FIG. 10.

In endeavouring to meet the requirement to keep ship costs to a minimum, the space allocated for maintenance (which directly affects hull size) has been examined critically. Without cost constraints, machinery space volumes and the density of machinery within those volumes would have tended towards Type 22 standards. In the design that has now been evolved the density of the installation, while greater than in a Type 22, is generally less than in Type 21 frigates and almost all installed equipments have adequate maintenance envelopes and removal routes. 'Soft patches' are fitted in the deck immediately above the four diesel engines and these have been sized to allow each engine to be removed or replaced as a complete unit.

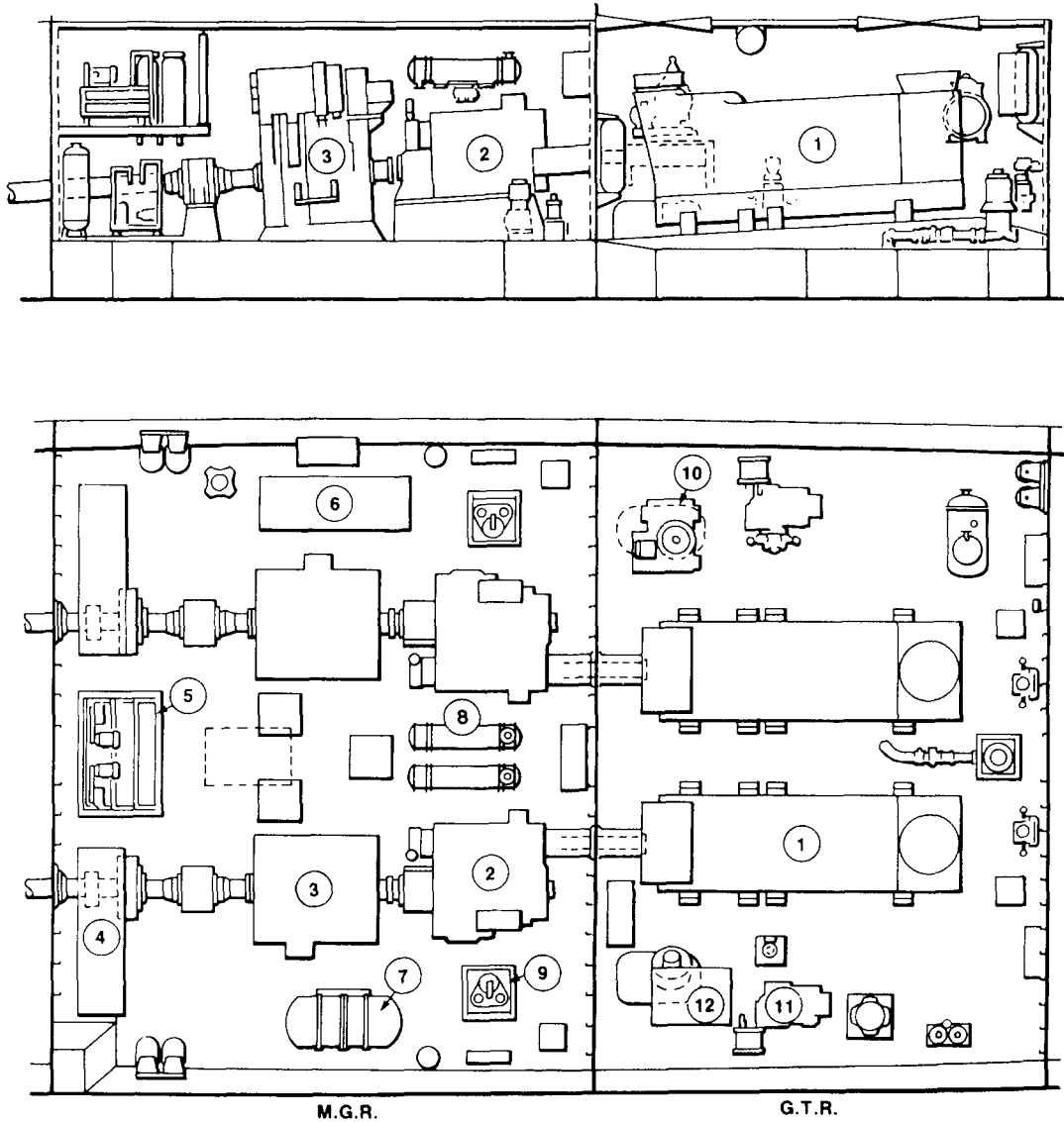


FIG. 10—MACHINERY ARRANGEMENT IN GAS TURBINE ROOM AND MOTOR GEAR ROOM

- Key:
1. SMIA gas turbine
 2. Gearbox
 3. Main propulsion motor
 4. Thyristor converter
 5. Reverse osmosis plant
 6. Chilled water plant
 7. Accumulator
 8. Lub. oil cooler
 9. Lub. oil centrifuge
 10. Stabilizer
 11. Fuel centrifuge
 12. H.P. air compressor

The removal route for the Gas Turbine Change Units (GTCUs) has been placed near the centreline between the two SM1A modules. Unlike previous designs, where the GTCU has been removed through the gas turbine intakes, in the Type 23 it will be removed sideways, then turned vertically through 90° and lifted through the ship on to the superstructure as shown in FIG. 11. The GTCU can then be manoeuvred outboard, picked up by the ship's boat davit, and swung out on to a jetty. It is recognized that normally this evolution will be undertaken using non-uniformed personnel and dockyard cranes but the design aims to bring this operation within the capability of an enhanced ships staff, should dockyard facilities not be available.

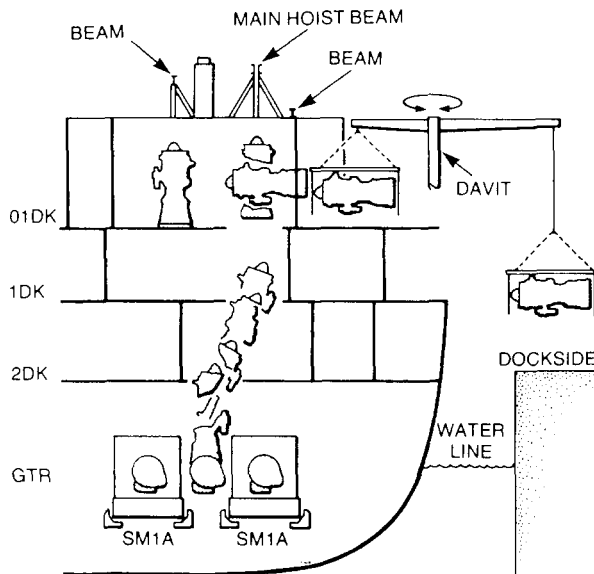


FIG. 11—GTCU REMOVAL ROUTE

Manning and Automation

Men are expensive to accommodate in ships. Hence one of the principal cost-saving measures of the Type 23 has been to design the ship to function satisfactorily in all its roles with around 100 officers and ratings fewer than are borne in the Type 22. The total complement will be about 150 excluding any training margins. One officer and 27 ratings have been allocated to the Marine Engineering Department, and the probable breakdown of engineering expertise to be carried on board during a normal mission (excluding the training margin) is given in TABLE I. When the Type 23 deploys Out-of-Area it is

intended that this complement will be augmented by at least one CPO MEA(M) and one POMEA(M)/(L). These augmentees will probably be drawn from the Type 23 shore support unit.

TABLE I—Marine Engineering Complement

Officers	Senior Rates	Junior Rates		
Marine Engineer Officer	CCMEA	1	LMEM (M)	4
	CPO MEA (M)	3	LMEM (L)	2
	CPO MEA (L)	1	MEM (M)	7
	PO MEA (M)	1	MEM (L)	4
	PO MEA (L)	1		
	PO MEM (M)	2		
	PO MEM (L)	1		

TOTAL: 1 Officer + 27 Ratings

The reductions in manpower, and in particular the requirements for watchkeepers in the SCC, have been reflected in the design of the machinery controls and surveillance systems. With computer technology readily available it is technically possible to design for a 1-man watch. In fact, the design is proceeding on the basis of a 3-man watch for the 'cruise' condition comprising 1 Senior Rate (Marine Engineer Officer of the Watch), 1 Throttle Watchkeeper and 1 Roundsman. The digital machinery controls are therefore being designed to enable a single operator to start and stop all main and auxiliary machinery and bring important services on-line, such as the automatic paralleling of additional generators as ship's speed is increased. There will be no Bridge Control of main engines: engine orders will be passed via 'fast' digital telegraphs.

Good surveillance systems for all the machinery is recognized as essential for satisfactory operation with the small SCC Watch. Television cameras sited in the machinery spaces have been considered but they should be unnecessary if the monitorable parameters for each equipment and the compartments hazard warnings, such as flood and fire, are well integrated. Visual Display Units (VDUs) are provided at the Marine Engineer Officer of the Watch's position so that any designated machine can be scanned for correct operation or standby state, and they can also provide maintenance data read-outs such as hours on load.

Much of the success of the controls and surveillance systems depends on the ergonomic layout of the SCC, which also incorporates the NBCD HQ1. Unlike some earlier designs, the Type 23 SCC is reasonably 'square' and the throttle watchkeepers will face forward. The layout of the SCC is shown in FIG. 12. The division of NBCD parameters from machinery controls and surveillance is by no means rigid, some of the auxiliary systems such as high pressure sea water are indicated by mimic diagrams on the left-hand side of the main panels. This is because this system is primarily a salvage system even though its output may support some machinery cooling.

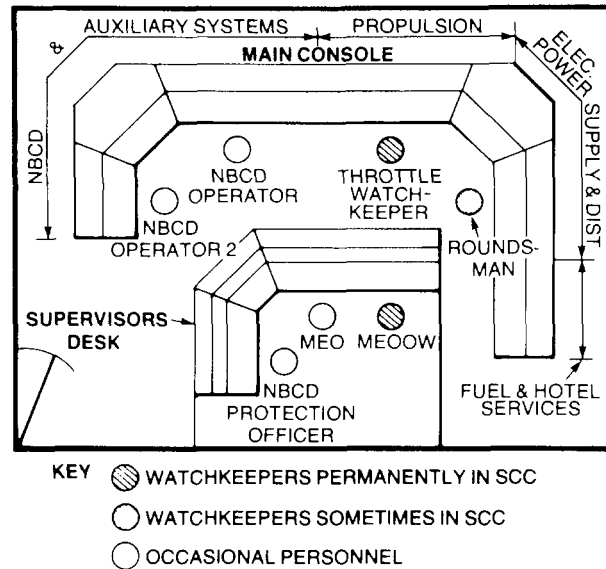


FIG. 12—LAYOUT OF SHIP CONTROL CENTRE

Lessons from Falklands

A great deal of misinformed comment has appeared in the national press in the past year about the vulnerability of R.N. warships. It is generally forgotten that the design for the Type 42 Destroyer was virtually completed in the 1960s and it is incorrectly assumed that somehow twenty years later the same design philosophies are still being applied.

The lower hull profile of the Type 23, designed before the Falklands operations, greatly enhances stability and obviates any need for aluminium structure or water-displaced fuel systems. The threat posed by sea-skimming missiles, well-known in the 1980s but almost non-existent in the 1960s, can and has been catered for in the Type 23. Fuel storage and service tanks are positioned below the water-line to reduce fire risk in the event of action damage. The conventional NBCD citadel is capable of being divided into dedicated zones with near-independent electrical, chilled water, seawater, and ventilation supplies. Some essential services, both electrical and seawater, have been routed at low levels in the ship as well as being run conventionally in a ring-main above the water line. One recent notable addition to the machinery has been a salvage generator, rated at around 250 kW, to be positioned near the quarter deck. This will enable the ship to deal with fires and floods should the centre of the ship become untenable due to smoke. Other additions to the design include more charging positions for breathing apparatus, more remote operating facilities for salvage-related systems, and hatches of increased size to improve accessibility.

Conclusions

In the current financial climate and with the political mood now prevailing, it is apparent that if there is to be a worthwhile surface fleet in the future new warships must be less costly in real terms than their predecessors. The design of the Type 23 has been developed against a background of two potentially conflicting priorities. Strict budgetary control has been applied to all aspects of the design with the aim of eliminating non-essential features from equipments and systems; yet since the Falklands war, certain extras have rightly been deemed essential and have been incorporated. The balance now achieved will enable the Type 23 to herald the introduction into the Fleet of some new technology integrated with generally well-proven equipments, and backed by traditional standards of design. As noted in the introduction to this article, the Secretary of State is on record as saying, 'I believe that in terms of fighting power it will offer excellent value for money.' As an Anti-submarine Frigate the Type 23 will be second to none.