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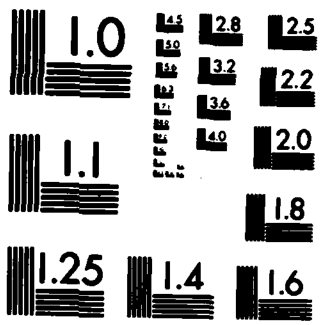
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NAVAL INTELLIGENCE SUPPORT CENTER

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TRANSLATION

TITLE: GAS TURBINES IN NAVAL PROPULSION

TURBINAS DE GAS EN LA PROPULSION NAVAL

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GAS TURBINES IN NAVAL PROPULSION

[Vazquez Torres, F.; Turbinas de gas en la propulsion naval; Revista General de la Marina, January 1983, pp. 71-76; Spanish]

The development of a new marine propulsion system is a process which encompasses a considerable number of years and requires the use of a great deal of equipment, as well as the utilization of different manufacturers who specialize in the various areas which play a role in complex modern installations. /71*

Obviously, there is a considerable investment involved, which requires an exhaustive study of its cost-effectiveness once in place and requires complete planning and coordination of the project's development.

In the case of the Navy, also required is a detailed study of the use of the ship to be built and a projection of the evolution of naval warfare techniques such that the new propulsion system will be able to adapt itself to changes through a continuing research effort.

Clearly, the adoption of a propulsion system in a warship is primarily dependent upon the power required by the ship's previously determined operating requirements.

Once the required maximum propulsive force is determined, a series of technical factors come into play which govern part of the decision of the planners/designers. These, in a broad sense, may be summarized as follows:

1. Specific fuel consumption.

2. Size and weight of the plant.

3. Flexibility of performance under various installation conditions.

4. Projected dependability under maritime conditions.

5. Unit production cost of the machinery.

6. Overhaul costs, down-time, and ease of repair.

7. Development cost.

Other, nontechnical considerations also play a very important role in the final decision. These include the maximum possible support available from the nation's industry, adequate logistic support (including wartime), potential for commercialization of the developments obtained, and normalization of the equipment utilized. /72

*Numbers in right margin indicate pagination in original text.

A medium-sized warship, between 3,000 and 4,000 t, requires over 50,000 hp of power to achieve her maximum speed, which is of the order of 30 kn.

Until very recently, the choice of a propulsion plant in a warship was limited to a system of steam turbines suited for the power requirement noted above. Thinking in terms of the reasonably near future and taking the actual evolution of naval technology into account, the operation, maintenance, and repair of a warship's machinery will be factors of prime importance. Thus, the propulsion plant becomes a fundamental arm of the ship, which makes the choice of propulsion system a much more complex problem than before. Consequently, there are now more factors to be considered before the final choice of the ship's main propulsion system is made.

The availability of highly qualified personnel who are expert in the operation, repair, maintenance, and support of modern propulsion plants is becoming more and more of a problem in all of the world's navies, for obvious reasons, and will be an intangible, yet perhaps the principal, factor to be considered in choosing a propulsion system.

Gas turbines, including the COSAG and COGOG systems, will soon come to be one of the standard propulsion systems, especially considering their inherent characteristics, such as their ease of installation, operation, and maintenance. Another point to consider is the drastic decrease in manpower requirements which will result from the use of these systems, and this, no doubt, will become an essential factor in the future of the maritime world, even in spite of the fact that increased specialization and training would be required for the engineering and shore support personnel.

Recent, gas turbines derived from those used in aviation have replaced steam turbines and diesel engines as primary means of propulsion in fast-moving warships. In the past decade, the naval plan of the British Royal Navy was based exclusively on gas turbines for all the new frigates, destroyers, and cruisers, and 20 other navies of the world already have gas turbines in ships either built or projected.

The adoption of the present COGOG system, which is the system most used in medium-sized warships, is the result of the evolution and experience acquired during the past two decades on gas turbines combined with steam or diesel.

It has always been recognized that operation of a warship at maximum power is required during only a small percentage of the ship's lifetime. Therefore, subdivision of the propulsion plant into: /73

a) a basic power unit with a long service life;

b) a lightweight additional unit with a short service life at maximum power, offered at the beginning, tremendous advantages over conventional systems having only one type of unit. It was believed that the base unit could be designed so that it would cover the ship's cruising requirements as a whole and would thus provide a substantial increase in yield and economy of operation, while the additional unit would produce extra power when needed.

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There exists a vast panorama of theoretical investigations concerned with determination of the ideal division in power between the base unit and the additional unit. However, it is clear that the operating requirements will ultimately determine the minimum power needed from the base unit. If the philosophy of the combined plant is taken to its extreme and a base unit with the least power possible for acceptable operation is chosen, then a diesel engine is the most likely candidate for this unit. However, taking wartime needs into consideration, a steam turbine is preferred as a base unit. The design of a new type of warship with a propulsion plant which does not provide at lease 50 % of the total power using a well-known conventional system was considered an excessive risk. In case of a failure in the new system having an additional gas turbine, a top speed of 85 % of the maximum could still be guaranteed. This premise required, of course, the choice of a steam turbine plant as the base unit, since there was no diesel engine with sufficient power that would also satisfy the weight and space requirements of a modern warship.

Besides the technical considerations, the operation of a warship dictated other characteristics of the system. One of the most important was the need to insure the capability to leave port or an anchorage in just a few minutes after a warning of a possible nuclear attack. This requirement altered the original concept of the base unit and the additional unit and converted it into the dual-propulsion-plant concept, since in such conditions the gas turbine has been shown to respond quickly and to be easy to operate as an alternate propulsion plant.

Consider the important advantage a gas turbine offers in connection with a warship's power needs in its quick-response mode, wherein standard readiness categories of modern warships range from 10 min to immediate.

The ability to provide immediate response from a cold start or to respond to sudden power change demands is an inherent characteristic of aviation-derived marine gas turbines. Under cold-start conditions, the turbine is able to accelerate to maximum power in a few seconds, producing an increase in the exhaust temperature from ambient up to 500° C (quick starts such as this, although an important operational feature, are obviously not recommended for routine operation, due to the thermal stresses produced in the exhaust system).

The success achieved by the COSAG systems in the ASHANTI- and DEVONSHIRE-Class destroyers and frigates persuaded the British Admiralty to continue to study the adaptation of aviation gas turbines to maritime use until a powerful and highly reliable system based /75 exclusively on gas turbines was found (COGOG). This system has been employed on the Type-21 AMAZON-Class ships as well as on modern ships of the Type-42 SHEFFIELD (recently sunk) Class.

The major negative feature of gas turbines is their poor efficiency when operated below their design power. This problem is solved by the utilization of cruising gas turbines.

The rationale behind adapting aviation gas turbines rather than designing them specifically for maritime use is complex and beyond the scope of this article. Suffice it to say that a major factor is the high degree of standardization achieved and utilization of the experience gained. For example, the Type-21 and -42 destroyers of the Royal Navy are equipped with Rolls Royce Tyne RM1A cruising turbines which have logged over 7 million hours in service, and with Olympus TM3Bs, which are also extensively used.

One of the basic principles of design of modern warships is that the key factor to increase operational availability is the reliability of systems and equipment, coupled with the ability to provide for maintenance by replacing inoperative components or those requiring major overhaul (Upkeep by Exchange--"U by E").

The "U by E" maintenance program requires great standardization of systems and major subsystems, in order that the program may be effectively applied to a maximum number of units. A very interesting point in this regard is that the Olympus turbines used by three European navies are maintained in common by the three and are replaced indiscriminately among all the ships involved. This provides an idea of the possibilities available for the logistic support of ships equipped with gas-turbine propulsion systems.

Apart from the inherent features of gas turbines, one can appreciate many other advantages that result from their installation, such as the ease with which they can be automated, controlled remotely, monitored, etc.

Conclusion. Considering their evolution and the experience gained in the warships of over 20 countries which are equipped with propulsion systems based on gas turbines, one can say that their development represents a technological advance in naval propulsion comparable to the exchange of hot-tube boilers and alternate machinery for water-tube boilers and steam turbines.

Considering also that the Spanish Navy will soon obtain surface ships powered by gas turbines, one can project a magnificent future for these units, even before they are built.

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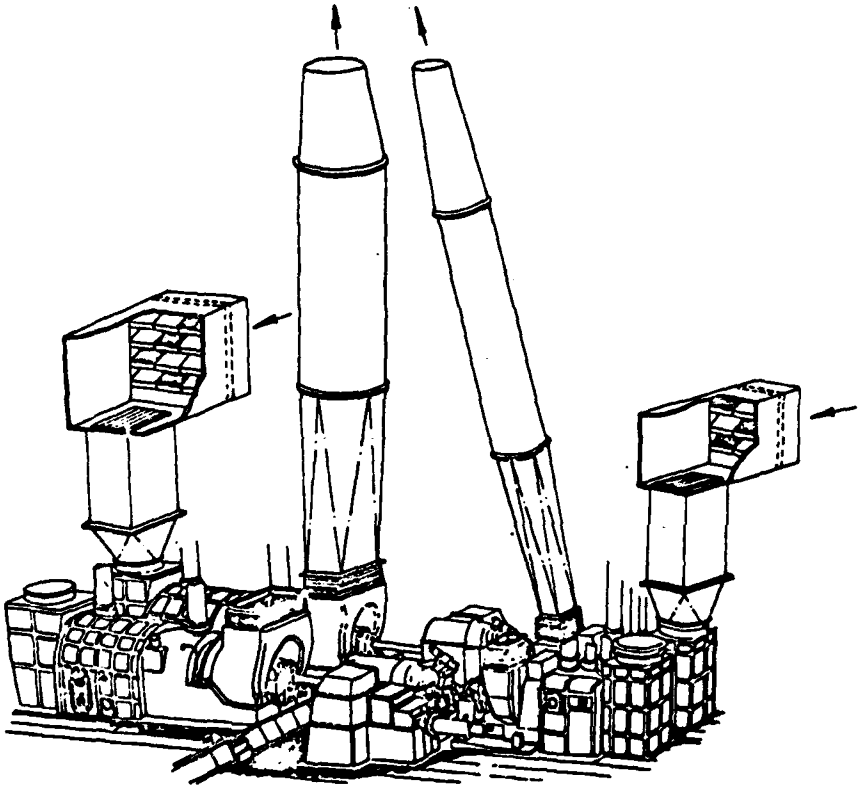
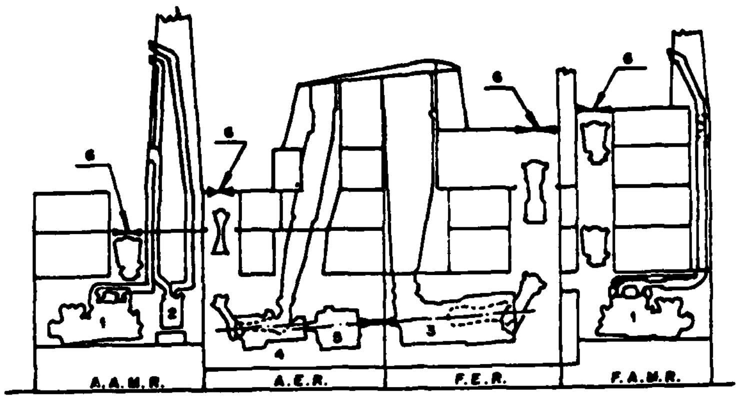


Main propulsion plant, Type-42 destroyer

Propulsion Plant in the Type-42 Destroyer



(1) Diesel generator; (2) Auxiliary boiler;
(3) Main gas turbine; (4) Cruising gas turbine;
(5) Main gearbox; (6) Removable plate.

--Mechanism for Removal and Replacement--

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