ANCILLARY SHIPBOARD SERVICES

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INTRODUCTION

A radical change in the pattern of ship construction and equipment has developed during the last two decades. In the early post-war years the ships which had been built during hostilities, usually steamers of utility design, were in demand. The need of ships built for landing and logistic operations was forgotten, except notably by Col. Bustard in this country, and the ship builder was asked to turn out conventional ships in large numbers.

These were similar to pre-war ships, but the main propulsion Diesel engines had improved in reliability to become a serious challenge to steam, and their ability to consume cheap grades of fuel oil established them as the favoured propulsion for all except the very largest ships.

The pressing demand for output from ship yards, and the abundance of goods waiting to be shipped prevented a clear appreciation of future requirements and various fleets were augmented by ships similar to their precursors, though somewhat bigger and more complex. It was therefore, possible for the tramp owner to charter his ship to a liner company, and later for the cargo liner to be chartered to tramping(1).

The bulk trades however, began to interest themselves in the movement of their raw materials. Atkinson(2) describes an ore carrier built in 1954 with machinery amidships. Later ships favoured the engines aft position and within limits imposed by facilities at loading and discharging points have increased in size.

Increase in size was most spectacular in tankers. Capey(3) has described how a drydock extension at Birkenhead was enlarged during the planning and construction stages, extending inland and into the river, as far as was possible, without catching up with the growth of tanker dimensions.

Drydocks on the Mersey can now take a ship of 120 000 tons. London River has accepted a tanker of 250 000 tons.

The largest tanker at the time of writing is *Universe Ireland* of 310 000 tons which has to unload offshore. Mintech has initiated design studies for tankers of 400 000 and 1 million tons. The Japanese shipbuilders have agreed to a limit of 400 000 tons.

EFFECTS OF SIZE

Size alone has little effect on the ancillary services, except in proportions, but the accommodation space in a big ship is such that living quarters can be provided on ample scale which in turn attracts amenity services. Such services are not exclusive to big ships, due to a high and rising standard of living ashore which is necessarily carried over to life afloat in all but the shortest and most regular passages.

Remote and, to some extent, automatic controls become necessities in the bigger ships, and have been found desirable for boiler steaming. Bigger ships, however, require higher power for propulsion and steam turbines have had a new lease of life in those ranges of output where a single Diesel engine was inadequate. Recent increases in cylinder dimensions and pressures have restored the Diesel to a competitive output (Table I).

TABLE I—LARGEST MARINE DIESELS CONTINUOUS SERVICE RATINGS

Maker	Bore mm	Stroke mm	B.m.e.p. Kg/Cm^2	Rev/min	B.h.p. per cylinder
B. and W.	980	2000	10·45	100	3500
Fiat	1060	1900	8·95	102	3400
Götaverken	960	1900	9·34	105	3000
M.A.N.	1050	1800	10·2	102	3600
Sulzer	1050	1800	9·0	103	3200

Bigger ships require more auxiliary power and while in a steam ship it is convenient to use steam to drive the major auxiliaries, in the motorships electrical power is more convenient. In both classes of ship turbo-generators have been commonly used because, in steam turbine installations they can be integrated into the steam cycle with advantage and because high-power Diesels have considerable waste heat in the exhaust which can be readily extracted in a waste heat boiler.

EFFECT OF INCREASED CARGO SPECIALIZATION

Ships are now built with close regard to the particular requirements of the trade on which they are to be employed and to the terminal facilities available. Where the trade is in a single commodity or a limited range of commodities, the ships are consequently highly specialized and may incorporate elaborate systems peculiar to their trade.

Tankers are an outstanding example incorporating cargo, heating, pumping, and stripping systems of some complexity, tank cleaning and gas freeing systems, and a ballasting system of high capacity.

On the other hand, the ore carrier plying between terminals with full facilities has virtually no cargo systems in the ship, but will have a large capacity ballast system.

The ballasting arrangements are of great importance in ships with a quick turn round in port, since time in preparing for sea after discharge or for loading after a ballast voyage is unremunerative. The systems are relatively simple, but require remote control of valves for efficient and economical operation.

Heavy lift ships require more elaborate ballasting arrangements. A projected 500 ton lift ship will transfer ballast between pairs of port and starboard tanks of 800 tons capacity, using a pump of 800 tons output to keep the list within bounds when moving the lift athwartships.

In container ships, ballasting acquires a new importance in that the heel and trim must be kept within limits to permit the containers to move freely in their guides.

Systems other than ballast may be installed for moving and conditioning the cargo or for its protection.

A simple example is the bulk edible oil pumping and heating

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system for oils which solidify at normal temperatures. This is advantageous in that the cargo oil tanks in general cargo ships are often required for good quality dry cargo and absence of internal coils allows easier maintenance and cleaning.

At the other end of the scale there are carriers of bulk chemicals, liquid phosphorous and liquified petroleum gas. The latter is a well established cargo and while it can be carried under pressure and at atmospheric temperature, the containing vessels are heavy. It is, therefore, more economic to carry large quantities at reduced temperature and at about atmospheric pressure.

Temperature may be maintained by evaporation of the liquid petroleum gas and its subsequent liquefication and return to the tanks. The latter are insulated and enclosed in an atmosphere of inert gas which is available for purging and gas freeing the tanks and for pressurizing them at discharge, where it would be impossible to do so from the vapour return system or by gas generated in the vapourizer.

Some special cargoes require no equipment at all—cars and trailers may be driven on and off the special transporter ships, containers are lifted on and off by shore cranes. At sea however, they may be sensitive to excessive ship movement, and stabilizers may be fitted.

Hydraulically operated, gyro controlled stabilizing fins were brought out in 1920 and were effectively developed during the war. Since then they have become popular in passenger ships and ferry services for which they are admirably suited (Fig 1). The stabilizing effect is proportional to their speed through the water.

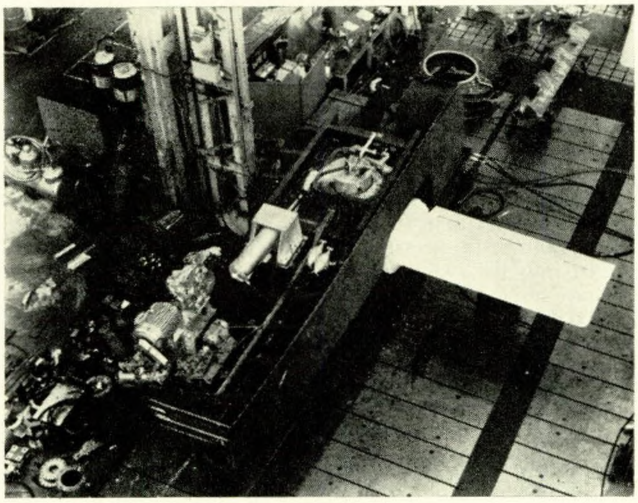

FIG. 1—*Stabilizer fin assembly*

Since the war requirements have arisen for stabilizing weather ships and missile tracking stations and for this purpose, an idea originally put forward in 1885 has been taken up with commercial success.

The roll of a ship may be excited by a relatively small wave motion, since it is the resonance of the wave pattern with the frequency of roll of the ship which causes exaggerated motion. By installing a tank, or a series of interconnected tanks, permitting free liquid flow back and forth athwart the ship with the same frequency as, but out of phase with the period of roll, a strong damping effect is obtained (see Fig. 2). The damping does not depend on the speed of the ship through the water and the system is cheaper and simpler than fins, although the installation may take various forms ranging from a simple tank fitted with swash plates to a system of port and starboard tanks connected through mechanically operated valves to tune the tank frequency.

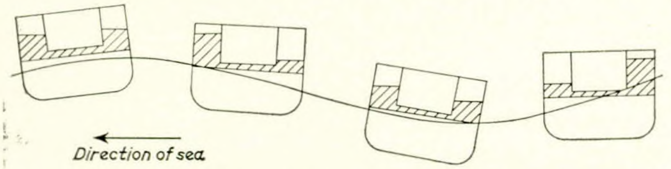

FIG. 2—*Damping effect of passive tank through a wave cycle*

This method is effective only at low values of GM and has the disdavantage of representing deadweight and free surface.

A 'passive tank' stabilizer has proved effective in ensuring that cars stowed on a vessel's transport deck are not subjected to excessive movement.

The care of many conventional cargoes has been improved by forced ventilation often associated with air drying plant or by methods of heating the cargo. Ventilation is not required for all types of cargo, but in most cases, and particularly on passages between extreme temperatures it is necessary to prevent excessive humidity. For this purpose the closed circuit ventilating systems incorporating a chemical drying plant for the air have proved very effective.

An alternative system has been proposed, whereby the atmosphere of the hold is circulated over a low temperature heat exchanger on which moisture condenses. This would be effective in drying the air, but would cool it thus reducing the temperature of the cargo. This could cause cargo sweat at discharge if the atmosphere were humid, and some form of reheating would be needed.

The conventional refrigeration of stores and cargoes has not changed much in recent years. The refrigerated gases have been standardized on Freon 12 and Freon 22 which are adequate for most applications. Elaborate brine systems are still needed for the large freezer ship, but the refrigerated cargo lockers fitted in so many smaller ships are usually cooled by air circulation direct over the evaporator, or by direct expansion into grids. Refrigerating machinery has improved, a screw type compressor has been developed and the technique of deep freezing otherwise perishable goods has led to lower temperatures being available in domestic stores and cargo rooms.

The small number of refrigerated containers carried in earlier years were usually self-contained, or could operate with a supply of electrical power only. A different approach is necessary to deal economically with the large numbers of tightly stowed containers in the latest ships, and systems have been evolved to distribute and return cooled brine or cooled air to the container stacks.

SAFETY

The statutory safety precautions demanded by governments have been the subject of various International Agreements, and common standards apply to a number of nations.

The requirements are directed to strength and stability and to the protection of the ship, by the provision of emergency power and of effective equipment for detecting and extinguishing fires in cargo holds and machinery spaces.

The traditional fire pump and fire main are still the foundation of ships' defence against fire. The latest rules are specific about the capacity of the fire pump and the size, materials and method of construction of the system. An emergency fire pump, outside the machinery spaces, with suitable valve arrangements to prevent loss of water through the machinery space system is required to prevent a fire in the machinery spaces putting the fire main out of action. The material of the fire main and joints must be fireproof.

Foam making branch pipes have a general use as well as particular application to hazardous chemicals. For machinery spaces and accommodation, small diameter hoses, pressurized up to the valve on the stand pipe have the advantage of being easily handled in the event of an emergency.

Fresh water from a tank charged by air pressure and arranged to cut in a sea water pump after a period might be used. This method is used for feeding of the sprinkler systems used in accommodation, where fixed piping systems are fitted with spray apertures sealed with temperature sensitive plugs. In the author's experience of three passenger ship installations, the rapidity with which the spray came into action extinguished the fire before the sea water pump cut in, and a great deal of consequent damage was avoided.

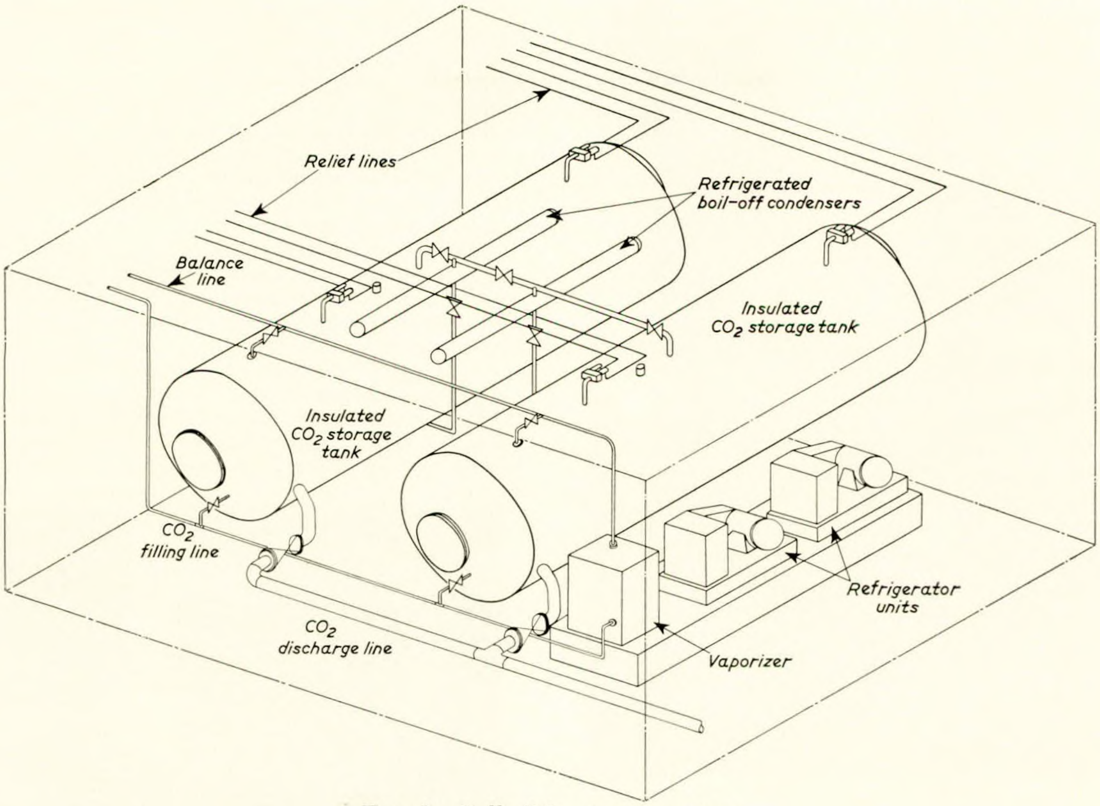

FIG. 3—*Bulk CO_2 storage system*

These installations, however, take up space, and the statutory requirement for inert gas fire smothering in the engine room and cargo spaces, takes up a good deal more, although less perhaps than some of the permitted alternatives. The quantities of CO_2 required for the big cargo spaces can be very large. For example, a hold of 7904 m^3 capacity will require a total of 94 cylinders each holding 45 Kg of gas.

An alternative to storage of CO_2 in cylinders is to hold the gas in two large insulated tanks, served by two small refrigerating plants. One or both of these are used to cool any gas boiling off the liquid, the condensate returning to the tank after losing its latent heat of evaporation. The temperature is maintained at 0°C and the pressure at 21 Kg/cm^2 in home waters (see Fig. 3). With this equipment it is practicable to carry a realistic quantity of carbon dioxide to provide protection for engine rooms and holds.

There have been other alternatives offered from time to time, including the continuous inert gas generator, which has been accepted for holds but not for machinery spaces and the latest high expansion foam which is B.o.T. approved for engine rooms but not for cargo spaces.

Both these have merit. The former has found applications not only in the liquid petroleum gas carriers, already described, but in an enlarged form in conventional oil tankesr, where during discharge a hazard exists from the mixture of air and petroleum. Pressurizing the tanks with inert gas prevents this hazardous condition being occasioned (see Figs. 4 and 5).

The second is fairly new, and has been tested and proved effective in spaces where it can flow freely. The foam is generated by a fan driving air through a mesh wetted with detergent. It operates by impeding free access of air to the seat of the fire, and by the cooling effect of the water entrained in the bubbles. It may be applied to car transporters and ferries, where the provision of CO_2 gas for the vast space of the decks is expensive and takes up space and deadweight. A system of distribution through ventilation ducting seems to be worth developing in the light of recent experimental work which appears to class as fairly limited the hazards associated with fires in parked cars.

Fire detection systems are required by statute in cargo spaces and in unmanned machinery spaces. The conventional smoke detecting system, which can be used for distribution of CO_2 gas to the holds, is generally acceptable but although there is a visual indication of smoke and often a photoelectric monitor as well, the smell of smoke has been, in the author's experience, the most reliable indication of fire in cargo holds.

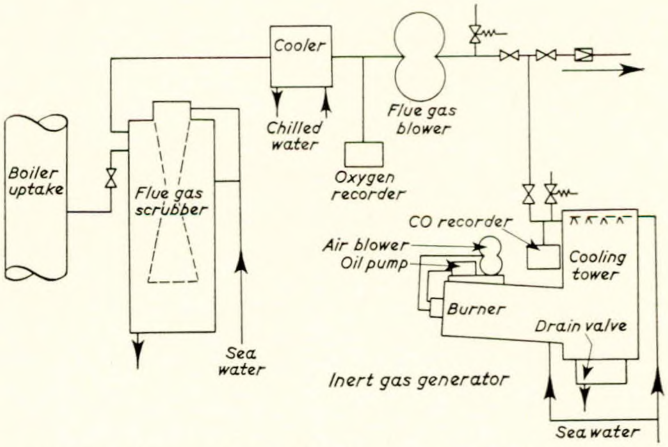

FIG. 4—*Flue gas system for inerting tanks with standby inert gas generator*

However, in the newer and larger ships especially where holds are fitted with closed circuit ventilation, smoke or fire detectors giving local indication of fire are desirable and the modern detector can be relied upon to detect early indication of smoke or fire.

AMENITIES

Of all the changes which have affected existing ancillary systems a rising standard of living ashore has had the greatest effect (see Fig. 6).

The larger ships and smaller crews provide opportunity

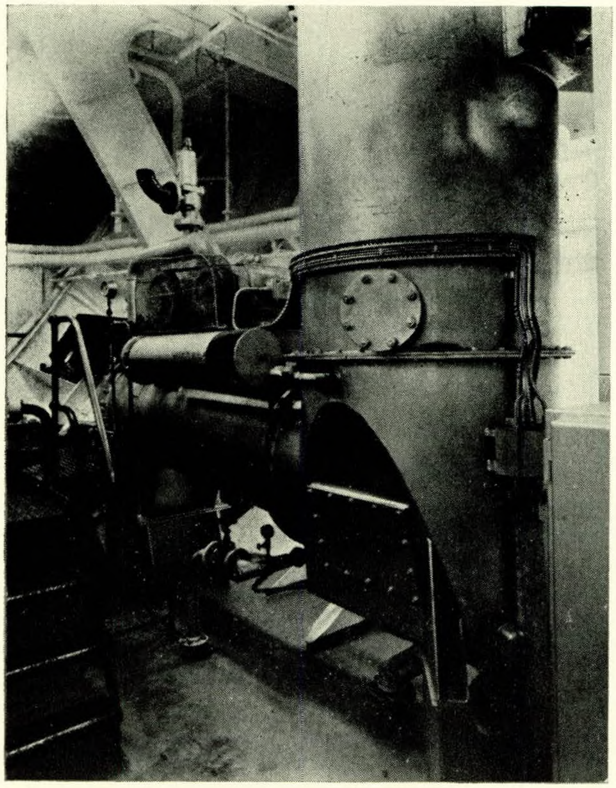

FIG. 5—*Inert gas generator*

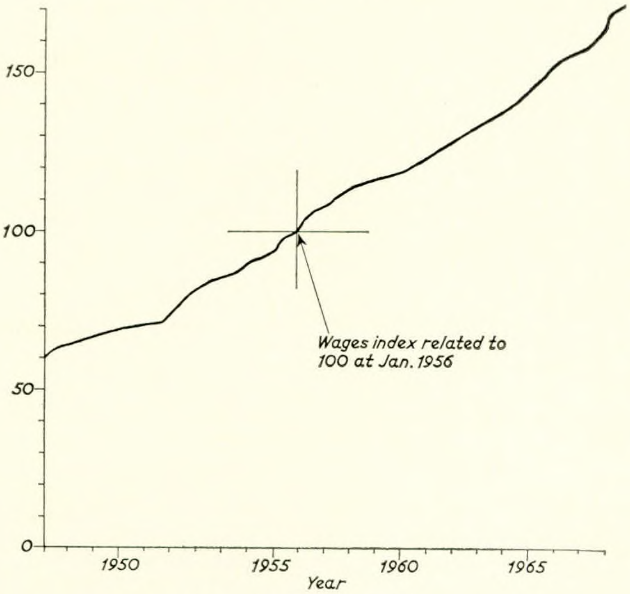

FIG. 6—*Wages index*

for adequate space in living quarters which in turn demand ventilation, with temperature control in ships navigating in extreme climates, good lighting and power for labour saving devices, ample supply of drinking water for domestic purposes as well as plenty of wash basins, showers, bath rooms and water closets conveniently placed.

Ventilation System

The modern ship is almost always fitted with a plenum system of ventilation capable of adjusting the atmosphere to a condition within the comfort zone, e.g. an effective temperature of approximately 23°C. Effective temperature is a useful concept deriving from the dry bulb temperature and the relative humidity, since one feels cooler at a given temperature when the atmosphere is dry than when it is humid. Suitable conditions are generally achieved by delivering heated or cooled air through a single trunking system, but with more elaborate systems twin trunks with hot and cold air are used.

A local mixing unit allows the temperature to be adjusted to suit individual requirements. A similar effect can be obtained from a single trunking system by delivering cooled air to a local unit embodying a heater.

Delivery of pre-conditioned air through a single trunking system is regarded as a standard application. The unit is generally a module, often complete as a unit containing a fan, heater and cooler with thermostatic control from the spaces served. The heater may be electric or steam. The cooler is usually a Freon unit with water cooled condenser (see Fig. 7). Freon 12 is the usual refrigerant because it is common with the ship's refrigerant plant but Freon 22 is used where the embarrassment of having two refrigerant supplies in the ship can be balanced against the greater efficiency of the Freon 22 unit which can be made smaller.

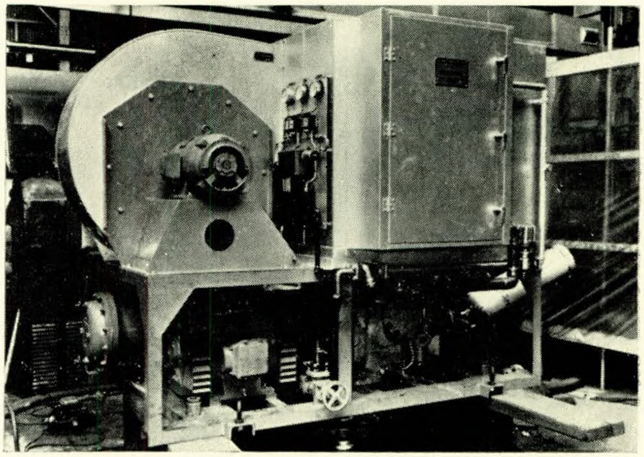

FIG. 7—*Air conditioning module*

The unit requires adequate drainage from the cooler since in humid atmospheres a surprising amount of water is taken out of the air. No satisfactory use has been found for this effluent although many efforts have been made to do so.

Distribution velocities are kept as high as possible and vary from 150 m/s to 300 m/s. The advantages of small diameter trunking, which are possible with high velocities, are balanced by the extra fan power required and the noise in trunking. Adequate sound installation is important, but it can be combined with the necessary thermal installation. Where trunking passes through unconditioned spaces, it is vital to ensure that the thermal insulation is sealed thus avoiding condensation on the outside of the trunking.

Where the ship has a brine refrigeration plant, a very effective arrangement can be made by using hot or cold brine, although this loses the advantage of the module system. It was used for a particular application by the author who engineered the installation of air conditioning in three passenger vessels already equipped with a brine refrigeration system. The ships were in the West African Mail Service where high humidity made conditions uncomfortable. They were originally built with a thermotank system of heating and ventilating and the conversion was made by replacing the original steam heaters by brine heat exchangers. A location for the plant was obtained in a lower hold space between the twin shaft tunnels and brine mains were laid from there to the units.

Vapour sealing of the existing trunking was overcome eventually by sprayed cocooning of the existing thermal insulation.

Domestic Water

Washing and sanitary facilities have lagged somewhat behind air conditioning but modern ships are well equipped.

It has been found possible to generate an adequate supply of fresh water by using waste heat, particularly from the jacket water of Diesel engines, in high vacuum evaporators which are a great improvement on the low vacuum evaporators used by the Navy up to the end of the war. The latter were adopted for passenger ships in the post war period but required skilled attention which cargo ships could not afford and bear no comparison with the automatic and fully reliable water generators available today (see Fig. 8).

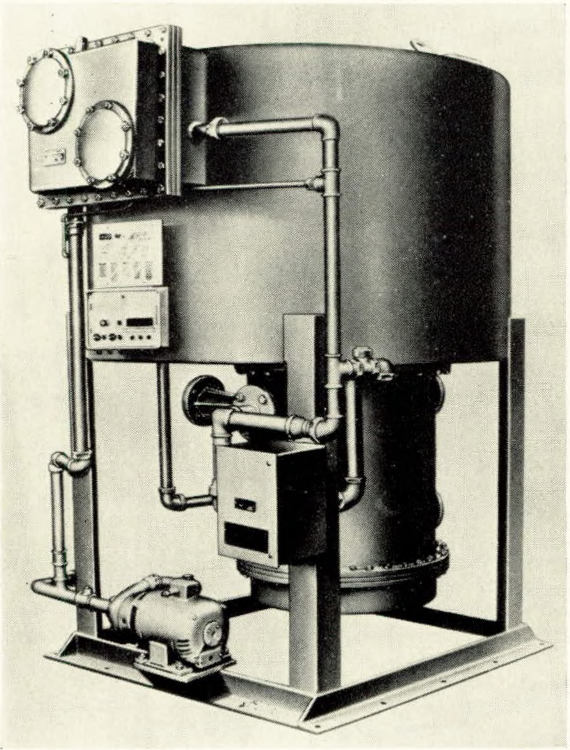

FIG. 8—*Fresh water generator*

Distribution for domestic purposes is by systems pressurized by air cushion tanks, the air pressure cutting in the supply pump as demand causes the pressure to fall. Treatment to make the water more palatable and safe to drink can be incorporated with injection of chlorine, alum and soda before filtration. Where the water is conveyed to storage tanks which may receive shore water, heavy chlorination is desirable. The water drawn from the tanks is passed through an activated carbon dechlorinator, after filtration.

The water is generally available to cabins throughout the ship and is intended primarily for washing purposes. There is still a statutory requirement for a separate drinking water tank to serve the galley and crew spaces. Chilled water has been supplied by way of a coil in the domestic cold room, but chilled water units with self-contained refrigeration are to be preferred.

Sewage Disposal

The availability of water on the present scale has raised problems of disposal of sewage. The original advantage of a sewage system was that the number of under water openings could be reduced to a minimum and for the ship trading generally, this remains the sole advantage. The incorporation of a solids collecting tank, however, enables the solid sewage to be retained on board in those ports where discharge of anything but liquid sewage is prohibited. Such ports and waterways are becoming increasingly common and where strict limits on the collecting of sewage discharge are insisted upon, considerable inconvenience can result unless the sewage system is adequate. In anticipation of the enforcement of strict limits over long distances, notably the St. Lawrence Seaway, elaborate bacterial and chemical sewage treatment plants have been developed. The bacteriological system illustrated gives an idea of the complication involved, although it is hoped that the system once set under way and appropriately treated will be largely automatic (see Figs. 9 and 10).

Chemical treatment has been more ambitious and rests on the principal of using fresh water flushing and by sedimentation and chemical treatment regenerating a supply of flushing water of acceptable purity. This has proved difficult.

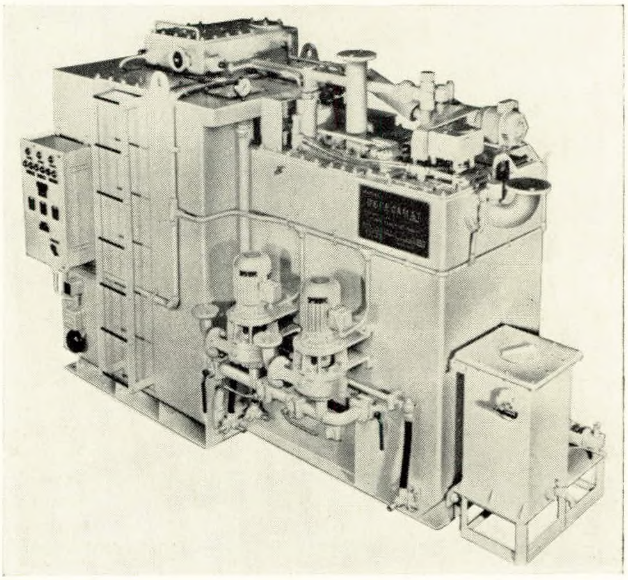

FIG. 9—*Sewage treatment module*

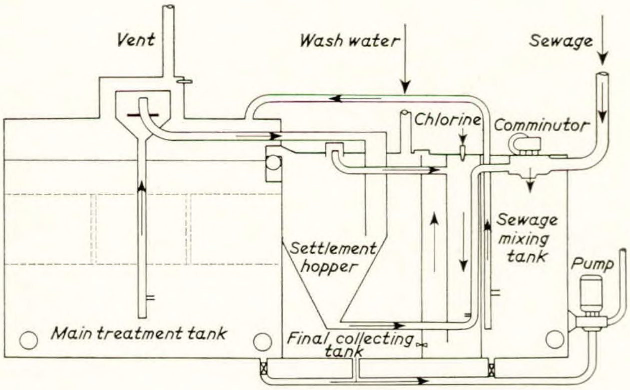

FIG. 10—*Diagram of marine sewage treatment unit*

AUTOMATION AND REMOTE CONTROL

The centralization of controls or their transfer to automatic means demand sources of power, for maintaining operating conditions and for activating valves and controls. Where power is electrical it does no more than add to the load on the electrical generating capacity of the ship, except in so far as the present state of electrical control development makes use of instruments susceptible to heat.

Where this occurs, it is effective to locate such instruments in an area which can be temperature controlled from the ships' air-conditioning system in a central control room, or in a console in the machinery space with air conditioning unit incorporated (see Fig. 11).

Control systems demand a source of power of which hydraulic and pneumatic are most effective.

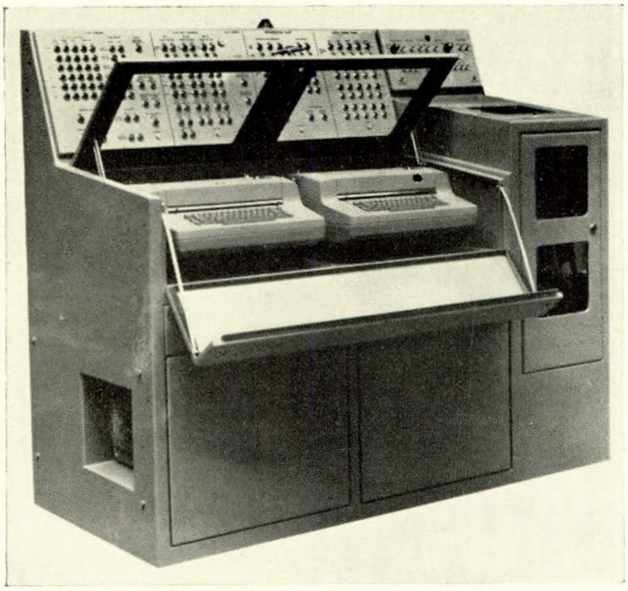

FIG. 11—*Data logger console with cooling plant incorporated*

Hydraulic systems can be combined with electrical control or may be in the form of simple servo mechanism. Generally they have the advantage of being sealed. Pneumatic systems, on the other hand, have the advantage that they can be used for sensing, particularly in tank sounding, as well as in the operation of valves.

The operation of valves has been made easier by radical improvement in design. Types of conventional valves can be operated by simple air motors, but butterfly valves are available and may be operated by an actuating cylinder. Improved methods of sealing make these valves completely effective.

For the source of power, the ship's air compressors can be used, though it is an advantage to have extra compressors operating at the pressure more appropriate to the function required. Filters and driers are vital components preventing interference with or damage to the operating parts.

THE VALUE OF ANCILLARY SERVICES

It is rewarding to examine critically all shipboard services before accepting them. In the context of the high cost of ship construction and maintenance it is necessary to weigh carefully the value of any component unit and system and to assess its reliability. Methods of doing this have been developed in management science which can be used profitably if discretion is exercised.

Work study is the systematic observation of the performance of tasks and the critical assessment of their contribution to the carriage of cargo in the ship. Falconer(4) has indicated how the technique can expose areas of wasted or misapplied expertise and how the information gathered may be applied to establishing a more effective work schedule employing a smaller complement of trained men on the work which is essential, while eliminating tasks which have no actual contribution to the effective running of a ship.

Some further work not yet published illustrates the method for assessment of areas where the frequency of essential tasks is undesirably high, and improvements to the stability and reliability of equipment are needed.

Where functions are found indispensible the system required to perform the function can be examined to establish the value of components in regard to the function.

The techniques for this, Value Engineering or Value Analysis, are relatively new and grew into a formal science in the U.S. Defence Programme. It was described by Matossian(5) and is defined as "an organized effort directed at analysing the function of hardware with the purpose of achieving the required function at the barest overall costs" (6).

A distinction is made between the value and the price of an item thus defining four basic types of value:

1) use value, based on the properties and qualities of a product and material fulfilling a specific use, work, and service.
2) cost value, based on the cost of a product in terms of money.
3) esteem value, based on the properties, features or attractiveness involved in pride of ownership of the product.
4) exchange value, based on the properties or qualities which make the product exchangeable for something else.

Only the first two would appear to be significant, although the third cannot be ignored and it is fortunate that they can be stated in precise objective terms for they must be related to a function also precisely defined in objective terms.

A great deal of care is required to define the term function. As an example a waste heat boiler in a motorship of medium power provides steam from the exhaust gases at sea and from oil firing in port. To do this, it requires a feed system, feed tanks built into the ship, feed treatment, blow down system, safety valves and waste steam pipes, oil burner installation and supply.

Its function in most cases is to provide heat for accommodation and ventilation, for the galley steamers, and possibly for heating cargo or fuel oils, all of which might be better provided by electrical means at the small cost of increasing the generator output, and having the great advantage of dispensing with the hazard of an oil fired boiler, making boiler watch keeping duties unnecessary, and saving money on the installation and maintenance of the boiler equipment and systems.

A feature of Value Engineering is a diligent and systematic search for alternative methods and materials to perform a function more efficiently, for often the designer of a system relies on the suppliers of equipment to bring forward alternatives.

For instance, the great work of Lamb established that fuel costing little more than bunker fuel could be used for marine Diesels by suitable heating and two-stage centrifuging. One stage of the centrifuge acted as a purifier, discharging water and unwanted solids while the second stage was arranged as a clarifier, to discharge only clean oil, leaving the last residues to be cleaned out of the purifier manually.

This system has been improved by using self-cleaning separators which, usually hydraulically, empty their bowl of sludge and maintain in a single stage the necessary efficiency to eliminate the need for clarification.

An alternative has been found in filtration of the oil at a suitable temperature and a number of plants are in use. They have the advantage of doing away with the rapidly moving parts of a centrifuge although they are not completely static, and the controls for heating, pumping and fuel changeover appear formidable. The degree of filtration must be very fine.

A relatively new treatment process might be taken as a alternative for value engineering purposes. This is homogenizing, after heating and removal of metallic and large particles by filtration. The object of the process is to break up the fuel into such small particles that the liquid becomes homogeneous so that the less combustible matter is burnt with the rest.

The process consists of directing a jet of fuel at high pressure onto a target plate, and there seems no reason why it cannot be applied (with duplicate equipment in case of any failure) to the direct supply of fuel to the ring main of the main engine.

This would eliminate the "Clean" daily service tank and the sludge tank, reducing the initial cost of the ship's installation, its maintenance, and the staff required to operate it.

As an indication of the direction a value engineering application could take, the author would refer to an installation used for application where sludge disposal was very difficult.

The elimination of part of the fuel system in this application is a very desirable end to the process. The demand for more services in ships and the sophistication of control mechanisms and systems causes so much equipment to be crammed into ships that maintenance has become a problem, and if systems can be eliminated they should be eliminated on that score alone.

THE RELIABILITY OF SERVICES

It does not seem possible to greatly reduce the maintenance burden on the ship's staff, but a great deal can, in part, be done by the systematic examination of the reliability of machines and systems, and the establishment of maintenance routines which ensure that work of refurbishing machinery is done to a plan, at times which are convenient and at such a frequency that, on the one hand unscheduled, i.e. breakdown, repairs are seldom if ever occasioned, and on the other that the plant is not opened up unnecessarily.

Systematic examination of the deterioration of performance is a field of Reliability Engineering, also borrowed from the Defence Programme, and while it appears as a very familiar outline to many experienced engineers, it is necessary to be more accurate in assessing procedures for investigation and correction of breakdowns.

A number of machines and systems has been developed over years to a high degree of reliability, and the optimum frequency of inspection has been established, often at lengthening intervals following developments in, for example, cylinder lubrication of Diesel engines, or of water washing techniques in main boilers. It is true to say that machinery in the modern ship requires less frequent attention, but closer adherence to overhaul schedules and procedures.

At one stage it seemed as if the machinery would outlast the systems themselves, particularly sea water piping system which, when made of galvanised mild steel, gave shorter and shorter life. This was due to higher speeds, and to galvanic action, and it is now common practice to make sea water piping of non-ferrous material to ensure that inconvenient renewals are not required during the life of the ship. The choice of material, the design and manufacturing methods have caused difficulty, but it is clear from recent experience described by Falconer(7) *et al*, that these difficulties can be overcome by a rigid application of good design and close specification throughout.

A British Standard embracing all aspects of design, specification, installation and testing is in preparation and B.S.R.A. are producing Standards for valves to match.

A further activity of B.S.R.A. is the publication of designs for modules, whereby in designing an installation the parts can be ordered up in a form which reduces the detail siting of units and gives the manufacturer an opportunity for standardizing his product.

FUTURE PROSPECTS

It is clear from the present state of the shipping industry, and its history, that ships as we know them are only likely to survive as part of an integrated transport system, and under conditions where they can be used to their fullest economic capacity.

They must be constructed to maintain such schedules as will satisfy the availability of cargoes and the requirements for delivery, and must have such gear as is needed to handle the cargo. At the same time, port facilities should be engineered to make cargoes readily available and to permit rapid discharge and quick turnround.

The ship should not have to carry additional weight, machinery, or be more complex than is necessary, nor should it be constructed to such standards as would outlast its useful life. In the provision of ancillary services, those for cargo handling will probably receive most careful attention, partly on account of their general novelty these days, but the ships' services require to be closely tailored to the ships' requirements to obtain a reliable and economic installation.

In pumping services this is greatly facilitated by the use of non-ferrous materials for piping which retain smooth surfaces and permit accurate calculation of pressure drop, and the choice of pump size to give the most efficient operation. Modern a.c. power supplies demand constant speed motors matched to their load requirements. Oversized motors operate at low power factors, and oversized pumps cause unacceptably high water velocities which demand output regulation by throttling, and cause undesirable turbulence.

This is important, because whereas the manual control of d.c. driven motors and operation of valves achieved with acceptable accuracy the flows required in the systems, the present day automatic controls are generally expected to work to closer limits, without the benefit of motor speed control. The required stability is difficult if not impossible to achieve if the working conditions are obtained by drastic throttling.

Successful design of a ship, therefore, must be founded on clear 'staff requirements' formulated in the light of the expected transport pattern. It seemed at one time impossible to contemplate an economic successor to the 'Liberty' Ships, which like other general cargo ships were coming to the end of their useful life. It is interesting to review the different solutions to this particular problem

As it appears likely that the function of new ships must be closely defined to permit them to operate profitably, their size, shape and method of propulsion may be radically affected in the future.

Heretofore the approach of Naval Architects has been understandably conservative, and in this country, according to Bishop(8) stultified to a degree by the lack of educational and professional opportunity at both graduate and post graduate level.

The effect of university participation on a grand scale in ship design and construction has been seen in the progress made by the Japanese, and while it has had most effect in their country in the development of large tankers, the general application of similar effort will radically change the style of other classes of specialized ship.

The impact of such change on ancillary shipboard services is hard to assess, but, for example, the requirement for low headroom in car ferries gives the medium speed engine an advantage. Such engines often incorporate pumps and heat exchangers, which simplify the ancillary engine room services.

The impact of Defence Programme thinking on general design principles has already been mentioned, and some significance attaches to the decision of the Royal Navy to use exclusively gas turbines for main propulsion and main power generation, also to the entry into service of the gas turbine driven vessel *Admiral Callaghan.* The simplification of the systems and the installation generally must be considerable.

On the other hand nuclear propulsion, which has been hanging fire for so long, may find a place in vessels employed in tanking and in container traffic, where a sufficient proportion of time is spent under way, and where terminals may be used which are safely out of range of areas of dense population. The ancillary services for the prime mover would in this case be greatly extended.

Two types of vehicle have been developed for marine transport, the Hovercraft and the Hydrofoil. Both are increasing in size and effectiveness, and in spite of the present drawbacks, appear to be establishing themselves in the short-sea fast ferry services.

Looking into the future, as clearly as can be seen, the shape of ancillary services appear to take the forms of:

1) an increasing extension of amenity services, but in proportion to restricted manning scales.
2) continuance of the present growth of automatic and remote controls and power assisted operation of the ship's gear.
3) a systematic use of modules and packages in design which will reduce the installation costs of units.
4) an attention to the durability and reliability of systems by improving reliability of machinery, and by the use of superior materials for piping systems.
5) an extension of cargo handling, and conditioning, and installed tank cleaning systems.
6) an increasing demand for electrical power.

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