BRIDGE CONTROL OF MARINE STEAM TURBINE PLANT, AN ANALYTICAL APPROACH

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Authors' Reply

Many comments had shown that the marine industry was now realizing that proper application of instrumentation on board ships was of the utmost importance and that good instrumentation resulted in improved operation of the propulsion machinery. Other contributors had voiced their agreement with the authors' opinion that close co-operation between the plant designer, marine engineer and the control engineer was essential. The authors' would emphasize that without this co-operation the development of the bridge control system, as evolved in its present design, would have been much more difficult if not impossible.

The discussion had given a very clear illustration of the authors' difficulties in establishing exactly what was needed, especially in connexion with the operating constraints of the plant. Therefore, they appreciated very much Mr. Forrest's appeal to manufacturers to do some homework on the limitations of their installations. There was no definite reason, even from the economic viewpoint, why the superior knowledge existing in the aircraft industry in this respect should not also be available in the marine field.

Mr. McNaught had questioned whether in a black-out or other machinery emergency, the bridge control system would automatically apply astern braking steam as would normally be done manually by the engineer to reduce the risk of turbine bearing failure. The bridge control system as built did not provide the automatic opening of the astern valve under such circumstances because the vessels in the fleet of the authors' company were equipped with automatic turbine safety devices and a trip valve in the ahead turbine steamline.

In circumstances as described by Mr. McNaught the engineer could operate the astern turbine manoeuvring valve as required by switching the system to manual. The incorporation of emergency control circuits in the bridge control system such as automatic application of astern braking steam on "loss-of lubricating oil" would unnecessarily complicate the system.

The Chairman and Mr. McNaught had also asked what facilities were available on the bridge to override built-in time delay programming when navigational emergencies occurred. With precaution against inadvertent operation, the bridge officer could, by one simple action, obtain full emergency astern power in the shortest possible time without hazarding the main machinery. Loss of the main engine must not occur as it would effect the manoeuvrability of the vessel. Another essential operational requirement of the bridge control system was the provision on the bridge to stop the automatic blasting of the turbine in emergencies, e.g. wire fouling the propeller, etc. Application of either "overriding" system operated an audible warning in the engine control room.

Mr. Gray and Mr. Cane had rightly stressed the importance of co-ordination in the study of the design of all the control systems as a whole. Indeed, previous experience in the authors' company had shown that to obtain acceptable results explicit owners' specifications and good co-ordination were of vital importance. It was true that not only was the design carried out by owners but to some extent also the system engineering, One of the reasons was that standardization of equipment in the fleets was required. Vessels for the fleets in the authors' company were being built in Europe and Japan involving a number of yards and many sub-contractors. Without the owners' involvement in both the design of the control systems and its engineering rationalization, standardization of instrumentation would have been impossible.

The design of the bridge control system was influenced by a great number of opinions, in large part subjective. For example, the ahead/astern safety system protected the astern turbine from overheating but at the same time dropped down the boiler to minimum load. It was a matter of what was considered the most undesirable condition and a compromise was necessary. By making the ahead/astern safety system adjustable the system could of course be adapted after operational experience had been obtained. In *Myrina*, when adjusted at a value around 30 rev/min, the ahead/astern safety system was not expected to have much influence on the stopping time and distance of the ship. A propeller trailing speed of 30 rev/min corresponded to a ship's speed of about 12 knots and it was the authors' opinion that the application of astern steam at a ship's speed higher than this value did not have a detectable influence on stopping a large oil tanker like *Myrina*.

The authors agreed with Mr. Gray's statement that for new types of large steam plants now being built for marine application it was almost essential to do a computer simulation study before deciding how the plant would be controlled. Such studies might even indicate where and how the design of the plant itself should be altered to obtain easier operation. Mr. Walker had demonstrated an interesting alternative for the limiter and time delay. The authors remained in favour of their own system, however, for various reasons.

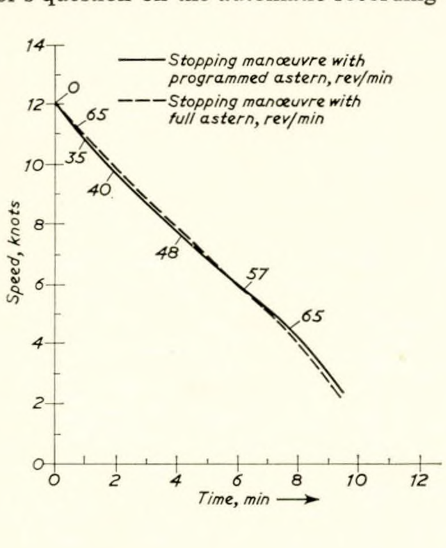
In their system, if necessary, the limiter value could be made a function of any physical quantity in the plant by replacing the pressure reducers of the limiter with function generators (see Fig. 6 of the paper). Further, in Mr. Walker's solution (Fig. 16) for reducing command signals, there was only one time delay for controlling the speed of manoeuvring from full away down to stop or astern; it seemed impossible to adjust this time delay to a value satisfactory for bridge order variations both in and above the manoeuvring range. Moreover, for downward manoeuvres the response to small bridge order variations would take as much time as on large ones, which was not acceptable.

Both Mr. Walker and Mr. Cane had commented on the use of one controller for both ahead and astern turbines, although the characteristics of these turbines were different. In *Myrina* for the astern turbine, on large—3½ in—manoeuvring valve was used; for the ahead turbine first a smaller valve (2½ in) had to be opened before the large one started to open. The influence of the smaller astern turbine efficiency on control loop stability and controller settings was thus compensated by the choice of a larger valve. Mr. Cane had questioned whether it was possible to design a system which, on the basis of ship's speed, could control the amount of steam to the astern turbine to obtain optimum propeller efficiency. The authors considered this to be attractive but much more information than available at the present time must be gained. Little was known about cavitation or ventilation of propellers operating behind a hull as opposed to the open water condition.

Moreover, propeller efficiency seemed to be influenced not only by cavitation or ventilation but also by vortex formation around the stern of the ship.

Mr. Proctor had rightly underlined the need for reliable primary elements (transmitters). Indeed acurate and reliable operation of the primary elements was basic to successful operation of the bridge control system. In this context it was decided that, rather than take account of operating limits of the boiler by measuring a number of plant variables, a simpler and more reliable solution would be to design into the bridge control system means to limit the rate of change of shaft rev/min. This would only require the measurement of shaft rev/min.

The selected pneumatic bi-directional speed transmitter was subjected to a laboratory evaluation and had already proven its reliability over several years of service in various other applications. To obtain optimum reliability two such transmitters were continuously in operation with audible alarming if their output signal differed by more than 5 rev/min. In general the bridge control system had been designed to fail safe wherever possible. For example, on loss of instrument air the manoeuvring valves would be closed. Answering Mr. Proctor's question on the automatic recording device, the recorder used was a conventional telegraph recorder which printed data such as date, time, bridge order and actual shaft rev/min.



Commenting on Commander Goodwin's contribution to the discussion, the authors stressed that they were not trying to spread the idea that a sacrifice in stopping distance was or should be acceptable. It was their opinion, and now also their experience, that, at least for very large oil tankers a stopping manoeuvre, with the application of gradually increasing astern rev/min as a function of ship's speed, is at least as effective as the immediate application of full astern rev/min.

This was illustrated by Fig. 20, showing the results of two different stopping manoeuvres carried out in *Myrina* in November, 1968. The figures along the curves indicate astern rev/min. The courses followed by the ship were exactly the same during both manoeuvres. Experience with manoeuvres applying gradually increasing astern rev/min was still scanty, mainly because they could only be carried out accurately when having a good system for closed loop rev/min control. The authors also believed that, whichever action was taken with the propeller, the course followed by the ship during the stop manoeuvre was the major factor when the speed is still above about six knots.

In connexion with Mr. Forrest's statement about optimum control techniques (Pontriagin's maximum principle) the authors were anxious to learn more about the data underlying that work especially about thrust deduction and wake factors for a propeller running astern behind the hull as opposed to open water tests. Regarding Commander Goodwin's remark on quick manoeuvring in war time, it was almost certain that the Royal Navy had gathered during that time a lot of information on plant limitations and the authors would welcome the disclosure of more quantitative data on this point. Mr. Forrest's remark on the liveliness of the boiler when having variable propeller loads in a seaway was important because it was fundamental to plant safety. Apart from the question whether a derivative unit was applied, the more accurate the closed loop rev/min control was adjusted, the more violently the manoeuvring valve would react to these torque variations. Indeed in this respect it was important that the limiter circuit was also active on variations in measured value and not only on the desired value, as was the case with a number of other systems. Yet, when sailing at full away rev/min with fully open manoeuvring valves, the variations in propeller torque did not result in a lively boiler because the controller was in a more or less saturated state.

This did not of course hold for the situation when, owing to heavy weather, propeller rev/min had to be reduced. In this respect it should not be forgotten that the engineer might switch over to manual rev/min control whenever he considered the boiler too lively.

Mr. Forrest had mistunderstood the remarks made on page 42 of the paper* concerning system testing facilities. These were incorporated in the system on board the ship for the purpose of ensuring that the equipment was fully operational before entering or leaving port, or for analysing faults. This facility had no connexion with an analogue computer. No "physically scaled down units" were used, only (as explained in the paper) a time delay unit representing a dummy turbine. Critical speed ranges were of course considered but were not of significant importance in this particular plant.

Referring to Mr. Hinson's remark that by avoiding cavitation the astern turbine might overheat, this would not be so, provided the ahead/astern safety system was adjusted to the right value. Mr. Hinson's suggestion that it would have added to the value of the paper if control engineering terms used had conformed to the British Standard 1523 Part I, 1967, was wholeheartedly accepted by the authors. They agreed that any future paper on control engineering should use standard symbols and terms for easy reference.

Mr. Wickstrom's contribution was interesting especially

* *Trans.I.Mar.E.*, February 1969, Vol. 81.

in so far as it stated that the use of quick acting valves would eliminate the need for derivative action. The authors agreed. However, they were not convinced by Mr. Wickstrom's reasoning that the valves should have a linear characteristic. Referring to Fig. 17 they did not see how the upper loop could possibly be faster than the lower one. The propeller torque variations followed rev/min variations instantaneously whereas in the upper loop there was always the time lag in controller and valve (even though it was small). The statements given in connexion with Fig. 19* were not entirely complete because for control loop stability also phase shifts should be taken into account.

The above-mentioned statements could be given in a more or less reversed way, hence going from 100 per cent–57 per cent of maximum rev/min. Then for a linear valve the gain remained constant at point C, but at the cost of an increase in phase shift, which from a point of view of loop stability was not attractive. The situation became still worse when rev/min were reduced to a value below 57 per cent of maximum. The authors had come to the conclusion that a quick acting valve could be attractive but should preferably be of the equal percentage type.

The feed forward system suggested by Mr. Owen was under active consideration and might be adopted in due course should the necessity arise. At the present time, however, satisfactory results were being obtained using the boiler following system.

A number of speakers referred to the choice of pneumatic instrumentation in preference to electronic. The authors emphasized the statements made on page 35 (basic design considerations) and on page 43 (conclusions) of the paper.*

The system as designed used standard pneumatic components because all the instrumentation on the vessels in question was pneumatic. However the system could readily be converted into the electronic equivalent if required. The authors stressed that they were not against the use of eleccronic instrumentation in the engine room. Considerations such as purchase costs for the instrumentation, their maintenance, etc., were the deciding factors. It might well be that in future electronic instrumentation would show to advantage and the authors' company would be among the first to change from pneumatic to electronic instrumentation.

Finally, the authors appreciated the lively discussion and thanked all contributors, especially Mr. McNaught, for their valuable contributions to the discussion.

* *Trans.I.Mar.E.*, February 1969, Vol. 81.

Marine Engineering and Shipbuilding Abstracts

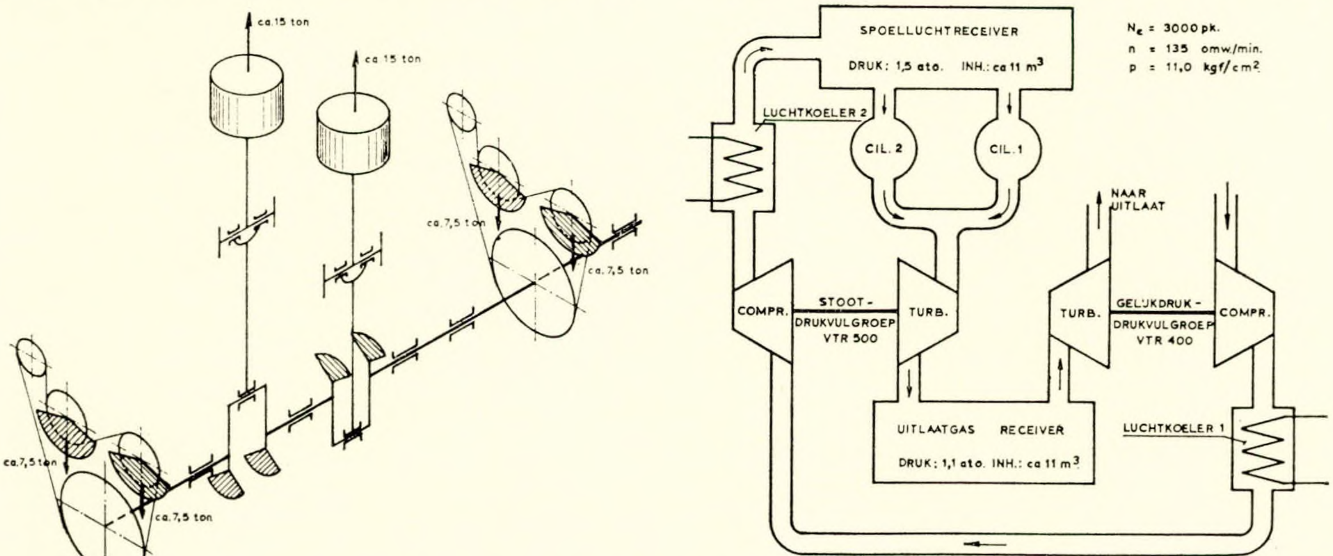
No. 3, March 1969

Large Sulzer Engine for Research

Royal Dutch Shell are building and equipping a new engine test laboratory at Amsterdam where research will be concentrated in connexion with lubricating oil and fuels. The single-cylinder Sulzer 1T48 engine which has been in use at the Delft research station since 1938 and the two-cylinder Bolnes 2DKL engine, which has been used for research in England since 1960, will be transferred to the new establishment.

More important, however, is the new Schelde-Sulzer 2RF69 engine now ready for delivery. This is a two-cylinder non-reversing version of the 680 mm bore engine widely used for marine propulsion. A two-cylinder engine such as this would give rise to considerable vibration unless special balancing arrangements were provided and as the test house is near other laboratories, where such vibration is intolerable, special steps have been taken. The mass forces of the running gear are entirely balanced insofar as those occurring at crankshaft speed are concerned since the cranks are at 180°. However, the forces arising at twice engine speed are not inherently balanced and to compensate for them special balancing gear has been arranged at both ends of the engine. The reciprocating forces at 135 rev/min have a total magnitude of 30 tons.

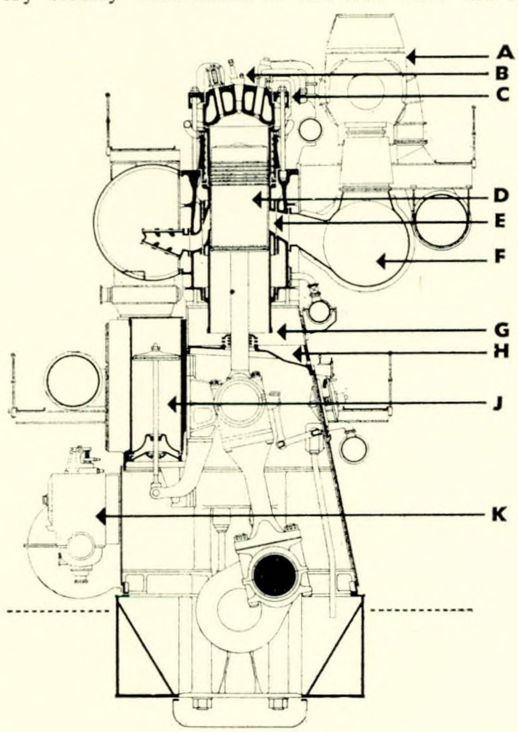
Chain-driven for each end of the engine are a pair of



Sulzer 2RF69 engine—arrangement of Lanchester balancers and two stage turbocharging and intercooling system counter weights rotating in opposite directions at twice engine speed. To overcome the problem of irregular running, since the engine has only two cylinders, a 17·5 ton flywheel with a GD2 of 113 tm² has been provided. The output of the engine is some 3000 bhp at 135 rev/min corresponding to a b.m.e.p. of 11 kg/cm², a rating considerably in excess of the normal 680 mm bore Sulzer engine. In order to develop this power, two-stage turbocharging is to be employed with a BBC VTR 500 turbocharger operating on the impulse system directly from the engine exhaust ports as the second stage of compression with a BBC VTR 400 turbocharger operating on the constant pressure system as the second stage of the gas process and the first stage of the air process. In order to obtain a maximum efficiency in this two-stage system approximately four fifths of the compression is performed by the VTR 400 constant pressure machine and one fifth by the impulse turbocharger. A very large exhaust receiver is arranged between the gas sides of the turbochargers and there are intercoolers after both stages of compression as well as a large charge pressure receiver immediately upstream of the scavenge ports.—*De Schelde Jnl, 28th June 1968, No. 13; Marine Engineer and Naval Architect, September 1968, Vol. 91, p. 389.*

Ten-cylinder Engine of 34 000 bhp

The first order for a ship to be powered by the new Fiat 1060S engine has been placed. It is for a 253 000 dwt motor-tanker which will be built at the Monfalcone (CRDA) yard of Italcantieri for Italnavi, Genoa. The ship is to be 1080 ft long, 170 ft in breadth, 84 ft in depth and 63 ft in draught and will have a service speed of 16 knots. These particulars tally very closely with those of the new Esso 253 000 dwt



A) constant pressure turbocharger
B) central fuel ejector
C) separate bolt ring on cylinder head
D) thin-walled oil-cooled pistons
E) exhaust ports with cooled bars
F) large exhaust manifold affords access for ring inspection
G) open liner skirt
H) sludge trap
J) second stage reciprocating scavenge air pumps
K) fuel pumps at platform level (elements can be changed while under way)

Cross section through Fiat 1060S engine showing short connecting rods, jackbolts securing bearing caps and steel cylinder liner support ring

class. The main machinery is to consist of a 10-cylinder version of the 1060S engine which has a cylinder bore of 1060 mm and a piston stroke of 1900 mm. The continuous service output is 34 000 bhp (3400 bhp/cyl, at 102 rev/min, corresponding to a b.m.e.p. of 8·95 kg/cm² (127 lb/in²) and 6·46 m/s (1272 ft/min) mean piston speed. The 1062S two-cylinder research engine is now running in Fiat's large engine experimental establishment at Stura, outside Turin.

The Fiat 1060S follows current Fiat two-stroke constant pressure turbocharged engine practice and incorporates a number of new features already used in the new 780S design but does not have the greater stroke/bore ratio of that design which, at 2·05, is exceptional in the Fiat range.

Frames and bedplate of production engines are fabricated, the latter of a rectangular box section, and the cast steel cylinder heads are held down by separate cast steel bolting rings. The main bearing caps are secured by jackbolts fitted under the arches of the frames. Two-part cast iron liners have the more highly stressed upper part fitted with a steel "strong back" ring.

The pistons are in three parts. A relatively thin crown with spray-coated thermal shield and ring carrier with chrome-plated ring grooves is cantilevered from a heavier centre part which is attached to the piston rod. The skirt carries a number of wear rings. A semi-built crankshaft is made in up to six-cylinder sections for a maximum weight of 160 tons. The scantlings of the engine have been designed for loadings of up to 10 kg/cm² which would correspond to 3800 bhp/cyl at the same speed of 102 rev/min.

The 10-cylinder engine ordered will be 71 ft 3 in long and will weigh 1400 tons.—*Marine Engineer and Naval Architect, September 1968, Vol. 91, pp. 361–362.*

Investigation of Slamming Characteristics

An investigation of slamming is now in progress at the Webb Institute of Naval Architecture on behalf of the American Bureau of Shipping, making use of the recently installed wavemaking equipment.

This work includes tests of a Mariner model conducted in the Robinson Model Basin in irregular head seas roughly equivalent to a gale (Beaufort 9) in the North Atlantic.

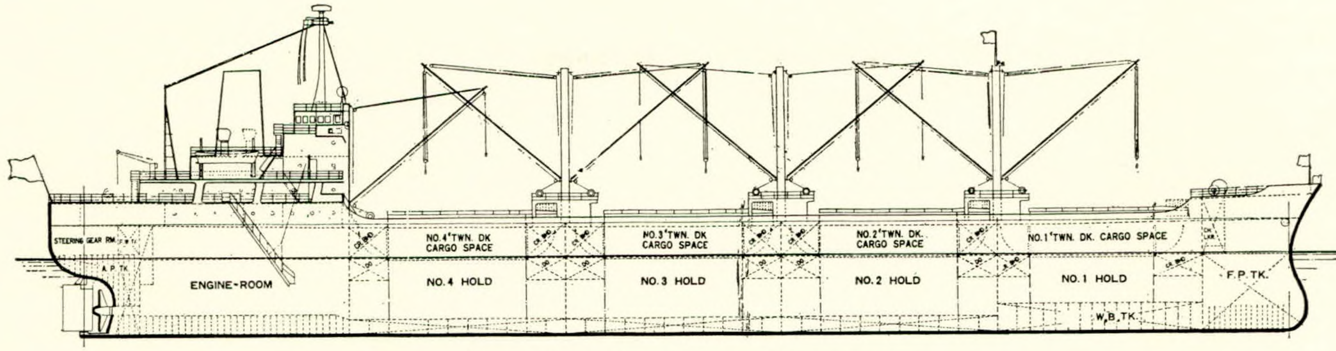
The model is jointed amidships, and when slamming occurs the hull vibrates in roughly the same way as the ship. The slam can be identified either by an accelerometer or by the pressure recorded on the bottom forward. At the same time, records are made of the relative vertical motion between a point on the keel and the water surface, as well as the slope between the keel and the water. Hence, the extent that the keel emerges and the relative velocity and angle of impact can be established at the instant of slamming. Relative bow motion is also measured in a series of regular waves, so that predictions of slamming in irregular waves can be made by the superposition technique.

These predictions can then be checked against the actual occurrence of slamming in irregular waves. With the help of analytical studies of hull structural response to slam loads it is hoped to clarify the question of how to allow for the effects of slamming in developing more rational design standards for longitudinal strength.—*Marine Engineering/Log, July 1968, Vol. 73, p. 48.*

Mitsui *Concord* Class Cargo Ship

The first multi-purpose cargo vessel of the Mitsui *Concord* type developed by Mitsui Shipbuilding and Engineering Co. Ltd. is the recently delivered *Sylvia Cord*, the first of two sisterships delivered by the Mitsui-owned Osaka Shipbuilding Co. Ltd. to her owners, Concord Line A/S of Denmark.

The Mitsui *Concord* type vessels were basically designed and developed not simply as Liberty replacement ships but



General arrangement m.v. Sylvia Cord

also as efficient multi-purpose cargo vessels to carry a combination of general cargo, light and heavy grain, coal, ore, scrap, long steel products, containers etc.

Principal particulars of m.v. *Sylvia Cord* are:

Length, o.a.	478·02 ft
Length, b.p.	452·75 ft
Breadth, moulded	72·18 ft
Depth, moulded	40·52 ft
Deadweight	15 574 long tons
Light draught:	
forward	0·41 m
aft	4·68 m
Centre of buoyancy fwd of midships	2·79 m
Gross register	9857·78 tons
Net register	6045·12 tons
Capacities	
Cargo (grain)	765 992 ft^3
Cargo (bale)	720 571 ft^3
Fuel	1172·5 m
Diesel oil	84·9 m^3
Fresh water	304·2 m^3
Ballast	3584·0 m^3
Service speed (without sea margin)	15·9 knots
Fuel consumption ...	29·79 metric ton/day
Endurance ...	14 500 nautical miles
Complement, total	33 persons

For carrying cargoes such as ore, the tank top and other related structures in each cargo hold have been sufficiently strengthened to withstand a stowage factor of 25 ft^3/ton thus qualifying for Lloyd's notation, "Strengthened for ore cargoes".

Main propulsion is by a Mitsui-B. and W. 762-VT2BF-140-type engine developing a maximum continuous output of 8400 bhp at 125 rev/min. The engine is remotely controlled by an electro-pneumatic system from the wheelhouse and by mechanical links from a centralized control station located on the second deck in the engine room. Shipboard electricity is produced by three a.c. generators each powered by a Mitsui-B. and W. 3T23HH engine. At sea, steam is supplied by one exhaust gas economizer and from an oil-fired boiler while in port.—*Motor Ship, November 1968, Vol. 49, pp. 382–384.*

Single-point Mooring

Major oil companies are finding the single-point mooring a solid and simple answer to many of the handling problems generated by the supertanker. The single-point buoy is not an inexpensive device, but it is being found to be economic when compared with the cost of an entire pier and its attendant dredging or a fixed sea island.

The concept of the single-point mooring is as simple as can be. Oil is fed from shore through an underwater pipeline that terminates in water deep enough to accommodate the deepdraft tanker. A flexible connexion carries the oil to this floating buoy, which is moored securely by at least four heavy anchor chains. The buoy is designed like a doughnut, in place of the hole is a rotating oil connexion and mooring bollard.

An IMODCO buoy will suffice to show how these work in 1968. The terminal is a strongly constructed steel vessel which has the approval of Lloyd's Register. The outside diameter can be as much as 12·5 m (41 ft) for a tanker of 200 000 dwt, and the pumping rates are determined by the diameter of the hoses. 5000 tons/h is the figure given for one projected buoy, which is able to operate with a tanker of the aforementioned size with a wind velocity of 35 knots, wave height of 18 ft, current velocity of 4 knots and tidal range of 23 ft.

The terminal is moored in position by four sets of chains and anchors spaced at 90° intervals around the hull, subdivided into four, watertight sections. On the upper deck is the product distribution unit which permits continuous passage of oil cargo while the moored vessel is rotating about the terminal. Attached to the lower section are the three necessary components that rotate with the ship, i.e., the mooring bollard to which the vessel secures, the cargo manifold which carries the flow system from the terminal to tanker hoses to the product distribution unit in the centre, and the rotating balance arm which, in addition to maintaining the terminal on an even keel, projects out to a point parallel to the submerged main hull skirt fender to provide a boat landing platform. All three components rotate as one unit. The peripheral fender is there to prevent damage to the floating hoses and terminal should the tanker ride up against it.

The rotating unit and the product distribution unit is a patented design by IMODCO. A system of seals and frictionless bearings permits the movement of oil without leakage at 150 lb/in^2 working pressure.

The Shell Buoy, which is constructed by I.H.C. of Holland, consists of an inner and outer cylinder. The space between these two cylinders may be filled with plastic foam for reserve buoyancy in case of collision. The underwater hoses are brought up through the inner cylinder and attached to a central pipe assembly on which a specially designed swivel unit has been mounted. This swivel is connected to a turntable and rotates freely around the central pipe assembly. The mooring cables an the hose connexions to the ship are on the turntable.

I.H.C. claims that the design of the central swivel is such that the hydrodynamic oilstream forces are hydraulically balanced. This minimizes thrust-bearing forces and results in swivel unit of lighter construction.

Shell-type buoys with a capacity of 60 000 bbl/h have been installed. A higher capacity is, of course, feasible where hoses of a larger bore are employed.—*Marine Engineering/Log, July 1968, Vol. 73, pp. 45–48.*

Steam Turbine Cargo Liner

Bencruachan is the fourth in the series of the *Benledi* class of cargo passenger ships operating on the Europe/Far East run. Unlike the first three ships in the class, which have Diesel engines, *Bencruachan* is powered by steam turbine machinery. She was built by the Scotstoun Division of Upper Clyde Shipbuilders Ltd., formerly Charles Connell and Co. (Shipbuilders) Ltd.

Bencruachan is very similar in construction to the other ships in the class and has been built to the same high standards for classification by Lloyd's Register ✠ 100 A.1. The ship has five holds with Nos 3 and 4 fitted with triple hatch covers.

Principal particulars are:

Length, o.a.	565 ft 0 in
Breadth, extreme	77 ft 6 in
Draught, summer	33 ft 9 in
Deadweight	14 650 tons
Cargo capacity	
Grain	802 730 ft^3
Bale	703 227 ft^3
Insulated cargo space ...	12 030 ft^3
Liquid cargo	1500 tons
Machinery output	
m.c.r.	20 000 shp at 101·7 rev/min
n.c.r.	19 000 shp at 100 rev/min
Service speed	21 knots

Propelling machinery of *Bencruachan*, which has been built by Barclay Curle and Co. Ltd., is a Pametrada 'Standard Frame' design steam turbine developing 20 000 shp at 101·7 rev/min at m.c.r. and 19 000 shp at 100 rev/min at n.c.r. Gearing is of the single tandem double reduction articulated type to Pametrada standard P.S.G. 20 with a quill shaft drive between the primary and secondary gearing. The secondary pinions are hollow and the quill shafts pass through them to give maximum flexibility. Each turbine is connected to its primary pinion through a flexible coupling designed to allow up to ¼ in axial movement and to accommodate small differences in alignment. A solid four-bladed propeller of Meridian design, manufactured in Superston 70 is fitted. This Stone's propeller is right-handed and has a diameter of 22 ft 6 in, a mean pitch of 22·27 ft and a developed surface area of 248·5 ft^2. A spare propeller in manganese bronze, having the same diameter and developed surface area but with a mean pitch of 22·07 ft is stowed aft on a special platform on the starboard side of the bridge deck.

Boiler plant consists of a main boiler for propulsion with one auxiliary boiler for port and emergency use. One low pressure steam generator for bunker heating and ship's services is also installed. The main boiler is of the Foster Wheeler E.S.D. type having the following particulars:

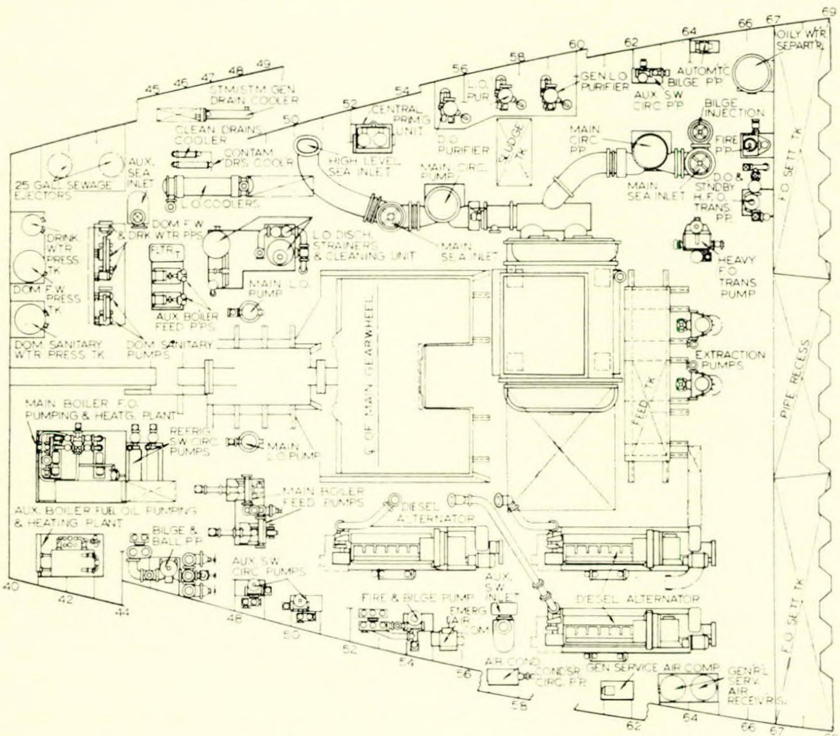
Evaporation, normal	136 000 lb/h
Evaporation, maximum	148 000 lb/h
Superheater outlet pressure ...	600 lb/in²g
Superheater outlet temperature...	900°F
Feed temperature	280°F
Steam-air heater	100–260°F

One set of automatic combustion control equipment has been fitted, designed to control the rate of steam evaporation in response to the boiler steam pressure when compared with the desired boiler steam pressure.—*Shipping World and Shipbuilder, October 1968, Vol. 161, pp. 1602–1606.*

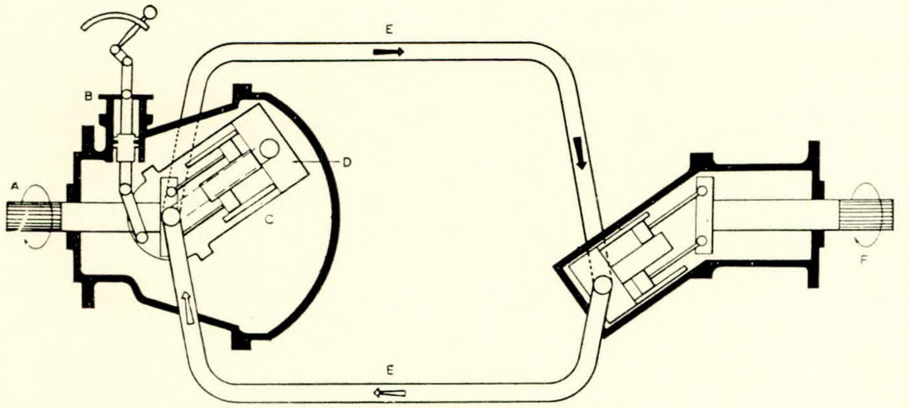
Hydrostatic Transmission System for Net Winches

A new hydrostatic transmission system, which permits fishermen to set the most efficient speed for net winches independently of the main engine rev/min as well as to read trawl-warp tension from the system's pressure gauges and to control the entire operation from the wheelhouse by means of a single lever, has been introduced by Dowty Hydraulic Units and will be shown at Ships' Gear International. The system, known as the Dowmatic Type 2, was recently approved and recommended by the White Fish Authority after sea trials lasting a year aboard the seine trawler, *Opportune II*.

The drive consists of a variable displacement hydraulic

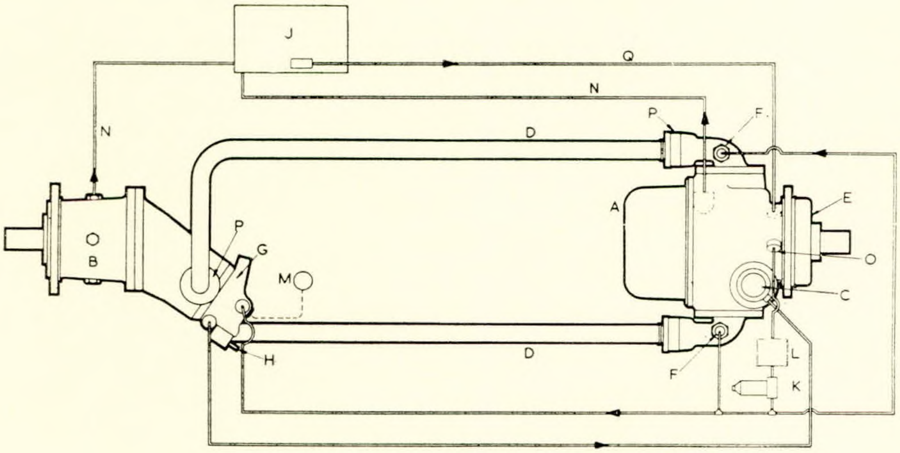


Steam turbine cargo liner floorplate level plan



Key to top drawing

A) Drive shaft	D) Timing plate
B) Servo jack	E) High pressure pipes
C) Pumping elements	F) Motor output shaft



Key to lower drawing

A) Pump	K) Filter
B) Motor	L) Cooler
C) Servo	M) Tapping for pressure gauge
D) Primary circuit	N) Case drains
E) Gear pump	O) Gear pump delivery
F) Non-return valves	P) Pump and motor connexions
G) Valve block	Q) Gear pump suction
H) Manual unloader	
J) Reservoir	

Top: Pumping elements for net winches
Lower: Valve block for net winches

pump (0-12·41 in^3/rev, 0-203 cm^3/rev) connected by two high pressure pipes to a fixed displacement hydraulic motor (12·41 in^3/rev, 203 cm^3/rev). The pumping elements are located in a swivelling yoke (see top drawing) which allows the head of the pump to be tilted by a servo-jack through an angle of 35° on either side of the neutral position. This tilting movement adjusts the stroke of the pistons in the pump, which in turn varies the delivery rate and direction of the oil flow to establish the direction of rotation and speed of the motor. Identical rotating parts are used in the motor and they are contained within castings set at the maximum angle of 35°.

A valve block (see lower drawing) containing the control valves for the circuit is attached to the end of the motor case. This incorporates a high-pressure relief valve to act as a limit on the output torque which can be applied. The servo-jack contains an integrally mounted selector valve and a force of approximately 2 lb is all that is required to activate the unit. The Dowmatic system is claimed to provide a saving of up to 30 per cent in length of warp or four coils when seine netting. Another important feature is the elimination of the below-decks hazard to the crew caused by a belt and pulley type of drive; eliminating this type of space-consuming drive also provides more storage area for fish.—*Shipbuilding and Shipping Record, 26th July 1968, Vol. 112, p. 118.*

Dual Shield Welding Process

Among the conventional shielded arc welding processes its one which uses flux cored wire and shields arc CO_2 gas only. A disadvantage of this process is that the chargeable amount of flux is limited by the diameter of the cored wire and, in strong current welding in particular, a shortage of molten slag, resulting from an insufficient amount of flux, causes slackened de-oxidation of molten metal, formation of blowholes, increased spattering and decrement of deposition efficiency. To attain efficient welding by this process, therefore, it is necessary to increase the amount of flux by enlarging the diameter of the wire into which flux is charged. Large wire diameter, on the other hand, makes arc concentration wider and decreases its penetration depth, reducing the effect of high welding current. Moreover, it is not desirable to enlarge wire diameter from the viewpoint of welding workability.

To carry out strong current welding without enlarging wire diameter, it is advisable to use argon gas to make up for the shortage of molten slag, but argon gas is expensive. The Mitsubishi Dual Shield Welding Process is a very economical and effective process for the above purpose. Equipment designed for this process has dual gas nozzles of special shape and is so designed that argon gas is emitted from the inner nozzle to shield globules and CO_2 gas is emitted from the outer nozzle to protect the molten pool from atmospheric air. Cored wire of this diameter turns into fine globules (molten metal and molten slag) by applying high current arc. The globules are transferred to the molten pool as shielded by the dual gases, are de-oxidized by the action of the flux to form a good quality deposited metal. Being transferred to the molten pool as shielded by the dual gases, these globules are scarcely oxidized and obtain higher deposition efficiency and larger flux effect, almost eliminating spattering. High current and high current density arc produce a deep penetration of deposited metal.

CO_2 gas emitted from the outer nozzle shields the molten pool against the atmosphere and also prevents oxidation or nitrization of molten metal by air with the effect of molten slag, producing deposited metal of bead appearance. Employing cored wire and dual shielding system, this process produces welds of good quality, increases welding workability and improves efficiency. The features of this process are as follows:

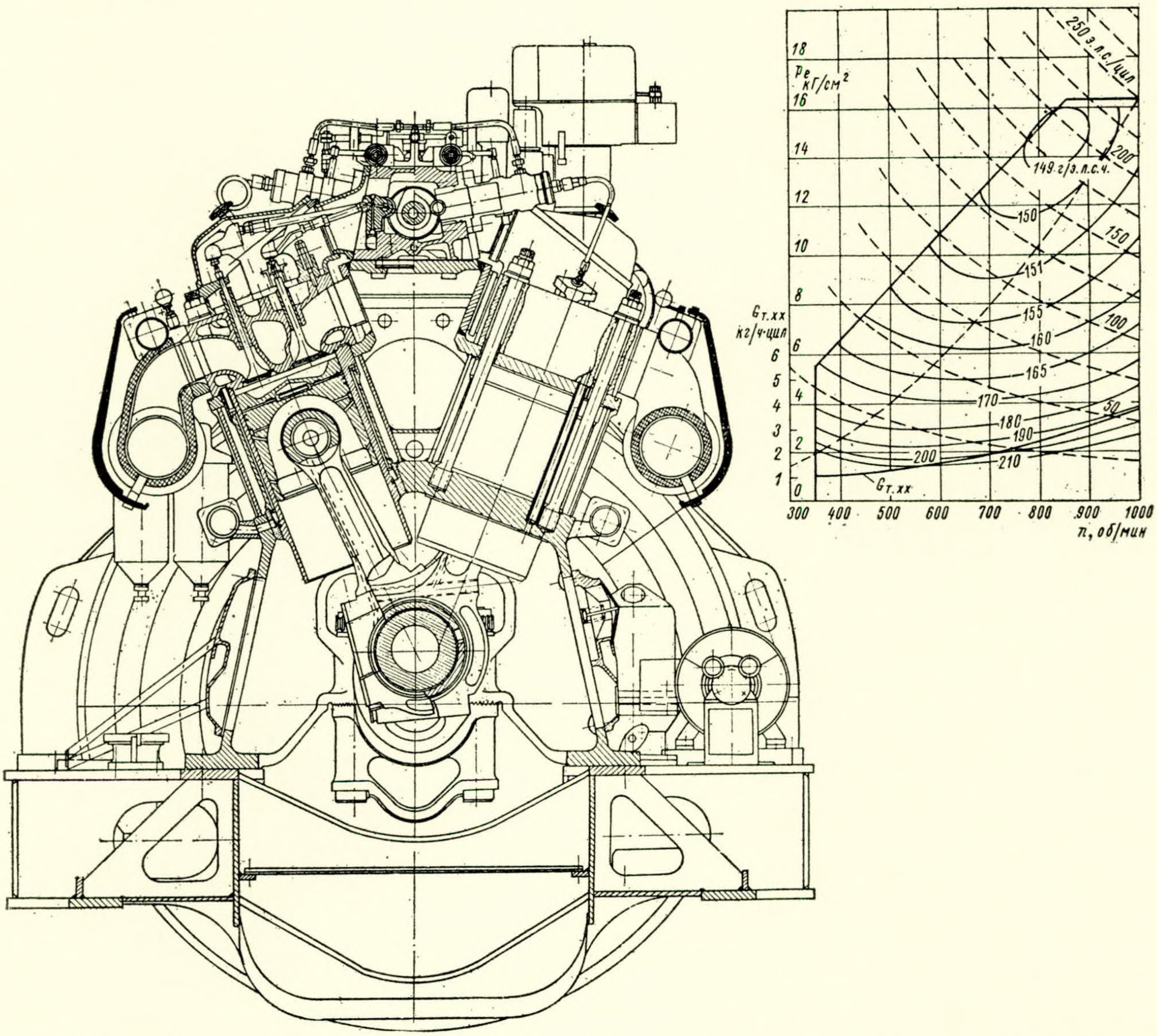
1) no spattering;
2) strong current welding is possible;
3) good quality welds can be obtained;
4) high deposition efficiency;
5) deep penetration;
6) least blowhole formation;
7) minimum effect on base metal surface (such as formation of rust);
8) low welding cost;
9) welding set in use can be utilized with slight improvement;
10) can be used either with d.c. or a.c. power source.

This process can be employed either for full automatic welding or semi-automatic welding.—*Mitsubishi Heavy Industries Review, July 1968, No. 13, pp. 13–14.*

Russian Universal Engine Design

The types of Diesel engine presently available in Russia do not meet all users' requirements, but the wide diversification of types which are manufactured there results in a pattern of production which does not assist the national economy. This problem could be met by developing a new design of Diesel engine, so that a very wide power range would be possible by permutation of different cylinder numbers and configurations to suit the requirements of the majority of users.

This has been a principal aim of Russian Diesel engineers during the current five-year plan. Locomotive builders need lightweight four-stroke engines covering the range from 800 to 4000 bhp per unit at 1000 rev/min, the marine engineering industry calls for trunk-piston engines with unit outputs from 800 to 10 000 bhp while drill rigs need from 800 to 2000 bhp. The project was for a unified 750 to 1000 rev/min advanced Diesel engine family suitable for locomotive, marine, oil drilling, portable generators and other applications. The practical work on the resulting Ch26/26 D-49 series has been undertaken by the Kolomna Loco Works. The



Section through basic Ch26/26 D-49 vee engine—speed/b.m.e.p. and I.S.O. fuel rate chart (broken lines=bhp/cyl) basic model in this series is of vee-form.

Principal particulars are:

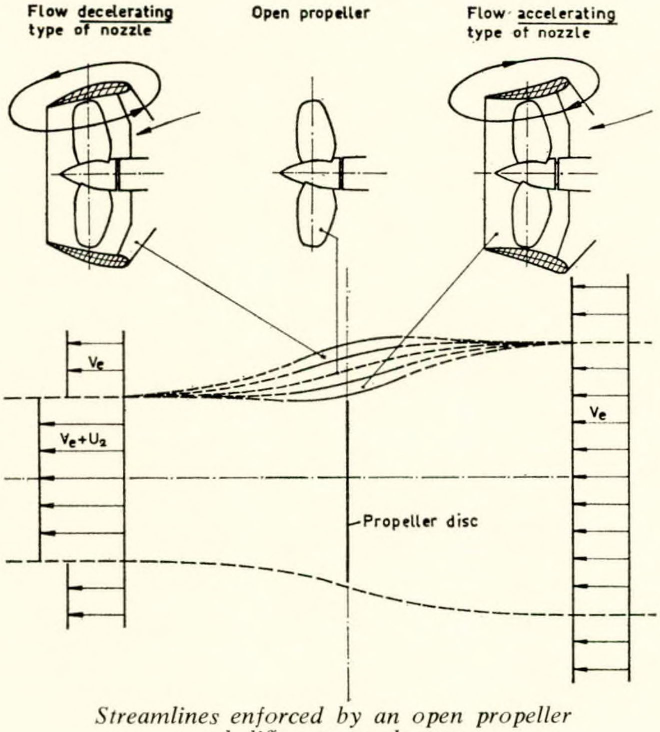
Cylinder diameter	10·24 in
Piston stroke	10·24 in
Vee-angle	42°
Cylinder capacity	842 in³
Cylinder centre distance	14·96 in
Crankpin diameter	7·87 in
Crankpin journal diameter ...	8·66 in
Weights of components	
Piston, less pin	59½ lb
Slave connecting rod ...	33 lb
Master connecting rod ...	72¾ lb
Cylinder cover, with valves	187½ lb
Cylinder liner	141 lb
Fuel pump	15½ lb
Nozzle	6½ lb

The specific fuel consumption, with Diesel oil of calorific value 10 200 kcal/kg, over the range 60–110 per cent of present rated power (125 bhp per cylinder), is 146–155 g/bhp-h.

The variation of unit output is effected by increasing the number of crank throws in the crankshaft from four up to 12 and by changing the number of cylinders per row (in-line, vee-form, W-form and X-form—the last two configurations have two cylinder blocks arranged about a common crankshaft); and finally by varying the degree of pressure-charging to give b.m.e.p.'s from 155 to 235 lbf/in² and later up to 312 lbf/in² with or without subsequent charge cooling.—*Oil and Gas Power, November 1968, Vol. 64, pp. 292; 294.*

Non-cylindrical Nozzles for Large Tankers

When selecting propulsion devices for ships, propeller induced vibration and cavitation must be considered in addition to the ever present desire for high propulsive efficiency. In an attempt to provide large tankers and bulk carriers with superior propulsion devices, the application of ducted propellers has been the subject of extensive investigations performed at the Netherlands Ship Model Basin.



Streamlines enforced by an open propeller and different nozzle types

Insight into the shape of ducted propeller systems can be observed in the figure. Here, the flow through different types of ducted propeller is compared with the flow through an open propeller. Both open and ducted propellers are designed for the same mass flow rate and velocity in the ultimate wake.

The momentum law leads to the conclusion that the ideal efficiency and the thrust of these systems are equal. In the ducted propeller, the axial force on the impeller differs from the net thrust of the system. A positive or negative force will act on the duct depending on the operating condition. Due to the effect of the nozzle, the inflow velocity of the impeller can be either less or greater than the inflow velocity of an open propeller under equal conditions. The shapes of flow-accelerating and flow-decelerating nozzles are schematically shown. The figure shows also that the ratio exit area of the nozzle over the disc area of the impeller for the flow-accelerating nozzle is larger than that for the decelerating nozzle.

Investigations into the optimum nozzle shape from an efficiency point of view have led to the conclusion that a maximum acceleration of the flow by the nozzle should be aimed at. The accelerating nozzle itself produces a positive thrust. However, the acceleration of the flow is limited by the risk of flow separation on the interior surface at the aft part of the nozzle.

Investigations performed at the N.S.M.B. concerning nozzles of the accelerating type have led to the development of a standard nozzle (No. 19A) applied by the N.S.M.B. in the case of heavy screw loads. This nozzle meets various practical requirements; it has an axial cylindrical part at the inner side of the nozzle at the location of the impeller, the outside of the nozzle profile is straight and the trailing edge of the nozzle is made relatively thick. For this nozzle the Ka-screw series were specially designed. These screws have wide blade tips, uniform pitch and flat face sections.

Experimental investigations showed that, with regard to efficiency and cavitation, this impeller type is just as good as those calculated according to vortex theory.—*Oosterveld, M. W. C., Shipbuilding and Shipping Record, 8th November 1968, Vol. 112, pp. 595–596.*

World's Largest Fishing Vessel

The world's first atomic icebreaker *Lenin* was built at the Admiralteisky yards in Leningrad. These yards are now constructing *Vostok*, which in size and equipment will surpass all fishing ships that exist in the world. *Vostok* will be both a large fishing and a processing vessel.

The main advantage of *Vostok* will be her sea endurance—four to five months. Principal particulars are:

Length, o.a.	738 ft 2 in
Breadth, o.a.	91 ft 11 in
Depth, approx.	55 ft 9 in
Displacement	43 400 tons
Propulsive power	26 000 hp
Speed	18½ knots

On deck *Vostok* will carry 14 fishing boats each with a displacement of 60 tons. Their main fishing gear will be trawls and purse nets. Each seiner will have a crew of five.

The seiner hulls will be made from glass fibre, weighing only one-fifth of the equivalent steel structure. Synthetic materials have been used, since *Vostok* is expected to operate mainly in tropical waters where corrosion is severe, while glass fibre has a high resistance against it.

The *Vostok* mother ship will be able to process fish of various species and produce a wide variety of products: frozen and salted fish, fillet, canned goods, fish meal, and non-edible fat. She will produce 21 000 tons of frozen fish and 20 million tins of canned fish per year. *Vostok* has been designed to process 30 tons of fish daily.

Vostok has been designed so that all basic production processes will be mechanized and automated. She is equipped with the latest radio, navigational, sonar, fish detection, fishing, fish processing and refrigerating equipment. *Vostok*, for example, will have installed on board a computer which on the basis of reports from helicopters (there are to be two of them on *Vostok*), observations and predictions of sailors working on fishing boats, will produce the precise answer where to fish with greater efficiency.—*Shipbuilding and Shipping Record, 6th September 1968, Vol. 112, p. 303.*

Catamaran Offshore Floating Crane

The Russians have built a remarkable craft, *Ker Ogli*, for placing offshore drill rigs in the Caspian Sea where, due to the relatively shallow water, they are all of the standing type and hence cannot be towed to site. The dimensions of this craft are such that she can pick up the support frame, the platform and the drilling tower, sail out to site, erect the tower and return to base. As the illustrations show the heavy crane structure is supported entirely on one hull of the catamaran which is decked all over to provide stowage space for the load.

Principal particulars are:

Lengtth, o.a.	425 ft 0 in
Extreme breadth	164 ft 0 in
Pontoon depth as sides	23 ft 0 in
Height to top of fixed crane structure	150 ft 0 in
Surface area of deck	53 800 ft
Displacement with full load ...	11 370 tons
Maximum crane lift	250 tons at 30 m radius
Auxiliary hook ...	140 tons at 55 m radius

This craft is self-propelling, the Diesel-electric machinery consisting of six 5D50 engines with a total output of 6000 bhp. Each hull has both propeller and rudder at bow and stern. The after screws are driven by 1500 kW motors and the bow ones by 100 kW motors.—*Sudostroenie, August 1968; Marine Engineer and Naval Architect, October 1968, Vol. 91, p. 434.*

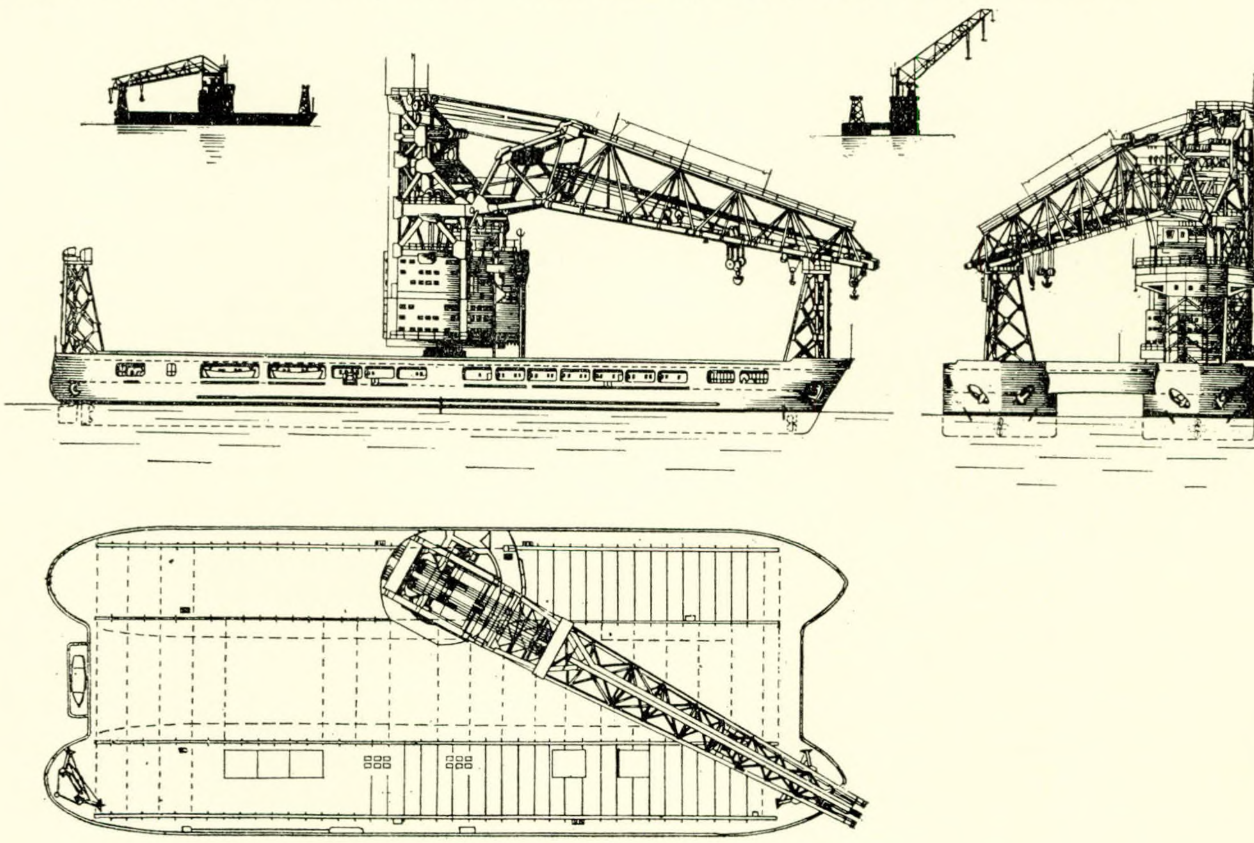
Metallurgical Research and Welding Practice

Problems may arise in the welding of metals either as a result of cracking or inferior properties of the weld metal or heat-affected zone. Many of these problems are of metallurgical origin, and the reason why they occur must be fully understood if they are to be avoided in the most economical way. In this paper the role of metallurgical research in avoiding such problems is discussed, both generally and with reference to specific examples.

It is suggested that the objectives of metallurgical research applied to welding technology should be the definition of the metallurgical factors responsible for each specific welding problem, followed by the quantitative application of the results, both in predicting where the problem will occur and in developing future materials of improved weldability. Recent research on five specific problems is reviewed critically in the light of these objectives; the five problems are:

1) burning and hot tearing in the heat-affected zone;
2) hydrogen induced heat-affected zone cracking;
3) heat-affected zone cracking during heat treatment;
4) poor fatigue properties of high strength steels;
5) brittle fracture.

It is concluded that, although research has already led or is leading to a definition of the problems considered, much more emphasis will be required in future on the problem of quantitative prediction. It is also argued that a more progressive attitude towards the formulation and modification of material standards is necessary if the results of research work are to be applied to the best advantage.—*Baker, R. G., Welding Jnl, July 1968, Vol. 47, pp. 323s–331s.*



Russian catamaran crane

Stern Trawlers Being Built in U.S.A.

Two Diesel electric stern trawlers, *Seafreeze Atlantic* and *Seafreeze Pacific*, are at present under construction at the yard of the Maryland Shipbuilding and Drydock Co. for American Stern Trawlers Inc. of New York.

The two vessels have almost identical specifications. Principal particulars:

Length, o.a.	295 ft
Length, b.p.	262 ft 6 in
Breadth	44 ft 3½ in
Depth, approx.	25 ft
Refrigerated capacity for 760 tons of frozen fish	43 000 ft^3
Fish meal storage capacities of	8000 ft^3

Electronic fishfinding and navigational equipment is to include Elac Superlodar Netsounder and Fischlupe, a Simrad sounder and scope, Loran navigator and Apelco radio direction finder. Radar installations are the Decca true motion type TM626 and relative motion type RM 326. Radio equipment includes an Apelco radio-telephone type AE160M for each vessel.

Main propulsion machinery consists of two General Motors type 12-645E2 Diesels producing 1500 bhp each, and one GM type 8-645E2 producing 975 bhp at 900 rev/min. The electric propulsion system driven through an F. Tacke gear-box is the AEG d.c. constant current loop type driving two solid Superstone four-bladed propellers via two electric propulsion motors each producing 1500 bhp. Generating machinery for the main propulsion system of each vessel consists of two 1000 kW and one 670 kW generators and two 400 kW d.c./a.c. converters. One 200 kW Diesel generating set for harbour and emergency use will be fitted in each vessel.

The designed speed of the vessels is 14½ knots and both are to be equipped with Propulsion Systems Inc. Frydenbo rotary steering gear.

The main winch is an AG Weser Greenland trawl winch with two main drums, four auxiliary drums and two warping heads, powered by two electric motors of 260 hp each. Auxiliary deck machinery includes two AG Weser net handling winches and two a.c. Hoyle cargo winches.—*World Fishing, August 1968, Vol. 17, p. 44.*

Braking of Large Ships

The headreach or stopways of large tankers during a crash stop have become inpracticably long. Distances of more than three miles have been measured while trying to stop tankers of more than 100 000 dwt on a straight course.

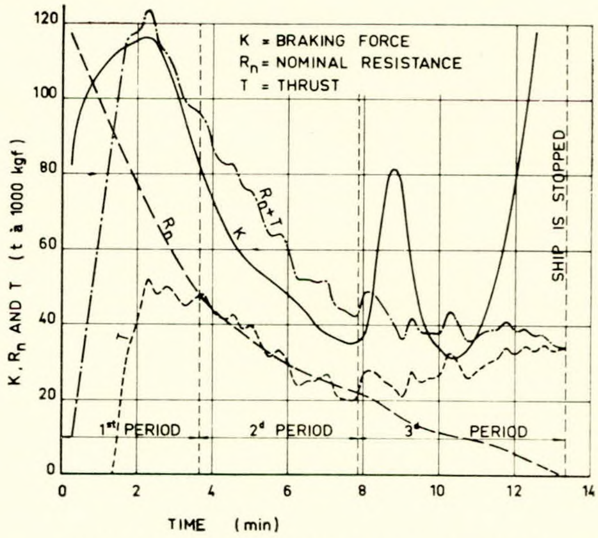
The Institut de Recherches de la Construction Navale in Paris conducted a series of stopping tests during the sea trials of large tankers with the intention of studying stopping conditions in detail. About the same time, the Netherlands Ship Research Centre followed up a suggestion of the first author for model tests of a new hydrodynamic brake system. As a result, both the French and the Dutch research institutes have worked together for many years to solve this problem.

Sea trials were carried out under favourable conditions so that different aspects of the stopping characteristics could be studied. All the ships tried were single-screw turbine tankers, varying in deadweight from 50 000 to 100 000 tons.

The figure represents the results of the tests on one of the ships. It shows the breakdown of this trial into braking force, thrust, nominal resistance, and the sum of the thrust and resistance. The figure also makes it possible to subdivide schematically the stopping manoeuvre into three parts, giving successive time periods.

During the first period, the speed decreases by one third over a distance of about 40 per cent of the headreach. At the end of the second period, about 80 per cent of the stopway has been covered and the speed is reduced to about one half.

At all normal trials it was found that these values differed little, while the parallelism between thrust and resistance during the second period was always present. This particularity is probably related to the effect of the suction of air in the propeller (ventilation).



Analysis of a conventional crash stop trial

Thus, the slight influence of the astern power may be explained. In fact, this power cannot be important during the first period, when it grows slowly and progressively, nor during the second period when the growing of the thrust is braked off. It can only become fully effective in the third period which represents only 20 per cent of the stopway and every gain will be only a small part of the whole way. Therefore, the hydrodynamic stopway of a ship depends on the design of the submerged part of the hull and not on the power installed.—*Jaegar, H. E. and Jourdain, M., Maritime Reporter/Engineering News, October 1968, Vol. 30, p. 42.*

Reheat Propulsion Turbines

Seven improvements characterize the latest developments in steam propulsion for large outputs, according to AEG of Hamburg. These are:

1) higher live steam pressures and higher live steam temperatures;
2) a single main boiler instead of two boilers;
3) oil burning with little more than the theoretical air requirements;
4) reheating to the live steam temperature while retaining the two-casing turbine design;
5) omission of the main cooling water pump and transition to a single flow scoop condenser;
6) a shaft generator as well as a main gear-driven feed pump;
7) low propeller speeds.

With full application of these possibilities and at powers of 25 000 to 30 000 shp the total fuel consumption is of the order of 180 to 190 g/shp-h metric (0·4 to 0·42 lb/shp) depending on the live steam conditions and the number of feed water preheating stages; in other words, the result is a saving in fuel of between 15 to 20 per cent against the earlier conventional installations of 60 at 450°C (850 lb/in^2, 850°F).

By lowering the propeller speed from, e.g., 112 rev/min to 80 rev/min, a power saving of seven to nine per cent is achieved. In other words, the complete propulsion installation can be designed about eight per cent smaller at a speed of 80 rev/min than at a sped of 112 rev/min.

The shaft generator makes one of the two turbo-generators superfluous, while the other can be equipped with a cheaper turbine (Curtis overhung wheel only) exhausting directly to the main condenser when in emergency operation; similarly, with the main gear-driven feed pump. There is thus a saving in cost which can also be offset against the extra cost for the propeller, the propeller shaft and gearing at 80 rev/min.

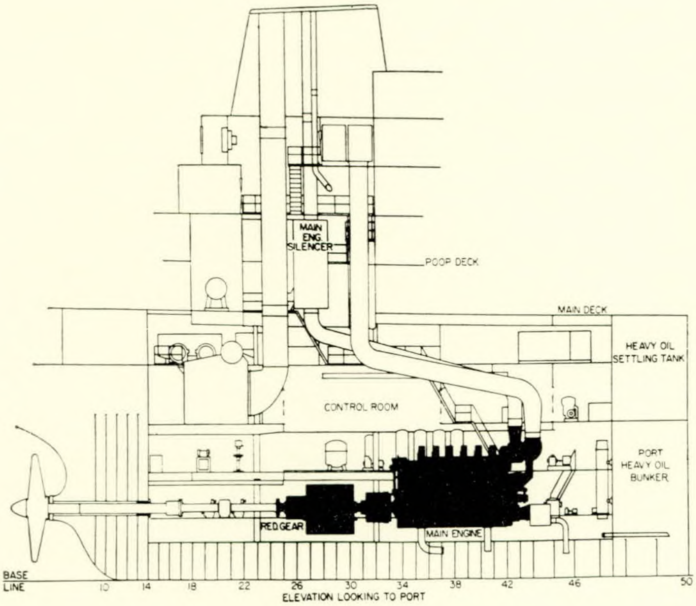
The main reduction gear is of the double helical two-plane design, i.e. the secondary pinions will be in the plane of the axis of the main wheel (first plane) and the primary pinions are arranged above their respective wheels (second plane). The reduction ratio is 5500/4500/80 and the diameter of the main wheel is about 16 ft. An a.c. shaft driven generator of 750 kW can be connected by means of a flexible coupling at the aft end of the secondary L.P. pinion at 600 rev/min.—*Shipping, September 1968, Vol. 57, pp. 26–27.*

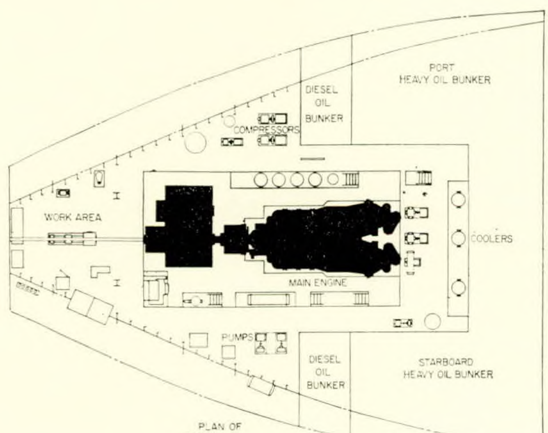
America's First Large Post War Motorships

In 1967 Falcon Tankers Inc. decided to order four 34 000 dwt motor tankers from Ingalls Shipbuilding Co., a division of the Marine Group of Litton Industries, and it was stated at the time that Fairbanks-Morse 38A20 engines of the new asymmetric opposed-piston design would be used in their first marine application.

The main power system for each ship will consist of one 12-cylinder direct-reversing 38A20 engine rated at 15 000 bhp at 450 rev/min driving a fixed-pitch propeller through reduction gears. The 38A20 engine was brought into production in early 1966 initially at 1000 bhp/cyl at 400 rev/min and is now rated at 1250 bhp/cyl at 450 rev/min. It has the highest cylinder power of any medium-speed engine in current production and is the most powerful Diesel made at present in the U.S.A.

The engines in this application are to operate on residual fuels and will have attached lubricating oil jacket water and raw water pumps. Fairbanks-Morse are responsible for the supply of the reduction gear, couplings, monitoring equipment and wheelhouse controls.—*Marine Engineer and Naval Architect, September 1968, Vol. 91, pp. 365–366.*





Machinery arrangement of Falcon tankers with side layshaft reduction gearing

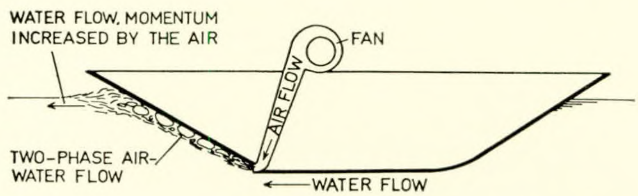
Two-phase Air/Water Propulsion System

Many ships are operating on the boundary of the two phases, air and water: they are using either water or air as a propellant fluid. In recent years a great deal of interest has been centred on the two-phase flow in connexion with airlift pumps, bubble contactors, pneumatic breakwaters etc.

Unfortunately very few studies have been made on the application of two-phase flow to ship propulsion.

The principle in question is presented in the figure. The thrust of this propulsion is a reactive force affecting to the inclined stern part of the vessel. A propulsion device is thus an essential part of the hull and therefore it is practically impossible to measure the thrust only.

Further the interaction of this device with the hull is totally different from the interaction of an air water ramjet propusion.



Principle of two-phase propulsion based on gravity effects

This device is working at least with low air flow rates inside the boundary layer and it does not change the potential flow picture, while an ordinary propeller is working partly outside the boundary layer and affects also the potential flow around the vessel. Thrust deduction is often considered as a reaction of the hull to the potential flow changes caused by the operation of a propeller. In this case it does not exist. On the contrary, the preliminary model tests have indicated that, at least in the tested hull form, the operation of this two-phase propulsion at higher speeds results obviously in the decrease of resistance. This is probably due to the decrease of the eddymaking resistance. Further, this propulsion is working mainly inside the boundary layer and the water which has been retarded by the friction is accelerated and thus the energy of frictional wake can be better regained.

The details of this propulsion are too obscure to permit an exact analysis of the problem. By applying dimensional analysis we can obtain guidance on the laws governing this system. — *International Shipbuilding Progress, September 1968, Vol. 15, pp. 319–327.*

Largest Ship Yet Built in Scandinavia

The first ship to be powered by Burmeister and Wain's new super large-bore Diesel engine type DM 7K98FF which has a maximum continuous rating of 27 500 bhp at 106 rev/min and a normal continuous rating of 25 000 bhp at 103 rev/min is *Bergebragd*, built by A/S Rosenberg Mekaniske Verksted, Stavanger, Norway, for Sig. Bergesen d.y. and Co. This vessel, with a deadweight of 156 680 tons, is the largest to be delivered from any Scandinavian yard up to the present time and is on a six year charter to the Japan Line for operation, carrying crude oil, between the Persian Gulf and Japan.

Principal particulars are:

Length, o.a.	956 ft $0\frac{3}{4}$ in
Length, b.p.	913 ft $4\frac{5}{8}$ in
Breadth, moulded	134 ft 10 in
Depth, moulded	80 ft 0 in
Draught, summer	62 ft $4\frac{5}{16}$ in
Deadweight at summer draught	156 680 tons
Gross tonnage	80 002·88
Net tonnage	61 442·28
Machinery output	
m.c.r.	27 500 bhp at 106 rev/min
n.c.r.	25 000 bhp at 103 rev/min
Normal service speed	$15\frac{1}{2}$ knots

The main pump room is situated between the engine room and the aftermost centre tank with a smaller pump room forward which contains an emergency fire pump and transfer pumps for bunker oil. Ventilation for the pump room is by means of two fans each with a capacity of 25 000 m^3/h. Cargo handling is by four vertical turbine-driven Eureka pumps type CBBX 18-22. Each pump has a capacity of 3500 m^3/h against a head of 125 m. The pumping turbines, each rated at 2250 hp, are placed on a platform in the engine room with shafts going through to the pumps in the pump room below. Two stripping pumps of the vertical reciprocating duplex type, each with a capacity of 350 m^3/h are installed.

The main engine, a new large-bore engine, is a seven-cylinder, two-stroke single-acting reversible Diesel engine type DM 7K98FF and is of welded design. The cylinder bore is 980 mm and the stroke 2000 mm. Normal service output is 25 000 bhp at 103 rev/min with a mean indicated pressure of 11·3 kg/cm^2. Maximum continuous rating is 27 500 bhp at 106 rev/min. The length of the engine is 16·83 m, its height 13·15 m and its weight about 1100 tons.

This engine drives a Lips six-bladed propeller of nickel-aluminium bronze having a diameter of 7·2 m and a weight of 34·5 tons. The pitch at 0·7 radius is 5·602 m and the blade area ratio is 0·688.

In the accompanying figures, curves are given which show the results of the trials of this ship in ballast and loaded conditions with the towing tank predictions of bhp and rev/min in the former.—*Shipping World and Shipbuilder, September 1968, Vol. 161, pp. 1478–1483.*

Twin-hull Multi-purpose Ship Design

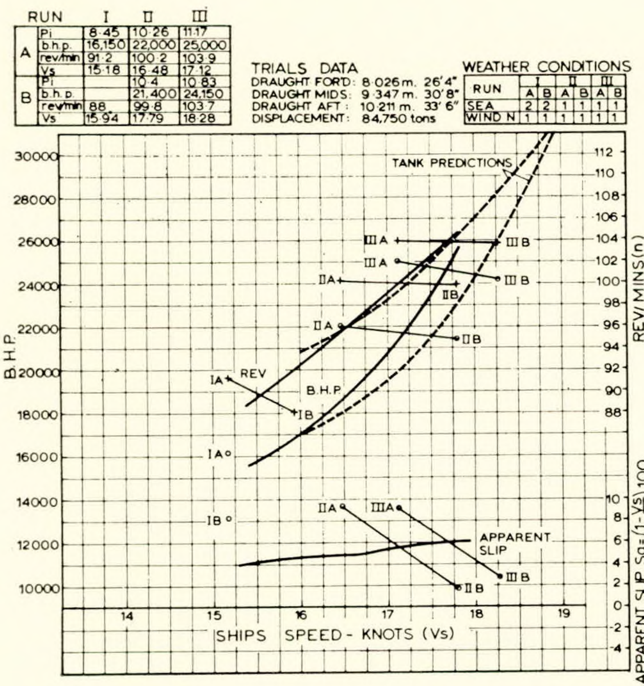
A new two-hull ship, the development of which was recently announced by Tesoro Petroleum Corporation, San Antonio, Texas, is designed to provide a self-propelled, floating platform for such offshore operations as drilling, dredging, or other marine engineering applications, or as a tender. This design also offers possibilities as a carrier for containerized cargo.

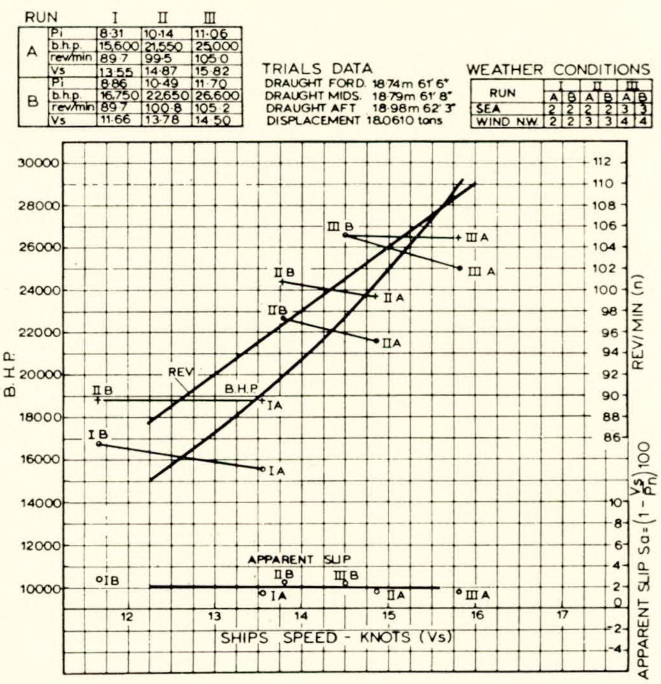
The ship now under construction has the following principal dimensions:

Length	133 ft
Width	57 ft
Depth	38 ft
Draught	17 ft
Displacement	1000 tons
Payload	500 tons
Platform	50 ft × 120 ft

Ships of this design offer several advantages compared either to conventional, single-hull ships, or to other types of floating work platforms such as are used for offshore drilling.

Based on model tests at Wageningen, the two-hull ship would provide a safe platform under conditions of Force 12 (Beaufort Scale) winds and waves running 50 to 60 ft. Pitch and roll are said to be confined to 2–3°. The orbit radius of surge and sway would be limited to about 2 per cent of the





Results of sea trials in ballast (left) and loaded (right) conditions for 156 680 dwt Bergebragd water's depth. Heave at the centre of the platform and at the sides are said to be the same and should vary from about 20 to 30 per cent of wave height, depending upon the size of the waves.

Normal platform motion is said to be very gentle: natural periods for rolling, pitching and heave are roughly 32, 25 and 18 seconds respectively.

By adding Voith-Schneider propellers to the normal propulsion equipment, precise dynamic positioning is possible. In practical terms, this means that it would be possible to keep the two-hull ship in position within tolerances required during drilling operations, to maintain the ship headed into the wind for continuing operations, or for more precise control of the ship when under way in ports, through canals, etc.

The ship's plant can provide a service speed of up to 10 knots, thus eliminating the need for towing. In addition, the dynamic positioning capabilities of this ship eliminate the need for assistance in manoeuvring in narrow channels, crowded harbours, etc. No power increase is needed when sailing in heavy seas as compared with smooth seas.—*Shipbuilding and Shipping Record, 27th September 1968, Vol. 112, p. 403.*

Swedish-built Tankers for British Owners

The first of a series of four oil tankers of 24 000 dwt has been built at Eriksbergs Mek. Verkstads AB, Gothenburg, for the BP Tanker Co. Ltd, London. This vessel *British Liberty*, is a multi-product carrier capable of transporting several different grades of oil at the same time. A series of three tankers of 19 800 dwt, the first to be built in Sweden for BP, was also constructed by Eriksbergs three years ago. The new ship has a six-cylinder Diesel engine giving service speed of about 14 knots. A control station has been provided for the remote operation of the cargo pumps and pump room valves. Remote control of the propelling machinery and some of the auxiliaries has also been provided.

British Liberty has been built to the highest classification of Lloyd's Register. Prior to the construction, self-propelled model tests were carried out in model tanks in the U.K. and Sweden to determine the optimum hull form for mean draughts of 30 ft, 24 ft and 18 ft, no trim at 30 ft and 24 ft draughts, and 6 ft trim at 18 ft mean draught. Tank tests were carried out with and without a bulbous bow—those carried out with a bulb being the more satisfactory.

Principal particulars are:

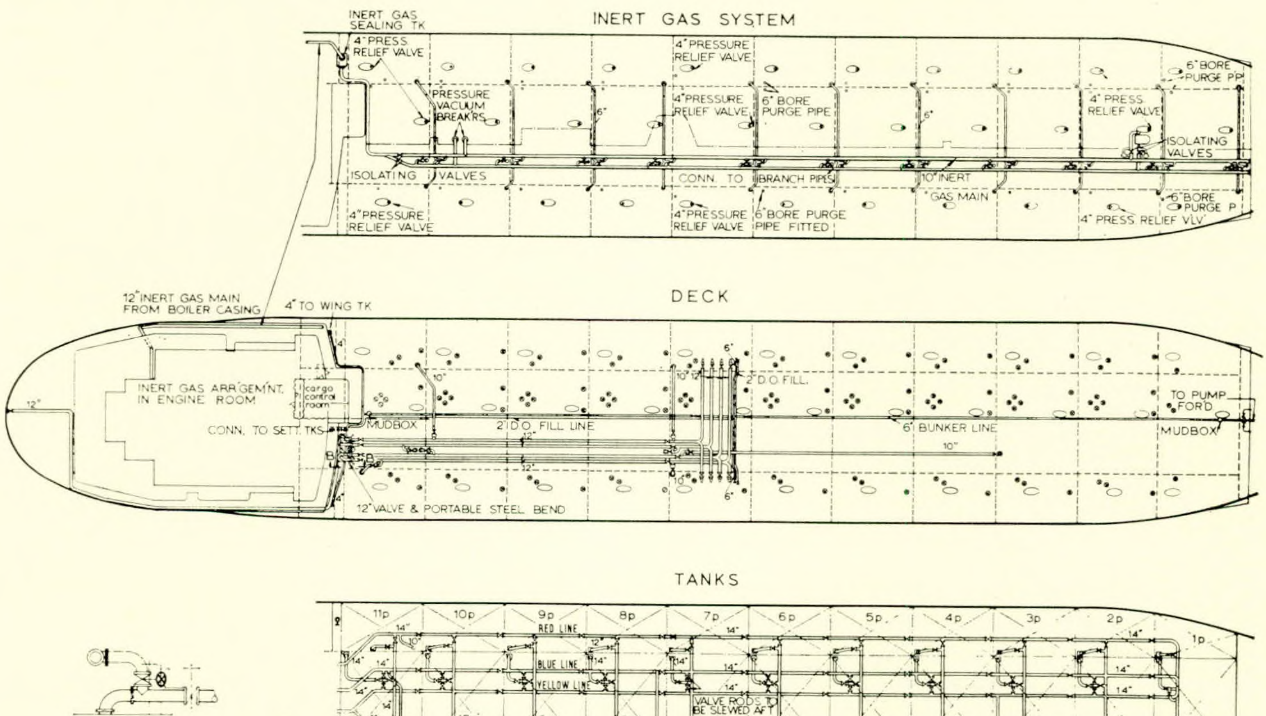
Length, o.a.	556 ft 6 in
Length, b.p.	525 ft 0 in
Breadth, moulded	81 ft 3 in
Depth to upper deck	41 ft 0 in
Draught, summer	31 ft 4 in
Deadweight	24 000 tons
Cargo tank capacity	1 152 855 ft^3
Machinery output	7500 shp at 117 rev/min
Service speed, about	14 knots

The propelling machinery in *British Liberty* consists of a six-cylinder turbocharged two-stroke Diesel engine having an output of 7500 bhp at 117 rev/min, and a bore and stroke of 740 mm × 1600 mm. Remote control from the engine room and also from the bridge has been provided.—*Shipping World and Shipbuilder, July 1968, Vol. 161, pp. 1067–1071; 1089.*

Canadian-built Train Ferry for Pacific Coast

A new self-propelled railway car ferry, *Haida Transporter*, has been built by Allied Shipbuilders Ltd., Vancouver, for the Kingcome Navigation Co., the marine subsidiary of MacMillan Bloedel Ltd.

The ship carries 26 40-ft railway cars on four tracks.



Inert gas and cargo piping system—Swedish-built tankers for British owners

She has a trim, streamlined appearance with the bridge and boat deck superstructure forming a span over the forward section of the rail car decks and with two wide profile funnels placed on each side towards the stern.

Principal particulars are:

Length, o.a.	326 ft 0 in
Length, b.p.	306 ft 0 in
Beam, moulded	55 ft 6 in
Depth, moulded	19 ft 0 in
Loaded draught	13 ft 0 in
Gross register	2553 tons
Deadweight	2800 tons
Machinery output	3100 bhp
Trial speed	14·6 knots

The propulsion machinery consists of two six-cylinder, Stork/Werkspoor type TM396 Diesel engines. Each engine is capable of developing 1550 bhp at 288 rev/min and is directly connected to a Stork/Werkspoor c.p. propeller. Two-station engine controls of the single lever type are located on the bridge and in the engine room. The electrical power is obtained from two 100 kW Canadian General Electric generators, each driven by a 225 hp Volvo-Penta model TD-100A Diesel engine. A bow thrust unit, controlled from the bridge, is driven by a Caterpillar D352 Diesel engine developing 320 hp at 1800 rev/min. A number of special features are incorporated in the ship as, for example, electric drive for all the engine services including the salt water circulating pump, the fresh water and lubricating oil pumps and the fuel pumps.

The most notable feature is the special ballasting system that is used to trim the ship for the loading and unloading of railway cars by the bow. This consists of ballast tanks located forward and aft with a total capacity of 1200 tons equipped with air-operated valves, remotely controlled from the engine room, directing the discharge of a 6000 gal/min propeller-type Sturtevant pump driven by a Caterpillar D333 Diesel engine.—*Shipbuilding and Shipping Record, 27th September 1968, Vol. 112, p. 393.*

First Manises-Sulzer Engine

At the Manises Works (Valencia) of Astilleros de Cadiz, S.A., the first Manises-Sulzer 12 RD 90 27 600 bhp engine has been put into service. It is, so far, the most powerful engine built in Europe and the second most powerful in the world.

This one built in Spain is destined for a VLCC of 151 000 dwt at present under construction at the Cádiz works of Astilleros De Cadiz, S.A., for Fletamientos Maritimos, S.A. (Marglet).

The bench plate is of the plain welded type bolted on the ship's double bottom and weighs 127 tons.

The crankshaft is of the semi-armoured type with massive cranks, each weighing 9460 kg net. The crankshaft diameter is 680 mm and is divided into two pieces: each half crankshaft weighs about 84 tons, whilst the whole assembly, including the thrust axis, flywheel, etc., weighs 202 tons. At the crankacse bow end a Holset vibration dampener weighing 9700 kg has been arranged; the necessary flywheel located at the opposite end weighs 11 200 kg.

Each cylinder-block, with its jacket, studs, etc., weighs 15·2 tons, whilst the block assembly with its shields, intermediate pieces weighs 246 tons.

The weight of a whole alternative gear, i.e. the piston, stud, cross-head, connecting rod and bearings assembly is 10·2 tons. That of the complete cylinder head is 2714 kg and that of a single injector 37 kg.

The regulation and remote control elements have been arranged in a sound-proofed cabin in the ship's engine room. Efficient control is assured from the desks containing all indicating and repeating instruments for all important measure points to be supervised.

The remote control equipment is of the pneumatic low-pressure type.—*Tanker and Bulk Carrier, September 1968, Vol. 15, p. 297.*

Cargo Motor Vessel for Heavy Lifts

The cargo motor vessel *Stella Nova* recently entered the service of her owners, Rederij "Stella Maris", of Rotterdam. *Stella Nova,* which combines heavy masts and derricks with a single large hatchway, is not only unusual from the point of her appearance, but also for the special arrangements she incorporates.

The cargo gear consists of two derricks each of which can lift 50 ton loads at a length of 21 m and an angle of 25°. The arrangement of the gear is such that the derricks can be topped and slewed at the same time, which enables them to be worked like cranes. For this purpose three winches are installed per derrick—one cargo winch and two topping/slewing winches which can be operated from a central position. As the winch speed adjusts itself automatically to the load, no special measures are needed when light loads are to be worked. In addition, a separate runner system for low weights is available for the rapid handling of general cargo.

The cargo winch and the topping/slewing winches are of Hydraulik Brattvaag manufacture. The cargo winch has a pull of approximately 9 tons on a single wire, while the topping/slewing winches have a pull of approximately 8½ tons. The cargo winch is provided with four speed steps which ensure that speed increases when lighter loads are handled; the speed of the empty hook is then even more than six times the full-load speed. The speed steps engage automatically while speeds continue to be controllable between zero and the maximum. A similar arrangement has been adopted for the topping/slewing winches, which have three speed steps.

Other "Hydraulik" deck machinery includes a windlass for 34 mm high-grade steel studlink chain cable and a 3-ton capstan, while the topping/slewing winches can be used as mooring winches. The winches are driven by two electro-hydraulic pumpsets each developing 57 hp.

Principal characteristics are:

Length, o.a.	75·05 m
Length, b.p.	67·50 m
Breadth, moulded	13·40 m
Depth, u.s. keel	6·97 m
Tonnage draught	3·84 m
Corresponding deadweight ...	1285 tons
Maximum draught	5·05 m
Corresponding deadweight ...	2510 tons
Grain capacity	125 200 ft³
Main propelling machinery:	
Werkspoor Diesel engine type TEBS 296 of ...	1500 hp at 500 rev/min

Speed on tonnage draught, approximately 13 knots

To limit the list occurring during the handling of heavy lifts the ship is provided with heel-correction tanks in the wings. Filling and emptying of the tanks or transferring the contents of the tank during cargo handling operations can be effected from the wheelhouse. For this purpose the wheelhouse is provided with remote control facilities for the pump, four pneumatically operated valves in the engine room, and a clinometer. An all-station loudhailer installation is provided for hailing the two winch stations simultaneously.

The main propulsion machinery consists of a Werkspoor Diesel engine type TEBS 296, a direct-reversing two-stroke supercharged engine with a continuous output of 1500 hp at 500 rev/min. The engine is flexibly coupled to a Tacke reduction gear-box with reduction 2:1 and drives a Van Voorden four-bladed manganese bronze propeller with a diameter of 2600 mm. The main engine is provided with a Werkspoor fully automatic pneumatic remote control system and is suitable for unattended operation.—*Holland Shipbuilding, July 1968, Vol. 17, pp. 32–34.*

Japanese Container Ship

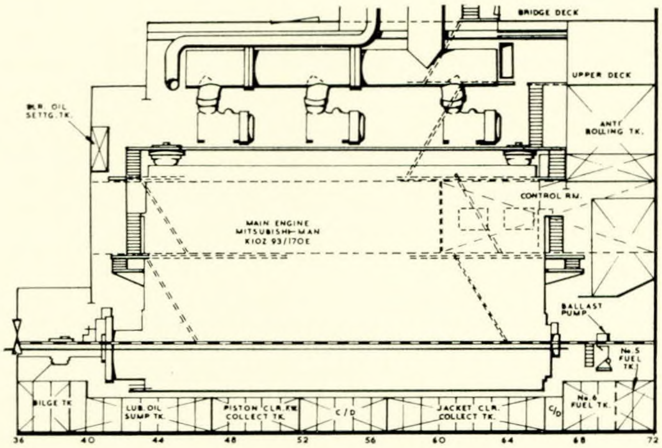
Nippon Yusen Kaisha (N.Y.K. Line), Tokyo, has commissioned the first Japanese full container carrier. Named *Hakone Maru*, the 16 300 dwt ship was built at the Kobe shipyard of Mitsubishi Heavy Industries. *Hakone Maru* is, to date, the world's largest non-American ship using the lift-on/lift-off system together with cellular construction in the holds and has entered service before the much-publicized European ships of similar and larger size.

The ship has inaugurated a new Trans-Pacific service between the Japanese ports of Kobe and Tokyo and North American terminals at San Francisco and Los Angeles. The first ship has now been joined by *Haruna Maru*, a sistership jointly ordered at the Kobe yard by N.Y.K. and Showa Kaiun Kaisha. Each ship has a container capacity for 752 ISO 20 ft units and will be able to complete one round trip in 28 days, of which the transit time between the U.S.A. and Japan will be 8½ days.

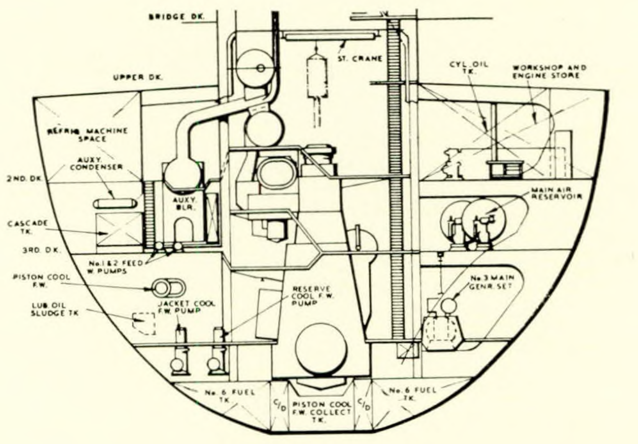
The power required to maintain a fully loaded service speed of 22·6 knots (26 knots maximum trial) is provided by a M.A.N. K10Z93/170E engine built under licence by Mitsubishi at its Yokohoma engine works. The unit, rated at 27 800 bhp at 115 rev/min, is equal to the highest powered installations of this design of engine afloat to date. In service, the engine will be run at 109 rev/min at 23 600 bhp.

To obtain optimum container stowage in the parallel body of the hull, the machinery space has been placed fairly far aft and because of the relatively high installed power for a vessel of this size, special measures have had to be taken to prevent vibration. The limited space in the engine room is well shown in the elevation view in the accompanying machinery layout drawings.

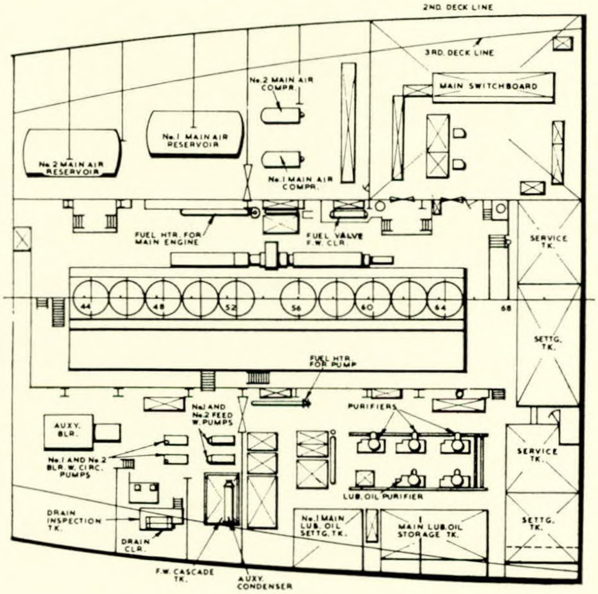
In keeping with the modern concept of the vessel, a machinery control room is provided whence main and auxiliary machinery can be remotely controlled. Indicators and alarms for the lubricating oil and cooling fresh water for the main engine, fuel transfer and purification systems, generators, compressed air, auxiliary boiler, container refrigeration plant and bilge systems, are also provided in the control room.—*Motor Ship, October 1968, Vol. 49, pp. 333–336.*



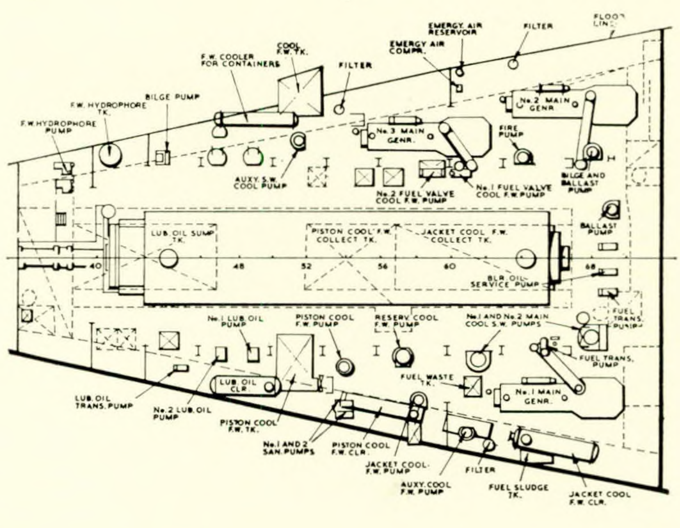
ELEVATION



FRAME 60 LOOKING AFT.

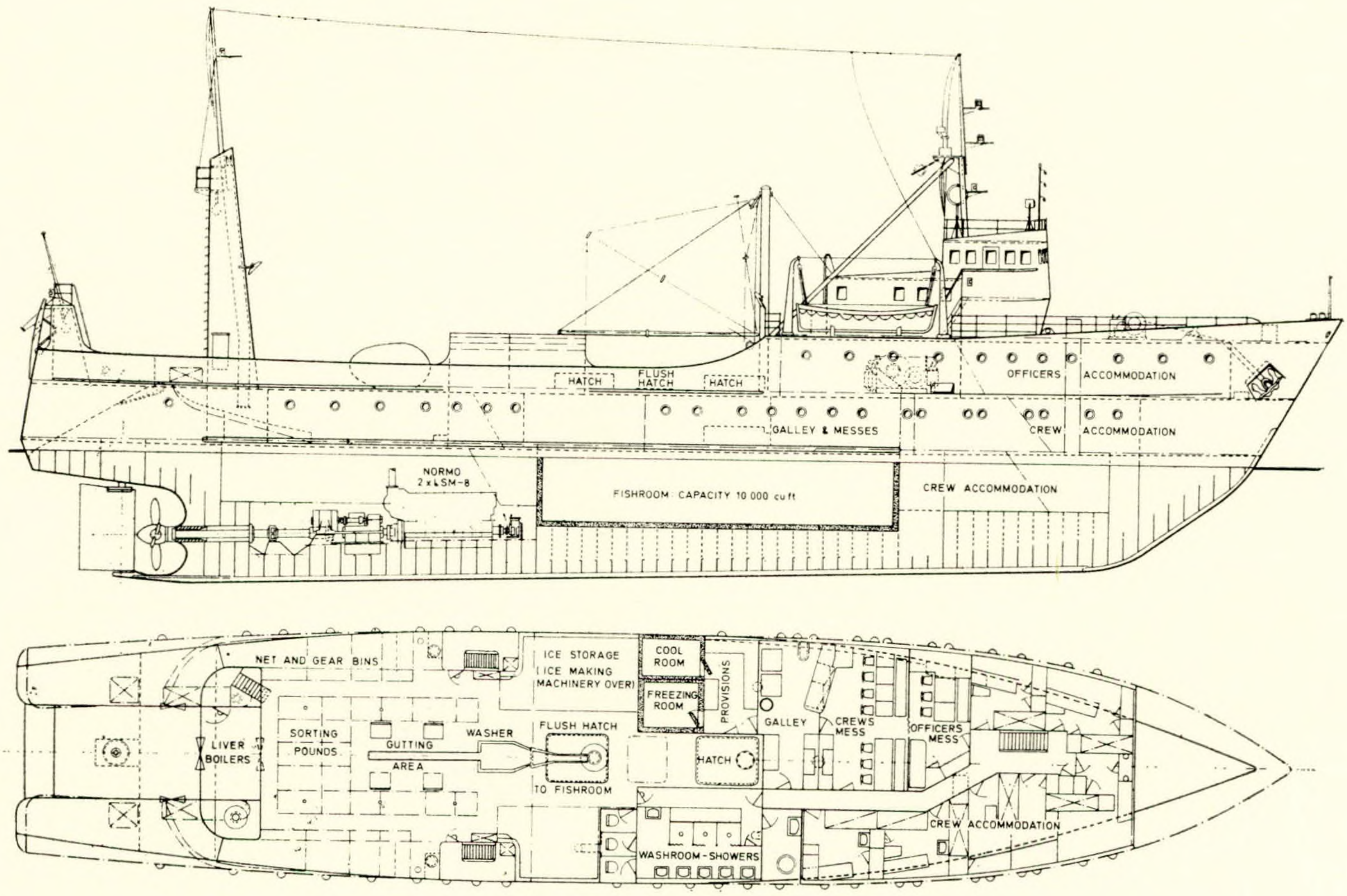


3RD. DECK PLAN



LOWER FLOOR PLAN

Machinery arrangement drawings of the 27 800 bhp Mitsubishi—M.A.N.—engined ship Hakone Maru



Stern trawler for Greenland

Stern Trawler for Greenland

The Royal Greenland Trading Co. which has its headquarters at Copenhagen, is to have a 164 ft stern trawler which will operate out of Godthaab. The purpose of the vessel is to ensure a supply of fresh fish to the filleting and processing stations on shore, with a secondary role of salting the catch if required.

The calculation of the ship's dimensions and layout were entrusted to Bergens Mekaniske Verksteder of Bergen, who used computer techniques to select the optimum characteristics for the job the ship would have to do and the area in which it would have to do it.

The tonnage selected was 499 tons gross and a length, o.a. of 164 ft, with a beam at main deck of 31 ft, and depth to main deck of 15·1 ft. The vessel would have two decks, a main deck and trawl deck, with stern ramp aft and two fish hatches to the processing area below.

The working space on the main deck provides for fish to be sorted before being placed in cleaning bins, whence they are taken to the gutting tables. After further washing, they are iced and packed in boxes for stowage in the hold, which has a capacity of 2800 aluminium fish boxes.

Below the main deck, aft, are the after peak and stern tanks and cabins for eight men.

Special consideration was given to the engine arrangement, since the vessel will be used for both bottom and midwater trawling. It was considered that the power required to tow a bottom trawl in moderate weather conditions at three knots would be 700 hp, but that required to tow a pelagic trawl at five knots in all weather up to Force 7 would be nearer 1900 hp. If a single engine installation were used, it would be working below optimum revolutions when bottom trawling and for this reason, two similar engines were decided upon, each to be of about 1100 hp so that a bottom trawl could be towed with one engine. In order to economize on space, the generators and the oil pumps for the hydraulic winch will be driven from the main engines, each being capable of carrying normal load independently.

The engines recommended were LSM8 Normo Diesels, each developing 1100 hp at 750 rev/min and driving a single four-bladed c.p. propeller at 195 rev/min to give a speed of 14·5 knots, or 12·5 knots on one engine.

The Norwinch hydraulic trawl winch has been arranged for use with twin engines and has two hydraulic motors.—*World Fishing, November 1968, Vol. 17, p. 33.*

Sea Bed Grading Vessel

Mitsui Shipbuilding and Engineering Co. Ltd. has recently delivered the sea bed grading vessel *Kinryu Maru* to a local harbour construction bureau of the Japanese Ministry of Transport.

Principal particulars are:

Length	124 ft 8 in
Breadth, moulded	32 ft 10 in
Depth, moulded	14 ft 9 in
Draught	11 ft 2 in
Gross	540 tons
Service speed	10·3 knots

Believed to be the first of its type in the world, the vessel is designed to level the sea bed by means of a blade attached to extending arms on each side of the hull. As the vessel moves through the water, the blade scrapes and levels the sea bed. It is able to work at depths down to 59 ft at a speed of one knot.

Both the blade angle and digging depth can be remotely controlled from the bridge to suit the conditions of the sea bed. The blade is 32 ft 10 in wide and is designed to dig up to 328 ft/min in Nagoya port, although trials have shown it to be capable of digging up to between 984 and 1640 ft/min.

Unevenness in the sea bed can be checked by a vertical section type 200KC multipoint phonometer together with a twin element phonometer of the same type, readings of which are given on screens on the bridge. In addition, a television system is provided to give a visual picture of the undulations of the sea bed.

Kinryu Maru is fitted with Decca Navigator equipment to enable her to be located at the exact working position. In addition, the vessel incorporates all the necessary equipment for navigation in coastal waters.

The propulsion machinery comprises two Mitsui-B. and W. 628VBF-50 Diesel engines each having a maximum continuous output of 1100 hp.—*Shipbuilding International, August 1968, Vol. 11, p. 49.*

World's Most Powerful Voith-Schneider Tug

The world's most powerful Voith-Schneider propelled tug was recently added to the fleet of the N.V. Nieuwe Rotterdamse, Sleepdienst. *Indusbank*, is equipped with two Voith-Schneider propellers and powered by two Werkspoor Diesel engines with a combined power of 3400 hp. The ship is stationed at Europoort to assist the largest tankers in operation. At the same time *Indusbank* is equipped to perform salvage operations on the North Sea. The new tug is the ninth ship in the company's fleet, which consists of six VS-tugs with powers ranging from 1250 to 3400 hp and three screw-propelled tugs with outputs from 1250 to 1650 hp.

Indusbank has been built by the N.V. Scheepswerven v/h H. H. Bodewes, Millingen-on-Rhine.

Principal characteristics are:

Length, o.a.	36·50 m
Length, b.p.	33·50 m
Breadth, extreme	11·20 m
Breadth, moulded	10·80 m
Depth	3·80 m
Draught	4·60 m

Main propelling machinery:
Two Werkspoor Diesel engines,
each developing 1700 bhp at 1000 rev/min

The ship is powered by two 12-cylinder single-acting Werkspoor Diesel engines, type RUB 215 × 12 each developing 1700 bhp at 1000 rev/min. The two Voith-Schneider propellers have diameters of 3·20 m and blades of 2 m in length. The positioning of the propellers is such that they give the ship a particularly high manoeuvrability, while the danger of capsizing when assisting ships is practically eliminated. The propellers are driven via Tacke gear and liquid couplings. The Norwinch towing winch is of the type S-250 and has two drums each for 500 m of steel wire of approximately 6 in. The drums have a diameter of 950 and 1750 mm, respectively and a length of 750 mm. The winch is provided with brakes calculated for and adjustable at 100 tons pull on the wire when the brake starts to slip. The brakes are provided with servo hydraulic remote control. One warping head is arranged on the port side. It has a diameter of 1000 mm and is provided with ribs.—*Holland Shipbuilding, July 1968, Vol. 17, pp. 48–49.*

Catamaran Stabilizing Fin

A 60 per cent reduction in vertical acceleration at the forward end and a 40 per cent reduction in pitch is claimed for a sea-going catamaran fitted with a new type of hydrofoil, for which patent application has been made, developed by the National Physical Laboratory. The device can also sharply reduce, or even eliminate, slamming on the span deck.

The probable reason for the comparative lack of adoption of the catamaran form for a variety of ship types, such as ferries, container, mooring, survey and research vessels, is the lack of resistance to pitching, particularly when driven fast into head seas.

N.P.L. research has shown that a submerged hydroil span forward, between the hulls, has a considerable curative effect. Tests on a model of a 220-ft length overall by 68-ft beam overall sea-going catamaran, moving at 14 knots into a head sea of 12·5-ft significant height, suggested these reductions:

Heave	6 per cent
Pitch	42 per cent
Forward acceleration	58 per cent
Aft acceleration	18 per cent

In addition, slamming pressures on the underside of the span deck forward were reduced to a barely perceptible level—from 20 lb/in^2 down to 5 lb/in^2.

In calm water the fin produced a small increase in resistance, equal to a speed reduction of 0·35 knot in the full size vessel. In head seas of force 5–6, however, an approximate gain of 0·6 knot pertained. On a typical coastal passage a net overall average increase in speed of 0·15 knot, due to the fin, is estimated.

The fin, in addition to its hydrodynamic advantages, adds considerably to the structure of a catamaran, sharply reducing the racking stresses when advancing in oblique seas.—*Shipbuilding and Shipping Record, Vol. 112, 20th September 1968, p. 370.*

Greenland Ferry

Built by Svendborg Skibsvaerft to the order of Northsea, Copenhagen, for service in Greenland water, *Disko* is a single-screw passenger vessel, ice-strengthened with ice-knife at the rudder and ice-fins protecting the propeller.

Principal particularls are:

Length, o.a.	231 ft 4 in
Length, b.p.	206 ft 8 in
Breadth, moulded	44 ft 4 in
Depth to m.d.	18 ft 4 in
Depth to pron.d.	26 ft 3 in
Draught, maximum	13 ft 10 in
Deadweight	610 tons

The father and son propulsion installation comprises two unidirectional M.A.N. Diesel engines, a nine-cylinder G9V 30/45 ATL 1910 bhp at 500 rev/min father and a seven-cylinder G7V 23·5/33 m.A.L. son unit turning a four-bladed 8 ft 6 in-diameter stainless steel KaMeWa 79S/4 c.p. propeller through Vulcan elastic couplings, pneumo-hydraulically operated disc couplings and a Renk A5L 114/110 two-into-one reduction gear-box. An AEG type DKL 5112/10 MoD 320 kW 380 V three-phase 50 c/s alternator is interposed between the son motor and the gear-box.

A four-bladed 4 ft 3 in-diameter KaMeWa propeller, powered by a 400 hp AEG squirrel cage motor, is set in a tunnel forward and provides a transverse thrust of 4·5 tons.

This installation offers the following operational alternatives:

1) normal on voyage working with both father and son engines providing a speed of 14 knots;
2) normal manoeuvres with the father engine turning the main screw and the son unit driving its generator to power the bow thrust unit;
3) emergency operation by either father or son engine providing speeds of 13·2 or 8·5 knots respectively; the son unit, in such circumstances, may be supplemented by its generator, operating as a motor supplied with current by one of the auxiliaries, to give a speed of 9·8 knots;

4) in the event of a failure of the auxiliary generators the board may be supplied by the shaft generator driven by the son engine; in this case the father engine provides the propulsive power and the bow thrust unit may not be used.

—Shipbuilding and Shipping Record, 2nd August 1968, Vol. 112, pp. 163–164.

American Vessels with Heavy-lift Gear

The installation of three 120 ton capacity cargo booms aboard *Transcolorado* gives her and her sistership, *Transcolumbia*, the greatest single and combined lifting capabilities of any vessels in the U.S. merchant fleet.

Transcolorado is one of two C-4 troopships under a ship conversion contract from Hudson Waterways Corp., New York, an affiliate of Seatrain Lines, Inc. Each of the two ships has the unique capability to load and stow four LCU landing craft. Extra large hatches and high headroom lower decks permit stowage of the heaviest military tanks, construction machinery, railroad locomotives and outsize equipment.

Of German design, each of the Stuelcken cargo booms is 100 ft long and weighs 45 tons.

Two 296 ton capacity water ballast tanks were installed on the port and starboard sides amidships, and can hold the vessels' lists to within a recommended operating limit of 12°. The tanks are served by newly installed rapid pumping systems.

The Stuelcken booms are made of high-tensile steel and all the heavy lift bearings, wire rope sheaves, gooseneck pin sockets and span swivels are equipped with anti-friction bearings. Each boom is rigged with 5500 ft of $1\frac{1}{4}$-in wire rope. It is not unusual, according to the manufacturer, for Stuelcken cargo gear of this design to operate for at least four years before any maintenance is required.

Each boom is served by four Westfalia Lunen heavy cargo winches, arranged in pairs (one cargo and one span), one above the other in each kingpost.

Each of the winches is remote-controlled by a portable control box with two hand levers. Each lever controls one topping and one cargo winch simultaneously so that one operator can control four winches at a time. Lever operation corresponds with boom movement. Each boom is equipped with an electric winch load indicator showing the working load being handled. The booms have a maximum reach of 50 ft over the side.*—Maritime Reporter/Engineering News, 15th August 1968, Vol. 30, p. 14.*

Steam Propulsion Systems

The steam plant as it has developed over the years consists of an assembly of discrete functional components. Since many of these components are shared in application with the larger power generation industry, a flexibility of application has resulted which generally has allowed an infinity of combinations to suit the constantly changing needs of the shipbuilding industry.

Propulsion turbines can be provided in a wide variety of shapes and sizes to suit all conceivable needs, ranging from small single casing units for low powers to cross compound machines with multiple exhausts for capacities beyond today's needs.

The single casing unit with all of the steam path including the astern turbine on the same shaft is practical and economic for ratings somewhat in excess of 10 000 hp. Beyond this level, cost and performance factors favour a cross-compound arrangement with a high speed, high pressure turbine and a slower running, low pressure turbine, each contributing about 50 per cent of the total power.

As power requirements increase, the low pressure end becomes a limiting factor. The exhaust volume flow becomes very large, requiring longer and heavier last-stage blades. Excessive centrifugal stresses are avoided by reducing rotating speeds, a satisfactory procedure until an uneconomically low speed is reached as power ratings are further increased. Beyond this point, double flow, low pressure ends would be provided, wherein the flow is divided and passed through turbine stages in parallel. With last stage designs now available and in service, single-flow exhaust ends can be provided well beyond 50 000 hp.

The steady growth in propulsion engine power has been matched by extensive development in main reduction gears. Functionally, the reduction gears permit accurate matching of the widely separated speed-power characteristics of the turbine and propeller. The gear also provides flexibility of arrangement for both single and multiple casing turbines to conserve both space and weight. As the main engine power has increased, an additional requirement has been added to the gear to provide appropriate power takeoffs for some of the larger auxiliary equipment.*—Rohde, E. C. and Spears, H. C. K., Maritime Reporter/Engineering News, September 1968, Vol. 30, pp. 22; 25–26.*

Safety Features of Freedom Ships

Of the 50 vessels of the Freedom class of Liberty ship replacement believed to be ordered to date, some 10 ships are now in service and, appropriately, the builders, Ishikawajima Heavy Industries, have issued information at the request of owners, charterers and underwriters, which describes the main safety features of the ships.

The Freedom ships do not have a forecastle deck but have extra sheer on the forward part of the main deck. This arrangement is claimed to be structurally stronger than a ship with a conventional forecastle deck. The additional water ballast tank capacity created below deck, provides more buoyancy forward and has added safety in the event of damage. Only a rope store and a compartment for the windlass electrical gear are located forward, an arrangement which is said to reduce stores handling hazards and which also avoids frequent exposure of crew on the main deck forward during bad weather, as the storerooms and deck workshop are located in the mast houses.

All supply lines for fire and washdeck, steam and exhaust and compressed air lines, as well as electric cables, are fitted below the main deck to reduce maintenance repairs and the possibility of heavy weather damage. The washdeck line, located in the wing tanks, is not so susceptible to frost and thus eliminates one of the common causes of damage to cargo.

The water ballast capacity of the Freedom design is claimed to be 20 per cent greater than that normally available on ships which have 'tweendecks. This feature reduces pounding in heavy seas and ensures steerage and course stability when in a ballast condition. When empty, of course, the ballast tanks provide a corresponding amount of additional buoyancy which serves as further protection against foundering following a collision or grounding.

All water ballast is carried in separate tanks none of which is required for alternate use as cargo space. This feature eliminates the need to deballast partly prior to arrival at a loading terminal. Also, ventilation of cargo spaces can be properly maintained. All water ballast can be discharged in nine hours—a salient factor should flooding occur after collision damage. The main ballast tank valves and the entire ballast suction system are accessible in both loaded and ballast conditions.

The turning circle of a Freedom vessel is four ship lengths, which is said to be less than normal for a vessel of similar type and size. A gyro auto pilot and bridge control of the main engine are fitted.

Main engine manoeuvring is facilitated by an air-operated combined clutch and coupling system between the engine and the main gearing. Only when requiring to go astern must the engine be stopped and reversed. It is also possible to warm up and check the main engine before leaving port without the danger which would occur in so doing with a direct-coupled engine.—*Motor Ship, October 1968, Vol. 49, p. 323.*

Largest Afloat Joining Operation

The largest single hull joining operation ever undertaken afloat was completed when the fore and aft bodies of the 210 000 dwt tanker *Melania* became one hull at the Amsterdam shipyard of the Netherlands Dock and Shipbuilding Co. (NDSM). The first in a series of three M-class tankers for the Shell Group and another similar vessel for A. P. Möller, *Melania* is the largest vessel yet to be built in Holland.

Much thought and caution preceded the joining of the hull while afloat, which was carried out by both external and internal welding and not, as in the case of a method used by one Japanese yard, by internal one-sided welding.

After the two parts of the hull were ballasted to the same draught, a specially designed fabricated steel caisson was lowered by blocks and tackles into the water in the intervening gap which was initially about 5 m. The caisson was then further lowered until it was partly beneath the foremost edge of the aft body. The two hull parts were then pulled together until they were exactly 7 mm apart—the gap required for welding. At this stage the centre portion caisson was supported from above by six steel flat bars each 5 mm in thickness, thus allowing them to pass between the two hulls.

The water in way of the join, some 1200 tons, at a draught of 5 m and a distance between the watertight transverse webs of 5 m and the ship breadth of 50 m, was then pumped out. This resulted in outside water pressure pressing the rubber-sealed caisson firmly against the external surfaces of the hulls. A similar effect took place longitudinally, the hulls being maintained at the prerequisite distance apart by three sets of multi-rams, one set on deck and two sets on the bottom plating. Three locating sockets were also provided to facilitate alignment. A further precaution was the very accurate ballasting of each body to ensure a level trim, thus eliminating any vertical stresses. Welding was then carried out from both sides, the caisson being about 5 ft deep internally.

From the foregoing, it can be seen that the joining operation was completed with great care and accuracy and, regarding the latter aspect, it should be mentioned that a laser beam, directed through a series of check points on the upper deck and then through a revolving prism to obtain a right angle check on the plane to be joined, was used on each hull before and after launching.—*Motor Ship, October 1968, Vol. 49, pp. 328–329.*

Boeing Hydrofoil Gunboat

The American Navy has been investigating the possibility of modern hydrofoil craft for some years, and recently sponsored a design competition that has produced the Boeing designed hydrofoil gunboat, PGH2 *Tucumcari*.

The Boeing design is perhaps the most advanced at present in existence. Built as an entry in the U.S. Navy design competition, the vessel is 71 ft long, displaces 57 tons and, though the speed has not been announced, can be judged to have a maximum in excess of 50 knots in still water. Propulsion is by water jet, the jet pumps being driven by a single Bristol Siddeley Proteus marine gas turbine. An interesting comparison here is the Vosper Thorneycroft *Perkassa* class gunboats, which are planing vessels of comparable size and need three Proteus to achieve a speed of 50 knots.

The foil system is interesting and of a very advanced type, incorporating many innovations. Three sets of foils are used, two which carry the main weight of the vessel and one forward which is steerable. All the foils and struts are made of steel, are very thin and have a high aspect ratio. There are control surfaces on the rear of all foils and the rear two sets have a marked anhedral, as well as carrying the propulsive water jet intake.

The advantages of using anhedral foils are two-fold, firstly they improve directional stability by providing a side force that is not affected by surface air entrainment or foil exposure in rough seas and secondly, during high speed manoeuvres when the vessel banks steeply, the tips of the after foils will not break the surface.

This is the first time that anhedral angles on foils have been used and if they fulfil expectations we can expect to see a wide use of the principle, for foil exposure and air entertainment/ventilation has been a problem of hydrofoil designers for many years.

In common with other fully submerged foil designs, steps have been taken to provide automatic stabilization in wave conditions. This takes the form of a sophisticated system of ship attitude and motion sensors, together with command signal devices which feed information into a central computer which transmits command signals to a servo system that hydraulically operates the foil control surfaces. No details of this system have been released, but it can be assumed that the sensors feed information on vessel motion and control commands to the computor which evaluates it, predicts the wave frequency and the vessel's reaction to commanded manoeuvres and produces control signals that ensure that the hull remains relatively horizontal by operating the foil control surfaces to vary the amount of lift. This is directly analogous to an aircraft's automatic pilot which operates the control surfaces of an aircraft to maintain stability in disturbed air by sensing accelerations in the various planes of movement.

The water jet propulsion system used in the PHG2 has eliminated the need for gear-boxes, shafting and allied systems that would be required if propellers were used.

One 3200 bhp Proteus is used to drive two centrifugal pumps for high speed foil-borne operation, a small Diesel engine driving a smaller pump for use at low speed off-the-foils operation.

Water is drawn into the pump through intakes mounted in the leading edges of the rear foils, from there it passes into the pump and is ejected through two jets under the stern at a rate of 100 tons/min at full speed. The jets can be vectored or reversed for steering or reverse, though it can safely be assumed that reverse cannot be engaged when operating on the foils.

An unusual feature of this craft is the retraction of the foils during hull-borne operation. This considerably reduces the risk of foil damage during berthing, enables the vessel to operate in shallow waters as a conventional displacement boat and reduces the time that the foils are submerged, cutting down the extent of fouling and corrosion.

The after foils retract by hinging the struts outwards and up through approximately 180°, the forward foil strut hinging forward some 90° and entering a slot in the bow. The slot incorporates doors that close to present a faired surface when the foil is extended or retracted.

The hull is constructed entirely of welded aluminium using a conventional former and stringer method. The use of this system has kept the weight of the hull down to the very low figure of 10 tons.—*Clark, A., Design Engineering, October 1968, pp. 49–50.*

Propeller Lifting-surface Corrections

Correction factors for camber, ideal angle due to loading and ideal angle due to thickness, which are based on propeller lifting surface theory, are presented for a series of propellers. The results of the calculations show that the three-dimensional camber and ideal angle are generally greater than the two-dimensional camber and ideal angle at the same lift coefficient.—*Morgan, W. B. and Denny, S. B., 13th–16th November 1968, S.N.A.M.E. Paper No. 10.*

Interaction of a Sloshing Liquid with Elastic Containers

The coupled oscillations of a liquid partially filled container having an elastic bottom or elastic walls have been studied. The effect of flexibility of the bottom of a rectangular tank shows a reduction of natural frequencies of the system. For a cylindrical container the frequency increases with wall thickness and exhibits lower values for larger liquid heights. —*Bauer, H. F., Hsu, Teh-Min and Wang, J. T., 6th–9th May 1968, A.S.M.E. Fluids Engineering Conference, Paper No. 68-FE-20.*

Friction and Wear Testing Machines to Evaluate Lubricants

Friction and wear are complex phenomena. In the past, absolute answers to specific friction, wear and lubrication problems have not been readily obtainable in the laboratory. Nevertheless, increased awareness of the factors influencing these complex phenomena combined with increasingly sophisticated friction and wear testing instruments are making laboratory tests more meaningful. This paper discusses the problems and pitfalls of laboratory testing for friction and wear and describes a number of machines used today to provide more significant laboratory results.—*Azzam, H. T., Lubrication Engineering, August 1968, Vol. 24, pp. 366–376.*

Independent Solution for Piston Gas Compression

The author presents a new comprehensive equation for the "compression efficiency" of a piston compressor. Based upon the geometric ratio of the piston to valve area and the physical properties of the gas, it is also related to the sonic velocity created at the point of minimum restriction. The new analysis makes it possible to evaluate the intensity of the suction and discharge pulsation and the power loss. Also, it gives a more accurate projection of the discharge temperature.—*Scheel, L. F., 6th–9th May 1968, A.S.M.E. Fluids Engineering Conference, Paper No. 68-FE-46.*

Effect of Container Capacitance on Thermal Transients in Plane Walls, Cylinders and Spheres

The effect of container capacitance on the thermal response of plane walls, infinite cylinders and spheres subjected to sudden changes in ambient temperature is analysed. A series solution is presented for each geometry which can be obtained by the method of separation of variables. The first three eigenvalues necessary for the numerical evaluation of the series are tabulated for each configuration.—*Kotecki, D. J., 11–14th August 1968, A.S.M.E. Heat Transfer Conference, Paper No. 68-FE-18.*

Work of Thrust Bearings with Spiral Grooves on the Force Pump Rotor

Experimental and theoretical analysis of the work of the thrust bearings with spiral grooves cut on the blower rotor show that bearings with a packing surface have the highest load-carrying capacity. At high rotational speeds small changes of the lubricant medium pressure do not influence the load characteristics upon the bearings.—*Lochmatov, A., 17th–20th June 1968, A.S.M.E. International Symposium on Gas Lubrication and Exhibition, Paper No. 68-LubS-20.*

Investigation of Externally Pressurized Steam-lubricated Journal Bearing

This paper reviews the progress of experimental studies of externally pressurized journal bearing operation. Its purpose is to point out the special problems of lubrication with a condensable vapour and to offer guidelines to overcome these problems. These guidelines include special features of the bearing design and of the lubricant supply system and limitations on bearing operating conditions.—*Orcutt, F. K., Dougherty, D. E., Malinovski, S. B. and Pan, C. H. T., 13th–20th June 1968, A.S.M.E. International Symposium on Gas Lubrication and Exhibition, Paper No. 68-LubS-24.*

Gas Turbine-powered Water Jet Undergoing Operational Tests

Pratt and Witney Aircraft and Thunderbird Products Corp. have begun testing a new gas turbine powered water jet propulsion system. The water jet is mounted low in the deep vee-hull of the 32-ft formula boat, which is in the 40-knot class. At low speeds, when manoeuvring around docks and other vessels, the water jet exhausts below the waterline. At high speeds, when the hull is planing, the water jet exhausts above the waterline for increased efficiency.—*Maritime Reporter/Engineering News, 15th August 1968, Vol. 30, p. 60.*

Electric Propulsion of Radical Concept

Russian marine engineers are studying a different system of electric ship propulsion - plate electrodes and a magnet fastened to the bottom of the hull. A model of this type of electric ship is reported. The principle of the system is that when a direct current from a generator is applied to the electrodes, the salt water gap between them begins to conduct electricity. The current flows at right angles to the magnetic lines of force compelling the conductor to push the hull away from it.—*Maritime Reporter/Engineering News, 1st October 1968, Vol. 30, p. 50.*

Effect of Ship Stiffness upon Structural Response of a Cargo Ship to an Impulsive Load

The purpose of the study was to set up a computer programme to investigate the dynamic effects resulting from an impulsive loading on a ship and to determine how these effects tend to vary with the stiffness of the hull girder. The hull is treated as a Timoshenko beam and the solution is obtained by finite difference technique. Application is made to a dry cargo ship.—*St. Denis, M. and Fersht, S. N., September 1968, Ship Structure Committee Rep. SSC-186.*

Exhaustion of Ductility in Compressed Bars with Holes

The brittleness of mild steel subjected to tension after compressive prestraining has been in part attributed to the collapse of microscopic flaws or voids and to the resulting severe straining, work hardening and sharpening of the flaw edges. A similar mechanism of embrittlement should operate also with artificial microscopic flaws such as holes. This was checked with tests of axially compressed bars.—*Kabayashi, S. and Mylonas, C., June 1968, Ship Structure Committee Rep. SSC-184.*

Ultrasonic Welding of Metals to Nonmetallic Materials

Bond formation of metals to nonmetallic materials, such as plastics and glass, was investigated under the application of ultrasonic energy and variable load conditions. Successful weldings of low carbon steel to polypropylene, acrylics and glass were obtained using an aluminium foil interleaf. Deformation of nonmetallic materials under load was considered and its effect on bond strength analysed.—*Shin, S. and Gencsoy, H. T., Welding Jnl, September 1968, Vol. 47, pp. 398s–403s.*

Review of Gas-Bearing Gyro Development in the United Kingdom

This paper describes development and progress in the application of aerodynamic gas bearings to gyro-spin axes in the United Kingdom since early 1959, when work in this field was begun by the British Navy. The greater complexity and the more exacting requirements of gyros of higher precision, such as are needed for marine inertial navigation, have made necessary the evolution not only of higher accuracy machining and metrology, achieved with co-operation from British Industry, but also of new techniques for dynamic measurements.—*Patterson, A. G., 17th–20th June 1968. A.S.M.E. International Symposium on Gas Lubrication and Exhibition, Paper No. 68-LubS-29.*

Welding Processes in the Deep Ocean

This paper anticipates a future need for welding processes in depths to 5000 m. Arc cutting and joining processes are found to be most suitable for depths in excess of 1500 m because they avoid the problem of gas liquefication. The underwater arcs are enhanced by constricting effects produced by the deep ocean environment, and no problem with heat generation is expected. Argon or nitrogen shielded arcs are advised for deep sea work.—*Silva, E. A., Naval Engineers Jnl, August 1968, Vol. 80, pp. 561–568.*

Pressure Tests on Cylindrical Pressure Vessels Reinforced with Steel Wire Wrapping

The potential strength and crack arrest benefits that may be gained by adding circumferential wire wrapping on a cylindrical pressure vessel are examined. Tests show that:

a) circumferential wire wrapping limits total extension and rate of extension of longitudinal cracks and restrains crack propagation;
b) the bursting pressure of a wire-wrapped cylinder is greater than that of a non-wrapped sphere.—

Bower, J. E., 22nd–26th September 1968, A.S.M.E. Petroleum Mechanical Engineering and First PVP Conference, Paper No. 68-PVP-24.

Freezing of Hydraulic Systems

A theoretical technique is developed for predicting conditions under which an hydraulic system freezes shut. The investigation considers laminar liquid flow through a tube between two reservoirs. Freezing is assumed to occur within a portion of the tube having uniform wall temperature lower than liquid freezing temperature. Analytical results indicate the minimum allowable pressure drop which must be maintained across the system to prevent it from freezing shut—*Des-Ruisseaux, N. and Zerkle, R. D., 11th–14th August 1968, A.S.M.E. Heat Transfer Conference, Paper No. 68-HT-24.*

Effect of Shot Peening on Stress Corrosion Properties and Stress Distribution in Aluminium Alloy

Stress-corrosion data have been obtained from shot-peened specimens cut in the short transverse direction from an aluminium alloy extrusion to specification D.T.5054. The specimens were prepared for test in three different ways to obtain three different residual macro stress systems typical of the conditions in which the alloy is used in service; it has been shown that after shot peening, the stress corrosion properties of each of the three groups tested have been improved to a marked extent.—*Hawkes, G. A., British Corrosion Jnl, September 1968, Vol. 3, pp. 258–261.*

Application of General Methods of Reliability Theory to Analysis of the Maintenance of Marine Diesel Engines

Statistical principles are given for the selection of optimum intervals for maintenance operations on main Diesel engines. A theoretical basis is proposed for the classification of components according to the degree of risk of failure. Examples are given of the preliminary analysis of service data for fuel pumps and engine bearings in existing motor ships.—*Vinogradov, V. I., Central Scientific Research Inst. Merchant Marine, U.S.S.R., 1967, No. 81; Jnl of Abstracts B.S.R.A., July 1968, Vol. 23, Abstract No. 26 578.*

Automatic Mooring Winches and Remote Control of Anchor Windlasses

The mechanisms of self-tensioning mooring winches with steam and with electric drive are explained in some detail, special attention being paid to load-balance arrangements which limit line-tension peaks to not more than 20 per cent over the nominal rating. The use of synthetic rope on mooring winches in the automatic mode is inadvisable (rope life being reduced by adhesion of adjacent turns) unless the main load is taken on a warping head and the rope coiled on a special reel.—*Sverer, Z., 22nd–24th November 1967, Symposium on Shipbuilding Automation, Opatija, Yugoslavia; Jnl Abstracts B.S.R.A., September 1968, Vol. 23, Abstract No. 26 688.*

Corrosivity of the Exhaust Gases of a Marine Diesel Engine

On ships and in total energy systems, waste-heat boilers are installed to utilize the exhaust gases from large Diesel engines burning heavy fuel oil. This note describes brief tests to measure the possibility of corrosion in such boilers due to the formation of sulphuric acid. The exhaust gases from a marine main propulsion engine were found to have a higher level of SO_3 than is found in conventional oil-fired boilers. Care must therefore be taken in designing waste-heat boilers for this purpose to maintain metal temperatures above the acid dewpoint.—*Mackenzie, K. J., Jnl Inst. Fuel, October 1968, Vol. 41, pp. 401–405.*

Jet Impact and Cavitation Damage

On the basis of presently known erosion theories, an analogy is made between jet impact and cavitation erosion, and confirmed by experiments. As a consequence of this analogy, data on jet impact experiments are used to explain some peculiar aspects of cavitation damage.—*Carnavelis, R., 6th–9th May 1968, A.S.M.E. Fluids Engineering Conference, Paper No. 68-FE-3.*

Shock Damage Mechanism of a Simple Structure

Two sets of four cantilever beams loaded with tip masses were mounted on the floating shock platform and shock tested by underwater explosions. These simple mechanical models were designed to undergo appreciable plastic deformation. Three analytical approaches to predict shock damage were applied to these beam-mass models:

a) one considering elastic, perfectly plastic mode response;
b) one considering an energy balance to predict displacement bounds;
c) one considering an inelastic deformation mode approximation.

Shock and Vibration Bulletin, Naval Research Laboratory, January 1968, Vol. 37, No. 4, pp. 71–77; Applied Mechanics Reviews, August 1968, Vol. 21, p. 827.

Instantaneous Energy Dissipation Rate in a Lap Joint

Equations are derived for the load deflexion relations, the energy dissipation per cycle and the instantaneous rate of dissipation. The energy dissipation per cycle is only valid for steady-state cyclic loading, whereas the load/deflexion equations and instantaneous dissipation rate are valid for arbitrary loading and take into account the previous loading history.—*Metherell, A. F. and Diller, S. V., 12th–14th June 1968, A.S.M.E. Applied Mechanics Conference, Paper No. 68-APM-E.*

Cumulative Collapse of Cavitation Cavities

Highly nonsymmetrical bubble collapses are viewed photographically and it is noted that the collapses occur in such a fashion as to produce liquid jets. These are considered as similar to shaped charges used in explosives, and a model based on cumulative jet formation is postulated to explain the damaging power of such collapses. The damage from cavitation bubble collapse is examined and found to be similar to that from water jet impact.—*Kozirev, S. P., 6th–9th May 1968, A.S.M.E. Fluids Engineering Conference, Paper No. 68-FE-2.*

Tube-to-tubesheet Attachment Welds

Joining tubes to tubesheets by welding has been treated largely as a problem of manufacturing and welding engineers and it has been given little attention in design codes and standards. A specific example is presented to illustrate the difficulties that can result from manufacturing and welding problems and it is suggested that many service failures may be caused by joint design rather than by welding.—*Impagliazzo, A. M., 22nd–26th September 1968, A.S.M.E. Petroleum Mechanical Engineering and First PVP Conference, Paper No. 68-PVP-16.*

Chlorination without Chlorine Gas

The Cychlor electrochlorinator provides chlorination without using chlorine gas. A small part of the ship's sea water intake is diverted through the equipment where, passing between plates connnected to a d.c. supply, its sodium chloride is electrolysed. Each electrolyser contains a large number of plates, so that abundant quantities of sodium hypochlorite are produced.—*Reed's Marine Equipment News, October 1968, Vol. 12, p. 14.*

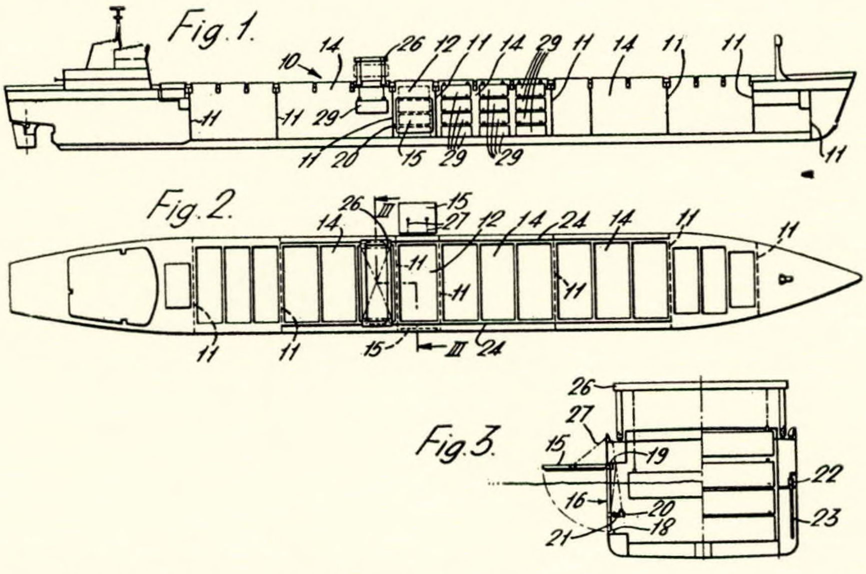
Explosive Welding of Tubes and Tubeplates

Results are given to indicate the current state of explosive welding of tubes into tubeplates for both single and multi-hole assemblies. Various mechanical tests for determining joint strength are described and nondestructive methods of examining the joints indicated.—*Chadwick, M. D., Howd, D., Wildsmith, G. and Cairns, J. H., British Welding Jnl, October 1968, Vol. 15, pp. 480–492.*

Patent Specifications

Improvements Relating to Cargo Ships

As shown in the drawings, a cargo ship (10) is divided by watertight bulkheads (11) into a number of compartments (12) extending transversely across the ship and disposed amidships, and three storage compartments acting as barge holds (14), of which two are provided forward of the dock compartment (12) and one aft. At opposite ends of the dock compartment (12), doors (15) are provided for closing access openings (16).



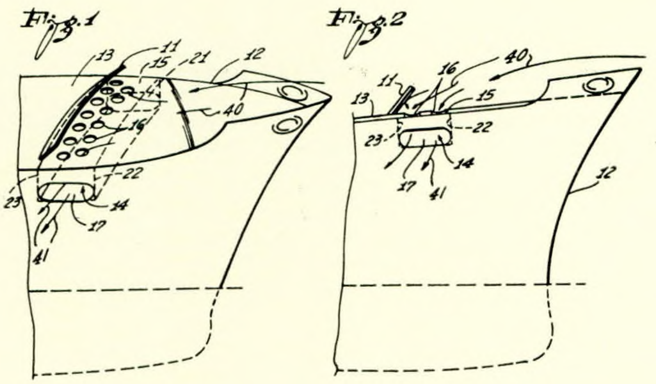
Each door (15) is provided with a watertight sealing device (18) and is pivotal about a horizontal axis by means of an hydraulic hinge 19). A sluice valve arrangement (20) provided with a strainer (21) is disposed in the dock compartment (12) and communicates through the hull with the sea water so that by opening the sluice valve (20) the dock compartment can be flooded. Pump (22) connected in suction pipe (23) is provided for pumping water from the dock compartment.

There are two rails (24) and a gantry crane (26) mounted for movement along them over the dock compartment (12) and the barge holds (14).

When the ship is to be loaded, the dock compartment (12) is flooded and at least one of the doors (15) is opened and retained in its open position by wire stays (27). Barges (29) carrying goods are then floated into the dock compartment and subsequently transferred to the barge holds (14) by the gantry crane (26).—*British Patent No. 1 130 626 issued to Turnbull Marine Design Co. Ltd. Complete specification published 16th October 1968.*

Watercraft Breakwater Arrangement

This invention relates to ships equipped with breakwater means adapted to dissipate wave energy from boarding seas to prevent damage to the ship's superstructure and deck cargo.

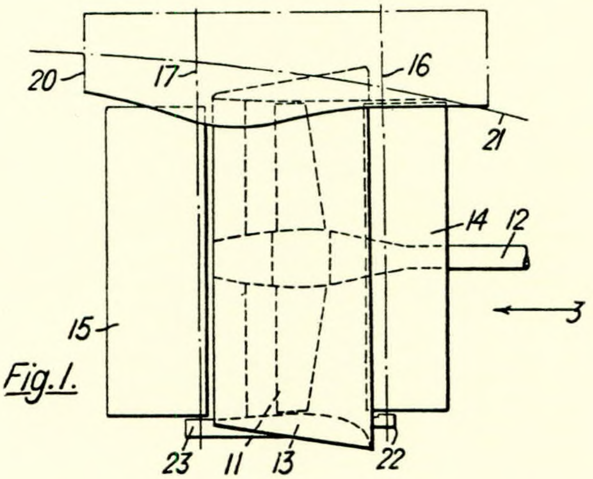


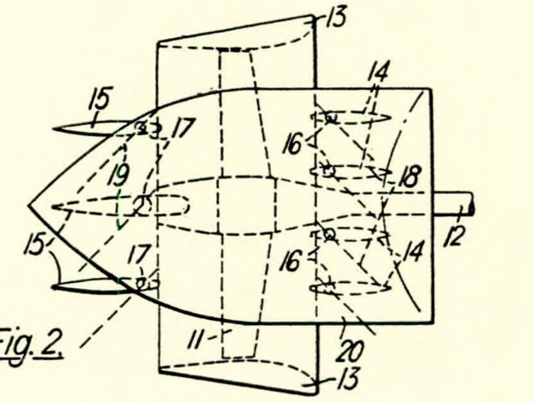
Referring to Figs 1 and 2 a breakwater (11) is mounted forward on ship (12). This is a flat structure mounted at an acute angle to the deck and running athwartship, extending nearly to the edge of deck (13). Forward of this breakwater (11) is a deck well (14), also running athwartship parallel to breakwater (11). A water-pervious cover (15) is provided over the well (14), fitting flush with deck (13). Cover (15) is rendered water-pervious by a number of apertures (16) communicating with the well (14). Freeing ports (17) and (21) are also provided to communicate directly with well (14). As illustrated by arrows (40) and (41) in Fig. 1 and Fig. 2, water coming over the bow is collected and absorbed, i.e. drained, by the openings (16) into the well and discharged through ports (17) and (21). Thus breakwater (11) in combination with well (14) can handle a much larger wave taken over the bow than can the breakwater alone.—*British Patent No. 1 131 198 issued to Litton Industries Ltd. Complete specification published 23rd October 1968.*

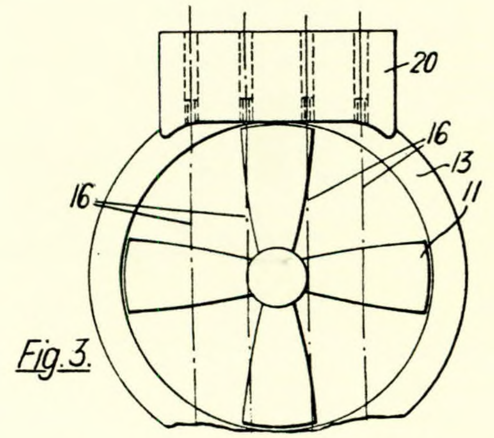
Steering of Vessels Fitted with Propulsion Nozzles

In Figs 1–3, a propeller (11) driven by a propeller shaft (12) works in a fixed propulsion nozzle (13). At the nozzle entry are fitted four equidistantly-spaced vertical rudder blades or shutters (14) and three further equidistant blades (15) are fitted at the nozzle exit. The entry blades (14) are each mounted to turn about a respective vertical pivot (16) near the aft edge of the blade, while the exit blades (15) have pivots (17) near their forward edges. It will be observed that the spacing and dimensions of the blades are such that, both in the case of the entry blades and the exit blades, each multiple rudder can be turned to a normal steering angle at which the nose of one blade is covered, in the fore and aft direction, by the tail of the blade next to it, as illustrated by the set of broken lines (18), (19) in Fig. 2, so that the set of blades operates as a cascade.

A head box (20) overlies the nozzle (13), projecting beyond it both forward and aft and serves as the means of securing the unit to the ship's hull (21). Pintles for the multiple rudder blades (14), (15) are journalled at their upper ends in the head box (20) and at their lower ends in bearing







brackets (22), (23). Within the head box the blade pintles of each multiple rudder may be coupled together so that the blades turn in unison.—*British Patent No. 1 131 611 issued to Hydroconic Ltd. Complete specification published 23rd October 1968.*