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*The Design and Construction of Diesel-engined Tankers.

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Synopsis.

This paper has been prepared in broad outline without any attempt to delve into intricate calculations and/or controversial points regarding the merits or demerits of the different forms of hull construction and types of Diesel machinery.

It is necessary, however, to have some idea of the variety of liquids carried by tankers since there are several inherent characteristics which must be studied in order to provide for their safe carriage. To name but a few, they include petroleum and its many products, creosote, whale oil, turpentine, vegetable oils and molasses, and in fact any liquid which is suitable for carriage in bulk, varying from the lightest fractions of petroleum having a specific gravity as low as ·65 to, in special cases, molasses with a specific gravity of 1·45.

Liquids vary greatly in volume with change of temperature, particularly in the case of petroleum products, and they are also unstable. The first requirement, therefore, is a design which provides for change in volume and will permit of loading without leaving large masses of liquid to surge and cause damage. As other than liquid cargoes cannot be carried commercially, there must normally be many ballast passages and construction must therefore allow for safe ballasting.

Other problems include such matters as prevention of leakage and contamination during operations of loading, carriage and discharge which entail the study of piping system, valves, gas lines and cofferdam separation.

The dangerous nature of some of the liquids calls for special attention to fire prevention and fire fighting apparatus. Crude oil, owing to its gassy nature and low flashpoint and which, when mixed with air, will explode at any normal temperature in contact with a spark, must always be treated as a dangerous cargo. On the other hand creosote and viscous oils must be warmed to facilitate easy pumping when discharging.

With these general points in mind the main subject matter of the paper is divided into five sections, viz.:—

(1) General description of oil tankers.
(2) Design of the ship.
(3) Construction of the ship.
(4) Speed and power.
(5) The machinery installation.

The prototype of the modern ocean-going bulk-oil carrier was built in 1886 on the Tyne. The "Gluckauf" as she was called was 300ft. long and carried about 3,000 tons. Previous to this oil was carried in drums or barrels in the holds of ordinary cargo ships.

During the war of 1914-1918 much of the bulk oil transport was made by means of large cylindrical tanks let into the structure of ordinary cargo ships. This was not a really safe practice, at any rate for the carriage of benzine, as leakage was liable to occur from the tanks to the holds and cause an accumulation of dangerous gases.

The really important development of tankers for bulk oil carrying has taken place since the last great war, and until recent years the centreline longitudinal bulkhead tanker with summer tanks was the standard type.

(1) GENERAL DESCRIPTION.

Main Structural Arrangements.

A typical midship section of a centreline bulkhead tanker showing the main structure is shown in Fig. 1. This type of vessel usually has longitudinal framing in way of the cargo tanks and transverse framing at the ends. The summer tanks, port and starboard, run longitudinally between the main and upper decks and extend from the ship's sides to the sides of the expansion trunk of the main tanks.

The object of the centreline bulkhead is to control the position of the centre of gravity of the cargo and, with the expansion trunk, to reduce the extent of the free surface of the liquid in the cargo tanks for reasons of stability, and it is desirable that sufficient cargo be loaded into the main tanks to prevent the surface of the oil from falling below the bottom of the trunk when the vessel is rolling.

It might be thought that the best way to avoid movement of cargo would be to fill the tanks completely, but this is impracticable because of the high coefficient of expansion of the liquid carried. Sufficient space should be left for change of volume due to varying temperatures, and when loading cargo at 60° F. a space equal to about 2 per cent. of the capacity of the tank is generally left empty.

The summer tanks are used when light oils are carried as in this case the same weight of cargo entails a much greater cubic capacity. An outline general arrangement of this class of vessel is shown in Fig. 2. Figs. 3 and 4 show typical midship section and outline arrangement plans of a coaster with an expansion trunk but no summer tanks.

During recent years most tankers have been built with two longitudinal bulkheads and no summer tanks, the bulkheads being usually spaced as shown on midship section, Fig. 5, and outline general arrangement, Fig. 6. The framing in this case is longitudinal on the bottom and under the deck and transverse or vertical on the longitudinal bulkheads and ship's sides. More flexibility can be obtained with the two longitudinal bulkhead type of vessel as the centre tanks can be loaded to the 98 per cent. mark and the wing tanks to any desired ullage.

Outline midship sections of the three main types of bulk oil carrier as shown in Fig. 7. The sections have been drawn with about 15° list to illustrate the effect of free surface in the cargo tanks.

The subdivision of the vessel along its length is indicated on the various outline arrangement plans. The transverse bulkheads dividing the tanks are of course made oiltight and form a sufficiently safe division between similar grades of oil. Where, as often happens, a cargo consisting of two or three parcels of oil—in which admixture would have more serious consequences—has to be carried, provision must be made for separation by means of cofferdams. A cofferdam in this connection is a space between two cargo tanks enclosed by the adjacent bulkheads of the tanks. In other words, the tanks are separated by two oiltight transverse bulkheads instead of one.

The cofferdams between the cargo tanks are usually made large enough to contain the cargo pumps and serve the dual purpose of pumproom and cofferdam. Forward of the cargo tanks, and separated from them by another cofferdam, is a cargo hold used for dry cargo and stores. Beneath the hold is a deep tank for oil fuel and forward of the collision bulkhead which bounds the forward end of the cargo hold is the usual fore peak tank with storerooms above. Aft of the oil cargo space in the order given are cofferdam, oil fuel cross bunker, propelling machinery space and after peak tank. The engines are arranged at the after end to minimise the danger of fire due to sparks from the exhaust and partly because of the extra work that would be entailed if the engines were amidships in constructing a long oiltight shaft tunnel through the cargo tanks aft of the machinery space. The double bottom space under the machinery is divided up into separate tanks for the carriage of feed water, lubricating oil and oil fuel.

The engines being aft make trimming conditions difficult as in

* Lecture delivered to the Gravesend and District Engineering Society.

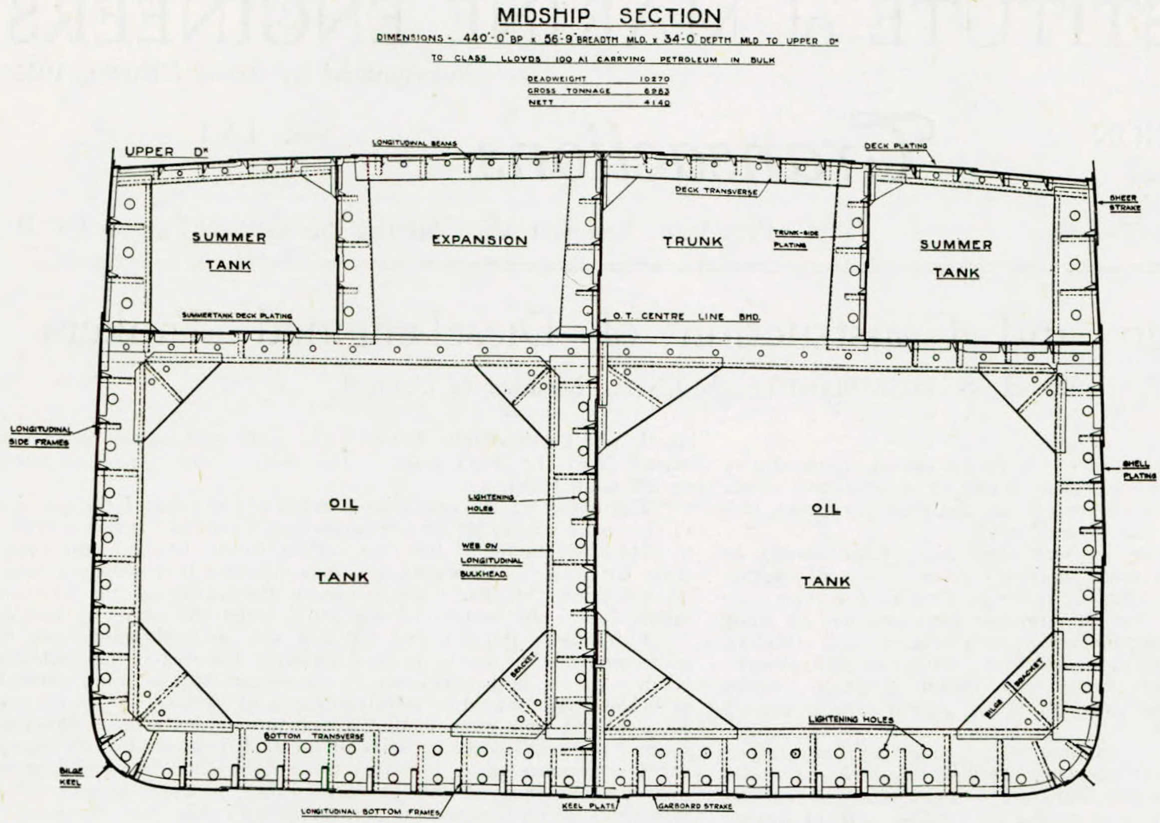


FIG. 1.—*Midship section of a centreline bulkhead tanker.*

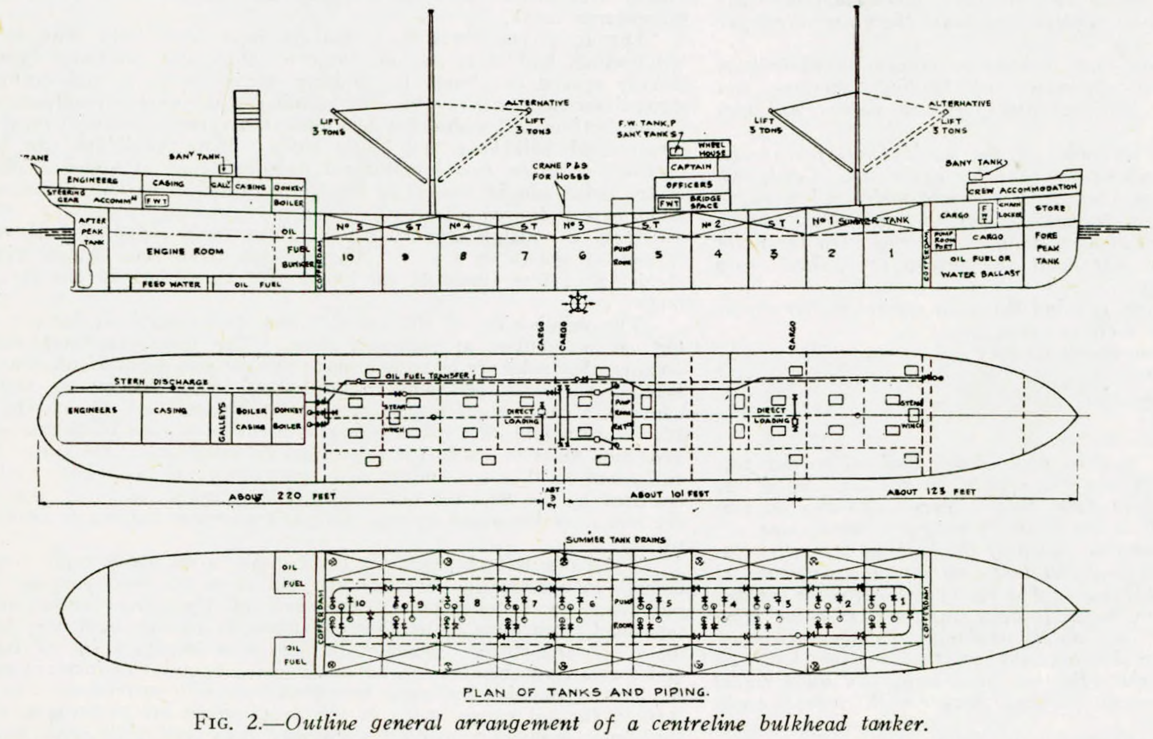


FIG. 2.—*Outline general arrangement of a centreline bulkhead tanker.*

the light condition the weight of the propelling machinery gives the ship a pronounced trim by the stern, while in the loaded condition the vessel should be on an even keel. This necessitates careful consideration of the loading arrangements when part cargoes have to be discharged at different ports. Another trimming problem caused by the consumption of oil fuel, perhaps 350 tons during the passage, is overcome by the use of the forward deep tank for oil fuel. The fuel can then be transferred from the fore deep tank to the cross-bunker during the passage to adjust the trim as necessary. For this purpose an oil fuel transfer pump is installed in the machinery space and another in the forward hold or forward cofferdam, the two pumps drawing from their adjacent oil fuel tanks and discharging to the oil fuel transfer line which connects the two. The forward oil fuel transfer pump is fitted in a compartment together with a ballast pump for handling the water ballast which may be carried in the fore peak tank, for draining the various compartments at the forward end and for pumping water from the sea to the washdeck line.

Above-deck Arrangements.

Tankers of the three-island type have a poop, bridge and forecastle above the continuous weather deck. The forecastle in new vessels is no longer used to accommodate the seamen as was standard practice a few years ago, and is now generally an open space. Its purpose, of course, is to make the vessel more seaworthy by providing reserve buoyancy, and by diverting broken water away from the ship whilst pitching.

The bridge in addition to providing reserve buoyancy together with the poop and forecastle is used to accommodate stores and sometimes fresh water storage tanks. Above the bridge are houses for the master, deck and engineer officers and spare rooms, also wheelhouse, chartroom and wireless office.

The poop erection is at least long enough to cover the engine room. It contains the machinery light and air casings, crew accommodation and steering gear. Above the poop are houses for messrooms, galley, engineers' washplaces and office and an officers' smokeroom.

The poop, bridge and forecastle are connected by a fore and aft gangway permitting the crew to pass from one erection to the other in safety. The necessity for some such provision as this is occasioned by conditions on deck in a rough sea and by the fact that tankers are permitted to load more deeply than ordinary cargo

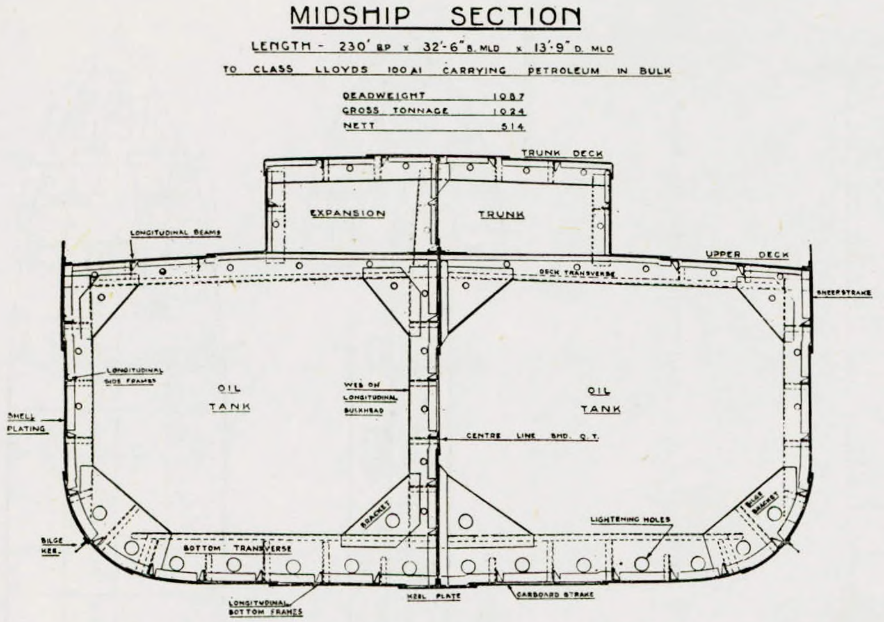


FIG. 3.—*Midship section of a coaster with expansion trunk.*

vessels. This deeper loading is allowed for the following reasons :—

The cargo hatches are very small as they are only used for access purposes and to admit light and air at certain times.

The hatch covers are of steel, as strong as the deck plating and are fastened down by means of drop bolts and wing nuts forming an oiltight joint with greasy hemp packing in channels about $1\frac{1}{2}$in. $\times$ $1\frac{1}{2}$in. all round the rim of the hatch.

There are no large open ventilators to the cargo compartments.

The cargo spaces when loaded have a very low permeability, that is, there is very little room for water to enter as they are already nearly full of oil.

The ship is very closely subdivided.

The fore and aft gangway forms a convenient bridge for the numerous pipelines which run along the ship. These pipelines consist of the steam and exhaust lines, steam smothering line, wash deck line, vapour line and oil fuel transfer line, all of which have been mentioned in other sections of the paper. In addition there are the main electricity supply leads, telemotor pipes for controlling the steering gear, and telephone and telegraph leads.

The modern tanker is equipped with all the latest aids to navigation such as main and emergency wireless sets, direction finder, echo-sounding apparatus and electric log. The crew accommodation is very roomy and comfortable, especially so because of the short time the personnel have in port and because of the nature of the service.

As previously indicated, accommodation for the master, deck and engineer officers and radio officers is arranged amidships, also spare rooms for any passengers who may have to be carried. The houses above the bridge deck usually are arranged in three tiers, the navigating bridge deck carries the wheelhouse, chartroom, wireless office and master's accommodation with usually a radio officer's room. The upper bridge deckhouse is arranged for the deck officers and apprentices, while the bridge deckhouse contains the engineers' accommodation and the dining saloon, pantry and hospital. This is a typical layout, but of course different companies have their own particular accommodation arrangements. The crew is berthed in the poop at the sides of the machinery casings, usually the engine-room staff on one side and the deck staff on the other. They have adequate washrooms and messrooms and modern practice is for each room to have beds for not more than two or three men so that a fair degree of privacy is ensured. If there is not sufficient space for all the crew to be comfortably accommodated in the poop, additional space is provided in the form of houses built on the poop deck for petty officers and messrooms. The galleys are also arranged on this deck, as well as officers' smokerooms and engineers' office and dressing room.

Large refrigerated storerooms are fitted in the poop with separate rooms for meat and vegetables.

Lifesaving appliances receive very special consideration because of the dangers of the service which are of course greatly increased in war time.

Lifeboats now must all be of steel owing to the fire risks and where four lifesaving boats are fitted (the usual practice) two of them are motor-boats. The boats are usually arranged with two amidships and the remainder aft and are fitted under mechanical davits. There are sufficient boats on each side of the ship to accommodate the total complement and now rafts are also provided so that in cases of damage to the boats the total crew can still be accommodated on the rafts, which are arranged for quick release and which should float off in the event of the vessel sinking. In addition the crew are provided with lifejackets and life-saving waistcoats, one for each man, and each equipped with an electric light having a globe tinted red to aid in rescue work at night.

The fully-equipped lifeboats include suits of protective clothing and the rafts are supplied with waterproof bags for protection in cold weather.

Cargo Measurement.

The amount of cargo in each tank is measured from ullage plugs situated near the centre of each tank. The ullages are measured by means of ullage sticks or tapes, from the top of each plug socket to the surface of the liquid. The tanks are calibrated by the shipbuilders and the capacities tabulated for every 6in. or so of ullage. The depths above the bottom of the tank are also quoted in case it is more convenient to find the quantity of oil by taking soundings.

The gas ejector pipes mentioned later are sometimes adapted to serve as sounding pipes.

Cargo Pumping.

The cargo is handled by pumps fitted in the one or two pump-rooms already mentioned. These pumps are usually of the horizontal duplex type and are supplied with steam from the deck steam line. The oil is drawn through cast iron suction pipes led along near the bottom of the tanks and discharged through pipes on the deck. The piping and the necessary valves in the tanks and pump-rooms are arranged to permit different grades being loaded and discharged without risk of admixture also the transfer of cargo or water ballast from one tank to another, of tanks being filled with water ballast and of the pipeline being washed out, a typical cargo pipe arrangement for a two-pumproom ship having four cargo pumps for carrying several grades of refined products is shown in Fig. 8, together with a diagram of the pumproom connections.

The cargo is loaded through the pumproom system and in some cases through direct-loading lines from the deck into the main pipe-line.

When heavy viscous oils are carried they have in many cases to be kept warm so that they can be readily pumped at the discharge port. For this purpose heating coils, supplied with steam from the auxiliary boilers, are fitted in the bottom of the cargo tanks. The heating surface is of the order of ·30 sq. ft. per ton of oil.

Ventilation.

Oil entering the cargo tanks naturally displaces an equal volume of air and as this may soon become charged with volatile and explosive gases, arrangements must be made to displace it in some harmless fashion. This is done by fitting vapour lines. A 4in. bore pipe is led from the crown of each tank, or from the hatch coaming, with a shut-off valve to each tank, into one or more 6in. bore fore and aft main vapour lines which are in turn led up the masts to not less than 12ft. above the masthead lights, each line being provided with a gooseneck bend and flame arrester at the outlet. It used to be general practice to fit "U" water gauges in the wheel-house connected to the vapour lines and hermetically seal the whole system. Any pressure or partial vacuum in the tanks could then be observed at once from the "U" gauges and readily rectified. More modern practice, however, is to fit a pressure valve and a vacuum valve at the junction of the branch lines with the main line. These valves are either spring or weight loaded. Any abnormal pressure in the tank lifts the pressure valve and discharges into the vapour line. A vacuum automatically opens the vacuum valve direct to the atmosphere and air flows in. By adopting either of these systems, losses by evaporation are reduced to a minimum. When different grades of clean oil are carried on the same voyage the vapour lines from the tanks containing the different grades are

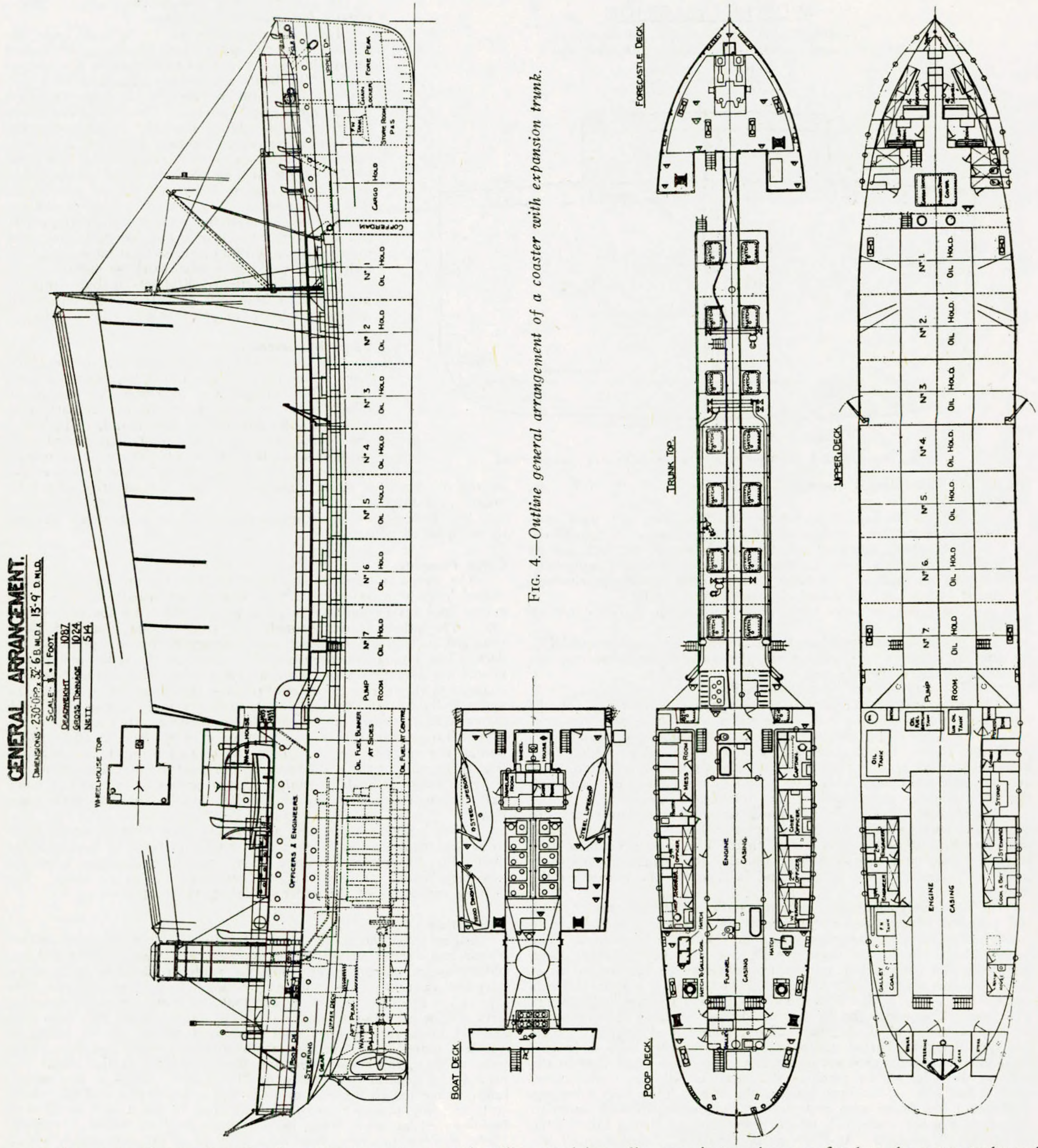


FIG. 4.—*Outline general arrangement of a coaster with expansion trunk.*

isolated to ensure that condensation from the gases of one grade will not mix with another grade and so affect the flashpoint.

Ventilation on the ballast passage, when the dangerous gases left after discharging cargo have been "killed" by means of washing down tanks and steaming out, is effected by means of windsails and gas ejectors. Windsails are large canvas tubes about 24in. diameter with a scoop at the upper end for trapping the wind which is directed down to the bottom of the tank and blows out the gases remaining. 3in. gas ejector pipes are fitted to the cargo tanks and other spaces for the same purpose.

Steaming Out, Fire Extinguishing and Air Salvage Arrangements.

Permanent 1in. bore iron pipes are fitted from the deck to within about 4ft. of the bottom in each cargo compartment and pump room for steaming out or fire extinguishing, the lower ends being plugged and the sides perforated by small holes. These pipes

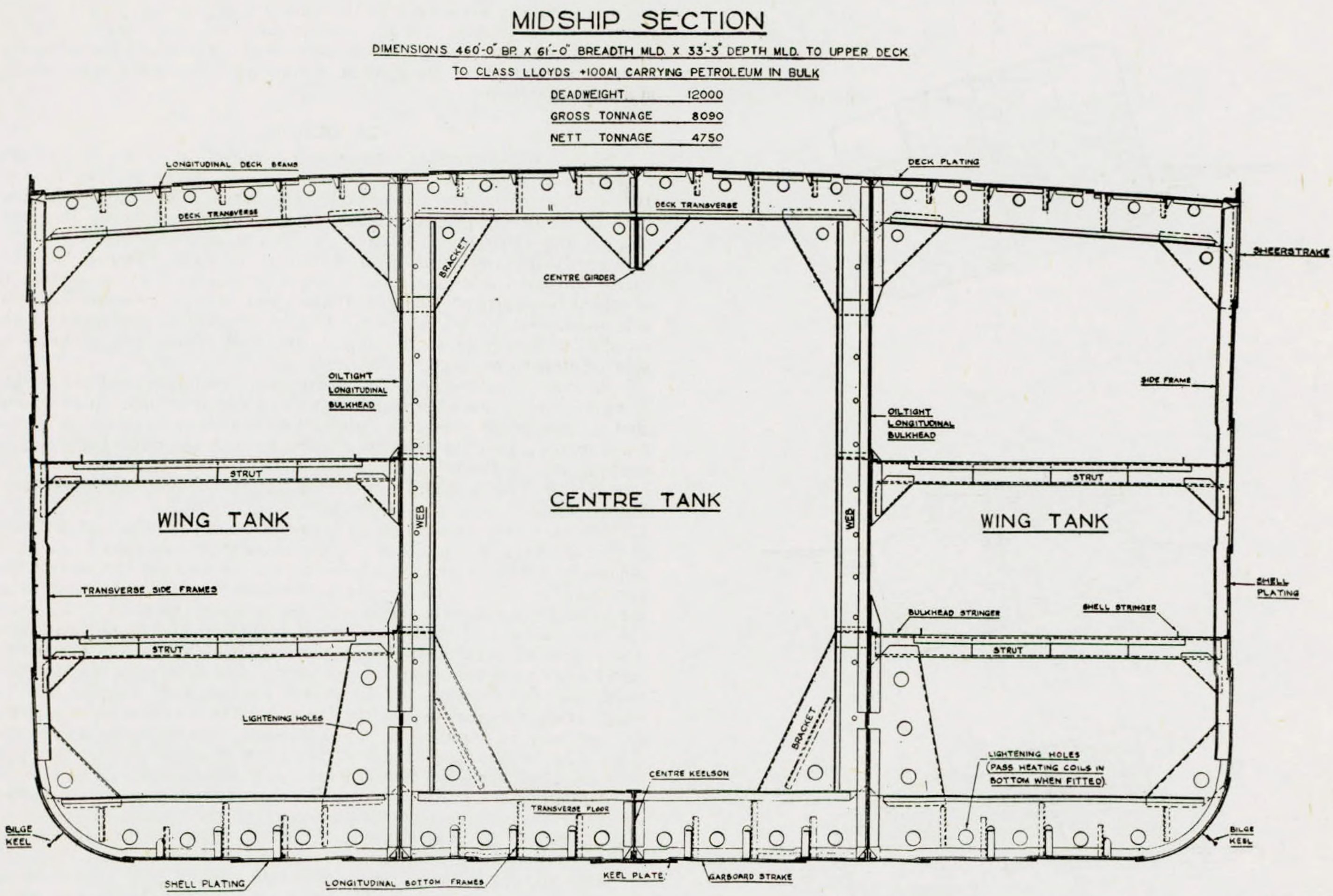


FIG. 5.—*Midship section of tanker with two longitudinal bulkheads.*

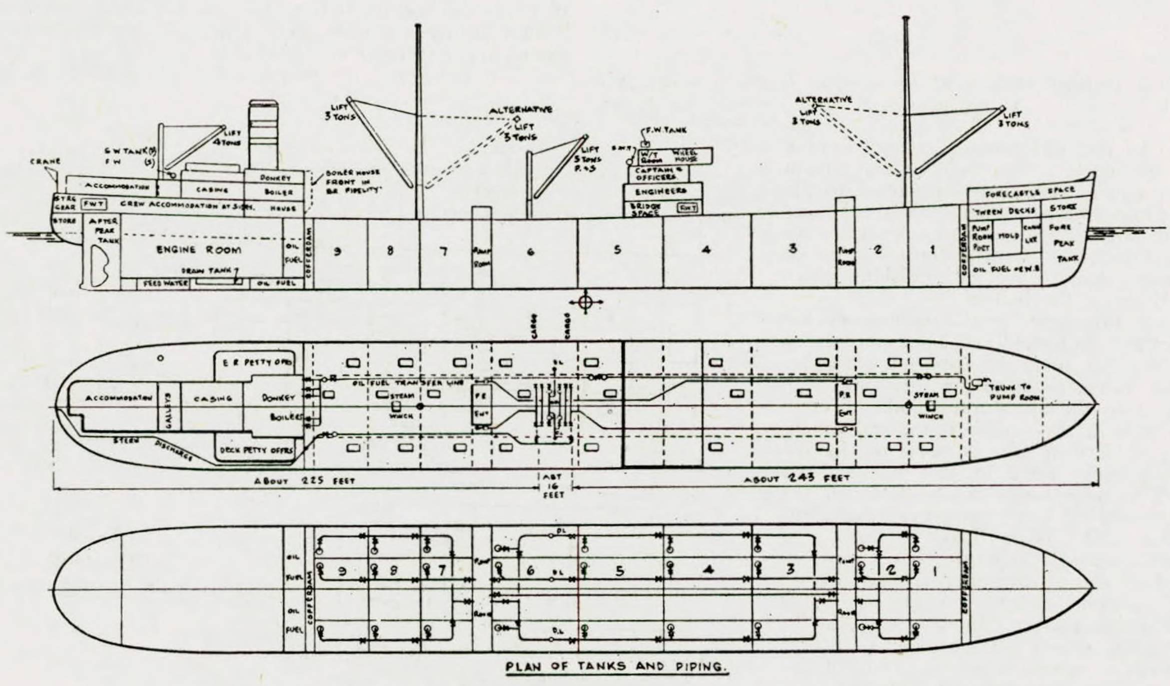


FIG. 6.—*Outline general arrangement of a tanker with two longitudinal bulkheads.*

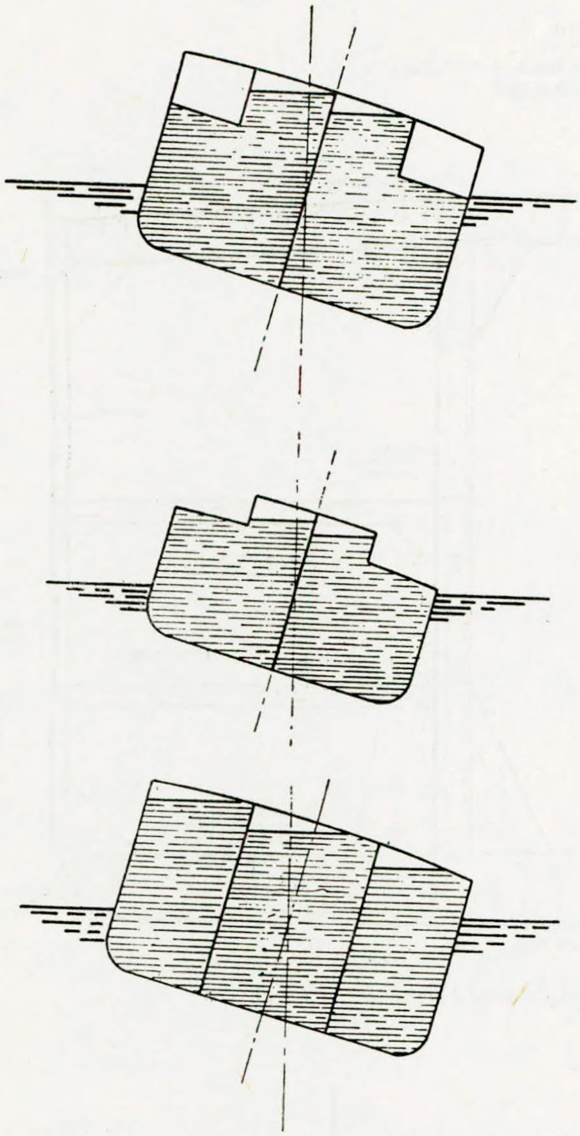


FIG. 7.—*Outline midship section of three main types, showing free surfaces.*

are connected to the deck steam line and have a stop valve on deck. An independent steam smothering system is also sometimes fitted to the cargo tanks, a 4in. line being led from the boilers along the fore and aft gangway to a branch over each cargo compartment with a control valve at the poop front. Steam fire extinguishing pipes are also fitted under the boilers.

A separate fire fighting and emergency air salvage equipment is provided. This consists of a 1½in. bore pipe led along the fore and aft gangway from the engine room to the forecastle with a connection from the air storage tanks through a reducing valve in the engine room and an independent Diesel-driven air compressor in the forecastle with cocks fitted on the fore and aft line to which portable hoses can be attached for leading compressed air to the cargo compartments when required, cocks being fitted to each tank hatch for that purpose. Separate connections are also provided so that if necessary air may be led to the deck steam line to operate the deck auxiliaries, steering gear, refrigerator, etc., in the event of the steam supply being put out of action. Three air-driven submersible pumps for fire fighting and salvage purposes are also supplied.

A wash deck line is also fitted along the fore and aft gangway connected to the ballast pump system in the engine room with wash deck and fire hose connections, each with valve, at various points on each deck. A very liberal supply of portable fire extinguishers is also distributed throughout the machinery spaces and accommodation.

(2) DESIGN.

Ships' measurements are usually stated in terms of length, breadth and depth but these expressions are likely to lead to confusion unless properly understood. The length most commonly used is B.P. (between perpendiculars) and is measured from the after side of the stern post to the forward side of the stem bar at the summer load water line. Breadth is usually given either as moulded or extreme and is measured at the widest part of the ship. Breadth moulded is measured over the frames and breadth extreme over the side plating at its widest part. Depth moulded is measured at the middle of length from the top of the keel to the top of beam at side of uppermost continuous deck.

A ship is an exceedingly complicated structure and its design is a compromise between many conflicting requirements. It is seldom that a mercantile vessel is designed primarily for speed as in the majority of cases the dimensions are limited by restricted draught, docking and harbour facilities available. Whatever dimensions are chosen the vessel's stability and trim in all working conditions must be satisfactory, also the deadweight.

When a ship is floating in water a certain amount of water is displaced from its position. This amount of displaced water is obviously exactly equal in volume to the volume of the underwater part of the vessel. Its weight is the same as the total weight of the vessel, consequently the word "displacement" is used to represent the total weight in tons of a vessel including everything on board. The centre of gravity of the volume occupied by the vessel's underwater portion is the centre of buoyancy. To determine the displacement and the position of the centre of buoyancy calculations are made from the drawing of the "lines". The position of the centre of buoyancy is required in two directions, longitudinally and vertically. The longitudinal centre of buoyancy is required for trim purposes and the vertical centre of buoyancy for stability. For a vessel to be floating in equilibrium in still water it must displace an amount of water the weight of which is equal to the weight of the vessel and its centre of gravity must lie in the same vertical line as the centre of buoyancy.

Deadweight is the amount of weight carried by a ship comprising cargo, fuel, stores, fresh water, crew and reserve feed water. Sometimes engine spare gear is also included.

Lightweight is the weight of the hull structure, fittings and propelling machinery in steaming order ready for sea. The amount of deadweight a vessel is able to carry is the difference between the displacement and the lightweight. A ship upon completion is supplied with a deadweight scale from which the deadweight is readily ascertained for any particular draught.

The gross and net tonnages are not actually weight at all but

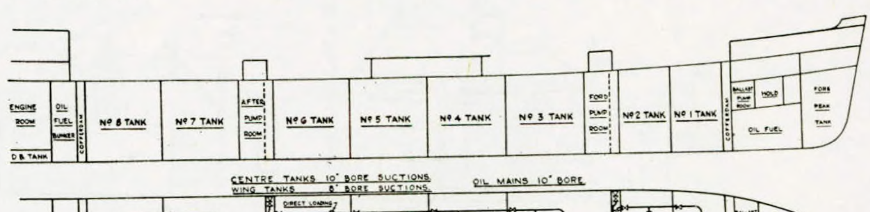


FIG. 8.—*Cargo pipe arrangement with pumproom connections.*

are measures of the volumetric capacity of the vessel. These are the figures of M.o.W.T. measurement and one ton in this case is equal to 100 cu. ft. The gross tonnage is the tonnage of the total enclosed spaces in the ship, with certain exceptions. The net tonnage is the gross tonnage less deductions for spaces occupied by the crew, navigation, ballast, fuel and machinery spaces and is an indication of the earning capacity of the ship.

The British Register Tonnages are recognised throughout the world but there are certain other tonnages, such as those for the Suez and Panama Canals, which though slightly different from the British figures are calculated on the same broad principles.

In designing a ship certain coefficients are used, the commonest of which is the block coefficient of displacement. This is the ratio that the actual displacement of a vessel bears to the displacement of a block which has the same length, breadth and draught as the vessel. An approximate formula for obtaining a suitable block coefficient for a vessel of moderate speed is $1{\cdot}04-\frac{V}{2\sqrt{L}}$ where V is the loaded service speed in knots and L is the length of the vessel in feet.

The midship section coefficient is the ratio that the immersed area of a vessel's midship section at any draught bears to the area of a rectangle whose breadth is equal to the breadth of the vessel and its depth equal to the given draught.

The prismatic coefficient of displacement is the ratio that the actual displacement of a vessel bears to the displacement of a prism whose length is equal to that of the vessel and the section of the same shape as the midship section of the vessel.

The block, prismatic and midship section coefficients are closely related to each other as if any two coefficients are known the remaining one can be found.

The first step in designing a vessel is to estimate the required displacement in loaded condition. Given the deadweight and service speed loaded it remains to estimate the vessel's lightweight. First of all it is necessary to ascertain the type of machinery as this affects the dimensions by influencing the weight estimates for propelling machinery, fuel bunkers, etc. An approximate estimate is then made for the proposed dimensions using the appropriate block coefficient. In ordinary merchant ships fullness and form have a greater influence on resistance than proportions, although the proportion of depth to length must be borne in mind from the point of view of strength and economical distribution of material. If the displacement is too high or too low the dimensions must be adjusted accordingly.

This now provides a basis to work on from which the actual design can be developed. From the approximate estimate the power necessary to drive the vessel at the required speed can be calculated by various methods and from this the weight of machinery. Calculations are then made for the weight of the hull steel structure, wood and outfit, the sum of which added to the weight of machinery gives the lightweight. The depth of the vessel is found by means of estimating the freeboard required by M.o.W.T. for the desired draught. Having arrived at the approximate dimensions, lightweight, deadweight, loaded draught and displacement, it is necessary to investigate the subjects of trim and stability, cargo capacity, bunker capacity, length of machinery space, gross and net tonnage and the correct distribution of weights throughout the vessel so that the centre of gravity will be in its required position directly over the centre of buoyancy at the required draught forward and aft.

The "lines" plan can now be drawn showing the proposed form of water lines, buttocks and transverse sections throughout the length of the vessel and submitted to the experimental tank for resistance and propulsive tests in order to ascertain the best form of hull and propeller for the required dimensions and displacement. When the necessary modifications to the lines have been made a plan of the amended lines is supplied to the builders by the experimental tank authorities and the usual work of preparing plans for the hull and fittings, including accommodation for the crew, electric wiring, cargo pumping, piping, ventilation, rigging and all the other innumerable details which go to make up a ship, is put in hand.

(3) CONSTRUCTION.

The specification and principal plans of the vessel having been finally agreed between the owners and builders, work is at once commenced in the shipyard and a ¼in. scale half model of the vessel is made of wood shaped in accordance with the amended lines. Upon this are marked all bulkheads, transverses, longitudinals, shell plate edges and butts. The size of each shell plate is carefully measured from the model and from the information so gained bills of material are prepared and sent to the rolling mills. Offsets are lifted from the lines plan and sent to the mould loft, a most amazing place with a low roof and vast expanse of floor, the latter painted black, and upon this immense blackboard the lines of the vessel are chalked, full size. The mould loft is becoming the nerve centre of the shipyard and a system of simple geometry, requiring great skill in application, is supplanting the practice of lifting from the ship. From the mould loft proceeds a succession of battens, moulds and templates for use in the fabrication of the various parts of the structure. A "scrieve board", consisting of numerous planks, fitting closely together and forming a huge platform, is laid at one end of the loft floor and painted black. Upon this is "scrieved" a full size body plan, showing the outline of all bulkheads and transverses, and the "flight" or direction taken on the moulded body, of all stringers, decks, longitudinals and shell plate edges, all clearly painted as required. When complete, the scrieve board is taken to pieces and conveyed plank by plank to the bending slabs of the frame turners, where it is reassembled. Steel templates are made for each frame on the scrieve board and clamped to cast iron bending slabs. Bars for the frames are then placed in long furnaces where they are made red hot; after which they are taken out and bent round the templates on the slabs, to the required shape and bevel.

In the meantime, a building berth has been prepared and keel blocks have been erected by the shipwrights or carpenters. These keel blocks consist of massive baulks of timber laid upon each other in such a way that they cannot trip, the top surface sloping down towards the water. On these the keel is laid, this nowadays consisting of long lengths of flat steel plates. The stern frame and stem bar are next erected.

Methods of construction vary in different yards according to facilities for handling the material. Usually, however, bulkheads and transverse frames are assembled and riveted up on skids near the berth and lifted bodily into position, the plating of which these members consist having been shaped from paper or light wood templates prepared in the mould loft. These templates, in addition to showing the shape of the plate, indicate the position of each rivet hole; and after the plates are marked they are sheared and, where necessary, planed and holes are then punched or drilled in them and countersunk. Frame bars are brought from the bending slabs and the whole member assembled and riveted up complete. Longitudinal and transverse bulkheads and transverse frames having been lifted into position, the longitudinals, shaped from templates prepared in the loft, are erected and attached to transverses and bulkheads.

All through the course of building, shipwrights keep careful watch over the structure to see that the proper form is maintained and kept fair.

By this time, although more or less hidden by a forest of staging, the steel skeleton begins to look like a ship. Shell plates and deck plates are prepared, marked, punched and lifted into position and bolted up. Plates are attached to the framing and to each other by rivets, the form of which varies according to the position they occupy. Particular attention has to be paid to those used in way of oiltight work, in order that no leakage of oil may subsequently occur. When the shell is completely riveted up and plate edges caulked, the compartments intended for oil cargo, water or oil fuel are filled with water, one at a time, in order to test the bulkheads and shell plating for tightness. At this stage the work is well advanced and pumps, piping, deck fittings, etc., are usually in position.

Launching ways, consisting of long lengths of timber of suitable width, are now laid under the bottom, one on each side of the keel plate, sloping down towards the water, the fixed portions, or standing ways, being laid on wood blocks and secured to the ground. On the top of the standing ways sliding ways are laid, the surfaces between the two having been heavily coated with tallow and soft soap. The sliding way is then packed up solid with the ship's bottom and cradles are built at each end, shaped to suit the form of the vessel. No weight as yet is taken by the ways. Sea valves having been fitted, the shell plating is painted, staging is removed and, for the first time, one gets an unobstructed view of the vessel.

The sudden appearance of a brightly-painted ship in the yard creates a new interest in the minds of those who helped to build it. The whole yard takes on a more cheerful aspect and the ship, ready to be launched, becomes the centre of attraction. The actual launch of a new vessel is a never ending source of delight to the shipyard personnel and their friends. The christening and launch are usually accomplished without any hitch, though there is considerably more in the successful launching of a big ship than meets the eye. Just before high water, the wedges over the keel and bilge blocks are driven out, either by hammers or battering rams, so that the weight of the ship is transferred to the ways. Last of all, at a given signal, the dog shores—which lock the ways, preventing premature movement—are knocked out, leaving the ship free to move.

A large, clean-lined vessel, sliding smoothly down the ways into the water, is an awe-inspiring spectacle, warranted to stir the blood, and a sight never to be forgotten. There is almost a feeling of desolation in the yard when the launch is over, the empty berth presenting a distinctly forlorn appearance, with only the ways and piles of blocks remaining. Yet in an astonishingly short space of time, the berth is cleared, keel blocks are again set up and sighted, and all is made ready for the laying of a new keel.

By the time the ship is ready for launching, the machinery is generally waiting to be put on board, and after the launch, work proceeds rapidly. The machinery is shipped and lined up and the boilers are installed. Deck fittings not already on board are shipped. Masts, rigging, etc., are fitted, joiner work in deck houses is carried out, the wood decks are laid, caulked and "payed" with marine glue, accommodation work is finished off and the upholstery fitted. Bunker heating coils are then tested and in due course trials of machinery take place. During the last few days before the sea trial, things appear to be slightly chaotic, tradesmen following, and almost falling over, each other in frantic efforts to finish off a multitude of jobs; and finally, as if by magic, the workers disappear and the great task is ended.

No article on the building of a ship would be complete without some mention of the shipyard and its workers. The general layout is designed to minimise the handling of material. The raw material enters at one end of the yard and passes through the various stages by which it is changed into its necessary shape until it finally reaches the building berth. Each trade or section has its own particular interest, from the mould loft with its floor, scrieve boards and templates, to the model shop where true-to-scale miniature editions of the ship are made. These various departments form a surprisingly comprehensive collection of highly skilled tradesmen including carpenters, joiners, cabinet makers, plumbers, tinsmiths, blacksmiths, fitters, painters and, last but not least, steel workers. This last group in itself comprises workers skilled in quite a number of different trades, namely, frame turners, platers who operate machines which shear, plane, punch, drill and countersink the steel plates, riveters, welders and caulkers. Incidentally, welding is taking the place of riveting to an ever greater extent in many yards, especially those abroad, and no doubt the time will come when the hydraulic and pneumatic power riveter will be almost as rare as the hand riveter is to-day.

One leaves the shipyard deeply impressed by all that one has seen and conscious of a feeling of pride that Britain still holds a leading place in such a great industry.

(4) SPEED AND POWER.

The total resistance of a ship is composed of skin friction, wave-making, eddy-making and air resistance. A large part of the resistance of a ship moving through the water when either submerged or on the surface consists of skin frictional resistance, about half to seven-eighths of the total resistance according to whether the speed is high or low. The remainder of the resistance is called the "residuary resistance" in the case of a model. A large proportion of the residuary resistance is wave-making resistance, the balance being made up by eddy-making and air resistance. In modern well formed vessels having streamlined rudders and stern frames, also cruiser sterns, eddy-making is a small item. Wave-making absorbs a considerable amount of the total resistance, particularly in high speed vessels. Air resistance may also be considerable with a high wind.

E.h.p. is the equivalent of resistance. It is the horse-power expended in overcoming the net resistance of the vessel. The term "resistance" means the pull on the tow-rope registered by means of a properly arranged dynamometer when towing a ship or model through still water. The resistance of a ship towed at various speeds may be inferred from tests carried out with a model of the ship in the experimental tank at the Wm. Froude Laboratory, the National Physical Laboratory, Teddington, or any other similar tank, of which there are quite a number now in existence. Models used for this purpose are made of wax about 20ft. in length and are towed naked, i.e., without bilge keels or other appendages, in order to ascertain the net resistance.

To enable a seagoing tanker to operate under average service conditions at the required mean speed an addition of 20 per cent. above the power required for average fine weather and clean bottom conditions should be made and the machinery should be capable of operating on full power trial at a power 10 per cent. in excess of that required for the service b.h.p. output. From the e.h.p. (effective horse power or tow rope horsepower) indicated by the tank resistance tests the shaft horse power at the propeller can be found by adding a percentage of 23 in the case of a single screw vessel for appendages, wind and disturbed water resistance and dividing the sum by the quasi propulsive coefficient, which in vessels of this class usually varies from ·65 to ·70.

The following is an example of power for a 12,500 tons deadweight tanker required to operate at a loaded service speed of 11½ knots:

Effective horse power (naked)	1,465
Quasi propulsive coefficient	·675
Shaft horse power at propeller $= \dfrac{\text{e.h.p.} + 23 \text{ per cent.}}{\text{Q.P.C.}}$	
for average fine weather and clean bottom conditions	2,670
b.h.p. required for service conditions	3,200

The quasi propulsive coefficient is derived directly from the model experiments and needs no correction when applied to the ship.

$$\text{Q.P.C.} = \frac{\text{Model resistance} \times \text{speed.}}{2\pi \times \text{torque} \times \text{r.p.m.}}$$

The horsepower required may be estimated from C curves, C is the resistance constant and depends only on shape and speed. The value of C is expressed as a constant for similar forms at corresponding speeds, whatever the absolute size of the vessel, and equals $\dfrac{\text{e.h.p.}}{D^{\frac{2}{3}} \times V^3} \times 427{\cdot}1$, D being the displacement in tons and V the speed in knots.

The value of C for vessels of the modern tanker class usually varies between ·60 and ·70, the higher value for the higher speed, the C curve for a reasonably good form remaining reasonably flat well beyond the service speed. Using data obtained from similar ships it is possible to estimate the approximate value of C from which the e.h.p. can be readily obtained. Working up to b.h.p. is the same as before.

The most commonly used approximate method for estimating the horsepower required is that known as the "Admiralty Coefficient", the formula for which is as follows:

$$\text{i.h.p.} = \frac{V^3 \times D^{\frac{2}{3}}}{C}$$

where V = speed in knots, D = displacement in tons, C = constant obtained from previous similar vessels.

It should be borne in mind that this method applies to similar vessels at corresponding speeds, i.e., speeds which vary as the square root of the lengths of the vessels and in such cases only can it be relied on to give satisfactory results. For a Diesel-engined tanker the i.h.p. in the formula would be assumed to be the equivalent steam i.h.p. and the necessary correction would require to be made to the power. The value of the constant C varies greatly in different vessels, but when discriminately obtained from a basis vessel the formula is very useful in the early stages of design.

By the independent estimate method the various resistances due to skin friction, eddy-making, wave-making and air, together with their corresponding e.h.p.'s, can be separately estimated from published data on the subject. All are added together to obtain the total e.h.p. and then by using a suitable propulsive coefficient the b.h.p. can be found.

Corresponding speeds vary as the square root of the lengths of vessels. To obtain a real comparison of the speeds of various ships the speeds should therefore be compared with the square root of the respective lengths by finding the ratio $\dfrac{V}{\sqrt{L}}$ known as the speed-length ratio.

Of all the methods used for ascertaining the horsepower required to propel a ship at the desired speed, the model experiment method is the most satisfactory and can in fact now be regarded as standard practice.

There is a strong public demand at the present time for faster merchant ships and in time of war, particularly in view of the submarine menace, there is no doubt that a fast ship has a decided advantage over a slow one but the subject is a difficult one, the supply of suitable machinery, labour, etc., being involved and is beyond the scope of this paper. In peace time the high speed cargo ship may not be an economical proposition, in fact in the majority of cases such a vessel could not compete in profit-making with the moderate speed vessel. An increase in speed necessitates a considerable increase in power and assuming the type of machinery to be the same a considerable increase in weight also. As there is a degree of fineness appropriate to speed the form of the vessel would require to be made finer so that in order to provide the additional displacement necessary on account of the extra weight of machinery and fuel and be able to carry the same amount of cargo the extra weight of the ship itself due to its larger dimensions would also require to be taken care of. In order to illustrate this point more clearly the characteristics of three Diesel-engined tankers, each designed to carry 12,000 tons of cargo (petroleum in bulk) and each having a steaming radius of 8,000 miles, but having different service speeds, i.e., 12, 15 and 18 knots, have been investigated. Fig. 9 shows the outline profiles of these three vessels and from the following principal particulars the increase in size of vessel and horsepower required for the higher speeds will be at once apparent.

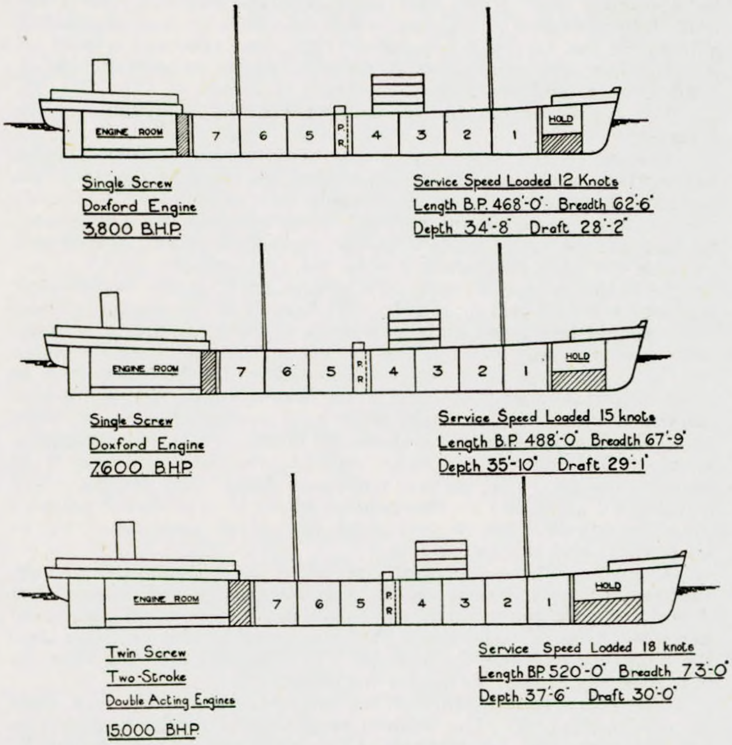


FIG. 9.—*Outline profiles of 12, 15 and 18 knots tankers.*

Speed, knots	12	15	18
Length, b.p.	468′ 0″	488′ 0″	520′ 0″
Breadth, moulded	62′ 6″	67′ 9″	73′ 0″
Depth, moulded	34′ 8″	35′ 10″	37′ 6″
Summer draft	28′ 2″	29′ 1″	30′ 0″
Block coefficient	·76	·70	·645
Displacement, tons	17,830	19,150	20,860
Deadweight, tons	12,770	13,150	13,760
Lightweight, tons	5,060	6,000	7,100
Service b.h.p.	3,600	7,600	15,000
Fuel consumption, tons per day	16	32	62
Cargo tanks	7	7	7
Cargo, tons	12,000	12,000	12,000
Bunkers, tons	570	930	1,540
Stores, etc., tons	200	220	220
Pump rooms	1	1	1

(5) MACHINERY.

It will be appreciated that the operative conditions governing the running and maintenance of a tanker fleet differ greatly from those ruling in general cargo vessels.

Normally it is quite usual for a tanker to discharge full cargo, and subsequently ballast, bunker and take in stores for the ensuing voyage in a period of 48-60 hours.

It may be generally stated, in terms of steaming days at sea per year, that over equal periods a tanker spends approximately 50 per cent. more actual running time than a general cargo vessel. Further, the nature of general cargo is usually such that general repairs and routine overhauls can be effected concurrently with discharging or loading operations. In tankers carrying various grades of crude oil, and also the lighter petroleum distillates, the volatile nature of the gases given off by the cargo is such as to prohibit any repair work entailing risk of sparks, etc., with probable consequent disastrous results. Even on completion of discharge of such cargoes, if any repairs have to be effected in the vicinity of the cargo tanks, these tanks have to be washed and gas freed preparatory to commencing repairs.

Bearing these operative conditions in mind it will be apparent that, to achieve the highest efficiency consistent with economy and the least delay, all running repairs, examinations, overhauls, periodical drydockings and surveys must be strictly planned to schedule and, as far as possible, co-ordinated. Regular operation of a tanker fleet entails a high standard of maintenance of hull and machinery as a first essential. To ensure this standard, and also reduce to a minimum risks due to unforeseen breakdowns, all examinations must be effected as a matter of regular routine, and all data relative to these examinations carefully recorded and tabulated.

During the last twenty years rapid progress has been made in the development of the Diesel engine. It is worthy of note, as exemplified in the well-known makes which have proved over a long period their reliability in exacting marine service, that steady improvement has been accompanied by a simplification of the operative mechanism. This is immediately reflected in easier maintenance, and in the continuing improvement of power/weight and power/space ratios.

For moderate powers, single acting engines are meantime the most widely employed in marine practice and these may be either of two or four stroke cycle type. The Doxford opposed piston engine, belonging to the former group, is one of the most favoured makes. Regarding double-acting engines, especially where high power output is essential, the two stroke type has much to recommend it, and doubtless the advent of war has, to a certain extent, delayed its further development and wider adoption. In the case of four stroke double-acting engines, this type has certain inherent disadvantages as regards accessibility and low power/weight ratio that have militated against its popularity.

In all types airless injection of fuel has practically become standard practice. In thus dispensing with the main compressor the mechanical efficiency of the engine is increased and, consequently, fuel consumption reduced. Further, it directly leads to a big reduction in overall weight, and also the elimination of compressor maintenance, which previously formed a considerable proportion of the cost of total upkeep.

Another modern trend is for all engines of moderate power to become, in effect, self-contained units, in that all pumps necessary for the engine services—forced lubrication, piston and jacket cooling, cooler circulating, etc.—are attached to and driven by the engine.

Supercharging is also becoming a standard feature in engines of four stroke cycle type, due to the considerable gain in power output derived thereby. The necessary additional air can be obtained either from rotary blowers operated by exhaust gas turbines on the Büchi principle or by independent drive, or, in the case of single acting engines, by using the underside of main pistons as low pressure air compressors.

It would be impossible to deal adequately with each engine type in the course of one paper. All function on the same fundamental principle however, and many features relative to care and upkeep are applicable to all types. It is proposed, therefore, to deal with the common features and to outline some of the latest ones in a few well known types.

For specially high-powered tankers, twin screw machinery may be necessary. High speeds are expensive; the higher the speed, for a given size of vessel, the smaller is the carrying capacity by reason of the finer lines of the hull, the increased bunker capacity and the increased steaming weight of machinery.

The following are some average sizes and powers of modern Diesel tankers :—

Speed, knots	10	11	12	13	14	15
Deadweight, tons ...	10,000	11,000	12,000	13,000	14,000	15,000
Displacement, tons ...	14,000	15,470	17,000	18,400	19,800	21,400
Length, b.p....	428′ 0″	443′ 0″	460′ 0″	476′ 0″	492′ 0″	510′ 0″
Breadth moulded ...	56′ 6″	59′ 3″	62′ 0″	64′ 6″	67′ 3″	70′ 0″
Depth moulded ...	31′ 10″	32′ 11″	34′ 0″	35′ 0″	36′ 3″	37′ 0″
Draught ...	26′ 0″	26′ 10″	27′ 7″	28′ 4″	29′ 3″	30′ 0″
Service b.h.p.	1,900	2,650	3,600	5,000	6,800	8,800
Fuel consump., tons/day ...	8	11	15	21	29	37

In ballast condition the speed will be increased by about 1 knot for the same power output and fuel consumption.

The consumption quoted does not include fuel used for special purposes, such as the supply of steam for cargo heating where necessary, but is for all steaming purposes at sea and assumes main engine exhaust gases are utilised in auxiliary boilers for providing steam to the steering gear, dynamos, accommodation heating, etc. The consumption figures will vary slightly according to the type of machinery fitted, and the speed may vary due to hull form, propeller and rudder design.

Simplicity in engine design, which is generally accompanied by accessibility and easy overhaul, is of primary importance. As the reliability of Diesel machinery is well established, vessels to which the figures just quoted are applicable are generally fitted with single screws, thus minimising maintenance costs and reducing weight. At this point it may be mentioned that cases of total breakdown of Diesel plant are as infrequent nowadays as in any other type of propulsion. When the necessity arises any competent engine room staff are able to cope successfully with any breakdowns likely to occur. Even in the event, for instance, of one cylinder of a complement becoming inoperative due to a defective piston, liner or cover, and assuming no spares available, no difficulty is experienced in cutting out the defective cylinder and proceeding on the remainder. In this connection, it may be observed, sufficient in the nature of engine spare gear is carried aboard to cover practically all eventualities.

Fuel Consumption.

All main engine types are subjected to test bed trials during which the fuel consumption is measured at various loads which are accurately determined from a water brake. It is found in service that the consumption practically corresponds with test bed figures, and sometimes even better results are obtained owing to the improved mechanical efficiency when the engine has been "run in".

The main engine consumption may vary from about ·34 to ·39lb./b.h.p./hr. according to the type of engine fitted, and the original figure should be substantially maintained throughout the life of the engine. Any deviation from normal consumption should be immediately investigated, and generally it is found that faulty combustion is the cause of any increase. Poor combustion may originate from any one or more of several possible causes and is usually indicated by smoky exhaust, high exhaust temperature, ignition knocks or irregular operation generally.

The mean indicated pressure in the cylinder under service conditions depends upon various factors in the particular design of engine, and average figures recommended for different types are as follows:—

Types of machinery.	*M.i.p.*
2 stroke cycle double-acting type...	80lb. per sq. in.
2 ,, ,, single-acting type	85lb. ,, ,,
2 ,, ,, opposed piston type	85lb. ,, ,,
4 ,, ,, single acting type	90lb. ,, ,,
4 ,, ,, ,, ,, supercharged type...	115lb. ,, ,,

These figures allow a safe margin for emergency or for a cylinder temporarily receiving too much fuel, and the fuel consumption and engine revolutions should be based on them.

A useful check on the performance of a vessel may be made by applying the two formulæ:—

(1) $$\frac{(\text{Displacement tons})^{\frac{2}{3}}\ (\text{Speed knots})^3}{\text{shaft horse power.}} = \text{constant.}$$

(2) $$\frac{(\text{Displacement tons})^{\frac{2}{3}}\ (\text{Speed knots})^3}{\text{Daily fuel consumption(tons) for steaming purposes.}} = \text{fuel coefficient.}$$

The results will vary according to hull form and propeller and rudder design, but for any given vessel, fair comparative voyage results can be obtained after due allowance has been made for weather conditions and the length of time since the previous dry-docking and painting. In a modern tanker, fitted with stream-line rudder, a constant of about 350 may be expected for mean service conditions; the fuel coefficient may be 85,000 to 90,000.

It will be observed that in formula (1) s.h.p. is taken instead of i.h.p., which latter is used in arriving at the Admiralty constant. This is to make the formula applicable to all types of machinery, including turbines, by comparing power output at the shaft, thereby making it unnecessary to allow for the different mechanical efficiencies of the machinery types in arriving at a fair comparative constant.

Diesel Fuel and Fuel Treatment.

There is, of course, a comparatively wide range of different grades of Diesel fuel, but provided the requisite fuel pump and fuel valve adjustments are effected to give the proper degree of atomisation, and the valves accurately timed, no particular difficulty should be experienced with engines of modern design in obtaining good combustion with most commercial grades of Diesel bunkers, even although the fuel characteristics of these may vary considerably.

The following is a specification of a standard type fuel which has given very satisfactory results in all types of marine Diesel machinery:—

Specific gravity at 60° F.	·88.
Flash point	175° F. minimum.
Viscosity Redwood I at 100° F....	60 seconds maximum.
Sulphur	1·3 per cent. ,,
Ash	0·01 ,, ,, ,,
Water and sediment	0·25 ,, ,, ,,
Calorific value (gross)	About 19,300 B.Th.U's. per lb.

It is of the greatest importance, in order to obtain fully efficient operation and smooth running, that every care should be exercised in ensuring that the fuel, before entering the engine system, should be absolutely free from solid impurities and water. This point must be emphasized; it is impossible to offset by any mechanical adjustment the use of unsatisfactory fuel, bad combustion with all its attendant and cumulative detrimental effects relative to valves, pistons, liners and heads must inevitably follow.

The course of the fuel from bunker tanks to cylinders is as follows:

The oil is first transferred from crossbunker to engine room settling tank, and, from there, gravitated via the fuel heater to the centrifugal purifier. After centrifuging it is transferred to one of the rectified fuel tanks, the rectified fuel thereafter being gravitated by way of the suction filters to the main fuel pumps, and thence through the high pressure filters to the fuel valves.

Self-closing syphon cocks are usually fitted on the crossbunker bulkhead with internal pipes led to the bottom of the bunker. These cocks should be opened at least once daily and thus timely warning will be given if any water is present. If such is indicated, the water can be drained off by means of the cocks. In this connection it must be pointed out that, even if the water content of the fuel as shipped is negligible, a certain amount of condensation or sweating takes place on the interior surfaces of tanks. There is, in addition, always a possibility of seawater leakage to a varying degree from outside sources. All settling tanks are fitted with similar cocks and internal pipes, and a corresponding check as regards the presence of water can be made at this point before the fuel passes to the oil heater prior to centrifuging.

Regarding the temperature at which centrifuging should be effected, this will depend on the specific gravity and viscosity of the oil and, to a lesser extent, on the amount of water and mechanical impurities held in suspension. With the usual grades of Diesel fuel the temperature should be 100°-110° F. Gas oils and low viscosity oils generally, however, require no heating.

The centrifugal purifier—there are several makes—is a most efficient mechanism. The modern types are of robust construction and the operations of dismantling, cleaning and reassembly can be effected very quickly. All work on the same principle of separation, and in each type a bowl, spinning at very high rotational speed, is the medium by which any water, sludge or solid matter is separated from the oil by centrifugal force. Due to the high speed of rotation —this varies from 6,000 r.p.m. to 17,000 r.p.m. depending on type— all the water and solid matter in the oil is precipitated radially outwards to the periphery of the bowl, forming, in effect, an annulus from which, by a suitable channel, all water and impurities are passed to one outlet of the machine. The purified oil, which may now be regarded as a liquid core, is led by another channel to a second outlet, and thence to a small pump which transfers the oil to the rectified fuel tanks. Various sizes of adjusting rings are provided to suit different specific gravities of fuels which may be used, and for most efficient separation, the lowest gravity disc should be used consistent with no oil coming from the water outlet.

Fuel Pumps and Fuel Valves.

The function of the fuel pump is to meter exactly and supply to the fuel valve the necessary quantity of oil per cycle to develop the required power output. Modern fuel pumps are invariably of glandless, single acting ram type, the rams being of hardened alloy steel operating in pump bodies machined out of solid steel blocks or having steel barrels. Depending on the type of engine, the reciprocating motion of the rams may be obtained through crank, eccentric or cam drive. The actual method of measuring the requisite quantity of fuel also varies, each of the following methods being in current use:—

(1) By tappet control of the suction valve, the valve being held off the face until a predetermined point in the discharge stroke. From this point until the end of the stroke, actual delivery to the fuel valve takes place.

(2) By the opening of a mechanically controlled spill valve at that point in the discharge stroke when the requisite quantity of fuel to meet the load has been delivered to the cylinder. The spill method is also used in pumps working on the Bosch principle. In this type a channel is cut lengthways in the plunger, one edge of the channel being cut in the form of a helix. On the discharge stroke, delivery of fuel to the cylinder ceases when the lip of the helix uncovers a port through which the oil remaining in the pump chamber is spilled. The actual amount delivered can be adjusted by rotating the plunger and thus altering the position of the helix edge of the channel relative to the spill port.

(3) By varying the plunger stroke to discharge the required quantity of fuel throughout the whole delivery stroke.

The amount of fuel actually burned determines the power output and in each of the methods of delivery control just mentioned the actual regulation of all pumps is effected by a lever or handwheel adjacent to the starting platform.

With the exception of the Werkspoor engine, where one fuel pump supplies all cylinders, practically all marine Diesel engines have one fuel pump per cylinder. The Doxford engine is so fitted, but the arrangement is such that all pump discharges can either feed into a "common rail" supplying all fuel valves, or the discharges can be isolated from each other and each pump supply one cylinder. Doxford fuel valves are, of course, cam operated. Where automatic pressure controlled fuel valves are employed, as in the latest Burmeister & Wain practice, each cylinder must be individually fed by one pump.

As already mentioned, airless injection of fuel has practically become standard practice. Due to this it must be emphasized that the fuel and fuel system require, if anything, even more strict attention that is the case where air injection is employed. In the latter system it is only necessary for the maximum fuel pump delivery pressure to be in excess of the blast air pressure, say, 800-1,000lb. per sq. in. When the fuel valve opens, atomisation is obtained by virtue of the blast air pressure . With airless injection atomisation is effected by the fuel pressure, which ranges from 4,000-8,000lb. per sq. in. in different type engines. It is therefore obvious that fuel pumps and valves employed in conjunction with airless injection have to be capable of much higher performance than is the case with air injection.

Lubrication.

The consumption of lubricating oil may vary, according to the type of engine, from about two to four gallons per day per 1,000 b.h.p. for cylinder lubrication, and from about one-and-a-half to three gallons per day per 1,000 b.h.p. for bearing lubrication.

Cylinder lubricating oil should be pure mineral oil with a comparatively high flash point, say, 400° F. of above, and have a viscosity suitable for the engine. No definite viscosity is laid down in general practice; good results have been obtained with various grades from 160 to 220 seconds Redwood I at 140° F. Cylinder oil, of course, is not recoverable after use, a certain proportion is burnt in the cylinder and the remainder drains off the liner walls, forming a black sludge of partly oxidised oil which is unusable.

The lubricating system is generally so arranged that the oil is drawn from a sump tank located in the double bottom by the forced lubrication pump, and delivered to the various lubricating points. After feeding all bearings the oil falls back into the engine bedplate and thence drains to the double bottom tank.

The previous remarks regarding the centrifuging of Diesel fuel apply generally to lubricating oil. Obviously the maintenance of the lubricating oil in the highest possible degree of purity is of vital importance. Although free from acid when new, it will become contaminated with water, acids, carbon and other solid impurities after use. This particularly applies in the case of engines where the cylinder liners enter the crankcase and consequently all waste oil and sludge from the liners can mix freely with the bearing oil in the crankcase.

The purifying arrangement generally forms a bypass off the main lubricating system, and the centrifuge should be in constant use except for the short stoppages necessary for cleaning purposes. The bearing oil should be heated to about 180° F. before centrifuging and the hot distilled drain water from the oil heater should be run with the oil into the centrifuge. This assists in washing the oil during separation and, by absorption, greatly reduces the acidity. Further, the mixing of the water with the solid impurities forms a resultant greasy sludge which discharges freely from the machine. This greatly reduces the number of stoppages necessary for cleaning, as it prevents the formation of a solid mass of impurities on the inner periphery of the separator bowl which would quickly choke the machine and prevent efficient separation.

It is also usual to install a lubricating oil settling tank with a conical shaped bottom and fitted with heating coils. This tank should be of sufficient capacity to accommodate the contents of the sump tank.

In addition to the foregoing, the greatest attention must also be paid to the filtration of the oil. Streamline filters are most efficient in operation, and also units of "Autoklean" or similar self-cleaning types.

Jacket and Piston Cooling.

In modern practice distilled water is generally employed as the cooling agent for cylinder jackets, heads and exhaust valves. Until a few years ago seawater was extensively used for this purpose, but apart from a comparatively slight saving in initial cost, due to the fact that no distilled water cooler and cooler circulating pump are required, seawater cooling has nothing to recommend it. Any initial gain is more than offset by the detrimental effect of heavy scale deposits, with consequent risk of fractures or seizures due to overheating. Further, where distilled water is employed, it is possible to work with higher cooling temperatures, say, 150° F. as against 125° F., this being conducive to higher mechanical efficiency. It may here be stressed that nothing is gained by over-cooling. On the contrary, by maintaining the cooling water temperature as high as possible consistent with the avoidance of steam locks in the system,

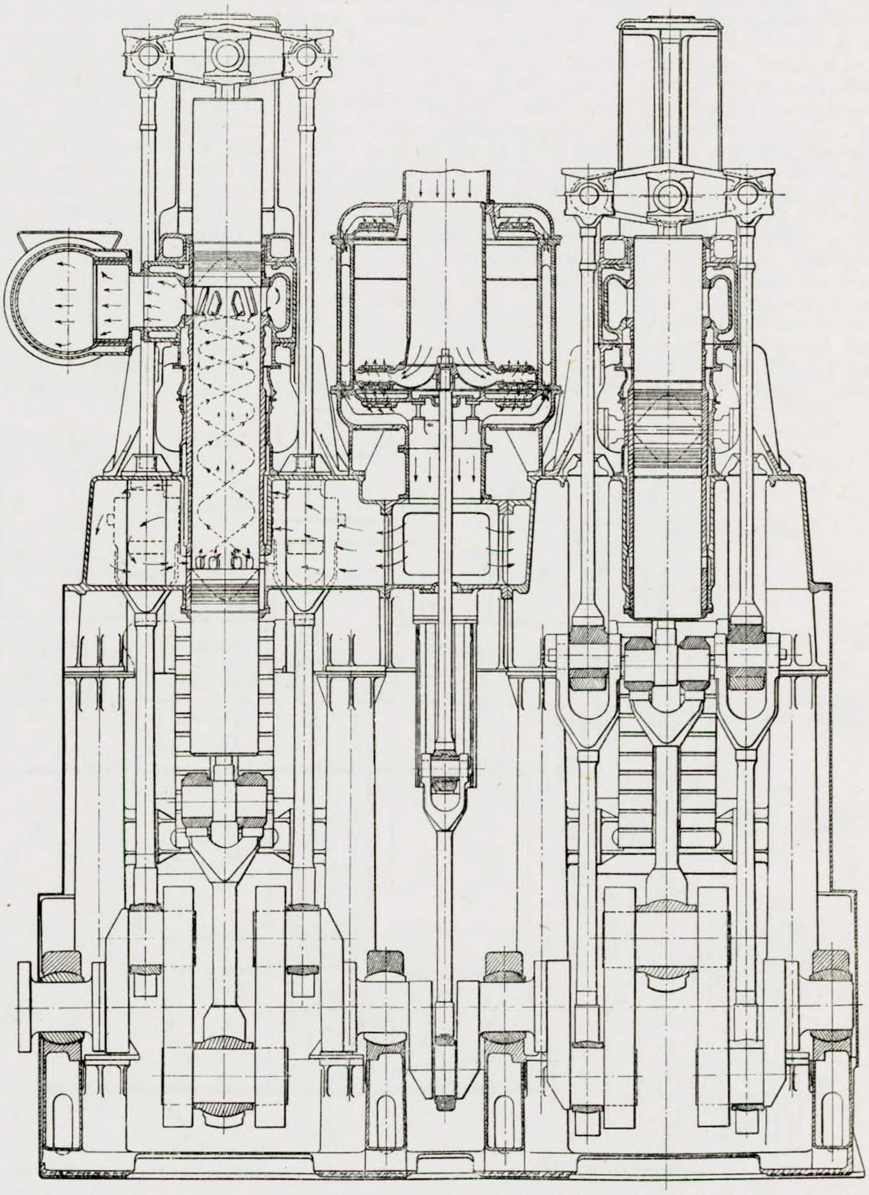


FIG. 10.—*Typical scavenging arrangement—Doxford Diesel opposed piston type.*

thermal stresses in the cylinder units are reduced and the fuel consumption improved.

Pistons may be water or oil cooled, and where water is employed the foregoing remarks are applicable. The use of oil as a piston cooling medium has much to recommend it. When the cooling agent for pistons passes, as it invariably does, through telescopic or walking pipes which are partly arranged in the crankcase, the mechanism is thoroughly lubricated where oil cooling is employed and wear and tear thus reduced to a minimum. Also, even if leakages do occur from glands, etc., in the crankcase, there is no risk of contamination of the bearing oil.

Waste Heat Recovery.

In the average Diesel installation fully 30 per cent. of the heat originally generated by the fuel is contained in the exhaust gases. To obtain the highest economy, therefore, the waste heat boiler has been introduced to recover usefully a portion of this otherwise lost heat. Where all pumps necessary for main engine cooling and lubricating services are driven by the main unit, the steam generated by the waste heat is generally sufficient to supply all other usual auxiliary services.

There are several types of boiler specially designed for utilising waste heat, but in tankers the usual method adopted is, in effect, to superimpose the waste heat system on the existing oil burning installation. Practically all tankers have steam driven cargo pumps, and in legislating for these a comparatively large auxiliary boiler installation is required on board. The following particulars relate to a modern tanker of 12,000 tons deadweight. Two Scotch type, single ended, multitubular boilers are fitted, 12ft. 6in. diameter by 11ft. long, total heating surface 3,800 sq. ft. There are two corrugated type furnaces to each boiler, and all furnaces are arranged for oil fuel burning with forced draught, or exhaust gas heating. The exhaust gas is controlled by a gear operated main change over valve, so designed as to prevent both outlet branches being closed at the same time. One branch leads to the vertical exhaust pipe through the silencer located in the funnel. The other branch leads along the front of the adjacent boilers with easy bends and flanged branches to each of the four furnaces. The usual oil burning furnace fronts have flanged branches on the underside, and between these flanges and the flanges on the exhaust branches isolating valves are fitted. Each furnace has an independent smokebox, uptake and funnel, and by means of the isolating valves the exhaust gases can be switched to any or all furnaces as desired. To augment the steam supply, if necessary, the oil burning system can be used in any furnace as required by merely closing the exhaust isolating valve on the particular furnace front.

Critical Speeds.

Hull pulsations will occur when the natural period of vibration of the vessel coincides with the disturbing forces from the machinery or propeller. For instance, several vessels of the same form and dimensions having a deadweight of about 11,000 tons are known to be subjected to vibration when the engines are running at about 85 r.p.m. The machinery of these vessels, however, is not identical, some being of the six-cylinder 2 S.C.S.A. type, some eight-cylinder 2 S.C.S.A. type, and others 4 S.C.S.A. type. These engines are in every case fitted with four-bladed propellers and it has been observed that by increasing or decreasing the engine revolutions from 85 r.p.m. the pulsating ceases. The indications are that the natural period of vibration of the hulls is an integral multiple of 85 coinciding with a harmonic of the forces transmitted from the propeller to the hull.

Shaft vibration may be equally or more serious. A Diesel engine applies its power to the propeller in a series of impulses which combine to give a torque which is varying from point to point each revolution. This varying torque can be split up into a series of harmonics, some large and some small, and covering a wide range of frequencies. Some of the harmonics cancel out depending on the firing order of the cylinders, the crank sequence, and the disposition of the various masses of the engine and propelling system, while others build up to serious dimensions. There are usually at least two natural modes of oscillation of the shafting, the first in which the engine shaft as a whole and the propeller with part of the intermediate shafting vibrate in opposite directions about a nodal point in the shafting, and the second in which the forward end of the engine shaft vibrates about a point near the after end, and the forward section of the intermediate shaft vibrating in the opposite direction, and propeller in the reverse direction again. The first of these modes of vibration often occurs at about half to one third the speed of the second, and if the unbalanced harmonics have a frequency which is a small multiple of either of the natural frequencies of the system, a condition of instability is reached where the vibrations may build up to a dangerous degree and, in time, may lead to fracture of the intermediate shafting or the engine crankshaft.

The speeds at which these resonances occur are the critical speeds and the dangerous ones must be avoided for prolonged running, if they cannot be eliminated or removed out of the running range by suitable design. Torsiograph readings should be taken from

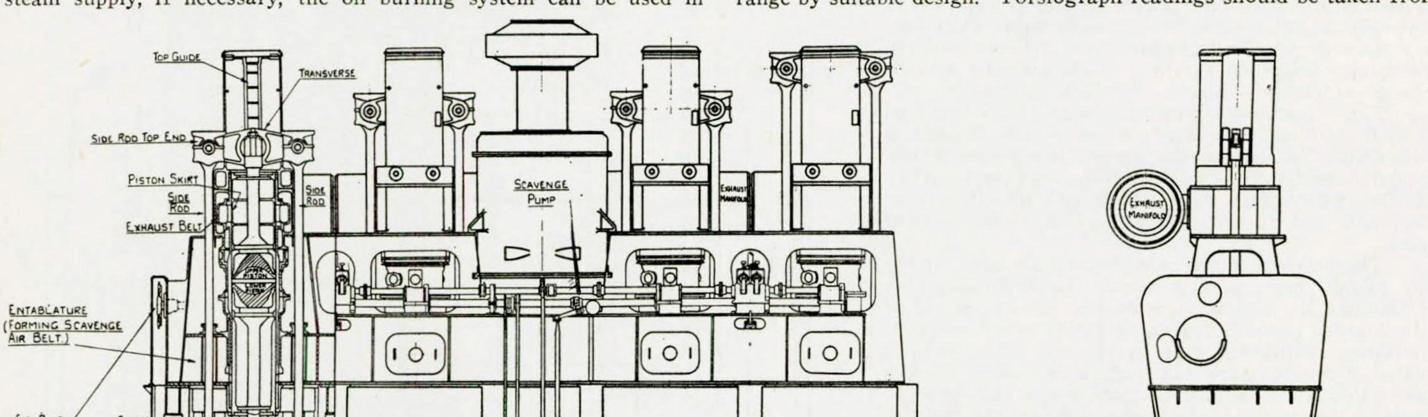


FIG. 11.—*Sectional arrangement of 4-cylinder Doxford opposed piston Diesel engine.*

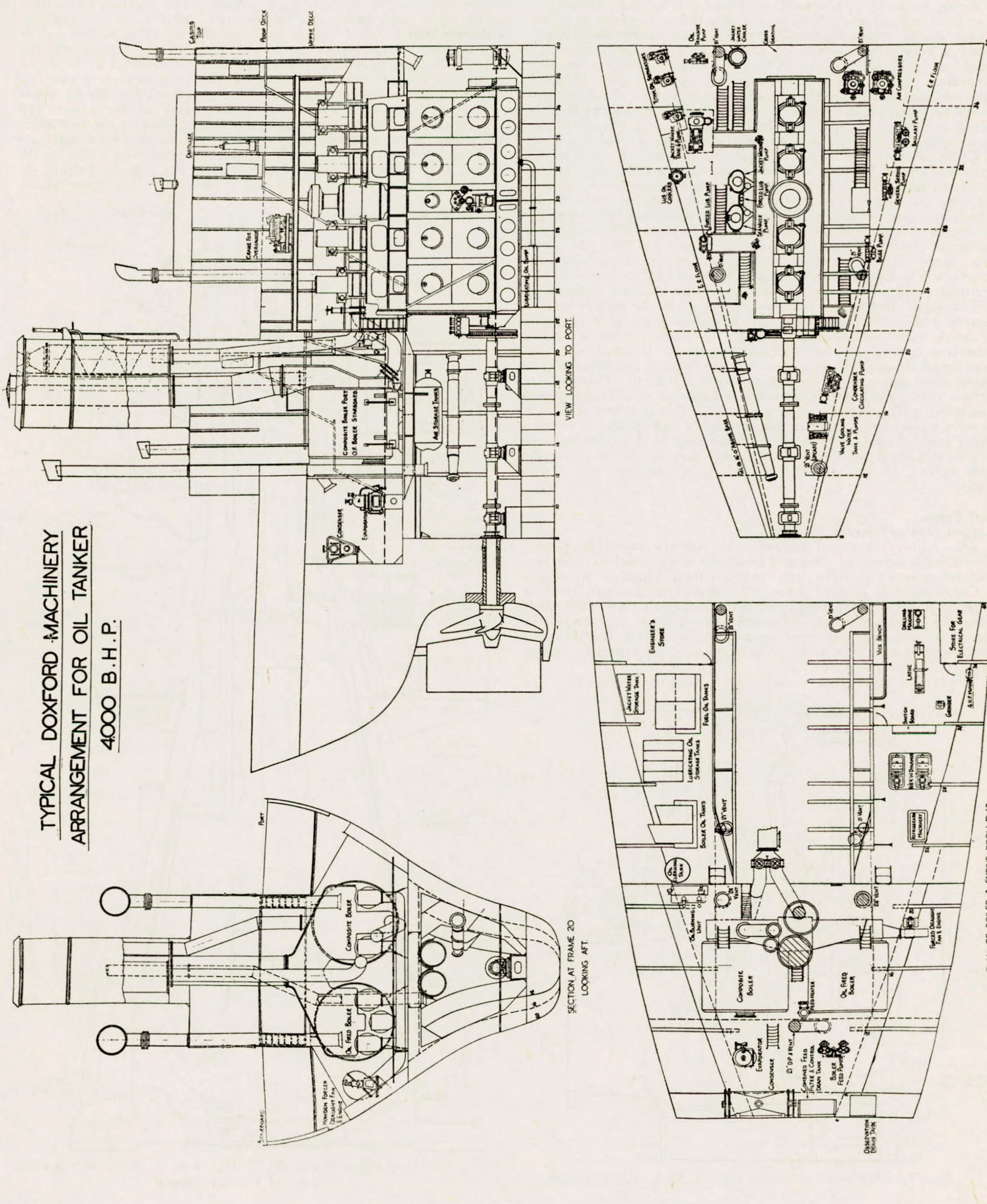


FIG. 12.—*Machinery arrangement with single screw Doxford engine.*

the shaft system before the ship is put into service, and the problem is carefully looked into by the shipbuilders and engine designers.

As an example in torsional vibration a 4 S.C.S.A. engine was found to vibrate excessively in way of the thrust block at 93 r.p.m.; the first degree frequency was 372 periods per minute. In all probability a very short amount of running at this speed would have resulted in shaft failure, and it was therefore imperative to place this critical speed outside the range of service speed. A short length of intermediate shaft of 24in. diameter was therefore substituted for the original one of 14¾in. diameter, thereby raising the natural frequency to 445 periods per minute and the dangerous critical up to 111 r.p.m., which was well above the normal revolution speed. In another case in a 2 S.C. engine the service speed of the engine was about 75 r.p.m. and the second degree 10th order critical was found to be at 73 r.p.m. As the 10th order was a somewhat dangerous one and 73 r.p.m. was too near the service speed, 3 tons of material were machined off the 13 tons flywheel, which brought the frequency up from 730 periods per minute to 790 periods per minute, so that the 10th order, viz., 79 r.p.m., was well above the service speed. These examples illustrate how, in service, a dangerous critical could be raised by increasing stiffness or by decreasing masses. A critical could, of course, be lowered by the opposite changes.

Torsional vibrations which would otherwise be dangerous can often be reduced to safe limits by fitting one or other of many alternative forms of vibration damper. A damper may be applied to the free end of the engine crankshaft in the form of a spring-driven small flywheel so arranged that the natural frequency of the sprung wheel alters with the amount of oscillation. This gives a detuning effect which prevents excessive build-up. Oil damping may be included in the damper, or, for certain purposes where it is only necessary to be able quickly to run through a bad critical, a friction damper may be used. Alternatively, there may be dampers on some or all of the crank webs. The best design depends on the particular circumstances of the installation and is a question for expert decision.

Diesel Types.

Doxford Opposed-piston Engine.

This highly successful engine works on the two stroke cycle with airless injection of fuel and possesses many original constructional features which have fully justified their adoption in service.

Combustion is effected when the opposed pistons are at their innermost positions, and the pistons move outwards from each other during the working stroke. Towards the ends of the stroke the exhaust and scavenge ports are opened, in that order, by the upper and lower pistons respectively, thus permitting of a perfect system of longitudinal scavenging.

The typical scavenging arrangement is depicted in Fig. 10. The scavenge pump may be crank driven from the main shaft as indicated, or located at the back of the engine and operated by rocking levers from one of the centre crossheads. The pump is of double-acting type with automatic suction and delivery valves, and the hollow piston is fitted with a trunk extension. The suction valves are formed on the upper and lower faces of the piston, and the delivery valves—four each top and bottom—are located in the upper and lower covers. During the upstroke the air in the pump chamber above the piston will be delivered, at low pressure, through the upper discharge valves—and the upper suction valve on the piston will remain closed. At the same time, due to the vacuum created under the piston by its upward movement, a fresh charge of air will pass through the hollow piston trunk and the lower suction valve on the piston, thus filling the pump chamber below the piston. During the down-stroke the cycle of events will be reversed. The scavenge air

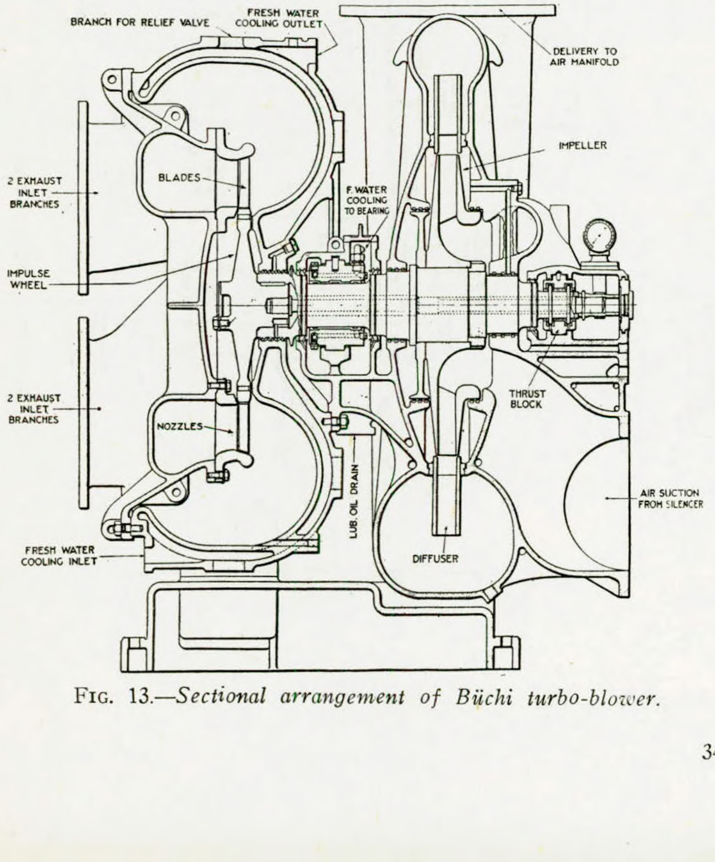


FIG. 13.—*Sectional arrangement of Büchi turbo-blower.*

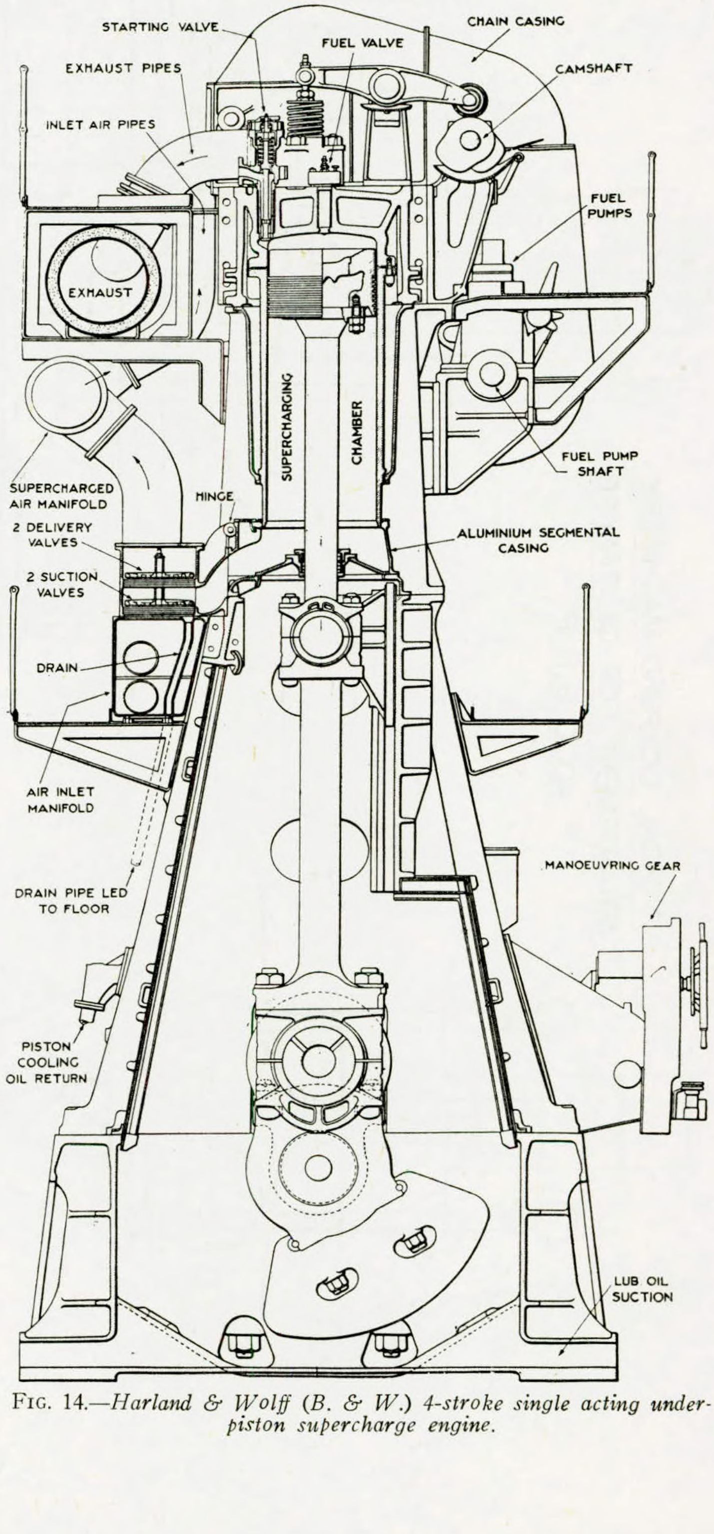


FIG. 14.—*Harland & Wolff (B. & W.) 4-stroke single acting under-piston supercharge engine.*

from the pump is delivered, as indicated by the arrows, to the hollow entablature which bridges the columns, and in which the lower portion of the cylinder liners are suitably located. The scavenge ports in the liner are so formed that the air entering the cylinder is given a rotary motion, and the spinning action so produced continues throughout the compression stroke while the pistons are moving inwards. This results in a very intimate mixture of the air with the finely divided fuel spray from the valves, of which there are two in each cylinder, and ensures a very high combustion efficiency.

In the latest type engines the scavenge piston is of the single plate type. In this case both suction and delivery valves are located in the top and bottom covers.

Fig. 11 shows a sectional arrangement of the Doxford engine. Some ten years ago welded, fabricated steel construction was adopted in the bedplate, entablature and columns with most successful results. As compared to cast iron this allows the employment of much lighter scantlings for equal strength and results in an improvement of the power/weight ratio. Fabrication also promotes better overall flexibility, an advantage that has been emphasized under wartime conditions. Steel sections not only offer greater resistance to the effects of shock and concussion generally, but any defects arising due to such wartime causes can be readily repaired by part renewal and welding as required. The relative disadvantage of heavy iron castings in this respect does not require to be stressed.

Another outstanding advantage of this engine is that no cylinder covers are employed, the cylinder forming, in effect, a plain open ended tube. This construction is ideal in that it allows of free expansion in the longitudinal direction.

The opposed pistons in each unit are connected to a three-throw crank. Pistons are of forged steel construction with cast iron bearing rings. The lower piston drives the centrecrank, while the upper piston drives the side cranks through the intermediary

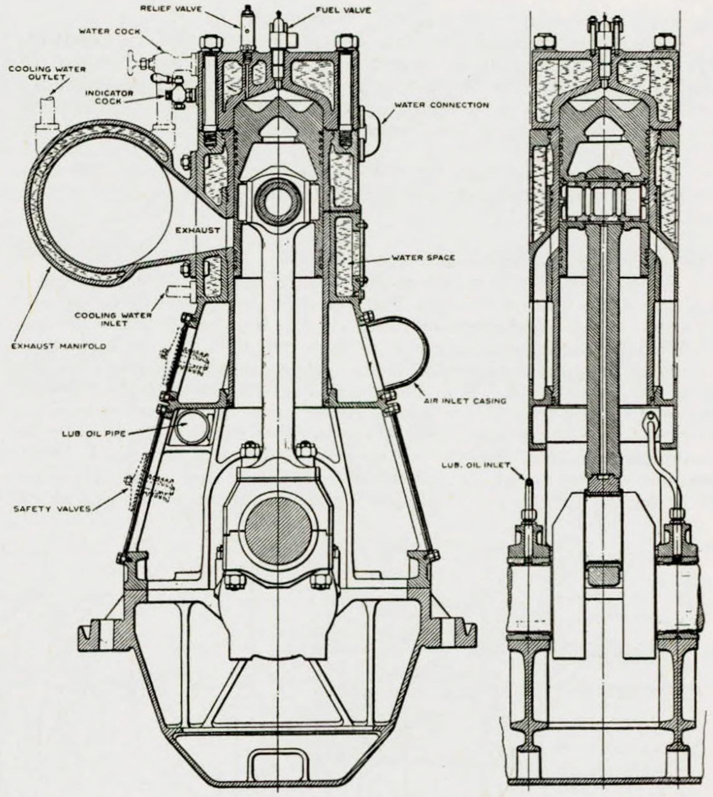


FIG. 16.—*Harland & Wolff auxiliary 2-stroke single acting engine.*

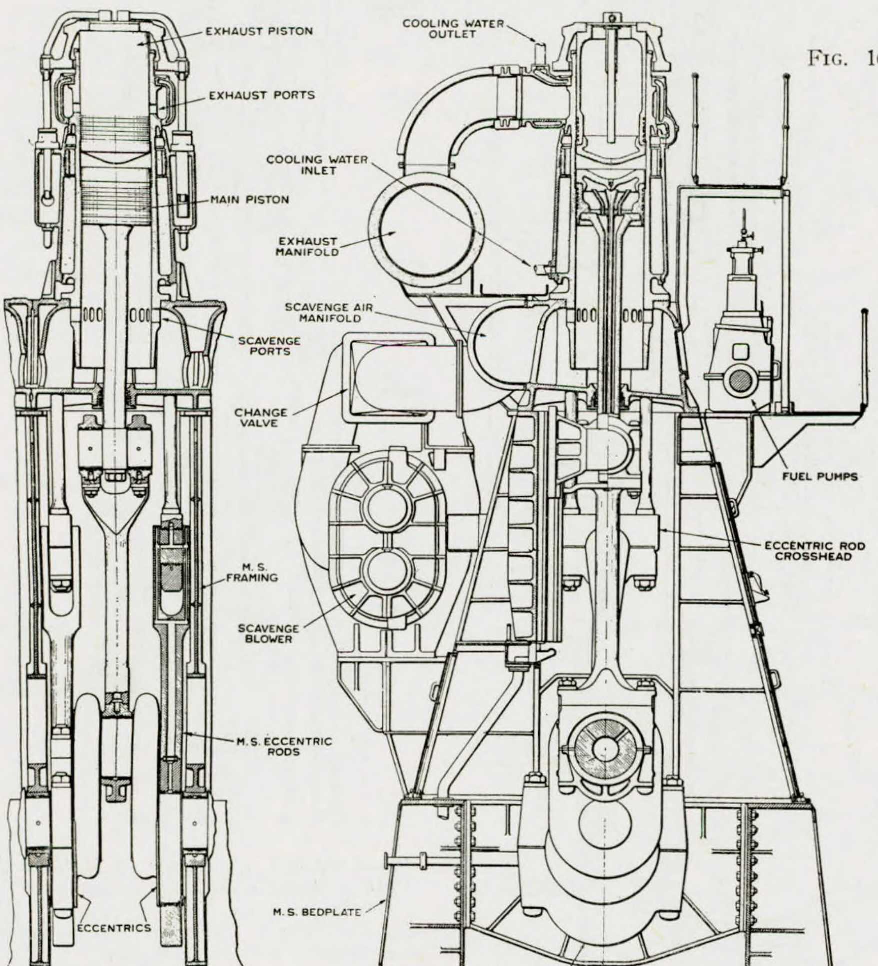


FIG. 15.—*Harland & Wolff (B. & W.) 2-stroke single acting engine.*

of the transverse beam, side rods and side connecting rods. This method of drive practically removes the direct piston loads from the main bearings, the reactions being transmitted to the moving parts instead of the engine framing.

All main and bottom end bearings are of spherical type, the bearing shells being adjusted so that they are just movable in their housings without binding. This constructional form ensures even distribution of journal load, conduces to flexibility and, within limits, provides against malalignment. The upper piston is connected to the transverse beam by means of a pin carried in the large bearings, under forced lubrication, located in the side arms of the transverse, thus allowing the upper piston to float freely. The spherical seats of the lower floating pistons are of cast iron, and the cap nut is screwed hard against the end of the stud, allowing 2/1,000in. clearance on the lubricated spherical seating.

Distilled water cooling is employed throughout. The fuel, starting and relief valves are also cooled by this medium, the valve cooling system being independent of the main and thus obviating all dangers of fuel oil deposits on the cooling surfaces of jackets, liners or pistons.

Two fuel valves, located diametrically opposite each other on the combustion space horizontal centre line, are employed in each cylinder. Valves are of needle type and cam operated.

Normal compression pressure is about 340lb. per sq. in. and at service power output the fuel valves open at 25° before, and close 25° after, the crank dead centres. This comparatively early injection, as compared with most other types, is due to the relatively low compression pressure. Fuel injection pressure at full load is about 6,000lb. per sq. in. and the mean indicated pressure about 88lb. per sq. in.

The starting air pressure employed is 600lb. per sq. in., and starting and reversing are completely effected by hand, no servo-motor being necessary to operate the reversing mechanism.

Relative to accessibility, the general construction is excellent; this particularly applies in respect of examination and overhaul of pistons. This feature facilitates easy maintenance and provided the necessary attention is given to periodical overhauls the opposed-piston engine proves a most reliable, efficient and smooth running unit in service.

A typical arrangement for a 4 cylinder Doxford engine, 670 m.m. bore, 2,320 m.m. stroke, developing 4,000 b.h.p. at 108 r.p.m. is shown in Fig. 12.

Four-stroke Cycle Single-acting Engines.

In ship construction, where the weight of propelling machinery and the space it occupies are vital factors in the consideration and selection of types, engines working on the four stroke cycle possess certain inherent disadvantages in modern practice. In the early days of Diesel propulsion the four stroke cycle was probably more reliable than the two stroke. The additional stresses, particularly thermal, imposed on the two stroke due to performing double the number of working strokes, for equal revolution speed, relative to the four stroke doubtless accounted largely for this discrepancy in reliability. Progressive improvement in operative mechanism and general design, accompanied by the practical developments due to metallurgical research have, however, eventuated in the present position where, as regards actual dependability, there is very little to choose between the two types.

The introduction of supercharging greatly improves the power/weight ratio of four stroke cycle engines, and practically all moderate and high powered units of this type now being built are supercharged. Briefly stated, supercharging simply means the air supply to the induction valves is increased to a pressure above atmospheric, with a resultant increase in the quantity of air present in the cylinder at the commencement of the compression stroke. As a result of this additional air charge, a proportionately greater quantity of fuel can be efficiently burned and the power output per cycle thereby increased. Since the proportion of air to fuel remains substantially the same, or slightly higher, as in non-supercharged units, there is no increase in combustion or exhaust temperatures. The mean indicated pressure will be considerably increased, but all other pressures in the cycle remain virtually equal to those existing with non-supercharging, this being achieved by the suitable adjustment of cylinder clearance volume and the timing of inlet and exhaust valves to conform with the additional air supplied.

Fig. 13 shows a sectional view of a Büchi single-stage turbo blower. The exhaust gases which actuate the turbine enter by two branches, these being connected to the two exhaust manifolds which each take the exhaust from a half complement of cylinders respectively. The exhaust gases from the turbine subsequently pass in the usual manner to the atmosphere by way of the waste heat boilers or the main silencer and exhaust pipe.

The turbo-blower casings are of cast iron, the turbine casing being water cooled. To obviate troubles from heat distortion the

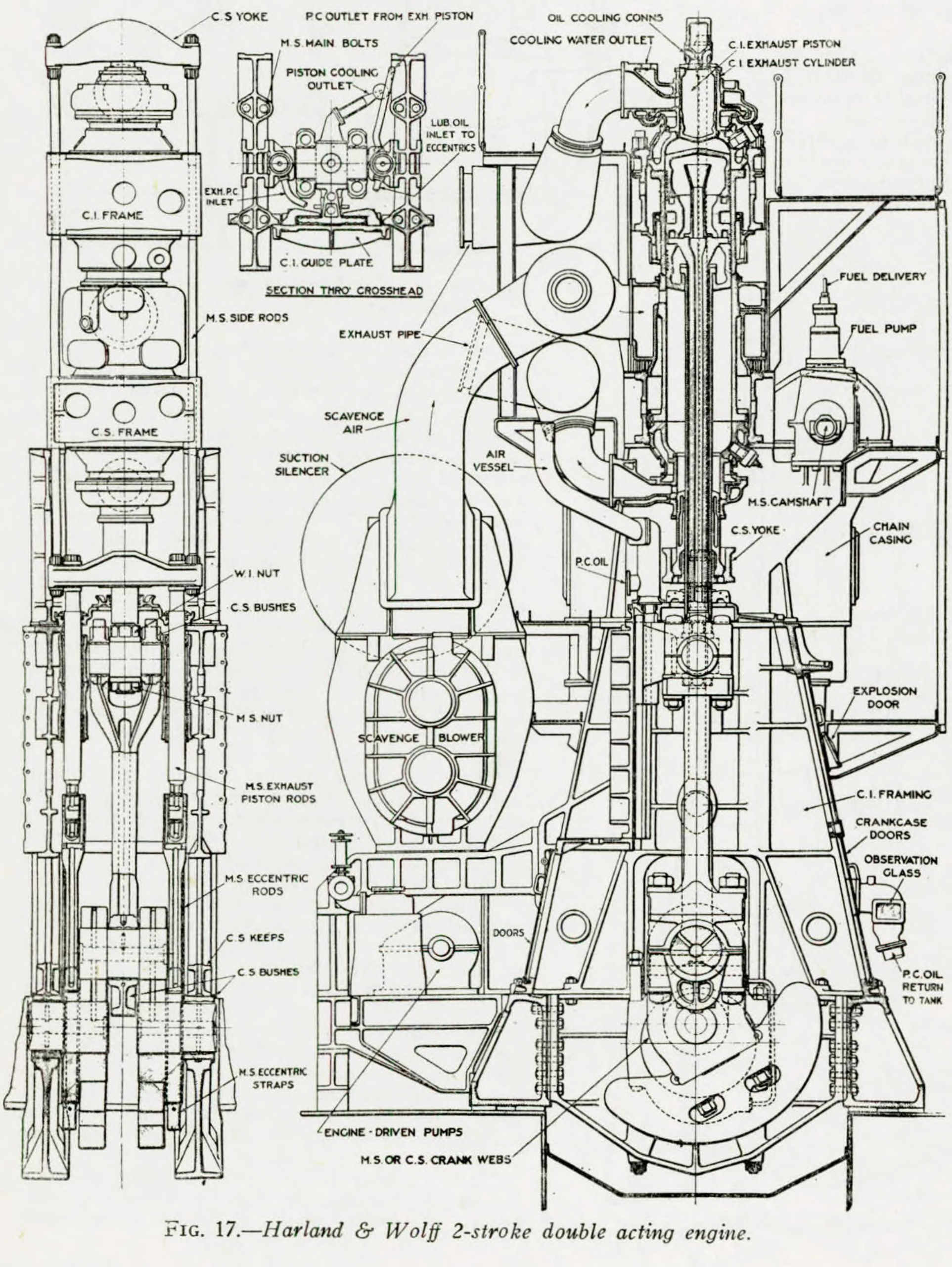


FIG. 17.—*Harland & Wolff 2-stroke double acting engine.*

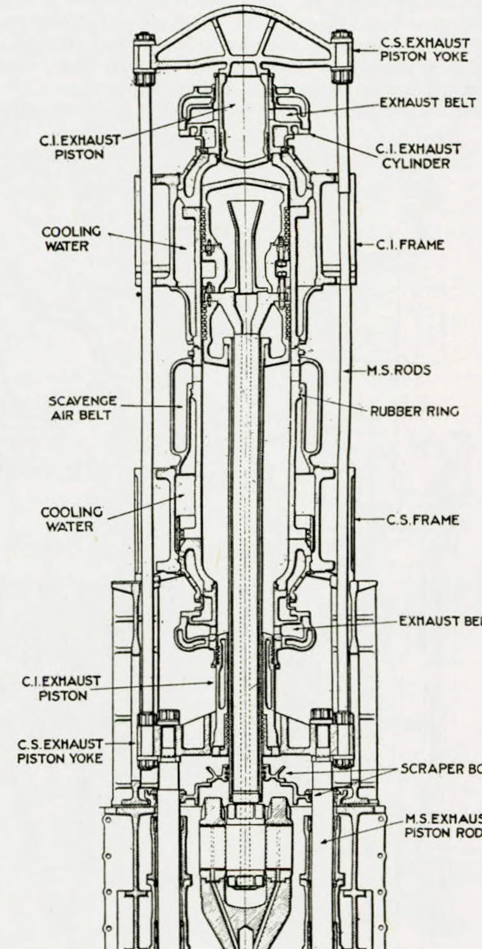


FIG. 18.—*Fore and aft section of Harland & Wolff 2-stroke double acting engine.*

impulse wheel is overhung. The bearing between the wheel and blower impeller is water or oil cooled, and a thrust is incorporated in the blower outside bearing. The thrust pressure is substantially reduced by the fitting of a balance piston within the blower casing. The wheel and impeller are secured to a common nickel steel shaft, the wheel secured by means of a mild steel tie rod as indicated. Air sealed labyrinth packing prevents the escape of exhaust gases to the engine room and air seals prevent the ingress of bearing lubricating oil into the blower chamber. The lubricating oil pressure is maintained by a gravity tank suitably located in the engine room and supplied from the main lubricating system.

Fig. 14 shows a Harland & Wolff, Burmeister & Wain type, single acting, four stroke engine with under-piston supercharger as widely installed in present day practice. The space between the cylinder bottom and crankcase top is wholly enclosed and the cylinder liners function as air pump chambers. A valve chest is incorporated in each cylinder unit, each chest being fitted with two suction and two delivery valves of Hoerbiger type. As there are two air delivery down strokes of the piston to each working stroke in any cylinder unit, ample air for supercharging purposes is supplied. This system is thoroughly reliable in service and requires little in the way of maintenance.

The cast iron bedplate of the engine is in two sections and is of deep box type, the cross girders which house the main bearings being incorporated in the castings. The housing of the main thrust forms an integral part of the after section of the bedplate. The cast iron main frames bridge the crankcase between each crank and at the outside of the forward and after cranks. The upper frames are located above the main frames and carry the cylinder units.

Long vertical tie bolts, secured at the lower end by nuts on the underside of the cross girders, extend to the top of the cylinder covers. There are two nuts on the upper portion of each tie rod, the intermediate nut secures the top and main frames to the bedplate, and the top nut secures the cylinder unit on the upper frames. This arrangement permits of the dismantling of cylinder units without disturbing in any way the other members of the engine framing.

Airless injection is employed, the fuel valves being of automatic pressure lift type. The quantity of fuel injected is controlled by rotation of the cam actuated fuel pump plungers, the effective stroke being governed by the helical edge of the groove in the plunger.

Cylinder jackets, heads and exhaust valves are either distilled or salt water cooled and the pistons are oil cooled, the piston cooling and main lubricating systems being common.

A high degree of reliability under service conditions, accompanied by easy manœuvring qualities, are two outstanding features of this engine.

Single-acting Two-stroke Engines.

The Harland & Wolff, Burmeister & Wain type, single-acting two-stroke engine is illustrated in Fig. 15. The engine shown is of 620 m.m. bore and 1,400 m.m. main stroke, plus 470 m.m. exhaust piston stroke, developing 750 s.h.p. per cylinder at 110 r.p.m.

One noteworthy feature of this engine is the scavenging arrangement. The scavenge ports are located near the bottom of the cylinder liner and air distribution is effected by the main piston. The exhaust ports near the top of the liner are controlled by an exhaust piston of equal diameter to the main piston. Each exhaust piston is actuated by two eccentrics on the crank shaft, the eccentrics being integral with the crankshaft webs. During the working stroke, the power derived from the exhaust pistons is transferred to the crankshaft by means of the eccentrics. Four long side rods, two to each eccentric crosshead, connect the crossheads to the exhaust piston yoke piece. This arrangement allows a very efficient longitudinal scavenging—the air scouring the cylinder for the full length—and obviates the employment of cylinder covers. Also, since the cross-sectional areas of the main and exhaust pistons are equal, and the latter are directly coupled to the crankshaft through the media of the eccentrics, the system, relative to the running gear, is practically self-balancing in the vertical direction.

Scavenge air is supplied by means of chain driven positive displacement rotary blowers situated at the back of the engine. Since reversal of the engine also entails the reversal of the direction of rotation of the blower, an automatic change flap valve is located between the blower and scavenge belt. By the movement of this valve, when the engine is reversed, the blower suction becomes the discharge and vice versa.

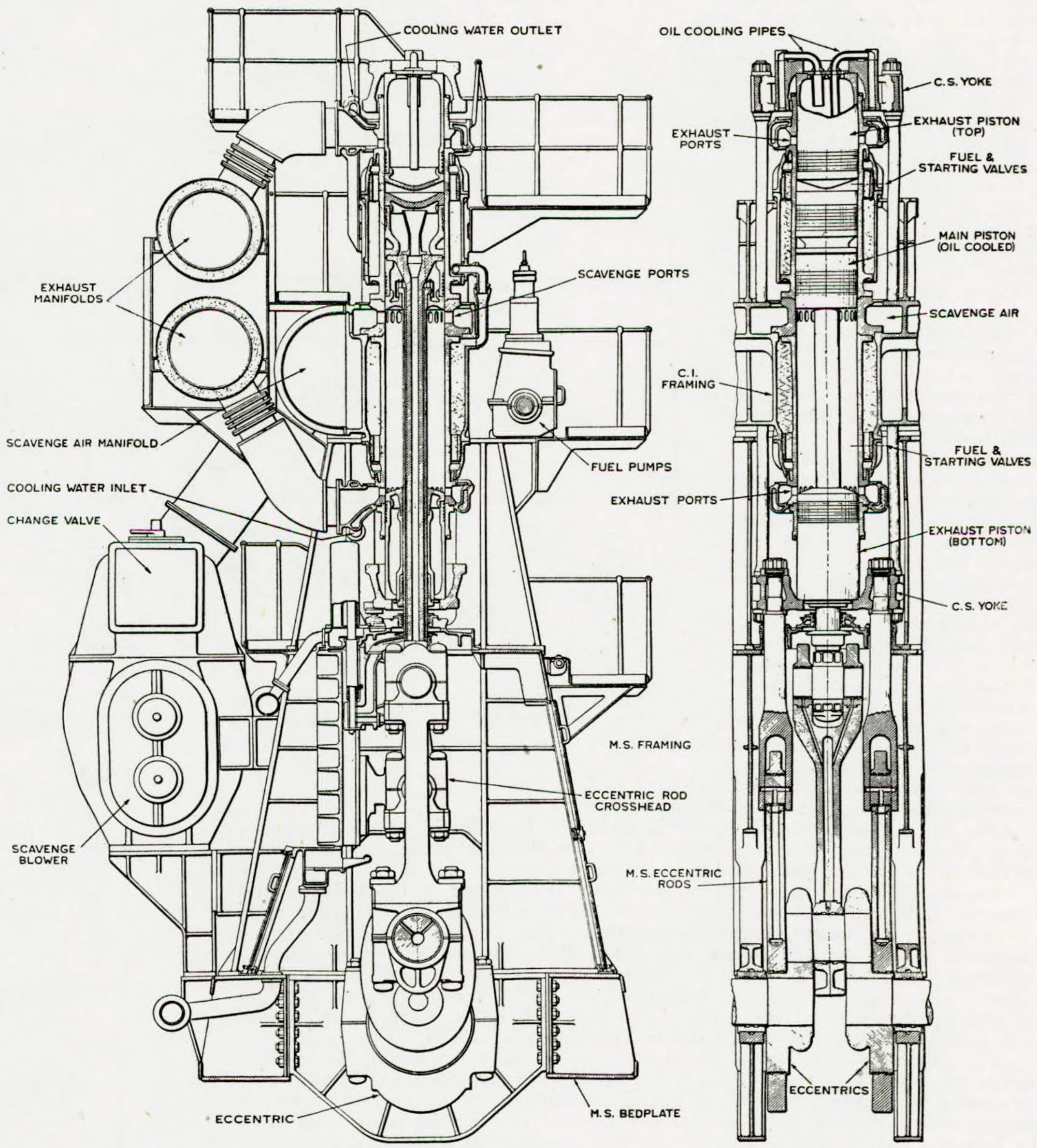


FIG. 19.—*Harland & Wolff 2-stroke double acting engine—latest design.*

Fabricated steel construction is employed throughout in the bedplate and framing. The scavenge air belt is secured on the engine framing, and the cylinder units are sited on and secured to the scavenge belt. This arrangement suitably allows of free expansion of the cylinders in the upward direction under working conditions.

The main and exhaust pistons are oil cooled from the main forced lubrication system, and distilled water cooling is employed for the cylinder jackets.

The fuel valves are of automatic type with airless injection of fuel.

Auxiliary Engines.

For the development of power for auxiliary purposes on board ship there are many reliable makes of Diesel engine of both two and four stroke type. A typical make of such an auxiliary is the Harland & Wolff, Burmeister & Wain type, single-acting two-stroke engine shown in Fig. 16. In this case loop scavenging is employed, but auxiliary engines of this make are also available with longitudinal scavenging, the exhaust in the latter case being controlled by cam actuated poppet valves in the cylinder heads. The jackets and cylinder heads are water cooled in the usual way, but the pistons are uncooled. In common with most types of smaller powered Diesel engines, no piston rod or crosshead is employed. All parts are readily accessible and easily overhauled.

Double-acting Two-stroke Engines.

Relative to various Diesel engine characteristics, the importance of the power/weight and power/space ratios have been stressed throughout the machinery section of this paper. It is fitting, therefore, to devote particular attention to the double-acting two-stroke engine as this type of prime mover is productive of the greatest power output per weight, or per space, in the Diesel class. It may be observed, in passing, that the teething troubles of the several makes of now fully reliable double-acting two-stroke engines have been many and various. Successive difficulties in design and construction have been met, and much experimental work with various materials of construction has been necessary in attaining present day reliability.

One of the most widely adopted engines in this group is the Harland & Wolff, Burmeister & Wain type. Fig. 17 illustrates one of the earlier designs of this engine, and a fore and aft section outlining the cylinder details of this unit is depicted in Fig. 18. In the earlier construction the bedplate and framing were of cast iron, and the bedplate cross-girders of cast iron or cast steel, the latter material being employed in the larger engines. Also, it will be noted, the top and bottom exhaust pistons operated in cylinder covers and were considerably less in cross-sectional area than the main pistons.

The latest design of this engine is shown in Fig. 19, the engine illustrated being 550 m.m. bore, 1,200 m.m. main stroke, plus 400 m.m. exhaust piston stroke, developing 1,000 s.h.p. per cylinder at 115-120 r.p.m.

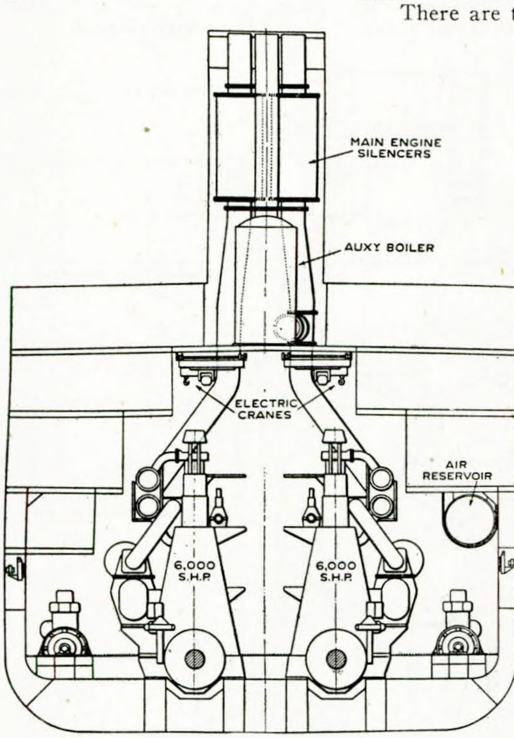
Fabricated steel construction is employed throughout in the bedplate and framing. The scavenge belt is located on the framing, and the cylinder units are carried, at mid-length, on the scavenge belt. This arrangement allows of free expansion of the cylinder above and below the scavenge belt under running conditions. The scavenge ports are located at mid-height in the liner, and the exhaust ports near the top and bottom of the liner respectively, thus allowing for effective longitudinal scavenging. The scavenge blowers are located at the back of the engine and are chain driven from the crankshaft.

The exhaust pistons are of equal diameter to the main piston, the top and bottom exhaust piston yokes being secured at a fixed distance apart by four side rods and thus reciprocating together. The exhaust gear is actuated by eccentrics integral with the crank webs, the bottom exhaust piston yoke being coupled to the eccentric rods by two side rods. By this construction all vertical forces are balanced within the running gear of the engine and the working stresses removed from the engine structure generally.

The piston rod is constructed of mild steel and is protected against the high temperatures of combustion, or any deleterious action of the hot gases, by a cast iron sleeve throughout its length. It will be noted that the piston rod passes through, and works in, the lower exhaust piston, and a stuffing box is formed within the latter to ensure tightness in operation. This stuffing box consists essentially of a carrier, the bore of which is suitably grooved for the location of six twin packing rings and a bottom ring of the compound sealing types. In way of the crankcase top a piston rod scraper box is fitted with three segmental scraper rings backed by garter springs. This arrangement excludes lubricating oil leakage from the crankcase.

The cylinder jackets are cooled by distilled water, and the main and exhaust pistons are oil cooled from the forced lubrication system. The oil for main piston cooling purposes is fed by telescopic pipe to the annulus formed between the piston rod and rod sleeve. The sleeve is thus effectively cooled, and the oil passes thence to the lower and upper portions of the main piston. From the latter the oil passes by way of a longitudinal hole drilled concentrically in the piston rod and an outlet spout to an observation hopper, and thence by the common piston cooling return pipe to the lubricating oil sump tank.

There are two automatic type airless injection fuel valves fitted



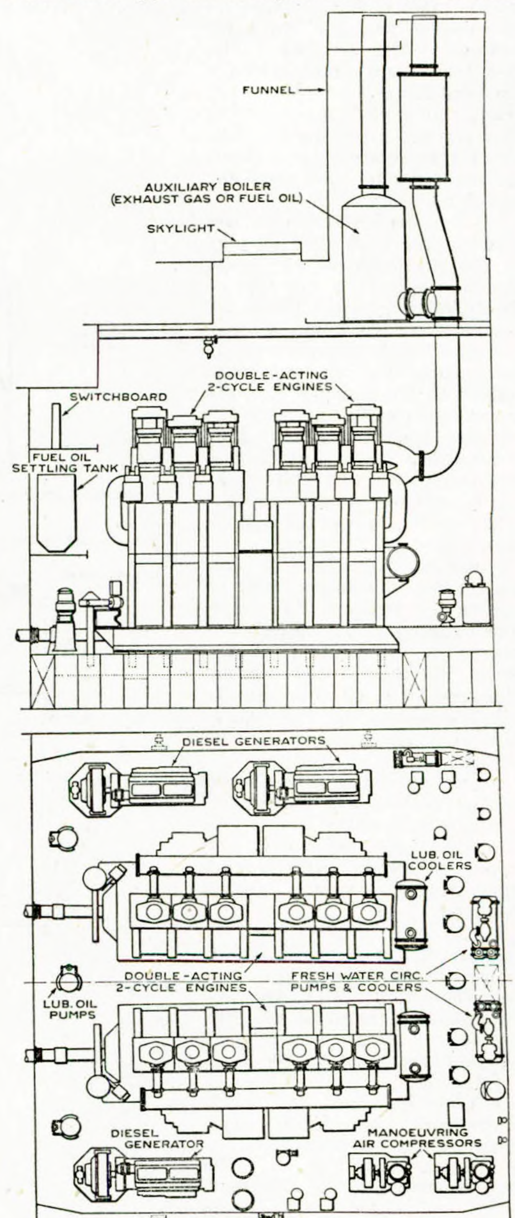


Fig. 20.—*Machinery arrangement with twin screw Harland & Wolff double acting engines.*

to each top and bottom combustion space. Starting valves are fitted to all cylinders, top and bottom.

To illustrate the compactness, combined with full accessibility, to which power development by engines of the type just described lends itself, a typical machinery arrangement for a twin screw vessel, of 12,000 s.h.p. total, is shown in Fig. 20. A most noteworthy feature is that the engine room length is less than 60ft.

Present Machinery Position and Future Trends.

In British practice, over the period more or less of the last fifteen years—except in the case where special services, the question of bunkering facilities, or more recently, the exigencies of wartime manufacture and supply have ruled otherwise—new tanker tonnage has been almost invariably propelled by Diesel machinery. A similar observation is equally applicable as regards Continental construction over a somewhat longer period. This is largely due to the fact that a moderately powered main Diesel engine, with attached pumps for all its own necessary services, and incorporating an exhaust waste heat system for steam generation, forms a most efficient all purpose unit. In fact, under such operative conditions, the actual fuel consumption per i.h.p./hr. of the main propelling unit can also be virtually regarded as an all purpose figure. The continued installation of Diesel machinery also indicates that this type of engine satisfactorily fulfils the special requirements of tankers in respect of protracted periods of service, quick turns round in port, etc., already mentioned when discussing operative conditions.

In visualising future prospects, however, it cannot be stated with any degree of certainty that the above position will continue without any alteration or modification. Indirect drive by means of geared multiple Diesel units is a form of propulsion not readily adaptable to tankers due to the engine room being invariably located at the after end in these vessels. The possibilities relative to electric drives are better, inasmuch as the location of individual generating units is not restricted to the immediate vicinity of the propelling motor.

Engineering progress since the last war has not been limited to the internal combustion engine, and steam propulsion, in the light of many developments during the last twenty years, is still in the field as a most healthy competitor. The advent of higher powered boilers and progressive improvement in their general construction, the wider application of superheat and better superheater design, the introduction of the reheat steam reciprocating engine, further development of the steam turbine and development of the regenerative type condenser in conjunction with improved closed feed systems are some of the most important factors which may influence future selection of tanker main engine types. With regard to steam plant, quite apart from greatly improved fuel consumptions and power/weight ratios, the relatively much lower machinery maintenance costs and ability to use cheaper grade fuels must also receive consideration. This is further emphasized by the fact that there is a present tendency towards greater carrying capacities and increased speeds—the former factor being limited, of course, by the adequacy of berthing facilities at particular loading and discharging terminal ports.

American tanker practice, both past and current, as compared with British and Continental, has been marked by a much wider selection of main engine types. Reduction geared turbines have been, and are being, largely adopted in the United States and are proving most reliable and economical in practice. In the latest installations of this type all purpose fuel consumption figures around 0·6lb./s.h.p./hr. have been recorded. One radical departure from conventional practice, as regards the machinery arrangement in the later American turbine engined tankers, is the installation of the boilers on a flat at the after end of the engine room, the space below the flat being utilised for the location of various auxiliary units. In thus dispensing with a separate stokehold a considerable economy in space is effected. Two water tube boilers are generally fitted, designed for a working pressure of 450lb./sq. in. and a total steam temperature of 750° F. at full power.

The indirect Diesel geared drive has also been introduced in several American tankers. To accommodate the varying turning moment of a Diesel engine, the reduction gearing must incorporate a flexible coupling between the engine shaft and the gearing to damp down the fluctuating forces. There are several suitable forms of flexible coupling, the one best known in British marine practice being the fluid or hydraulic type which was extensively adopted with the introduction of the Bauer-Wach turbines. There are also various forms of mechanical couplings where combinations of springs, dashpots, etc., are designed to smooth out inequalities in the turning moment. The form of coupling, however, now being largely adopted in American vessels is the magnetic slip type which appears to be giving every satisfaction in service.

The general advantages claimed for the indirect drive are that the fitting of more than one main unit will increase reliability, facilitate maintenance generally due to the smaller engine components employed, and also permit overhaul of single engine units as required at sea. Total power output can also be adjusted for different speeds by cutting out or starting up individual units as necessary. This latter advantage, however, is not applicable to tankers in general as these vessels usually operate at constant service power output. The necessary headroom required will be less, but it must also be observed that the breadth necessitated will be greater to allow of two engines, or multiples of two, being fitted abreast with provision of the requisite space for gearing. In tanker construction, due to the lines of the vessel tapering towards the stern in way of the engine room, the narrowing width of the tank top does not readily lend itself to the installation of this type of machinery.

Regarding the electric drive, this type of propulsion has been adopted in various American tankers in conjunction with either turbo or Diesel generators, but such installations have not found favour in either British or Continental practice. The same advantages that are claimed in the use of multiple power units in the case of the geared Diesel are applicable, but these, in conjunction with the added advantage that the actual machinery lay-out is more free from restriction as regards location, do not offset the relative disadvantages. Neither in the case of substituting turbo-electric drive for geared reduction main turbines, or substituting Diesel electric drive for direct Diesel propulsion, is there any saving in installation weight, and initial cost and fuel consumption are greater in both cases.

In conclusion, the author wishes to express his appreciation and thanks to Messrs. Harland & Wolff and Messrs. William Doxford & Sons, for the use of several machinery drawings, also to his colleagues in the British Tanker Company for their kind co-operation in the preparation of the paper.

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British Standard Specifications:—

No. 430-1944. Solid Drawn Steel Receivers.

No. 1157-1944. Tapping Drill Sizes.

The British Corporation Register of Shipping and Aircraft Ship and Machinery Rules:—

Section 24 (Revised February, 1944), Electric Arc Welding (In Ships).

Electric Arc Welding; Electrodes and Processes approved for use in Ship Construction.

Guidance Notes on the application of Electric Arc Welding to Ships' Structures.

1,000 Questions and Answers for Practical Engineers. By P. W. Blanford. Hutchinson's Scientific & Technical Publications, London, 88 pp., 2s. net.

This is an invaluable booklet which can be thoroughly recommended to engineering apprentices and students. The author is to be complimented on the great amount of helpful information which he has put into such a small book.

Economical Lubrication of Steam Turbines and Reciprocating Steam Engines. Industrial Bulletin, Oils No. 3. Published by the Ministry of Fuel and Power, 19 pp.

This bulletin issued by the Ministry of Fuel and Power gives briefly the more usual causes of deterioration of lubricating oils, the care necessary to prevent this and the steps required to maintain the oil in its highest state of efficiency. While it would appear to be primarily intended for engineers of land installations, its careful perusal would amply repay marine engineers.

The bulletin comprises two sections, one on steam turbines and one on reciprocating engines, and the amount of information which is condensed into the few pages allotted to each subject is remarkable.

Marine engineers have been fully alive for many years to the vital part which lubricating oil plays in the maintenance of the machinery, and all that is suggested in this bulletin is in accordance with what has been good modern marine practice for many years past. A copy of the bulletin should be in every vessel.

Development in the Design of Heavy Oil Engines. By R. A. Collacott, B.Sc.(Eng.), A.M.I.Mar.E., A.I.N.A. Crosby Lockwood & Son, Ltd., London, 72 pp, 21 illus., 6s. net.

This is an interesting little volume to anyone concerned in the study or design of oil engines. Its main fault is that it is obviously the result of bibliographic research. It would seem that the author has started with a sound knowledge of the high speed petrol engine and only a very superficial idea of the compression ignition engine; this work seems to be a collection of notes made during the study of the latter type. The result of this is that, particularly in the first pages, there is some confusion between the types, and deductions relating to the heavy oil engine are sometimes drawn from facts peculiar to the spark ignition petrol engine. This fault will make the book rather dangerous to the young student, on whom it should be impressed that the author's deductions should only be accepted where they can be verified. To the more experienced engineer, not likely to be misled in this way, the author's work should be of considerable value as it covers briefly a very wide field, and the reader is bound to discover much that is new to him even though his experience has made him familiar with much that the author reports. It is to be hoped that when a second edition of this book is issued the author will carefully re-edit it, cut out everything that might mislead and expand considerably those sections that deal with recent research. If this is done this work will be of real value to student and experienced engineer alike.

Gas Turbines and Jet Propulsion for Aircraft. By G. Geoffrey Smith, M.B.E. Flight Publishing Co., Ltd., 78 pp., 38 illus., 3s. 6d.

This little book is a historical review of gas turbines from the original Hero's æolipile to various designs tested in Switzerland, Sweden, France, Germany and elsewhere. Although the author makes no attempt to describe in detail all the technical aspects of each design—in fact details of materials and precise operating results are lacking—it is of considerable general interest. The fundamental principles of jet propulsion are described, particular reference being made to a jet-propelled aeroplane produced by the Caproni organisation and flown in Italy during 1940.

A very interesting chapter describes various attempts at producing lightweight steam turbines and boiler units for aircraft propulsion, and surprisingly enough the author holds out prospects of the success of such power units for the propulsion of very large air liners. Unfortunately the author does not state explicitly the "snags" involved in each design.

Reference is made in the concluding chapters to various gas turbines and in particular to exhaust turbo-blowers. From a review of the various designs which have been tested it is obvious that while, theoretically, such power units offer very favourable performances, they cannot be used in practice under conditions which are ideal for the attainment of satisfactory outputs.

Apart from its main drawback—the absence of fuller details and a review of technical difficulties involved in the production of satisfactory machines—this little book is both cheap and enlightening.

Plastics Scientific and Technological. By H. Ronald Fleck, M.Sc., F.I.C. English Universities Press, Ltd., London, 325 pp., 80 illus., 25s. net.

This new addition to the rapidly growing plastics library is for the most part a comprehensive survey of the chemical part of the plastics industry. There is an interesting review of the modern trends in macro-molecular chemistry, but the section on molecular weight determination is rather unbalanced. The great value of the ultra centrifuge in determining molecular weights and molecular weight distribution is hardly mentioned, while on the other hand, viscometric methods are unduly emphasized and details are given of ebullioscopic and cryoscopic molecular weight determination which have little or no application in the high polymer field.

The remarks in Chapter VII concerning the vapour phase rearrangements of α-pinene to camphene are interesting and it is regretted that a reference is not given. In some instances a lack of familiarity with industrial processes is shown, e.g. the description of the manufacture of casein plastic is quite misleading while elsewhere there is an uncritical acceptance of theoretical views put forward in literature, such as para-formaldehyde type structure for casein-formaldehyde plastic. The same unfamiliarity is shown in regard to the plant and engineering details in connection with which the author has, *inter alia*, described the working of hydraulic equipment, accumulator presses, etc., with more detail than accuracy.

There are one or two misprints, e.g. on page 109 the boiling point of styrene is given as 81° C. Taken as a whole, this book is useful as a broad introduction to the chemistry of plastics, but is insufficiently detailed or critical to be recommended for the expert.

Purchased.

Diesel Engineering Handbook, 1943. Originally edited by L. H. Morrison, revised by Charles F. Foell. Diesel Publications, Inc., New York City, 940 pp., copiously illustrated.

British Legion Guide to War Pensions and Service Allowances. Published by the British Legion, 63 pp., 6d.

A guide to Royal Navy, Army, R.A.F., Merchant Navy, Women's Auxiliary Services and Home Guard War Pensions and service allowances.

Aslib War-time Guides to British Sources of Specialised Information. No. 5. **Engineering, other than Electrical.** Association of Special Libraries and Information Bureaux, London, 38 pp., 6s.

The Merchant Navy at War. By Capt. Frank H. Shaw. Stanley Paul, London, 136 pp., 12 illus., 12s. 6d. net.

"It is an incredible story of victory against overwhelming odds, with the salt of the sea splashing through each vital incident".

Select Committee on National Expenditure. H.M. Stationery Office, London, 30 pp., 6d. net.

Minutes of the proceedings of the Committee, together with an index to the reports, Session 1942-1943.

U.S. NAVAL WARCRAFT DESIGNATION.

It is not realized how many designations of warcraft, mainly motor vessels, exist in the United States Navy. The list below represents the official symbols of the various types, and may be of interest and value to many who are now serving at sea.

AD Destroyer tenders
AE Ammunition ships
AF Storeships
AG Fleet auxiliaries (misc.)
AH Hospital ships
AK Cargo ships
AL Lightship
AM Mine sweepers
AN Net tenders
AO Oilers
AP Transport
AR Repair ships
AS Submarine tenders
AT Tugs—ocean going
AV Seaplane tenders—large
AKD Deep-hold cargo ships
AKI Cargo-stores issue ships
AKV Aircraft supply ships
AMb Harbor (base) mine sweepers
AMc Mine sweepers—coastal
AOG Gasoline tankers
APL Barrack ships
APV Airplane transports
ARD Floating dry docks
ASR Submarine rescue vessels
AVD Seaplane tenders—ex-destroyers
AVG Aircraft escort vessels
AVP Seaplane tenders—small
AVR Aircraft rescue vessels
BB Battleships
CA Heavy cruiser
CL Light cruiser
CM Minelayer
CMc Coastal minelayer
CV Aircraft carrier
DE Destroyer escort
DL Destroyer leader
DM Light minelayers
DMS Fast mine sweepers
DD Destroyers
PC Submarine chasers (steel—170′, 173′, 175′ and 180′ O.A.)
PCS Submarine chasers (wood—136′ O.A.)
PG Gunboat (over 1,000 tons)
PR River gunboat
PT Motor torpedo boats
PTC Motorboat submarine chasers
PY Converted yachts (500-1,000 tons)
PYc Coastal yachts (under 500 tons)
SC Submarine chasers (wood—110′ O.A.)
SM Mine-laying submarines
SS Submarines
YA Ash lighters
YC Open lighters
YD Floating derricks
YE Ammunition lighters
YF Covered lighters
YG Garbage lighters
YH Ambulance boats
YM Dredges
YN Boom (net) tenders
YO Fuel oil barges
YP District patrol vessels
YR Floating workshops
YS Stevedoring barges
YT Harbor tugs
YW Water barges
YAG Unclassified yard craft
YCF Car floats
YCK Open cargo lighters
YFB Ferry boats and launches
YHB House boats (floating barracks)
YHT Heating scows
YMS Motor mine sweepers
YNT Motor tugs
YNg Gate vessels
YOS Oil storage barges
YPD Floating pile drivers
YPK Pontoon stowage barges
YRC Submarine rescue chambers
YSD Seaplane wrecking derricks
YSP Salvage pontoons
YSR Sludge removal barges
YTT Torpedo testing barges

—By the courtesy of "The Motor Boat and Yachting".

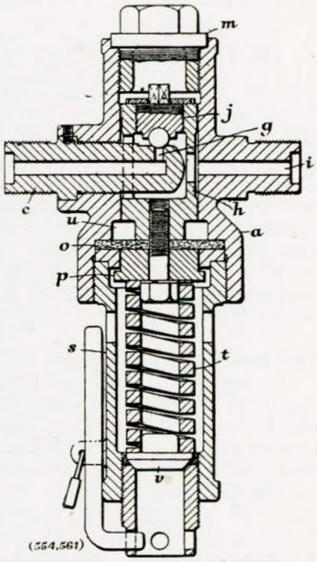
Abstracts of the Technical Press

Turbine Propulsion for Low-powered Steamships.

An article in a recent issue of the *Journal de la Marine Marchande* discusses the advantages and drawbacks of steam turbines for the propulsion of the smaller types of ships of relatively low power. The fact that it is necessary to provide a separate turbine for going astern is considered to be a serious disadvantage of steam turbine machinery for such vessels, and although the adoption of turbo-electric propulsion gets over this difficulty, the high cost of this type of machinery renders it unsuitable for use in ordinary small craft under present-day conditions. The usual practice is to design the astern turbine to develop from 50 to 60 per cent. of the power of the ahead turbines. This is usually sufficient in the larger class of vessel, where there is rarely occasion to do much manœuvring, but in the case of a low-powered cargo ship it may be found that the power developed for going astern is insufficient. Moreover, the operation of reversing the motion cannot be effected instantaneously, as the inertia of the rotating parts of the turbines and gears prevents any quick changeover and makes it necessary to exercise a certain amount of discretion during the operation of reversing the direction of rotation of the propeller. It is impracticable to close one steam valve and to open another simultaneously, as the turbine blading would thereby be subjected to an abnormal strain. A possible solution of this problem might be an increase of the power developed by the astern turbine to 75 or 80 per cent. of that developed by the ahead turbines, but the author points out that when a ship is manœuvring, the amount of steam pressure available is unlikely to be great enough to develop this astern power, and that the increased weight and cost of the machinery would almost certainly become unacceptable. He also declares that repairs to turbine blading usually take a considerable time and that any stepping up of the power of the astern turbine would probably have an adverse effect in this direction. The findings of the author are that for low-powered vessels, the reciprocating engine, whether steam or Diesel, is to be preferred to the turbine, which, in ships of this type, would require, in his opinion, inspection and overhaul at frequent intervals—say, once a year. Despite the author's observations, it should be remembered that small turbine-driven ships have given satisfaction over long periods in the North Atlantic service—a severe test for any type of machinery—and that improvements in existing arrangements for running astern may be anticipated. In this connection the Parsons Co. have evolved a hydraulic coupling, designed primarily for use with a gas turbine, which enables the direction of rotation of the propeller shaft and gearing to be reversed, and it is probable that an arrangement of this kind may in time replace the astern turbine.—*"Fairplay", Vol. CLXII, No. 3,168, 27th January, 1944, p. 198.*

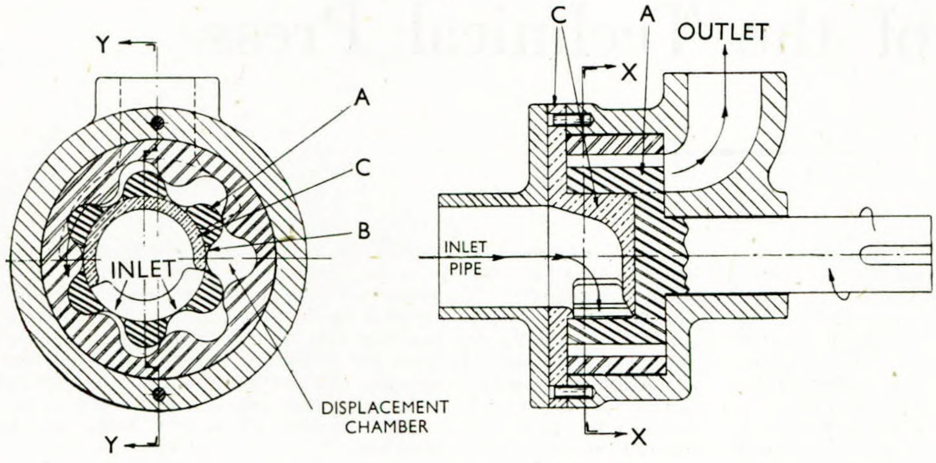
Improved Reducing Valve.

An improved design of reducing valve for steam, air and other gases or liquids has recently been developed by David Auld & Sons, Ltd., and forms the subject of a new British patent. Referring to the accompanying sectional elevation, the valve body (*a*) has an internally-threaded branch into which is screwed an inlet stem (*c*) having a central bore running down it to near the inner end. The other end is threaded for a coupling and a set-screw retains the stem in position. Towards the inner end of the stem is drilled a port (*g*) at right angles to the bore. Within the valve body is a cylindrical sleeve (*h*) having an opening to accommodate the end of the inlet stem (*c*) and dimensioned so as to leave the sleeve free for axial movement within the valve body. A second and smaller opening in the wall of the sleeve is in alignment with the outlet branch (*i*) of the valve body. The upper end of the cylindrical sleeve carries a threaded cylindrical plug (*j*) fitting over a ball which constitutes the actual valve. The plug can be locked against relative rotation within the cylindrical sleeve. The valve body above the cylindrical sleeve is closed by a screwed cap (*m*). A flexible diaphragm (*o*) is clamped between a boss on the end of the cylindrical sleeve and a floating piston (*p*), the outer edge of this diaphragm being clamped between a shoulder on the valve body and a flanged ring held in position by a cylindrical spring casing (*s*), which is screwed into the valve body and houses a helical compression spring (*t*). The piston fits loosely within the flanged ring. The annular space (*u*) is closed by the diaphragm and is in communication with the low-pressure side of the valve body by means of a clearance formed between the cylindrical sleeve and the interior wall of the valve body. The lower end of the spring bears on a spring carrier (*v*) supported by a sleeve screwed into the lower end of the casing (*s*). This sleeve has a number of tommy holes and is locked in position by inserting one end of the bar in a hole and padlocking it parallel to the casing between a pair of lugs. In assembling, after the diaphragm (*o*) has been clamped in position and the inlet stem (*c*) screwed into the valve body, and prior to the spring (*t*) being placed under compression, the plug (*j*) surmounting the ball valve is rotated until the ball seats while the diaphragm remains flat. The plug is then locked in position and the cap (*m*) screwed into the valve body, after which the spring is loaded to correspond to the low pressure required. The high-pressure fluid passes the ball valve and low-pressure fluid passes to the outlet branch and also acts on the diaphragm. Should the pressure on the L.P. side of the valve become excessive, the increased low pressure on the diaphragm closes the valve against the spring, the valve again opening when the pressure on the diaphragm becomes less than that of the spring.—*"Engineering", Vol. 157, No. 4,073, 4th February, 1944, p. 100.*



Minimising the Effects of Lubricating-oil Aeration.

Research work is now being carried out in this country and in America on the frothing of lubricating oil. Although this trouble is primarily one that is experienced with aircraft engines at high altitudes, it is also liable to occur on the ground with engines having lubrication systems of the dry-sump type. Large air bubbles in the oil are comparatively easy to deal with, but the small ones are much more difficult to disperse. The presence of this air in the main stream may lead to inadequate lubrication, particularly when the oil is cold; in such circumstances it will not flow readily into the pump and the percentage of air passed is considerably greater. In a paper by R. J. S. Pigott on "Oil Aeration" recently presented at a meeting of one of the American technical societies, the author referred to the Fleischer internal-gear pump, which has been designed to reduce aeration and of which some details are shown in the accompanying illustrations. The suction is taken from the centre of the rotor shaft, as in a centrifugal pump, and there is therefore no centrifugal force tending to resist the entry of the oil. The ports between the teeth are free of any appreciable restriction, so that internal losses are greatly reduced. In practice, it is claimed that the results are generally better than those obtained from spur-gear pumps of the conventional type. The design of the oil tank has a considerable bearing on aeration, although it has been shown by experiments that where this trouble is encountered the use of a centrifuge may remove up to 90 or 95 per cent. of the air present. It is suggested, however, that it is better to improve the tank design than to employ a makeshift. One method of reducing aeration with a dry-sump system is to employ a scavenge pump having two sections totalling the normal capacity. One part has the same capacity as the pressure pump, whilst the other provides the excess capacity and has its suction a little above normal sump level



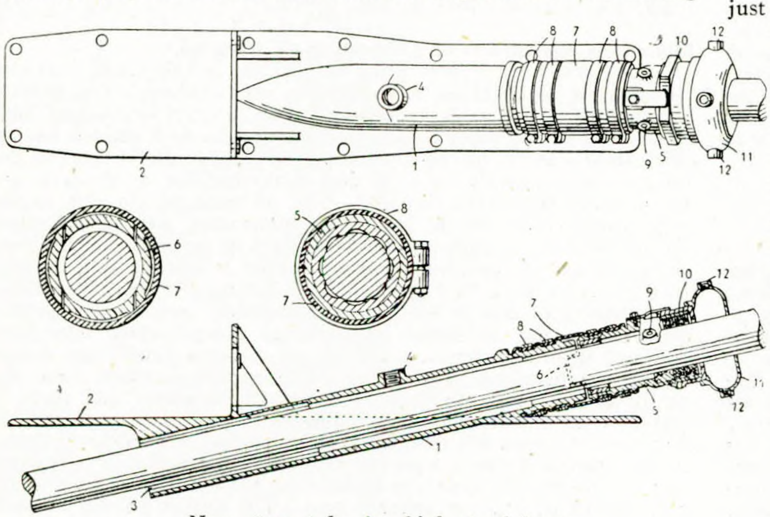
SECTION AT X-X SECTION AT Y-Y

An internal-gear pump which reduces aeration.
A—toothed rotor; B—oil-admission port; C—eccentrically mounted stator.

This excess pump delivers only air to the top of the tank, unless the level at the suction rises appreciably. Generally speaking, the resistance on the suction side of the pumps must be reduced as much as possible, and velocities in the suction pipes should not be allowed to exceed 5ft./sec. Restrictions of flow must also be minimised. Spur-gear pumps require to be improved and for this reason it is usually preferable to utilise pumps of the positive-displacement rotary type.—*"The Oil Engine", Vol. XI, No. 129, January, 1944, p. 230.*

New Scott-Paine Stern Tube.

An improved form of stern-tube fitting which allows a certain amount of flexibility in the shafting and is therefore primarily suitable for light, high-speed motor-boats, has been developed and patented in this country and in the U.S.A. by Mr. Hubert Scott-Paine. Referring to the accompanying illustrations, it may be seen that the tube is made up of two parts, one of which (*1*) embodies a plate (*2*) secured to the bottom of the hull and carrying a water-lubricated shaft bearing (*3*). Any water which may have entered the outer part of the tube can be drawn off through a connection (*4*) provided for the purpose. The inner tube (*5*), having metal bearings for the shaft, fits into the outer tube and is prevented from turning



New stern tube for high-speed boats.

by loosely fitting claws or lugs (*6*), so that if the propeller shaft is flexed the risk of seizure is minimised. The two parts of the tube are joined with a flexible rubber connection (*7*), tightly secured by metal straps (*8*). A grease lubricator (*9*) is fitted. In addition to the water gland nut (*10*), there is a drip catcher (*11*) with openings (*12*), any of which may be connected to a drain tank.—*"The Motor Boat", Vol. LXXVII, No. 1,916, February, 1944, p. 55.*

Dobbie McInnes Indicator with a Damping Device.

An engine indicator with a device for damping free oscillations which tended to superimpose themselves on the diagram is shown in Fig. 3. The indicator motion work is turned about a swivel (*13*) on the frame (*14*). A set-screw (*30*) secures the axle pin (*21*) shown enlarged in the left-hand sectional diagram. This pin and a sleeve (*22*) are provided with working surfaces between which minutely thin films of a viscous fluid exercise the damping effect. Around the surfaces of the bearings are sinuous oil-trapping grooves (*26*). The liquid used is a concentrate containing 20-25 per cent. of 15,000 molecular weight polybutene in a light lubricating oil, the viscosity being 105 poises at 100° F. The setting of the thumbscrew (*29*) determines the pressure with which the spring (*32*) tends to force the two bearing surfaces together. In operation, a diagram is first obtained with the thumbscrew slacked back. If the peak or expansion line of the diagram shows that the moving parts of the indicator are subject to free oscillation, the thumbscrew is tightened until finally a diagram is obtained from which all these oscillations have just disappeared. If any marked change in temperature has to be allowed for, the thumbscrew can be set to compensate for this, but there is a certain amount of automatic regulation, inasmuch as if the temperature of the oil film increases the viscosity and thickness decrease. It is stated in the specification that the sleeve (*22*) may be of phosphor bronze and the parts (*24*) of case-hardened mild steel or vice versa.—*"The Motor Ship", Vol. XXIV, No. 290, March, 1944, p. 418.*

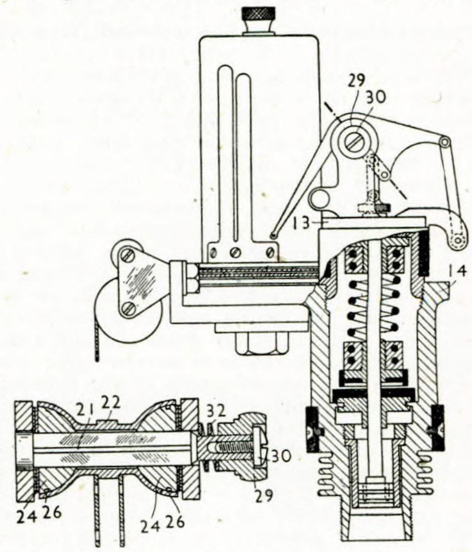


FIG. 3.

Götaverken Engine with Sleeve-valve-controlled Inlet Ports.

In Fig. 2 is illustrated sectionally the cylinder of a Götaverken single-acting engine with a valve at the top for the exhaust and a sleeve which controls the closure of the scavenging-air inlet ports. The air is compressed by the underside of the piston, of which the length may be considerably reduced owing to the method

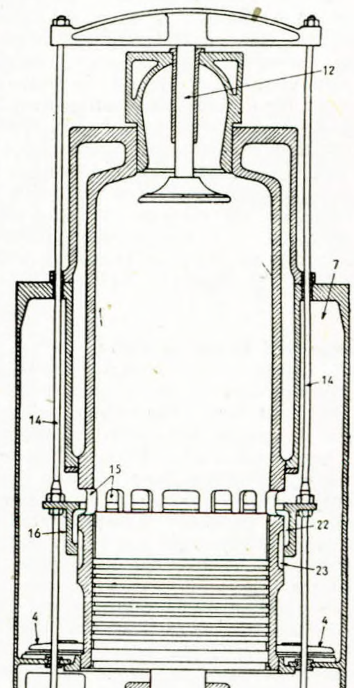


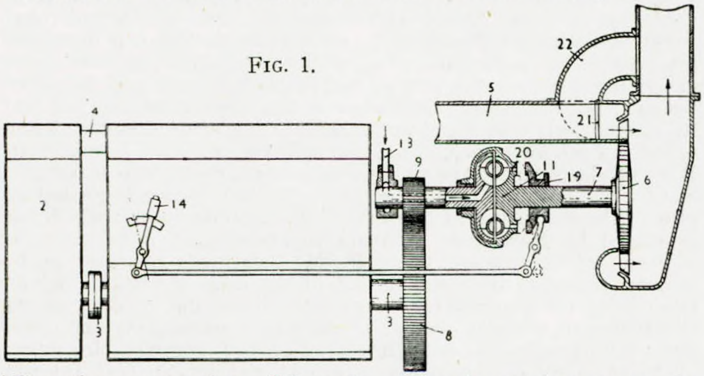
FIG. 2.

of port control adopted. In the scavenging-air space *(7)* are the pressure valves *(4)* which communicate between this space and the air-compression chamber *(5)*. Air enters through automatic inlet valves arranged at a suitable position *(24)*. The exhaust valve *(12)* is operated by a cross-bar and side rods *(14)*, while the scavenging-air inlet ports *(15)* are uncovered by the piston at the bottom of the stroke, thus admitting air from the chamber *(7)* to the cylinder. When the piston is at the top of the stroke the scavenging-air ports are again uncovered and in order to prevent air flowing from the chamber *(7)* into the compressed-air space *(5)* below the piston a sleeve valve *(16)* is provided. It is operated by the same rods *(14)* as the exhaust valve. The sleeve acts as a D-slide valve having upper and lower edges with a space *(22)* between. The cylinder surface has recesses *(23)* and in the open position of the valve, as shown in the diagram, scavenging air flows through the ports *(15)* by way of the recesses and the space *(22)* inside the sleeves, which keeps the ports *(15)* closed during the entire stroke, except at the exhaust and scavenging periods.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 384.*

Sulzer Reversible Supercharged Engine.

A supercharging compressor is embodied in the engine installation shown diagrammatically in Fig. 1, an exhaust-gas turbine being geared to the main shaft. Means are provided for preventing the turbine from racing when the engine is reversed. The scavenging-air pump *(2)* is of the reciprocating type and is driven by the shaft *(3)*, while the air supply is delivered to the engine through a pipe *(4)*. The exhaust pipe *(5)* is connected to the turbine *(6)*, which has a shaft *(7)* together with gearing *(8, 9)*. A Föttinger coupling *(11)* is arranged between the turbine and the gearing. The coupling is supplied with oil through a pipe *(13)*. Reversing is effected by a lever *(14)* and the oil passages *(20)* are opened and closed by a device

FIG. 1.



(19) acting as a valve. When the engine is running astern, the coupling *(11)* is out of action and a valve *(21)* directs the exhaust gas through a pipe *(22)* to the atmosphere. With the operation of the reversing lever *(14)*, oil is allowed to flow from the coupling *(11)* and the turbine would tend to race. This is prevented by arranging the oil passages *(20)* so that the coupling can never be completely empty. As the turbine turns in the opposite direction to the engine it acts as a brake. The engine gives about half its full output when going astern, an account of the loss of power accredited to the turbine when going ahead.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 384.*

Davey Paxman Engine Overhauling Gear.

For the purpose of facilitating the overhaul of engines installed in confined spaces on board ship, the apparatus illustrated in Fig. 3 may be used in such a manner as to tilt the unit, which is of the Diesel type with inclined banks of cylinders, conveniently on its side. The engine is disengaged from its generator (F) by dismantling the coupling (G), the cover of the coupling being bolted on to the crankcase. An extension (M) is fitted on the crankshaft and brackets (J, K) are placed under the ends. Jacks are embodied in the brackets and the weight is taken off the engine so that the stool plates (N) can be removed. In order to connect the lifting jacks (H, I) to the engine, plates (O, P) are bolted on the cylinders at the end remote from the generator and similar plates (Q, R) are fixed to the other end, all the plates being triangular and drilled to take the jacks in different positions. One jack (H) is first secured to the plate (O). The bracket (K) has a semi-circular bearing surface which engages the cover of the coupling. The jack (H) is extended until the engine, by turning round the crank axis, is at an angle of about 48°, when the second jack (I) is fixed to the plate (R) and the engine is

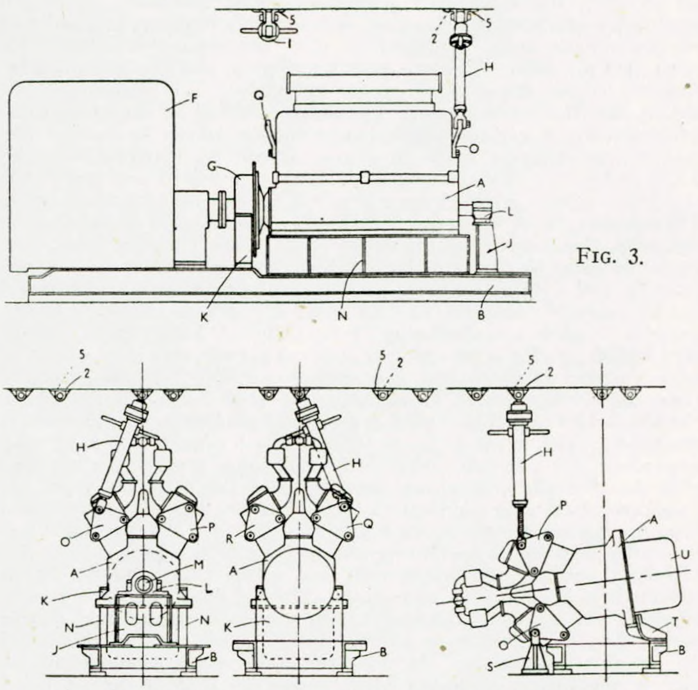


FIG. 3.

turned to its final tilted position, making an angle of 97° (according to the specification) with the normal vertical centre line. To secure the unit in place for overhaul, the jack (H) is replaced in a vertical position—as indicated in the lower right-hand diagram—between the bracket (2) and the plate (P). Subsequently, the position of the jack (I) is altered so that it is connected to the bracket (5) and the plate (R). In its tilted position, the engine is held firmly by means of supports (S) bolted to the apexes of the plates (O, R) and similar supports (T) bolted to the base plate (B) and the upturned base of the crankcase (A). The jacks in the brackets (J, K) are lowered and removed, together with the plummer block (L). The coupling cover (G) is then taken off the engine as well as the lubricating oil sump (U), so that access is then gained to the main bearings and the crankshaft.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 384.*

Very High-speed Marine Oil Engines.

At an informal meeting of the Institution of Mechanical Engineers, Mr. W. S. Burn put forward some suggestions regarding the design of marine oil engines of the future. He pointed out that the power output of the present-day aero engine approaches that required for the propulsion of 95 per cent. of cargo vessels, *i.e.,* 2,000 b.h.p. (or 8,000 b.h.p. in four engines for cargo liners), and that provided the reliability of the basic aero-engine type can be assured when the maintenance period is increased to some 4,000 hours, without increase in weight or aerodynamic disadvantages, such engines could be adapted for use in very wide fields of application, including the propulsion of ships. A system of periodic change of engine could then be introduced for facilitating maintenance, and the overall reliability of multi-engine sets made irreproachable. He considered that present-day maintenance costs are excessive. It is not uncommon to incur £1,000 per annum per 1,000 h.p., and sometimes more. The idea of using in groups engines of existing auxiliary types is impracticable owing to the excessive weight and space which would be involved. After the war, better ships and better engines will be essential if British shipping is to be in a position to compete with that of other nations, and one direction in which this can be done is by decreasing engine-room space and improving reliability. Mr. Burn then gave some particulars of a design of oil engine which should make it possible to build a 12,000-ton cargo liner with propelling machinery of 10,000 h.p. which would save 1,000 tons deadweight and thereby increase the cargo-carrying capacity of the vessel by 30,000 cu. ft. The aim of the proposed design is the provision of a light unit of low rating, in order to achieve long-term reliability. It is a 6-cylr. V-type d.a. 2-stroke engine, rated at 1,500 b.h.p. at 1,250 r.p.m. With cylinders of 7½-in. bore and 10½-in. stroke, the rating corresponds to a b.m.e.p. of 87·5 lb./in.^{2} and the weight is between four and five tons. There is one cylinder per crank, and adjacent pistons are connected to cranks set at 180°, the crankshaft preferably being undrilled. An open combustion chamber is suggested, with multiple injectors or combined pump-atomizer units, arranged to give progressive injection with controlled air swirl. There is port scavenging, and the eccentrically-operated valves are external to the cylinders. The pistons are oil-cooled, and the scavenging-air pumps are worked by the crossheads. Alternatively, a variable-displacement blower might be used. The fuel consumption of such an engine should be between 0·33 and 0·35lb./b.h.p.-hr. Two engines could be coupled to one generator, and four engines might drive a single propeller running at 85 r.p.m. The advantages of this type include the possibility of installation in the poop, thus increasing the cargo space. The cylinder dimensions would be only 50 per cent. larger than those in current aero-engine practice, and with a low m.e.p. and careful design, overhauls should not be necessary more often than every six months, or 4,000 hours, the cost on each occasion being of the order of £250 per engine, or, say, £5,000 p.a. for a six-engined ship. Although this may appear to be a big step from current aero-engine overhaul intervals, ranging from 200 hours upwards to the suggested 4,000 hours, the low m.e.p. combined with operation under commercial conditions should make it attainable. The crankshaft of the proposed engine would be easy to produce and maintain. Very little wear takes place in the bearings of a d.a. 2-stroke engine, and separation of the cylinders from the crankcase facilitates lubrication. The lubricating-oil consumption should not exceed the present figure of 2 gall. per day per 1,000 h.p. It would be possible to remove the pistons of the proposed engine without disturbing the piston rods and valves. This would permit intermediate overhaul if necessary. The bearings should not need touching for a year. Ordinary fuels could be used. Mr. Burn's design was subjected to a number of criticisms in the course of the ensuing discussion. It was suggested that development of such a revolutionary design would take too long to be of value in the first post-war period. Moreover, the aero engine is made of such specialized materials and operates under conditions so different from those of other power units that a true comparison cannot be made. It was likewise considered that Mr. Burn's proposals would not achieve the desired weight and that the piston speed would be too high. Furthermore it would be essential to use distillate fuels of high cetane number and residual fuels would be of little value. The opinion was put forward that Mr. Burn's fuel costs would be from 10 to 15 per cent. higher than those of existing engines, and that a 5 per cent. saving in fuel costs is sufficient to sway shipowners' decisions. In the circmstances it would, therefore, be preferable to employ medium-speed geared engines.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 379.*

Gas Turbines for Ships.

A paper on the above subject was presented by C. R. Söderberg and R. B. Smith at the November, 1943, meeting of the Society of Naval Architects and Marine Engineers. The authors pointed out that the idea of the gas turbine is not new, but that recent progress in metallurgy has greatly increased its practicability, and that when the obstacles associated with any new development of this kind have been overcome, the gas turbine will probably prove to be as suitable for continuous-duty marine service as the steam turbine. The maintenance problem should not be any greater than that of any other turbine installation and is certainly likely to be far smaller than that presented by Diesel engines. The starting problem is in process of rapid evolution, and it is somewhat difficult to predict the final solution. European practice favours the employment of auxiliary electric motors or Diesel engines for this purpose, but as this involves the introduction of other prime movers which may quite often be of considerable size, it might be preferable to utilise compressed air, stored in bottles in accordance with conventional Diesel practice. These bottles might be charged by bleeding the main compressor, or by means of a small auxiliary compressor. Computations, not yet substantiated by experiments, indicate that a 2,500-h.p. installation would probably require not more than 5lb. of air at a pressure of 80lb./in.^{2} for starting up. The reheat plant with constant-displacement compressors is capable of regulation down to less than 10 per cent., while for very low loads it might prove feasible to make use of a partial by-pass of the power turbine, thus approaching the conditions of starting operation. A satisfactory form of control for ahead operation would therefore appear to be attainable. The problem of astern operation is more complex, and as a number of mechanical problems have yet to be mastered, it would appear unwise at present to attempt reversing by the conventional means of an astern turbine. When a satisfactory variable-pitch propeller, or a reversible gear, becomes available, it may become practicable to use direct drive with gas turbines, but in the meantime, hydraulic or electric transmission will have to be adopted. Both can be made to give satisfactory manœuvring and reversing characteristics.—*"Mechanical Engineering", Vol. 66, No. 1, January, 1944, p. 70.*

The Three-Cylinder Doxford Opposed-piston Marine Oil Engine.

The author of this paper points out that the Doxford engine is the only 3-cylr. single-acting oil engine which has been built in quantity for the propulsion of ocean-going ships. First built in 1924 as a slow-speed engine with the object of introducing the economy of the I.C. engine to the shipowner, who had previously operated the tramp class of steamer of about 8,000 tons d.w. and 9-knots speed, it provided a simple short type of self-contained main engine which drove all its necessary pumps at sea. All other auxiliaries, such as the ship's pumps, steering gear, dynamos and winches, were of the well-tried steam-driven type with which these steamship owners were quite familiar. The paper describes some features peculiar to the 3-cylr. engine, and the later developments and modifications made when the all-welded engine was introduced in 1935 are discussed, with special mention of the crankshaft, thrust block, scavenging-air supply, the cooling of the pistons and the fuel-injection system. These components are dealt with in detail. A brief note on torsional vibration and on the measures taken to counteract its effects on the crankshaft, is also given. The 3-cylr. engine has been produced in a number of standard sizes up to 2,500 b.h.p., a power sufficient for the propulsion of a large proportion of the world's merchant tonnage, and there is no practical difficulty in building larger engines.—*Paper by W. H. Purdie, read at a meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, on the 18th February, 1944.*

Some Considerations on the Development of the Diesel Engine.

Although this paper is intended to be a general survey of the development of the Diesel engine since the days of Akroyd Stuart (1890) and Rudolph Diesel (1892), the greater part of it is devoted to a review of the application of oil engines to ship propulsion. After describing some of the earliest marine installations and discussing the developments which took place immediately after the last war, the author deals with d.a. 4-stroke engines, blast injection, the sliding-cylinder 2-stroke engine, the Scott Still engine, solid injection, the B. & W. d.a. 2-stroke engine, uniflow scavenging, *v.* loop scavenging, and the s.a. B. & W. 2-stroke engine. He then gives a brief description of the latest type of "coverless" d.a. 2-stroke engine which was developed by Burmeister & Wain in Copenhagen just before the outbreak of the present war. In this design the diameter of the exhaust pistons is increased to that of the main pistons, the advantages being (*1*) simplification of cylinder design due to the complete elimination of cylinder covers: (*2*) improved accessibility and consequent reduction in time for piston overhaul; (*3*) considerable increase of horse-power in proportion to weight and length; and (*4*) self-contained stress system. The new engine develops 1,000 b.h.p. per cylinder at 125 r.p.m. and weighs 15 per cent. less than its predecessor. A special feature of the design is that nearly 30 per cent. of the total power is developed by the exhaust pistons, whereas that developed by the smaller exhaust pistons of the earlier engine was only 10 per cent. The conversion of blast-injection engines to solid injection is briefly dealt with, and the progress made in the past 20 years in the design of Diesel engines for the propulsion of submarines is then reviewed. The new Deutz engines which the Germans are fitting in some of their submarines at the present time are of the V type with 16 cylinders, developing 1,600 b.h.p. at 700 r.p.m. and weighing 12lb./b.h.p. The Germans claim that the weight of the Diesel machinery in their modern submarines is only 50 per cent. of what it was in the last war. Other matters relating to the evolution of the present-day marine oil engine dealt with in the paper are opposed-piston, horizontal and sleeve-valve Diesel engines. The development of the Diesel engine as a prime mover in power stations on land is also referred to. In this connection the author remarks that an 8-cylr. d.a. 2-stroke engine constructed by Burmeister & Wain 10 years ago for use in the Municipal Electricity Works at Copenhagen, is probably the world's largest oil engine. Its cylinders have a diameter of 840 mm. with a piston stroke of 1,500 mm., and the engine develops 22,000 b.h.p. at 115 r.p.m. The total weight is 1,400 tons, the o.a. length 45ft., and the height 30ft. A large Diesel-engined power station designed for the Soviet Government contains two 12-cylr. d.a. 2-stroke engines each developing 45,000 b.h.p. Some details are given of typical applications of the Diesel engine to rail traction, road transport and aircraft. The author points out, however, that the Diesel aeroplane engine compares unfavourably with the petrol aero engine as regards weight and power output. Thus, the 9-cylr. liquid-cooled Bristol Phoenix

Diesel aero engine develops 420 b.h.p. and weighs 1,092lb. or 2·6lb./b.h.p., whereas the same makers' well-known "Pegasus XC" petrol air-cooled aero-engine with the same number of cylinders develops 920 b.h.p. and weighs only 1,015lb. or 1·1lb./b.h.p. Similarly, the Rolls Royce Co.'s 12-cylr. liquid-cooled Diesel aero-engine develops 500 b.h.p. and weighs 1,400 or 2·8lb./b.h.p., whereas their 12-cylr. liquid-cooled "Kestrel" petrol engine develops 700 b.h.p. and weighs only 955lb. or 1·36lb./b.h.p. The remaining sections of the paper deal with fuel injection, cylinder liner wear, piston design, exhaust valves, reversing gear, compressors, the supercharging of 4-stroke Diesel engines, the limitations of the 2-stroke type, and the probable future of the Diesel engine.—*Paper by D. Rebbeck, M.A.(Cantab.), read at a meeting of the Belfast Association of Engineers on the 17th November, 1943.*

Belliss and Morcom-engined Diesel-generator Sets.

A considerable number of Belliss and Morcom Diesel-generator sets have recently been installed in various vessels built or building in this country. Each set comprises a three-cylinder 4-stroke engine of the open-combustion-chamber type directly coupled to a 75-kW. Campbell and Isherwood generator running at 600 r.p.m., both the engine and the dynamo being mounted on a combination bedplate. The engine has uncooled C.I. pistons, vertical valves and C.A.V. injection equipment. The solid-forged crankshaft has integral balance weights and runs in four pressed-steel whitemetal-lined main bearings. The camshaft is driven by a heavy roller chain fitted with an external tensioning device. Among the special features of the engine design are external connections between the cylinder jackets and heads, a water-cooled exhaust manifold, and fuel and lubricating-oil systems which are claimed to make fuel contamination impossible. The engine is controlled by means of a single wheel which performs all starting and stopping operations in the correct sequences, there being no possibility of starting air and fuel being admitted simultaneously to the cylinders. The rating of the engine is conservative, the full-load b.m.e.p. not exceeding 70lb./in.^{2}.—*"The Marine Engineer", Vol. 67, No. 799, February, 1944, p. 60.*

New 6,400-b.h.p. Nordberg Engine.

It is reported that tests of the first of an improved design of higher-powered type of Nordberg 2-stroke Diesel engine have now been concluded, and that the engine has been installed in the first "Victory" ship. The new Nordberg engine is being produced with six, seven, eight and nine cylinders, and is designed for direct drive, developing its rated output at 164 r.p.m. The cylinder diameter is 29in. and the piston stroke 40in. The six-cylinder engine is rated at 4,275 b.h.p., whilst the nine-cylinder unit develops 6,400 b.h.p. at its normal speed.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 375.*

Feed-water Filtration for Marine Use.

A paper on the above subject was presented at the November, 1943, meeting of the Society of Naval Architects and Marine Engineers by A. C. Rohn, Chief Engineer and Assistant Director of the Technical Division of the U.S. Maritime Commission. The author stated that as it was found that marine-type terry-towelling filters did not remove all the oil present in the highly emulsified condensate from the reciprocating engines in certain ships of the Maritime Commission, the latter carried out a series of investigations with feed-water filters of the type used in power stations on land, which were redesigned for marine use. Tests were likewise carried out with filters in other services, modified for this purpose and adapted for marine use, in addition to which new marine filtering installations were developed. All the marine filtration systems investigated by the Maritime Commission were reviewed in the paper, which also contained a detailed description of the developments which at present are considered most likely to prove satisfactory for filtering feed water on board ship. In the course of the discussion which followed the reading of the paper, one speaker expressed the view that the filtering equipment described by the author was too bulky, expensive, troublesome to operate and generally unsatisfactory for marine service. He considered that the best way to solve the problem was to keep oil out of the feed water. This is substantially accomplished with modern geared-turbine machinery and electric auxiliaries, the small traces of oil in the feed water being absorbed by the colloidal components of the preparation used for treating the boiler water. With properly designed and operated machinery of this type, no trouble whatever is experienced with the feed-water filters. Another speaker said that insufficient emphasis had been given in the paper to certain phases of filtration which have recently shown greatly improved performance, although the ideal filter has not yet been evolved. He believed that the vertical-cartridge sand filter and some modifications of the horizontal sand-bed filters deserved further attention, and gave tabulated data relating to their features and performances as compared with those of diatomaceous-earth absorber and stripper types of filters referred to in the paper. Yet another speaker described the earth-absorber system of feed-water filtration used in the Kaiser-built aircraft carriers. These ships are propelled by two Nordberg-built Skinner-type engines of 4,500 h.p. each, but capable of developing up to about 6,500 i.h.p. per engine with a variation in the water rate of from 120 to 240 gall. (U.S.) per minute. The filter surface provided is approximately 200ft.^{2}, designed for a water rate of 150 to 200 g.p.m. Two filters are installed for each engine, one acting as a stand-by. Up to 3 gall. of oil per day enters the engine during the running-in period, and in order to remove this amount of oil from the condensate, diatomaceous earth is added in the ratio of about 1·5lb. of earth per lb. of oil. The filters are changed over and cleaned every 36 hours, and the resulting oil contamination of the feed water is well below 0·1 p.p.m. Pressure variations due to starting and stopping of the main engines have no effect on the operation of the feed-water filters in these ships.—*"Marine Engineering and Shipping Review", Vol. XLVIII, No. 12, December, 1943, p. 170.*

Boilers for Victory Ships.

The type of boiler being installed in the new steamships of the "Victory" class is a single-pass unit with an economiser in the uptake and with superheaters above the third row of tubes. Separate downcomers from the steam drum are used to supply the furnace-side tubes, and the latter also have separate steam risers leading to the steam drum above the water level. The tubes are smaller than those of the boilers in the "Liberty" ships, thereby saving a substantial amount of weight. The boilers of the new vessels therefore have a greater output capacity on less weight and may be forced to a higher steaming rate. As more waste heat will be absorbed by the smokebox economisers, there will be a reduction in the temperature of the gases in the uptake, with a corresponding gain in fuel economy. The single-pass boiler will be somewhat easier to clean on the fire side, owing to the elimination of any shelves and pockets where soot and ashes might accumulate. As the superheaters are located nearer the fire, more superheat per unit of surface is obtainable, whilst the provision of separate steam and water connections for the tubes of the furnace walls improves the circulation of water in the new boilers. It is claimed that the latter are lighter, more economical and able to provide a higher superheat temperature than the boilers of the "Liberty" ships. These claims are based on 10 years' experience with boilers similar to those of the "Victory" ships installed on board a considerable number of American vessels and operating at a steam pressure above 225lb./in.^{2}.—*"Marine Engineering and Shipping Review", Vol. XLVIII, No. 11, December, 1943, p. 218.*

Research in the Shipbuilding Industry.

The Shipbuilding Conference has announced that the British shipbuilding industry is to form a Research Association, which will be entrusted with the development of all branches of research work connected with shipbuilding, marine engineering, and ship repairing. This step has been taken after consultation with the Department of Scientific and Industrial Research and the Admiralty. The shipowners and the classification societies are also interested in this new development. The British Shipbuilding Research Association will, it is stated, consist of a Research Council elected by the Shipbuilding Conference, which will finance the Association and will be responsible for the general conduct and policy to be adopted. The Department of Scientific and Industrial Research will be represented on the Council. A Research Board will also be formed of members representing the various interests of shipbuilders, marine engineers, ship repairers, shippers and the classification societies. The setting up of this new Research Association will in no way restrict the research activities of private firms and other bodies which may have had long years of experience in the conduct of research work connected with the shipbuilding industry, but whose activities have not so far been co-ordinated on any national basis.—*"The Engineer", Vol. CLXXVII, No. 4,593, 21st January, 1944, p. 43.*

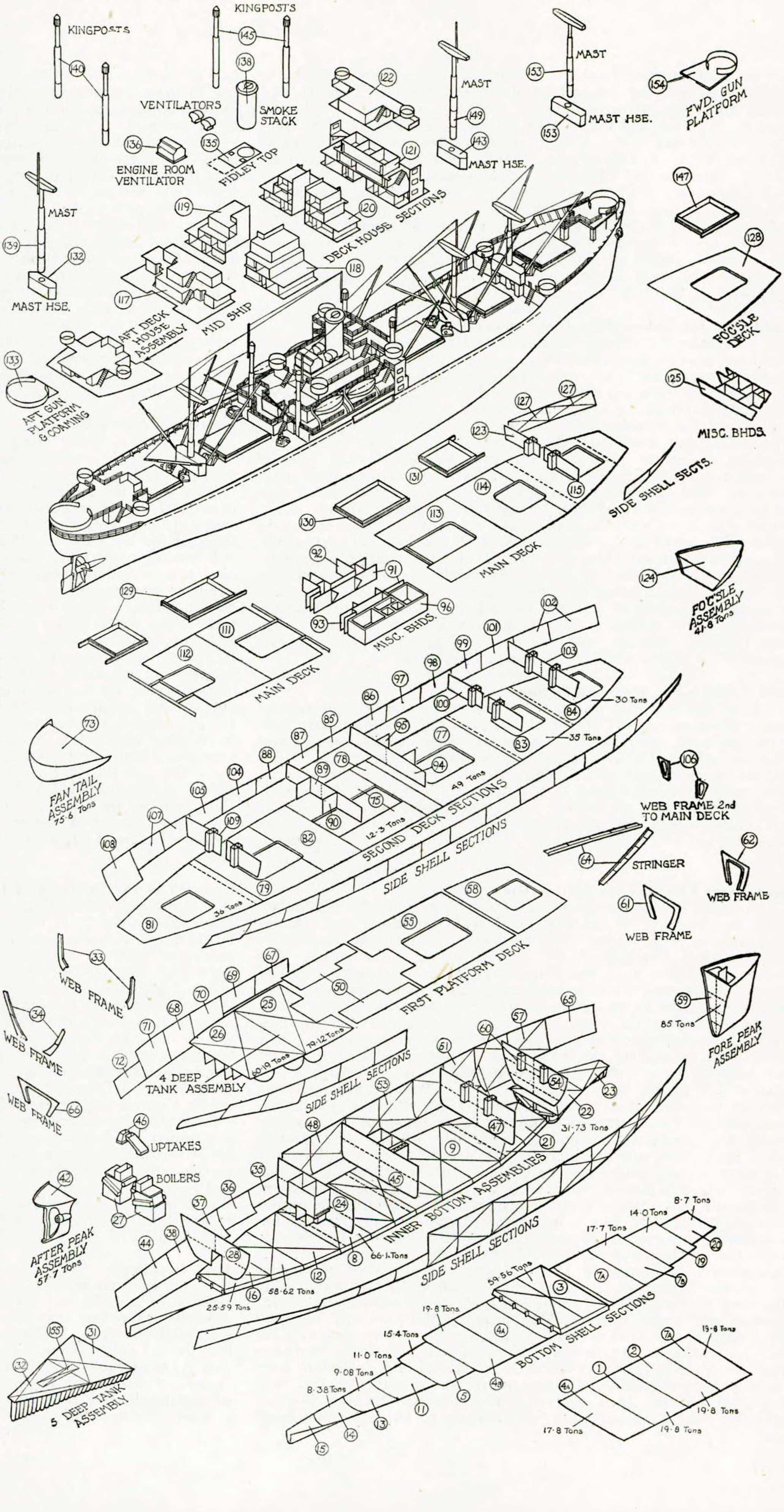
Deck Buckling.

Following on reports of hull defects in the nature of cracks or tension failures in the superstructures of some of the war-built welded ships, comes news of a form of defect of the opposite nature, *viz.*, local waving or buckling of the deck plating, apparently due to longitudinal compression. There is, however, no real contradiction, both types of fault being brought about by weld contraction. As the system of stresses set up in the hull structure by weld contraction is of a self-balancing nature so far as the cross-section of the ship as a whole is concerned, it follows that tension at one part implies compression at another. Buckling may be regarded as the less serious of the two related manifestations, since plating can continue to carry a substantial compression load even after waving has started. Moreover, the bending of the plate may quite well remain within the elastic limit, so that no permanent damage is suffered by the material. Buckling of the thinner parts of the decks of medium-sized ships is by no means uncommon under still-water loading conditions that cannot be regarded as abnormal, so that it would not be economic, or even essential from an engineering aspect, to ensure by design that every part of the structure was proof against any such distortion. —*"Shipbuilding and Shipping Review", Vol. LXII, No. 26, 23rd December, 1943, p. 603.*

Building the "Victory" Ships.

It is reported that 339 of the new "Victory" fast cargo liners are due to be constructed in the Kaiser Richmond yard during the present year. These vessels are 455ft. in length with a beam of 52ft. and a d.w. tonnage of 10,800. Most of them will be fitted with turbines, but a number are to have Diesel machinery. The service speed will be 15-17 knots, according to the power of the engines to be installed. The accompanying sketches indicate in diagrammatic form the manner in which the hull is prefabricated, the explanation of the numbers and details given in the sketches being set out below. The numbers indicate the erection sequence.

Gun Platform—154.
Kingposts—140, 145.
Masts and Mast Houses—132, 139, 143, 149, 153, 153.
Stack—138.
Ventilator—136.
Fidley Top—135.
Midship Deckhouse Secs.—117, 118, 119, 120, 121, 122.
Aft Deckhouse Assembly—116.
Aft Gun Platform—133.
Hatch Coaming—147.
Fo'c'sle Deck—128.
Misc. Bulkheads—125.
Side Shell—127.
Hatch Coaming—129, 130, 131.
Transverse Bulkhead—123.
Main Deck, 111, 112, 113, 114, 115.
Misc. Bulkhead—Mach. Space—92, 93, 96.
Machine Casing—91.
Fantail Assembly—73.
Fo'c'sle Assembly—124.
Side Shell—85, 86, 87, 88, 97, 98, 99, 101, 102, 104, 105, 107, 108.
Longitudinal Bulkheads—90, 95.
Transverse Bulkheads—89, 94, 100, 103, 109.
Second Deck—75, 77, 78, 79, 81, 82, 83, 84.
Side Shell—67, 68, 69, 70, 71, 72.
Web Frames—33, 34, 61, 62, 66, 106.
Stringer—64.
First Platform Deck—50, 55, 58.
Deep Tank Assembly—25, 26.
Aft Peak Assembly—42.
Boilers and Uptake—27, 46.
Forepeak Assembly—59.
Side Shell—35, 36, 37, 38, 44, 48, 51, 53, 57, 65.



Deep Tank Assembly—31, 32, 155.
Brackets—60.
Transverse Bulkheads—24, 28, 45, 47, 54.
Double-bottom Units—3, 8, 9, 12, 16, 21, 22, 23.
Bottom Shell—1, 2, 4a, 4b, 5, 7a, 7b, 11, 13, 14, 15, 19, 20.
—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 359.*

Stone McAlister Twin-screw Single-engined Propulsion System.

Two independent swivelling propellers driven by a single engine are shown with the arrangement illustrated in Fig. 1, applied to a shallow-draught vessel. The engine (C) drives a shaft (D) which enters a casing (G) at the stern, where it is geared to the lateral shafts (H). The vertical shafts (M) are driven by bevel gearing (K, L). At the bottom of each shaft (M) is a bevel gear (S, T) which drives the propeller shaft (P). The housing (O) for the vertical and horizontal shafts can be turned to the desired angle by means of a worm and worm wheel (Y, Z) driven by an electric motor, all the mechanism being duplicated to suit twin-screw propulsion. The two motors (*4*) are controlled from a panel (*5*) on the bridge and the position of each propeller is shown on an indicator at the same location. Thus, for getting away from a pier, one propeller can be set at right angles, as shown by the dotted lines in the centre diagram on the left, while the other screw revolves ahead, or the vessel can be driven astern by both propellers if required. The revolutions are set by the engine controls, which remain independent of the rotational adjustments of the propellers. At the top of each vertical shaft there is a housing (J) which is filled with oil circulated by a pump (*2*). The drive for the pump is taken from a gear-wheel (*3*) driven through the shaft (H).—*"The Motor Ship", Vol. XXIV, No. 290, March, 1944, p. 418.*

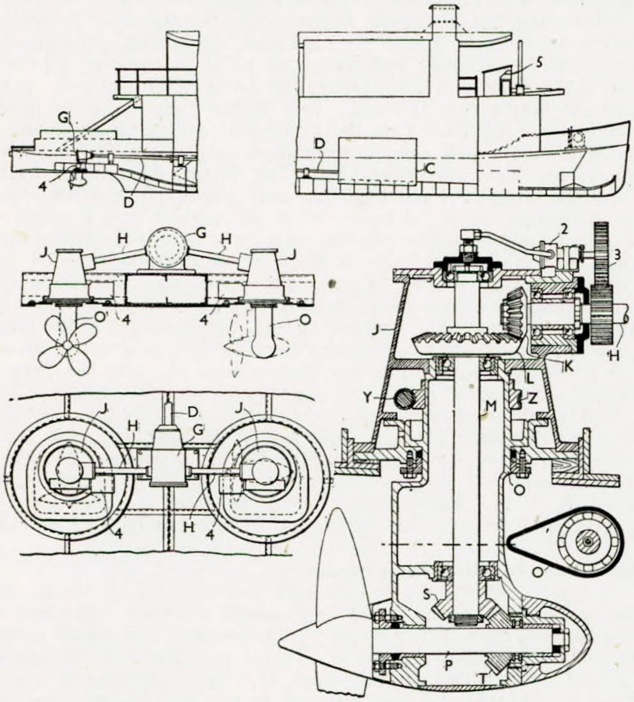


FIG. 1.

Apparatus for Cleaning Hulls Afloat.

A mechanically actuated device for hull cleaning while the ship is afloat is illustrated in Fig. 2. The base of the apparatus is buoyant and fitted with skid bars which make contact with the ship and prevent the cleaning brushes from crushing. The bars are adjustable and for the brushes may be substituted rollers for pulverizing scaly growths prior to cleaning. The base comprises, for example, two buoyancy drums (*5*) to which are welded the cross-members (*6*). The brushes (*8, 9*) are carried on shafts (*10, 11*) provided with sprockets (*14*) for a connecting chain (*15*). Bevel gearing (*17*) is fitted so that the brushes can be operated through a shaft (*18*), with sprocket and chain drive (*19, 20*) from a compressed-air motor (*22*). The air is supplied through a hose pipe (*24*) and in order to avoid the possibility of water entering the motor an atmospheric exhaust hose (*25*) is utilised. The stuffing box (*26*) is fitted to the driving shaft. Skid bars (*28*) extend along the base and these may be set to the required distance clear of the brushes by means of bolts (*29*) passing through elongated holes. At the ends of the bars, rollers (*32*) are fitted and the shackles (*36*) which are attached to the roller pins takes the ends of the operating cables (*35*). The method of working the apparatus is shown in the upper right-hand diagram, the cables being hauled up on one side of the ship and paid out on the other, so that the hull is cleaned progressively in strips or swathes athwartships, arranged to overlap to a certain extent.—*"The Motor Ship", Vol. XXIV, No. 290, March, 1944, p. 418.*

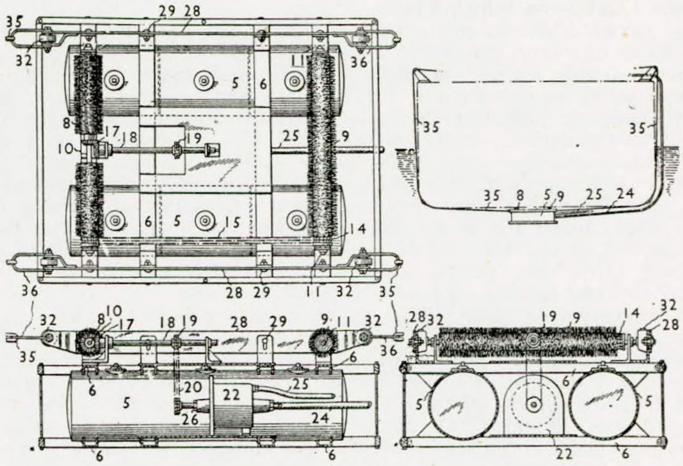


FIG. 2.

Jet Propulsion for Ships.

The publicity recently given to the success claimed to have been achieved with the application of jet propulsion to aircraft has led some people to believe that new possibilities with jet-propelled ships must be envisaged. In actual fact, however, the system of operation is very different in the two cases, quite apart from the fact that the fluids employed are different, one being a liquid and the other a gas. The jet-propelled aircraft makes use of what is in essentials the simplest form of I.C. engine, the fuel mixture being burnt, heated is drawn in through intakes forward of amidships and expelled in an astern direction by means of a propeller or pump. Experiments with pump-driven jets for the propulsion of ships were first carried out about 100 years ago and since then there have been many attempts to develop various forms of hydraulic propulsion. The Gill system was at one time adopted for a number of small craft, and the Hotchkiss system has likewise been used for driving river craft and other small vessels. In an early design of tug, equipped with a 120-h.p. Diesel engine, it was at first proposed to have a tunnel from stem to stern. The propeller was to be placed at the narrowest part of this internal tunnel, which expanded behind the screw in order that the velocity of the propeller stream might be converted to pressure. The propeller itself was more like a Kaplan turbine than an open-water screw. As a result of model tests it was discovered that better results would be obtained by substituting two intake passages, arranged one on each side of the hull, the water being and compressed in a moment of time. In the case of the ship, water discharged as before axially at the stern. Later, it was decided that it would be better to divide the discharge tunnel and to allow the water to be expelled from two jets so as to avoid interference with the single axial discharge by the vessels being towed. The Kort nozzle, which has proved so successful in the case of tugs, is actually an application of the jet principle of propulsion to ships. The increase of free pull when towing effected by the Kort nozzle may be as much as 20 per cent. as compared with ordinary screw propulsion. Nevertheless, it is doubtful whether sea-going ships will ever be jet-propelled. It would have to be decided whether good overall efficiency could be obtained at speeds other than the designed speed, and what the practical range of powers for any one design should be. As against this, the screw propeller is known to retain its efficiency over a fairly wide range of speeds of rotation. Moreover, there are other comparatively new systems of propulsion, as, *e.g.*, the Voith-Scheider, which will claim the attention of shipowners after the war, a feature of the last-named system being its high degree of quick manœuvrability. It would, however, be unwise to rule out the possibility that the latest discoveries in the aerodynamic field of jet-propelled aircraft might open the way to at least a few new applications of the jet for marine purposes.—*"The Shipping World", Vol. CX, No. 2,640, 19th January, 1944, pp. 107 and 109.*

New 12,300-ton British Tanker.

Recent additions to the fleet of the British Tanker Co., include a series of motor tankers of a type based on the general design of the 18 vessels ordered in 1936. The war-built tankers are said to have better accommodation for the deck and engineer officers, all of whom are housed amidships, whereas the engineers' accommodation in the earlier vessels was arranged aft. Among the ships of improved design is one built and engined by Swan, Hunter & Wigham Richardson. She has a cruiser stern and straight stem and is provided with a single telescopic mast. Longitudinal framing is employed under the deck, whilst transverse framing is used at the sides and on the fore-and-aft bulkheads. The total d.w. capacity is about 12,800 tons, the oil cargo being carried in nine centre tanks and an equal number of port and starboard tanks. Dry cargo space to the extent of about 48,000 cu. ft. is also provided. The ship's fuel tanks have a capacity of approximately 800 tons, whilst the ballast tanks hold nearly 600 tons of water ballast. The propelling machinery consists of a four-cylinder Swan, Hunter-Doxford engine of standard design, which drives all the pumps required for its own operation. Forward and above the main engine are two single-ended cylindrical boilers arranged for burning oil fuel under forced draught and also to utilise the exhaust gases from the main engine. The working pressure in these boilers is 150lb./in.^{2} and sufficient steam is raised at sea for running all the auxiliary machinery required without having recourse to the use of oil fuel in the boiler furnaces. The total fuel consumption of the ship when under way is therefore only 0·35 to 0·36lb./s.h.p.-hr. for all purposes. The steam-driven auxiliaries in the engine room include two 30-kW. 110-volt 600-r.p.m. dynamos, one of which acts as a stand-by at sea; a 190-ton ballast pump, which also serves as a stand-by to the engine-driven circulating pump; a 140-ton distilled-water cooling pump; a stand-by F.L. oil pump of 30 tons/hr. capacity; two 80-ton sanitary and bilge pumps; a general service pump of similar capacity, which is also used as a stand-by boiler-feed pump; and two three-stage air compressors, each capable of compressing 120 cu. ft. of free air per minute to a pressure of 600lb./in.^{2}. The cargo-pumping installation comprises four 230-ton main cargo pumps and two 40-ton stripping pumps. A steam-driven methyl-chloride refrigerating compressor serves the ship's cold rooms. The anchor windlass, deck winches and after capstans are also steam-driven, as is the hydraulic single-ram type steering gear, which has a rotary oil pump and telemotor control. This tanker and her sister ships have proved very satisfactory in service. She maintains her rated speed with a full cargo on a daily fuel consumption of 12 tons for all purposes.—*"The Motor Ship", Vol. XXIV, No. 287, December, 1943, pp. 276-285.*

U.S. Naval Construction in 1943.

Nearly 60 submarines were launched in the U.S. last year, their average time of construction being only about nine months. All of these craft are believed to be of the standard 1,525-ton type with a surface speed of 21 knots and an armament comprising ten torpedo tubes, a 3-in. H.A. gun and two A.A. machine guns. The hulls are of all-welded construction and have a high standard of living accommodation, including separate messing and sleeping compartments. Nearly 700 destroyer escorts have been or are being built. These ships are not small destroyers of a modified "Hunt" type, as originally reported, but frigates corresponding to the British "Captain" class. They are stated to be of 1,300 tons' displacement, with a length of 300ft. and a beam of 35ft. The designed h.p. of their machinery is 5,500 and their speed is reported to be 21 knots. Some of these craft have turbo-electric propelling machinery, others have Diesel or Diesel-electric machinery, and some are equipped with triple-expansion engines. Their average cost is a little over three-and-a-half million dollars per ship and the average building time is now stated to be substantially less than the 206 days which were formerly required to construct one of these vessels. Their armament comprises three 3-in. dual-purpose guns, two 40-mm. Bofors and four 20-mm. Oerlikon guns, in addition to depth-charge throwers. Apart from these destroyer escorts, 81 frigates, classed as such and very similar to the British frigates of the "River" class, are in various stages of construction. They are reported to be of 1,445 tons, with an o.a. length of 306ft. and a beam of 37½ft. Unlike the destroyer escorts, which are named after distinguished members of the U.S. Army and Navy, the new frigates are called after towns. Motor torpedo-boats, submarine chasers and other light craft are still being delivered in large numbers, 100 steel submarine chasers of improved design, 180ft. in length, having been built in 1943. Between 20 and 30 Diesel-electric cutters of the 935-ton tender type, usually referred to as the "Iris" class, were built or ordered last year. At least nine of them were launched in 1943, the latest to be reported being the "Spar". Several more old flush-deck destroyers, dating from the last war, have been converted into fast transports. Their boiler capacity has been reduced, bringing the speed down to 25 knots.—*F. McMurtrie, "The Engineer", Vol. CLXXVII, No. 4,593, 21st January, 1944, pp. 46-47.*

Victory Ship Production.

Considerable extensions have been put in hand at the Richmond yards of the Permanente Metals Corporation in California for the pre-fabricated production of the 50 Victory ships which are to be built there. An open-air storage area of nearly 25 acres is being levelled off for the storage of fabricated units in readiness for instant distribution where needed. New buildings have been provided for the fabricating and fitting-out departments, for the new facilities and sub-contractors' section, for the electrical, machinists', pipefitters' and sheet metal departments and for additional compressors. Three new piers, 114ft. wide and 540ft. long, are being constructed to provide fitting-out berths for 10 ships. Two 10-ton cranes will be installed on each pier. In Yard One the craneways are being extended 20ft. and the slipways will remain unchanged, whereas in Yard Two the slipways are being extended 15ft. The 36-ton stern-frame castings will be machined in Yard Two for both yards. The double-bottom units will continue to be made up at the present location and four new 70-ton trailers will be put into service to handle the large amount of new pre-fabrication to be utilised in building the Victory ships. A stress-relieving furnace is being put up on the south side of the present Yard Two pipe shop, in which all main steam piping will be "baked" to relieve the stresses caused by welding. The erection sequence planned shows that the heaviest pre-fabricated assembly to be prepared in readiness for lifting into place is the fore-peak assembly weighing 85 tons. The upper-peak assembly weighs 57 tons, the D.B. sections 59 tons, the deep-tank assembly 79 tons and so on. Excluding the main engines, boilers and shafting, etc., the erection sequence lists 154 sections from the heavy assemblies referred to above, in addition to gun platforms, masts, mast-houses, funnel, ventilators, etc.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 36,162, 6th January, 1944, p. 2.*

Ships' Cargo-handling Equipment.

A typical tramp built immediately before the war, having a d.w. capacity of round about 9,000 tons, would normally have five main cargo hatches, each served by two 5-ton derricks, and a heavy derrick with a lifting capacity of 20 to 30 tons would usually be arranged at No. 2 hold, which, in this class of ship, is always the largest. This arrangement was also adopted in the 60 "Ocean" type cargo vessels constructed in the U.S. for the British Government. In the new fast standard cargo ships now being built in this country there are six hatches serving the five main holds and the shorter No. 4 hold situated immediately forward of the machinery space. There are altogether twelve 5-ton derricks and six 10-ton derricks, in addition to three heavy ones—a 50-ton derrick at No. 2 hold, an 80-ton derrick at No. 3, the largest hold, and a 30-ton derrick at No. 5 hold. The cargo-handling capacity of this type of vessel is, therefore, about twice that of a normal tramp steamer, excluding the heavy derricks intended for dealing with specialised cargo. The time required for discharging in ports not equipped with suitable cranes will accordingly be reduced to an extent which should, at least, correspond with the higher speed of the ships. The cargo winches in these vessels are of the electric type and possess a number of advantages over steam winches, among which are reduced operating costs; the initial outlay involved, however, is far higher, and it is doubtful whether an installation of this type could be adopted for the average cargo vessel of the future on economic grounds. There is still room for improvement in the steam cargo-handling equipment generally provided in cargo ships, and the introduction of motor-driven winches on a large scale will probably result in improvements being made in the steam gear.—*"Fairplay", Vol. CLXI, No. 3,164, 30th December, 1943, p. 793.*

An Interesting Reconstruction Job.

An extensive and unusual reconstruction job was recently completed by Kockums Engineering Works, Malmö, Sweden. Of three Swedish destroyers which were damaged in an explosion at Harsfjärden, near Stockholm, in September, 1941, the 1,000-ton "Göteborg" has already been reconstructed and placed in service again. A thorough examination of the 900-ton destroyer "Klas Horn" after she had been raised, showed that only the forward part of the hull was repairable. The hull of her sister ship "Klas Uggla" was beyond repair, but the machinery was in good condition and fit for further use. The Swedish Admiralty thereupon decided to rebuild the hull of the "Klas Horn" and to make use of the "Klas Uggla's" machinery for the reconstructed hull of the "Klas Horn". The forward part of the last-named vessel was therefore towed to the Finnboda Yard, Stockholm, for repair, whilst a new after part was being built at the Malmö shipyard, where the two sections were subsequently dry-docked and joined together. The machinery of the "Klas Uggla" was then installed and the ship fitted out. Advantage was taken of the opportunity to make a number of improvements in the structure and equipment of the reconstructed destroyer. —*"Shipbuilding and Shipping Record", Vol. LXIII, No. 3, 20th January, 1944, p. 64.*

"Fundamentals of the Marine Screw Propeller".

The 16th Thomas Lowe Gray lecture recently delivered to the Institution of Mechanical Engineers by Dr. G. S. Baker, formerly Superintendent of the William Froude Laboratory, bore the above title and dealt with the essential features of propellers—how they work, how they waste work and their restrictions. The lecturer pointed out that the three main causes of loss of energy in a propeller are from slip stream, pitch and friction. He indicated the loss of efficiency from these causes and gave curves showing the maximum efficiencies obtainable, remarking that the loss through friction is much more important with low pitch ratios than with high ones, for which reason it is important that the blades of low-pitch propellers must have clean and polished surfaces. The depth of roughness which can be tolerated without an effect above that for a smooth surface, was stated to be about 0·004in. for a normal screw 20ft. in diameter and running at 100 r.p.m. Dr. Baker also discussed the influence of blade outline and the width of the blade in relation to the effective pitch angle, and gave an explanation of a case which sometimes puzzles a marine superintendent. If a propeller is replaced by a new one having the same diameter and other characteristics, but with a larger blade area, a higher speed of revolutions is often required to obtain the same ship speed and to absorb the same power. This will happen if the reduction of effective pitch, due to the increase in width of the blade, is greater than the increase in lift. The advantage of the aerofoil section, as compared with round-back sections, is well known, and this is a field in the development of which this country has led since the idea was originated As an example of the material advantages of aerofoil screws, the lecturer quoted the case of the German-built "Empress of Australia", in which the screws designed in Germany were replaced by new propellers designed at the National Tank. Over a year's working an increase in speed of ¾ knots was attained without any increase in the speed of revolution or shaft torque. A section of Dr. Baker's paper dealt with the number and position of screws. Proposals have been made to place the screws in every position round a ship, but for the reason that a propeller placed aft works in the water which has been set in forward motion by the drag of the ship, this location is always likely to give the most efficient result. Since a propeller works by producing suction of its forward blade faces, which extends some distance in front of them and augments the ship resistance, the best arrangement, from this point of view, is that in which this effect and that of the wake balance out. To take full advantage of this, a multiplicity of small propellers would be required, and, if the resistance of the shaft supports did not absorb more than 2 to 3 per cent. of the power available, a 15-knot vessel would be propelled by five small screws of about 8-ft. diameter, turning at 100 r.p.m. Similar adjustments could be made in an 11½-knot cargo ship, and such an arrangement would lend itself to the employment of small. fast-running units. The lecturer also stated that the question of the point at which it becomes profitable to fit twin screws, instead of a single screw, is now becoming important in view of the increased speed of ships, and, leaving aside considerations otner than the efficiency of the propellers, it would appear that the single screw is advantageous for speeds envisaged for the majority of cargo ships. —*"Fairplay", Vol. CLXII, No. 3,170, 10th February, 1944, pp. 254 and 256.*

Defects of Mass-produced Ships.

In view of suggestions made in the U.S. Senate regarding structural defects in mass-produced American merchant vessels and a demand by one Senator that the conversion of "Liberty" ships to troop transports should be discontinued pending an enquiry into reports that several had broken apart at sea, a statement on the subject has been made by Rear-Admiral E. S. Land, Chairman of the U.S. Maritime Commission. The Admiral said that the structural faults which had caused some "Liberty" ships to break up were capable of 75 to 80 per cent. correction, but not of 100 per cent. correction. The defects were locked-up stresses which, resulting from welding practices, eventually caused some ships to crack, or, as in a few instances in the past, actually to break in two. Only two ships—the "J. L. M. Curry" and the "Thomas Hooker"—have been lost as the result of structural defects, although a number of others have had to undergo extensive hull repairs in dry-dock to make good such defects.—*"The Syren", Vol. CXC, No. 2,477, 16th February, 1944, pp. 299-300.*

First American-built Self-propelled Concrete Cargo Ship Completed.

The first self-propelled concrete cargo vessel to be constructed in the U.S. during the past 20 years or more, is the steamship "David O. Saylor", of 4,300 gross tons, built at the Tampa, Fla., shipyard of McCloskey & Co., for the U.S. Maritime Commission. The ship, the first of a series of 24 such vessels ordered from the firm, is 350ft. long b.p., with a beam of 54ft. and a depth of 35ft., the d.w. carrying capacity being about 5,500 tons. The propelling machinery consists of a triple-expansion engine developing 1,300 i.h.p. Two sister ships, the "Vitruvius" and "Arthur Newell Talbot" are nearing completion, and three more are scheduled to follow a few weeks later. These concrete vessels are being built in huge basins at the Tampa yard, there being three main basins each accommodating three ships, so that nine can be constructed at the same time. When a basin iis flooded three ships are launched at a time. The "David O. Saylor" was launched eight months after her keel was laid and completed four months later, but it is anticipated that her sister ships will be completed more rapidly. Most of these concrete vessels will be operated by the Agwi Lines and Lykes Bros., and it is assumed that they will, for the time being, be employed in the coasting trade.—*"Marine Engineering and Shipping Review", Vol. XLVII, No. 12, December, 1943, p. 178.*

From Paddle Wheels to V.P. Propellers.

Some further details were recently published concerning the re-engining of the Swiss paddle steamer "Leman" with Diesel machinery driving variable-pitch propellers (*see abstract on p. 93 of* TRANSACTIONS, *October, 1943**). The "Leman" was built for passenger service on the Lake of Geneva in 1857 and was modernised in 1874. After 20 years of further service she was laid up for a considerable time, but was eventually equipped with new engines and boilers and once more placed in service. After a further long period of years it seemed that at last her fate was sealed, but once more there was a reprieve and it was decided to convert her into a twin-screw motorship with Escher Wyss adjustable-pitch propellers. Two 340-b.h.p. s.a. four-stroke Sulzer engines were installed and the ship now has a speed of 16 knots and a displacement of 197 tons with 450 passengers on board, as against her former displacement of 220 tons without any passengers. The engines run at 500 r.p.m. and the ship carries 660 gall. of fuel oil. The three-bladed propellers can be adjusted from the wheel-house for ahead or astern running at any desired speed without altering the speed or direction of rotation of the main engines, by means of an oil-operated servo motor. It is stated that the makers of the v.p. propellers prefer hydraulic actuation of the blades to mechanical control. Electric current for lighting and driving the auxiliary machinery is supplied by two Diesel-engined generators of 12 kW. and 7 kW. respectively. Compressed air is provided by exhaust-gas-driven compressors and the heating of the ship is effected by the circulation of water which is heated by the exhaust gases.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, pp. 356-357.*

*NOTE BY ABSTRACTER.—*The vessel was then incorrectly referred to as a 1,300-ton ship.*

Maintenance by Welding.

Some idea of the wide range of application of welding to the maintenance of marine machinery in operation can be gathered from an account given in a technical periodical of the methods adopted in a large colonial establishment in which the supply of spare parts and replacements from this country is apt to be difficult. The company possess a fleet of coasters, for the maintenance of which a considerable amount of welding is regularly done. This includes the repair of cracked Diesel-engine cylinders by bronze welding, and of exhaust silencers, burned-out portions of which are replaced by new sections built up of sheet steel and welded into place. In one instance, a section 24in. in diameter was constructed in this manner. Diesel-engine valve seats are replaced by grooving out a ring in the vicinity of the worn part and welding in an insert ring using a special hard-surfacing electrode, the weld metal being subsequently machined to the required dimensions. Copper steam pipes for the deck auxiliaries are joined up by bronze welding, and valve stems eroded by steam are quickly reclaimed with a minimum of expense either by bronze welding or hard facing. The firm's plant includes a large amount of hoisting and conveying equipment in which there are many parts such as hooks, shackles and links which are subjected to a considerable amount of localised wear. In some cases, the surfaces are subjected to a combination of corrosive and abrasive action, and it was found that when such surfaces were built up with metal from special wear-resisting welding-rods, they were able to resist the effects of this combined attack extremely well. As a result, bronze welding and bronze surfacing are coming into increasing use for maintenance work, many parts which require to have the strength of steel combined with corrosive resistance of bronze, being made of steel and completely coated with bronze by means of a bronze welding rod.—*"Shipbuilding and Shipping Record", Vol. LXII, No. 27, 30th December, 1943, p. 628.*

Destroyer Depôt Ship's Many Tasks.

Built by Scott's Shipbuilding and Engineering Co., Ltd., and completed since the outbreak of war, H.M. destroyer depôt ship "Tyne" is a vessel of 11,000 tons' displacement, having twin screws driven by Parsons geared turbines. She has a speed of 17 knots and a main armament of eight 4·5-in. guns. She is equipped with extensive workshops, including heavy and light machine shops and a foundry with two furnaces capable of melting 500lb. of metal at any temperature up to 1,500° C. This shop is run by a staff of eight, including five moulders. On one occasion they made a casting in 25 minutes for a ship just docking, a record for the department which has done jobs for warships of every type. The engineering personnel of the "Tyne" is able to carry out machinery repairs of every kind and includes scores of skilled mechanics, electrical artificers, shipwrights and stoker ratings. The ship's engineer officer, who also supervises all the repair work done on board, is Com'r.(E.), A. E. Kemp, O.B.E., R.N. The vessel is likewise equipped with very large provision rooms and refrigerated compartments to enable her to carry the fresh provisions for the ships based on her. The bakery has six ovens, two mixing machines and 12 mixing bowls; the daily output of bread is about 25,000lb.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 36,162, 6th January, 1944, p. 6.*

The Sinking of the "Scharnhorst".

The German battleship "Scharnhorst", sunk by units of the Home Fleet on the 26th December, was laid down in 1934 and completed in 1939. She had a displacement of 26,000 tons, with a w.l. length of 741ft. 6in., a beam of 98ft. 6in., and a mean draught of 24ft. 8in. Her armament comprised nine 11-in. and twelve 5·9-in. guns, in addition to fourteen 4·1-in. and sixteen 37-mm. anti-aircraft guns. Four aircraft were carried and there were two launching catapults. The normal complement of the ship was 1,461 officers and men. The side armour was 12in. to 13in. thick amidships, tapering to 3in. and 4in. at the ends, the gun turrets having 12-in. armour and the armoured decks being 6in. thick. The propelling machinery consisted of a three-shaft arrangement of geared turbines taking steam from high-pressure watertube boilers. Oil engines were installed for use at cruising speeds. Although designed for a speed of 27 knots, the actual full speed of the battleship was said to be about 29 knots.—*"The Engineer", Vol. CLXXVI, No. 4,590, 31st December, 1943, p. 515.*

Design of Constant and Variable Capacity Mechanical Oil Atomizers.

A paper bearing the above title was presented at the November, 1943, meeting of the Society of Naval Architects and Marine Engineers by J. F. Haney and A. W. Hermandorfer, both of whom are connected with the Babcock & Wilcox Co. They pointed out that the design of pressure oil atomizers (O.F. burners) with optimum spray angle and capacity variation for any boiler furnace of a given size and shape and load demand, depends on the proper selection of the size and shape of the atomizer whirling chamber and of the dimensions of the orifice. The main component of a standard straight mechanical-pressure atomizer is a whirling chamber to which the oil fuel is supplied tangentially and then discharged through a central orifice in the form of a cone-shaped spray. Although an atomizer of this type operates satisfactorily with load demands that are more or less constant, its capacity range is very limited, since the capacity varies substantially as the square root of the supply pressure. This limitation can be overcome by the use of wide-range atomizers capable of radical and rapid capacity variations. There are two general types of such atomizers, *viz.*, (*1*) the variable-orifice type which obtains its capacity range through a variation in the size of the orifices; and (*2*) the return-flow type which secures its capacity range through by-passing a portion of the oil supplied to the whirling chamber. Each of these types has been satisfactorily used in service, and the choice of type must depend on the extent to which the inherent characteristics of either atomizer combine to the best advantage with the requirements of the particular job. In the course of the discussion following the reading of the paper, one speaker remarked that the quality of spray is definitely related to the angle of spray and that the slot ratio constitutes the most important factor governing the latter. Other important factors, not mentioned in the paper, are the degree of tangency of the inlet passages to the wall of the whirling chamber, the length of these passages, the ratio of orifice length to diameter, the accurate centering of the various parts of the burner and the initial quality of its surface finish together with the ability to retain that finish over long periods of service. The effect of the air flow from the register on the spray angle and the flame angle is also a major factor. Where it is known that the spray angle changes, it has been possible to operate with the atomizer in a fixed position throughout a wide range of steam flow from the boiler due to the influence of the air flow from the register. Constant differential capacity control has been most successful and has been utilised for many types of boilers varying in steaming capacity from 10,000 to 750,000lb./hr. It is particularly useful with stand-by steam installations where continued operation at very reduced capacities is an essential requirement. Another speaker stated that automatic combustion control entails an accurate means of metering the oil flow by the control of a single variable, which, in the case of straight pressure burners, is the inlet pressure of the oil, and in that of return-flow burners, its return pressure. Unless the relation between the pressure and flow is simple, consistent and predictable, satisfactory combustion control is not obtainable. It has been found from experience that accurate combustion control with burners of the return-flow design is difficult to obtain when the return pressure is used as the criterion of oil flow. The flow for a definite return oil pressure should not vary more than ±3 to 4 per cent., due to unavoidable variations of inlet pressure, viscosity or tip dimensions, but up to the present time the effect of such variations on the flow has been considerably greater, more especially with the small tips or nozzles used in ships of moderate power and for operation in port. Yet another speaker declared that none of the burners discussed in the paper had the wide range necessary for full automatic control under all conditions in completely water-cooled furnaces. Burners should have a range of at least 10 to 1 and should operate efficiently at the minimum boiler capacity in port, which is about 3 per cent. The range of the straight pressure type burner is only about 1·7 to 1, which is far too low, whilst that of the return-flow type is about 3 or 4 to 1, which is likewise insufficient. In general, the service performance of this type has been unsatisfactory. The atomization should be extremely fine over the full range of burner capacity; it should, in fact, be much finer than is possible with mechanical atomization. Furthermore, the oil should be projected into the air stream at a very high velocity and with high kinetic energy so as to produce the high degree of turbulence required for rapid and efficient mixing. At present, the only burner suitable for ships' boilers which will give these results is the steam atomizing type. Several large twin-screw transports, built by the Federal Shipbuilding and Dry Dock Co., were recently equipped with steam atomizing burners. During the trials of the first ship, all burners of all boilers were in use under automatic control during the entire period before getting under way until after anchoring; the burners were not touched, the uptake and funnel were perfectly clear and the excess air was unusually low. During the full-power run, the average excess air was 8 per cent. There was no dust or dirt and the combustion was practically perfect. The speaker believed that this performance was by far the best obtained to date. The steam consumption of such burners is about 0·5 per cent. of the steam generated at normal power, and this is more than saved by the use of compressed-air soot blowers. He considered these steam atomizing burners to be far superior to mechanical oil atomizers of the straight pressure and return-flow types. He was a staunch advocate of the use of completely water-cooled furnaces, which are safer, more reliable and less costly to maintain, and he urged improvement in the design of air registers and oil-fuel burners on a scientific basis.—*"Marine Engineering and Shipping Review", Vol. XLVIII, No. 12, December, 1943, pp. 159-161.*

One Hundred Diesel Tugs for Towing Oil Barges on Inland Waterways of Eastern Seaboard of U.S.

In order to relieve the acute shortage of oil in the N.E. States of America due to the lack of shipping facilities during the winter of 1942-43, the U.S. Office of Defense Transportation arranged for the construction of a fleet of 100 Diesel-engined tugs and 500 oil barges for service on the inland waterways of the Atlantic seaboard. The work of designing these craft and superintending their construction was entrusted to the U.S. Engineer Corps, and contracts for the building of the tugs were placed with six different firms. Most of these vessels have already been completed and are reported to be giving highly satisfactory service. The principle characteristics of the design are an all-welded steel hull of unusually stout construction of approximately 86×24×10¼ft. and a mean draught of 8ft. The propelling machinery consists of a General Motors V-8 Diesel engine of 700 h.p. at 750 r.p.m., driving the propeller at 246 r.p.m.

through two Airflex couplings and reduction gearing. The engine is of the non-reversing type, reversal of the propeller being effected by means of a reverse gear incorporated with the reduction gearing. The engine is engaged to the pinion shaft either directly or through the reversing gear, as desired, through the medium of the two Airflex clutches. Each of the latter consists of a stout rubber or fabric gland bonded to an outer steel rim through which connection to the engine shaft is made by a bolted flange. The inner periphery of the gland carries a number of moulded-in asbestos blocks. This assembly is mounted on a friction drum in much the same manner as the brake assembly of a motor-car. The drum is attached to the driven shaft. When air at a pressure of about 100lb./in.^{2} is admitted to the gland, the distention of the latter causes the asbestos blocks on the inner periphery to grip the friction drum, thus making positive connection between the driving and driven members. The reduction gear is of the standard Falk type and reversal of motion is obtained by means of a sleeve mounted on the pinion shaft,, which is provided with a gear meshing with the reversing gear train. The reversing pinions straddle the main forward pinion bearing and the idler pinions, two in number, are carried in floating bearings. Two of the rubber gland units are incorporated in the engine flywheel and enclose two friction drums on the gear unit, one drum being attached to the ahead pinicn shaft, and the other to the reversing pinion sleeve. With the engine running constantly in one direction, the gland control is operated to inflate either gland at will, the ahead or astern pinion is engaged by the friction blocks, and the propeller shaft is rotated ahead or astern accordingly. The gland control is located in the pilot house, besides the steering wheel, and is operated by a single lever. The first movement of the latter, either forward or backward from the neutral position, engages the corresponding ahead or astern clutch. A slight sideways movement of the lever then engages the engine throttle control and further movement of the lever varies the engine speed as desired. The controls are interlocked so that when one clutch gland is inflated the other is deflated, and it is impossible to engage both clutches at the same time. The engine is started electrically, current being supplied by a battery. The engine is cooled by fresh water and a heat exchanger. A similar heat exchanger serves the lubricating-oil system. Electric power is furnished by two G.M. Diesel-generator sets, each of 30-kW. capacity, whilst compressed air for operating the engine clutches is supplied by two motor-driven compressors, each of 20 c.f.m. at 150lb./in.^{2} capacity. Automatic controls govern the starting and stopping of the compressors. The ship's rudder is operated by Sperry electro-mechanical steering gear. The motor-driven pumps in the engine room include a 44-ton centrifugal fire pump and a 22-ton centrifugal bilge pump. The electrical equipment includes a 56-cell, 200 amp./hr. battery for the provision of current when the Diesel generators are not running. This battery is additional to the one installed for starting the main engine.—*"Motorship", Vol. XXVII, No. 10, October, 1943, pp. 768-773 and 803.*

Colloidal Fuel.

The U.S. Bureau of Mines recently published the results of some tests with colloidal fuel carried out conjointly by the Bureau and the Atlantic Refining Company on an industrial steam boiler installation at the works of the latter. The fuel employed consisted of a mixture of 40 per cent. pulverised high volatile bituminous coal suspended in oil fuel (bunker quality) without the addition of any fixing or stabilising agent, such as lime resin soap, merely relying on intimate mechanical mixing. In this connection, it is pointed out that the general term "colloidal fuel" is entirely wrong, as most of the coal particles are not in the colloidal state, *i.e.*, they are not small enough to constitute molecules which would be impossible to separate from the oil. Colloidal fuel is about 10 per cent. heavier in weight per unit volume than oil and is seven to eight times as viscous, so that more power is required for pumping the fuel through the heaters to the burners. The pumping capacity of the O.F. pump installation is therefore reduced. Also, colloidal fuel is much more abrasive than oil, and if the coal does not remain in suspension pastelike accumulations occur in the tanks, heaters and valves. In addition, the ash from the coal is liberated in the combustion chamber and causes trouble that does not exist with oil. Various grades of bituminous coals were tried, averaging about 37 per volatile matter and 5 to 8 per cent. ash. These coals were, therefore, of a very good quality. Their ash softening temperature ranged from 2,300° to 2,700° F. Three different degrees of pulverising were tried, *viz.*, 88 per cent., 95 per cent., and 99 per cent. through a U.S. Standard 230-mesh screen (62 microns). This is much finer than normally used for pulverised-coal firing, and is necessary where no stabilising agent is employed. The finely pulverised coal was mixed with the oil in a horizontal cylindrical tank holding about 21 tons of oil fuel maintained at approximately 85° F. by means of steam heating coils. The pulverised coal, with hand-valve control, was allowed to flow slowly through a funnel into the stream of oil in a pipe circuit which included the mixing cylinder and a storage tank, the mixture being circulated continuously for 12 hours to ensure complete mechanical mixing. The pulverised coal was fed into the oil at the rate of about 1,500lb./hr. and the colloidal fuel circulated at the rate of about 36 tons/hr. The boiler used was a small water-tube unit of the industrial type set in brickwork 10ft. high at the front from the floor to the tubes and 6ft. high at the back. The combustion chamber was 5ft. wide and 15ft. long, with a volume of about 600 cut. ft. The burner, which was of the ordinary steam atomizing O.F. type, was located at the rear of the setting and the fuel was heated in a steam-operated tubular heater in the O.F. pump discharge circuit. The boiler was first operated on oil to establish normal working conditions, and then changed over to colloidal fuel, being operated at various rates from 40 per cent. to over 200 per cent. of the normal duty, although usually at 100 per cent. rating. Both for colloidal fuel and for oil the control valve was always set to give a pressure of about 30 lb./in.^{2} in the fuel pipe, whilst at the burner itself the pressure was practically zero for oil and about 2lb./in.^{2} for colloidal fuel. The steam consumption of the pump was increased by about 20 per cent. with colloidal fuel because of the increase in power required. The report states that it is not desirable to grind the coal any finer than necessary, as the extent of any settling that may occur is governed by the temperature of the oil rather than by the fineness of the suspended coal particles. The higher the temperature of the oil, the higher is the degree of settling because, of course, th eoil is more fluid. Consequently most of the settling takes place in the heater, and it is necessary to keep a close check on the temperature in the latter. During these tests it was found that there was an appreciable separation in the heater when 88 per cent. and 95 per cent. coal through the 230-mesh screen was used, but practically none with the 99 per cent. coal. Some settling in the storage tank took place with the 88 per cent. coal, but none with the 95 per cent. and 99 per cent., as long as the temperature in the storage tank was maintained at about 85° F. No settling or clogging was experienced in the pipe lines, although these were relatively long, but there was some clogging in the meters and screens. None of these difficulties were really serious and no boiler shut-downs occurred during the month's test. No trouble was experienced in burning the mixture with the existing oil burner, the flame responding smoothly to variations in the amount of air used for combustion. The CO_2 content of the waste combustion gases was 16 per cent., with no carbon monoxide. Troubles with the ash in the coal were much less than anticipated, whilst the boiler efficiency was approximately the same for both oil and colloidal fuel. Although colloidal fuel firing has not yet been utilised on a commercial scale in America, there is some talk of making colloidal fuel on a gigantic scale and selling it direct to steam users, and, it is calculated that with a production of 140,000 tons of colloidal fuel per annum, it would prove feasible to sell the product at the same price per 1,000,000 B.Th.U. as the standard oil fuel now being marketed in the U.S.A. Presumably such colloidal fuel supplied in barrels or drums would have to be mechanically mixed in a tank or other container before use. In general, the U.S. Bureau of Mines appears to think that there is a considerable future for a simple mixture of finely pulverised coal and oil, which, of course is intended, unless remixing takes place, to be used almost immediately so as to give little time for appreciable separation.—*D. Brownlie, B.Sc., "The Steam Engineer", Vol. XIII, No. 148, January, 1944, pp. 104-107.*

The E.R.A. and the Coaster.

Despite the advantages claimed for Diesel engines over steam engines for the propulsion of coasting vessels, it must be admitted that the problem of engine-room labour is liable to be serious where oil engines are concerned. Many of the older engineers of the pre-war coasters are now on war service and, apart from casualities, the natural wastage has been very high under the strain of war conditions. After the war, it is probable that a large number of E.R. ratings demobilised from the Royal Navy will become available for employment as engineers in coasting vessels owing to their technical qualifications. These men have received an excellent training at various naval establishments and have spent years handling a large variety of internal-combustion engines under difficult conditions, not only keeping them running at sea, but getting first-rate experience in maintenance and repair work at the bases.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 1, 6th January, 1944, p. 2.*

Future of Motorships in U.S.A.

In a discussion on Diesel-engine propulsion after the war at the recent American Merchant Marine Conference, Mr. R. E. Friend, president of the Nordberg Manufacturing Co., presented a paper in which he referred to the difference in the cost of bunker C oil fuel as used under boiler and fuel suitable for Diesel engines. He stated that "developments are under way which definitely promise that bunker C fuel may be used in Diesel engines". He pointed out, however, that this grade of fuel cannot be employed for such a purpose without prior treatment. It must be properly heated and cleaned to remove gums and foreign matter which would cause difficulties with injection systems, increased wear of liners and piston rings, and a certain amount of contamination of lubricating oil. According to Mr. Friend, the problem of obtaining experienced engineers for American motorships has now been overcome. Various training schools established by the U.S. Navy and Maritime Commission, supplemented by schools attached to Diesel-engine manufacturers' shops have turned out a large number of capable Diesel engineers. There is also no difficulty in obtaining properly qualified E.R. ratings for the considerable number of new Diesel-engined ships now being launched in America.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, p. 353.*

Improving the Coal-burning Trawler.

Although it is claimed that the motor trawler is a better commercial proposition than any steam trawler, and Continental trawler owners have greatly increased their fleets of Diesel-engined trawlers in recent years, it must be remembered that foreign countries have not the abundant supplies of coal available in Great Britain and that the reduction of their imports by reducing their demands for oil, is not of such vital consequence as it will be in this country after the war. Coal is admittedly a bulky fuel to stow, and the coal consumption at full power of a 160-ft. trawler with an 800-h.p. engine is of the order of 1·8lb./s.h.p.-hr. This works out at 15½ tons a day, but in actual practice, a trawler of this power uses only 55 per cent. of this amount, or 8½ tons a day, since full power is not used continuously. The engine and boiler also take up a lot of space, whereas the total amount of space required by Diesel engines, for which the fuel oil can be carried in D.B. tanks, is substantially smaller. This fact makes the motor trawler an attractive proposition, but as it may become a matter of vital importance to run our trawlers on home-produced coal after the war, it will be essential to reduce the fuel consumption and size of the machinery. The adoption of the Howden-Johnson boiler in lieu of the Scotch boiler would save a good deal of weight and space, in addition to which the higher boiler efficiency and steam pressure would render possible an appreciable reduction in fuel consumption. The addition of an exhaust turbine to the main engine would make it feasible to reduce the size of the latter. This has already been done in at least one new steam trawler. With superheated steam at a pressure of, say, 270lb./in.^{2}, and preheated combustion air, for which provision is made in the Howden-Johnson boiler, and with feed-water heating by the exhaust steam from the dynamo engine, steering engine and evaporator, the coal consumption might be reduced to 25 per cent., which is equivalent to a consumption of 6·4 tons per day for all purposes. Another improvement would be the provision of a mechanical stoker with elevators and conveyors to feed the stoker hopper from hopper bunkers. As lower-grade coals can be used with mechanical stokers, a 20 per cent. saving in fuel costs should be attainable, although the coal bunkers would take up the same amount of space. An engineer and an assistant for each watch should suffice to look after such machinery. The first cost of a steam trawler of this kind would be substantially lower than that of a Diesel-engined trawler with an electric winch; or even of a motor trawler with a steam winch and an exhaust-gas boiler. A mechanical stoker with its accessories would increase the first cost, but the saving in wages and coal bills would more than offset this item.—*W. O. Horsnaill, "Shipping", Vol. XXXII, No. 279, February, 1944, pp. 18 and 20.*

The Electrical Equipment of Ships.

The author states that his paper on the above subject is based on the following considerations regarding the electrical equipment of new vessels or for incorporation in existing ships: (*1*) high factor of safety; (*2*) economy in first cost; (*3*) economy in running costs (or efficiency); and (*4*) economy in maintenance and/or repairs. The systems of generation and distribution in general use on board British ships are: (*a*) the d.c. 2-wire system at 100, 110 or 220 volts, with both poles insulated; and (*b*) the d.c. 1-wire system with hull return at 100 or 110 volts. Alternative systems, not extensively used are: (*c*) the d.c. 3-wire system at 220-440 volts between outers, with earthed middle wires; (*d*) the series a.c. system with constant current; (*e*) the a.c. 3-phase system at 400/440 volts with earthed neutral for power and heating, and 110/150 volts for lighting; and (*f*) the a.c. single-phase system at 250 volts for power and heating, and 110/150 volts for lighting. After a brief discussion of the particular features of these types of installations, the author deals with electrically-driven marine auxiliaries, including generators and prime movers, switchboards and switchgear, circuit breakers and fuses, electric motors, their duties and characteristics, starters and control gear. The section devoted to steering gears mentions the electro-hydraulic, the all-electric single-motor and the all-electric motor-generator (Ward-Leonard) systems. Motor-driven deck machinery, comprising windlasses, capstans, warping winches and cargo winches, is likewise discussed. Other sections of the paper are devoted to electric heating and cooking equipment; lighting, both general and emergency; low-tension equipment, such as telephones, telegraphs, alarms and bells, indicators and thermometers; special navigational equipment, including gyro-compasses and echo-sounders; and wireless apparatus and equipment. The paper concludes with some notes on a.c. installations, in regard to which the author states that, despite the undeniable advantages which they possess in several important respects, it must be admitted that two serious drawbacks of a.c. motors in their simplest form are lack of means of speed regulation and low starting torque. Although these disadvantages can be reduced or wholly eliminated, if necessary, this can only be done at the partial or entire expense of some of the principal advantages which normally characterise a.c. motors. He expresses the view that shipbuilders, consultants and designers may, in many cases, have to depart from normal practice in some degree or other, before a.c. motors may be ecoonomically utilised for all British marine auxiliaries. In ships in which the electrical requirements are mainly lighting and heating, however, and the power requirements (if any) are entirely suitable for the use of induction motors, the adoption of alternating current would undoubtedly be advantageous.—*Paper by S. Booth, read at a meeting of the N.-E. Coast Institution of Engineers of Shipbuilders on the 4th February, 1944.*

Effect of Oil Vapour in Machinery Spaces on Electrical Equipment.

The presence of oil vapour in machinery spaces is a constant hazard to electric motors and generators. Oil, although an insulator itself, seems to have a deteriorating effect on some insulating materials, more especially on mica, for which reason commutators suffer damage more frequently than other parts. There are other objectionable effects produced by the presence of oil or oil vapour on both a.c. and d.c. electrical equipment. Oil vapour, for example, in apparently low concentrations, will, nevertheless, often cause the deposition of surprisingly large amounts of oil in windings, cooling ducts and other parts of electrical machinery. This is due to the fact that despite the apparently light degree of concentration, *e.g.* one part in several million, the thousands of cubic feet of cooling air drawn through a machine over a long period easily accounts for the amount of oil deposited in it. The presence of a sticky film of oil on the windings, etc., leads to an accumulation of dust and dirt particles on the surfaces affected, in consequence of which the winding and cooling ducts are gradually filled with this mixture. Ventilation is thereby restricted, and if the dust particles happen to be conducting, as would be the case for carbon or metallic dust, creepage paths may be formed and electrical failure of the machine will occur. Oil vapour is usually caused by a turbulent body of hot oil, such as is present in engine crankcases, reduction-gear-cases, air compressors, centrifuges, or similar machines. The higher the temperature of the oil, the worse the vapour condition. The engine rooms of some of the older motorships often present typically bad cases. Little can be done to prevent the formation of oil vapour, although it may sometimes be possible to provide vents for gear-cases, etc., through which the oil vapour is piped elsewhere. Centrifuges can sometimes be moved to positions in which the oil vapour produced by them is less likely to injure electrical equipment exposed to its effects. Where the vapour condition is serious and where the affected electrical unit is of sufficient importance, it may be desirable to obtain its cooling air from a clean source by means of a special duct, but the ideal solution is total enclosure of the unit and recirculation of its air through a cooler. Experience indicates that the reduction in maintenance work and increased reliability secured by ensuring a supply of clean cooling air for electrical machinery justifies the provision of such arrangements on a much broader scale than is customary at the present time. The only alternative is the institution of a routine for washing the windings of dynamos and motors exposed to the effects of oil vapour at frequent intervals.—*E. H. Housler and W. W. McCullough, "Marine Engineering and Shipping Review", Vol. XLVIII, No. 12, December, 1943, p. 208.*