D seyester

1 THE SHIP

The function of sea transport, like that of any other form of transport, is to move things; and its success lies in finding people who have things that need moving, then transporting these things safely and efficiently.

Logically one should start with what needs moving, where it needs to be moved to, and how much of it there is. However, before we can make any really useful analysis it is probably better to examine what vehicles and hardware are at our disposal, and then to understand the basic jargon that has inevitably grown up around what must surely be the oldest form of transport.

The number and classification of ships

In the seventeenth century much of the business of the port of London was conducted in the various coffee houses in the city. One such coffee house, much frequented by people concerned with the shipping business, especially underwriters, was run by a man called Edward Lloyd. Anxious to please his clientele, Lloyd produced ships' lists, which gave some account of the various vessels likely to be offered for insurance. Lloyd's Register is a descendant of these lists, and in three large volumes it contains details of all the merchant ships in the world of over 100 tons gross. In 2001, this total was well over 87,500 ships and, as is shown in Chapter 2, is made up of a large variety of types, shapes and sizes.

Ships can be categorised not only by their specialist functions – ie tankers, general cargo, containers, etc – but also as to how they are operated.

There are two basic modes of operation. A ship can be employed as a *liner* – ie it runs on a regular line between two ports or series of ports. It has a regular schedule of sailings and an agreed list of tariffs or prices. Alternatively, a ship can be employed as a *tramp*. This means that the ship is chartered or hired out at the best price the owner can obtain. Such a ship may go anywhere with anything on board. There is in fact a third possibility. This is where merchants or organisations who have a lot of cargo to move, such as oil companies, operate their own ships.

A further tradition is to distinguish, for a variety of reasons, between ships that go a short distance, referred to variously as *coasters, home-traders* or *short sea traders*, and those that venture farther afield and are known as *foreign-going ships* (this will be dealt with in greater detail in Chapter 4).

Design and Classification Societies

Ships are designed by naval architects and they are bound by various constraints, such as the cost of different designs, what is technically possible, what cargoes the vessels are most likely to carry, environmental safety factors, and which ports they are most likely to trade between. The whole problem of planning is made more difficult by the fact that the design, ordering and building of a ship may take two or three years, and also that the expected working life of a ship is still in the region of fifteen to twenty years. Obviously in today's world much can change during this lapse of time.

Many shipowners have their own particular preferences and style, and because few ship types are mass-produced there is considerable room for manoeuvre here on superficial appearance factors such as the shape of the superstructure and funnel. In contrast, under water, the shape of the hull is critical and cannot be left to someone's artistic whims. So in order to prove vessels' viability in this respect, wax models are made and tested in special testing tanks. Being wax, their shape can be easily altered and re-tested and eventually an optimum shape is evolved for that size of ship, its speed and the anticipated sea conditions.

But of course the ship must not only be efficiently designed, it must also be soundly built; and the certificate of an independent body as to quality of design and construction may help a shipowner to convince an insurance underwriter that his ship is seaworthy. Such independent bodies are known as *Classification Societies*. There are numerous societies – but the oldest, largest and perhaps most famous is Lloyd's Register. (Edward Lloyd made comments on the state of the ship in his original circulars.) An International Association of Classification Societies was founded in 1968 (IACS) and IACS members classify 42,000 ships – which is more than half the world fleet – or around 95 per cent of the world's gross tonnage. There are about 40 small Classification Societies, which are not all IACS members. Some notable Classification Societies are given in Table 1.1.

In its original state, when the Register was started in 1760, it was known as the 'green book' and it was for the exclusive use of underwriters. Some years later a rival register was started by shipowners, but in 1834 the two registers were completely reconstituted to form an independent society. As a result, a definite system of classification was started, based on a book of rules. In its early days there were many classes (A1, representing the highest class, first appeared in 1775), but now there is only one class for all types of ocean-going vessel, ie 100 A1. (There are, however, four classes of ice-strengthening in the rules – vessels that are required to navigate in ice need to be strengthened accordingly, particularly round the bows and stern, which are obviously the most vulnerable areas when battering their way through ice. The degree of strengthening depends on the severity of ice anticipated, and charterers and operators need to know not only these rules, but also the expected weather.)

Name	*Symbol*	*Date founded*	*Nationality*	*Comments*
American Bureau	AB	1862	American	
Bureau Veritas	BV	1828	French	The rules of this Society admit two classes, excellent and seaworthy
Germanischer Lloyd	GL	1867	German	
Det Norske Veritas	NV	1864	Norwegian	
Nippon Kaiji Kyokai	NK	1899	Japanese	
Registro Italiano Navale	RL	1861	Italian	Also makes provision for two classes

To obtain Lloyd's class of ✠ 100 A1 the vessel must be built under the scrutiny of the Society's surveyors (the significance of the Maltese cross) and its strength and construction must satisfy the Society's rules. Similar conditions apply to the machinery of the vessel.

In order to *maintain* class, a vessel must undergo periodic surveys. These include annual surveys afloat, dry-docking (with a maximum interval of 24 months), and a special survey at four-yearly intervals (or a five-year continuous survey cycle), which becomes more rigorous as the vessel ages. Engines, machinery parts, boilers, screwshafts and a variety of specific items – depending on the type of ship – are also subject to *periodic* surveys in accordance with the Society's rules.

We must add that, in the UK at least, classification is voluntary – but in reality few shipowners would or could operate without it. It is not only the underwriters that the shipowners have to convince of the ship's seaworthiness, but also the charterers, shippers, financiers, various cargo interests and the port state authorities of the countries that the ship will visit.

Finally, Lloyd's Register includes all ships over 100 tons gross whether classed with Lloyd's or not, so is often referred to as the 'shipping man's bible'. For this reason, it is obviously important for us to be familiar with its format and content. The key shown at the top of the *specimen page* (page 4) has been inserted to help identify the data, but in the actual volumes the key is printed on an attached plastic bookmark. The Register of Ships is now also available on a CD-ROM.

1	2	3	4	5	6	7
LR No Call Sign Official No Fishing No Navigational aids AMVER	SHIP'S NAME Former names Owners Managers Port of Registry Flag SatCom Id	TONNAGE Gross Net *Deadwt Gross Net *Deadwt *(tonnes)	CLASSIFICATION Hull Special Survey Machinery Refrigerated cargo installation Equipment Letter Fee Numeral	HULL Date of Build Shipbuilders Place of Build Yard Number Length overall (m) Breadth extreme (m) Draught maximum (m) Length B.P (m) Breadth moulded (m) Depth moulded (m) Superstructures (m) Decks Riveted/Welded Rise of Floor (m) Keel (min) Alterations Additional tanker dimensions Conversions	SHIP TYPE/CARGO FACILITIES Propulsion Shiptype Passengers Shelter deck Ro-Ro facilities Holds & lengths (m) Cargo tanks & types Grain/Liquid (m^3) Bale (m^3) Insulated spaces (m^3) Heating coils Containers & lengths (ft) Hatchways & sizes (m) Winches Cargo handling gear (SWL tonnes) Cargo discharge pumps	MACHINERY Design Designation No & Type of engines Bore x Stroke (mm) Power Engine builders Where manufactured Boilers Pressures Heating Surface Furnaces Aux. electrical generating plant & output Special propellers Fuel bunkers (tonnes) Speed
7359632 OIHH 1576 Df Esd Gc Pld Rdr RTm/h/v	FINNJET Effdo 1 Oy Oy Silja Line Ab Mariehamn Finland	25 042 10 360 2825	NV	1977 Oy Wartsila Ab -Helsinki/Helsingfors (407) 212.81 24.44 6,700 196.32 14.81 4 dks rf 800	TGT or D-E Passenger/RoRo Cargo/ Ferry 548cbn 1544bth 28bdk P Ice strengthened Bow door & ramp L 9,00 W 4,20 Stern door & ramp L 5,25 W 4,80 Lane Length 1750 Cargo Width 4,80 Clear height 4,20 Cars 380 TEU 116 C.116/20'	Wartsila 18V32 2 Vee Oil 4SA each 18Cy 320 X 350 15 500bhp (11 401kW) driving 2 gen each 5300kW connected to 2 elec motors each 7205 shp (5300kW) & dr geared to sc shafts NE(Diesel) added 12/81 (Diesel) Oy Wartsila Ab Vaasa/Vasa 2 Gas Turb tr geared to sc. shafts (Turbine) Turbo Power & Marine Systems Farmington Ct Pratt & Whitney 75000 shp Gen 5 X 1360kW 380V 50 Hz a.c. 2 Controllable pitch propellers 2 Thw thrust propellers fwd 30.5kn
7608588 YLFI 0624 Df Esd Gc Pld Rdr RTv	PABAZI ex Sergey Lyulin-92 Riga Trawling & Refrigeration Fleet Base (Rigas Traleru & Refrizeratoru Flotes Baze) Riga Latvia	3017 1245 2063	RS	1975 VEB - Volkswerft Stralsund-Stralsund (454) 101.83 (BB) 15.22 5,650 91.90 15.19 9.71 2 dks	M Factory Fishing Fish-factory Stern Trawler Ref Ice strengthened 2 Ho In. 1 858 2 Ha (each 2,2 X 2,2) Der 2(5) 4(3)	MAN 8ZD72/48 Oil 2SA 8Cy. 480 X 720 3 880bhp (2 854kW) VEB Dieselmotorenwerk Rostock (DMR) Rostock Controllable pitch propeller 16.25kn
7719088 3FWD 12048-82 Df Esd Gc Pld Rdr Rt	PACHITEA Launched as Transatlantico Woodmere Enterprises Inc. Compania Peruana de Vapores S.A. (CPV) Panama Panama	8281 5003 15 984	(RI) + Classed LR until 20/9/89	Lch. 1975 Cmpl 1982-1 Italcantieri S.pA. -Monfalcone (4364) 154.24 (BB) 22.89 9,051 140.61 22.86 10.21 P 33.0 F 12.8 2 dks rf nil	M RoRo Cargo Quarter stern door/ramp (s) L 21.75 W 8,00 SWL 80 Lane Length 1300 3 Ho 13.1DTp 13.1DTs 17.6 35.2 33.2 1 TwD G.27 419 B.25 199 TEU 600 C.Dk 600/20 incl. 24' ref C. 8 Ha (stl) (5.4p&s X 4.2) (16.4p&s 31.2p&s 31.2p&s X 8.4) ER Cr 2(35) 2(25) 2(16)	GMT B550.8L Oil 4SA 8Cy. 550 X 590 with flexible couplings & sr geared to sc. shaft 11 200bhp (8238kw) Grandi Motori Trieste Trieste Gen 3 X 635kW 450V 60Hz a.c. Controllable pitch propeller 16kn

Courtesy of Lloyd's Register.

Parts of the ship

Figs 1.1 and 1.2 are typical of the general cargo ships built during the 1960s. However, it is useful to include them in this section on definitions as they contain most of the basic elements found in modern ships. Many ship 'definitions' used in legal documents -- as, say, for charter parties -- may well be decades out of date!

Although the drawings are labelled 'general cargo ship', ships, like cars and houses, vary within certain very wide limits in their design and layout. Even the methods of construction can vary considerably from the traditional floor, frame and beam construction shown in Fig 1.1. Ships used to be built upwards and outwards from the keel, but in most yards they are now built in huge prefabricated sections that are subsequently joined together.

Anchors These are very important and compulsory items of equipment, and the usual arrangement is to have two bow anchors and one spare. They are raised and lowered by a special winch known as the windlass, or perhaps by a

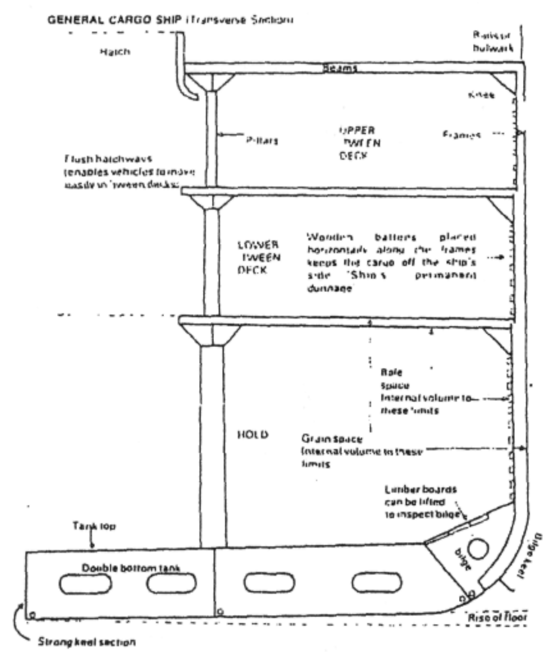
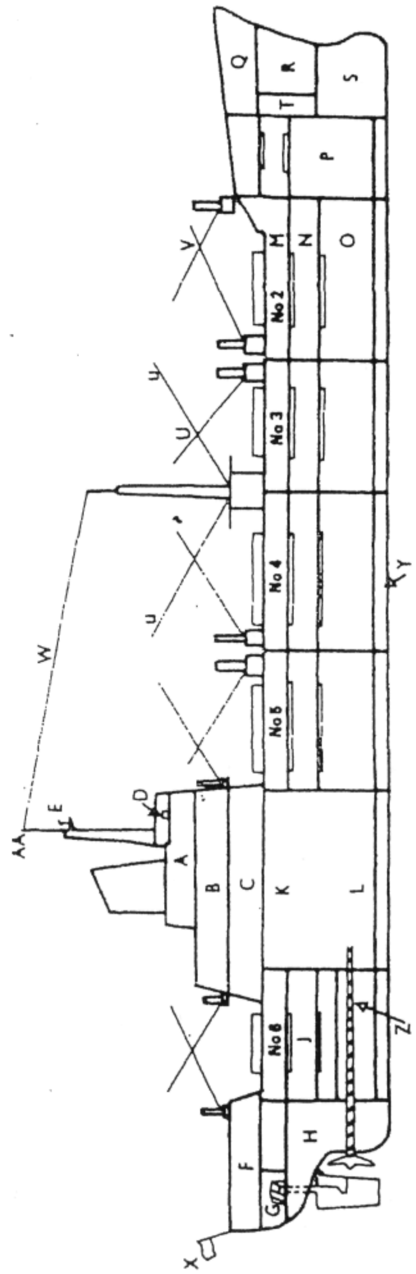


Fig 1.1 Internal structure of a general cargo ship.



GENERAL CARGO SHIP (longitudinal section)

AA Flag of country in (courtesy ensign) Company's house flag Signal flags and lights

- A Captain and passengers
- B Officer's accommodation
- C Crew accommodation
- D Wheelhouse and chart room
- E Radar scanner
- F Cargo space
- G Steering gear
- H Aft peak tank
- J Ref cargo
- K Refrig machy
- L Engine room
- M No 2 upper 'tween deck
- N No 2 lower 'tween deck
- O No 2 lower hold
- P Deep tank
- Q Store
- R Bosun's store
- S Fore peak tank
- T Chain locker
- U Derricks
- V Crane
- W Radio aerial
- X National flag
- Y Double bottom
- Z Propeller shaft

Fig 1.2 Longitudinal section of a general cargo ship.

capstan on very large ships. The cable drops down off the windlass into the chain locker. A few ships have stern anchors.

When considering an anchorage for a ship, the depth of water, the nature of the bottom and prevailing winds should be known.

On long salvage tows, the ship's anchor cable is often used as part of the towing line.

Ballast This is weight loaded to make the ship seaworthy when she has to go to sea without cargo. Originally this could have been anything -- and was often just sand and stones from the beach. However, modern ships use sea water in the double bottom tanks, peak tanks, and also specially constructed ballast tanks.

Bilges These are virtually ditches at each side of the hold where all the condensation, sweat and leaking liquids can drain and be pumped out. Before any loading, particularly of foodstuffs, the bilges must be cleaned out and inspected.

On some ships the double bottoms are carried out to the sides so there will be no bilges. When this occurs, a 'well' or drain is made in an isolated section in the double bottom which then serves the same purpose.

Bulkheads These are vertical partitions or walls, and all ships must have a specified number of bulkheads depending on their length. By dividing the ship into watertight divisions they reduce the danger of sinking if one compartment is holed. They also reduce the risk of fire spreading.

The for'd bulkhead, called the collision bulkhead, is made particularly strong as it has to withstand considerable buffeting if the ship steams to a repair yard having had her bows severely damaged in a collision. Had the *Titanic* hit the iceberg head-on instead of swerving and ripping a long gash down her side, she would almost certainly have made New York safely under her own power instead of being the most terrible maritime casualty of all time. One of the problems of Ro/Ro ferries has been the large undivided car deck spaces, which makes them very vulnerable to flooding and to the subsequent loss of stability. (Note the comments made later concerning 'slack tanks'.)

Decks The number of decks depends entirely on the trade and cargo for which the ship is designed. On some liner trades she may have three or four, and passenger ships may have many more. Ships designed to carry cars may have several portable decks. On the other hand, tramp vessels carrying bulk cargoes may only have one deck.

Deep tanks These are holds with facilities such as wash plates, pipelines and oil-tight hatches so that they can be used for the carriage of liquid cargoes or water ballast.

Derricks or cranes These are used on general cargo ships to lift the cargo on and off. They are usually capable of lifting between 5 and 10 tons, but the

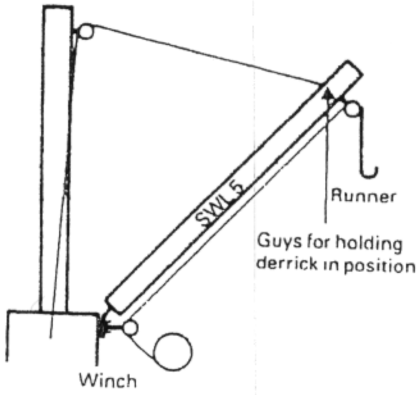


Fig 1.3 A derrick.

ship may be fitted with one or more heavy-lift derricks ('Jumbo') to cope with the heavier items of cargo. Derricks are usually used in pairs, with one being fixed over the hold and the other over the quay. The two runners are then joined together and the cargo lifted out of the hold by the ship derrick. It is moved over the ship's rail by slacking on the ship derrick and heaving on the over-side derrick, and the over-side derrick then lowers the cargo onto the quay. This is known as the *union purchase* method. This has the advantage of rugged simplicity and universal acceptance by stevedores. The shipboard crane is initially more expensive, but it requires fewer stevedores. It can pick up and put down the cargo over a much wider area (it has better 'spotting' facilities) and it is quicker.

Lifting-gear This is subject to the Merchant Shipping Notice number M 1347 concerning safety and it must be clearly marked with its *SWL* (safe working load). M 1347 gives information on 'The Merchant Shipping (Hatches and Lifting Plant) Regulations 1988', which came into force on 1 January 1989. These regulations form part of a package with the new Docks Regulations prepared by the Health and Safety Commission, and bring the UK into line with the ILO convention 152 concerning safety and health in dock work.

Double bottom tanks This is a double skin along the bottom of the ship. (From a ship safety point of view, these were not necessary in tankers with their smaller divided cargo spaces; however, from an environmental safety consideration, the American OPA 90 legislation is causing the new generation of tankers to have double skins.) Its purpose is to provide a safeguard in the event of grounding, which happens to about two ships a day. This space is used for water ballast, fresh water or bunkers.

Dunnage These are bits of wood, sacking, inflatable rubber bags – in fact, anything that is used to prevent damage to the cargo.

Flare This word means the outward curve on the bows. It gives two advantages: (1) it makes a larger fo'c's'le head; (2) it deflects the water when pitching into a seaway, and thus the vessel ships less water. This is very noticeable on container ships.

Hatchway This is the hole through which the cargo is loaded into the ship. Traditionally this hole has been a source of weakness in the structure, but modern technology has provided large steel hatchcovers that can slide back into place at the flick of a lever. Ships with these are allowed to load deeper than the older types covered only by the wooden boards and canvas (see Fig 1.4). There are many different types and designs of steel hatchcovers. The first seems to have appeared around 1937, and 1949 saw the introduction of the 'single pull' hatchcover which by 1955 had established itself as the standard hatchway for most new general cargo tonnage. The year 1952 saw the introduction of flush fitting hatchways in 'tween decks and in 1959 side rolling covers were introduced for bulk carriers.

Because of these developments the hatchway can be made much larger and this means the cargo can be dropped into position. If the hatchway is small, the cargo has to be carried or dragged into position at the sides of the ship. This takes time and costs money. It could be argued that the large 'open' hatchway is the basis of virtually all the major developments in improving ship productivity since the Second World War.

Some modern ships have large hydraulically operated doors in their sides through which fork-lift trucks can drive and stow the cargo directly.

Lock-up space Many breakbulk cargo ships have large rooms or lockers in some of the holds where valuable cargo can be locked up.

Peak tanks These are known as fore-peak and after-peak tanks, and are situated at the ends of the ship. They are usually used for ballast to 'trim' the ship -- ie to keep it level or at the angle required.

Reefer space Most liner ships have facilities for carrying refrigerated cargo.

Shaft tunnel If the propeller shaft has to pass through any holds, it has of course to be enclosed in a tunnel that must allow enough room for an engineer to walk along to inspect the shaft. This tunnel takes up considerable space in any hold, which is one argument for putting the engines right aft. Another is that it leaves the middle of the ship, with its large square holds, available for cargo. (Holds at the ends of the ship tend to be V-shaped.)

There were two traditional reasons for having engines amidships. It was essential when ships were fitted with paddle-wheels, and it also meant that vessels with the weight in the middle were on an even keel when completely empty, and thus the minimum of ballast was required. With modern ships, adequate ballast is seldom a problem, as sea water can easily be pumped in as needed.

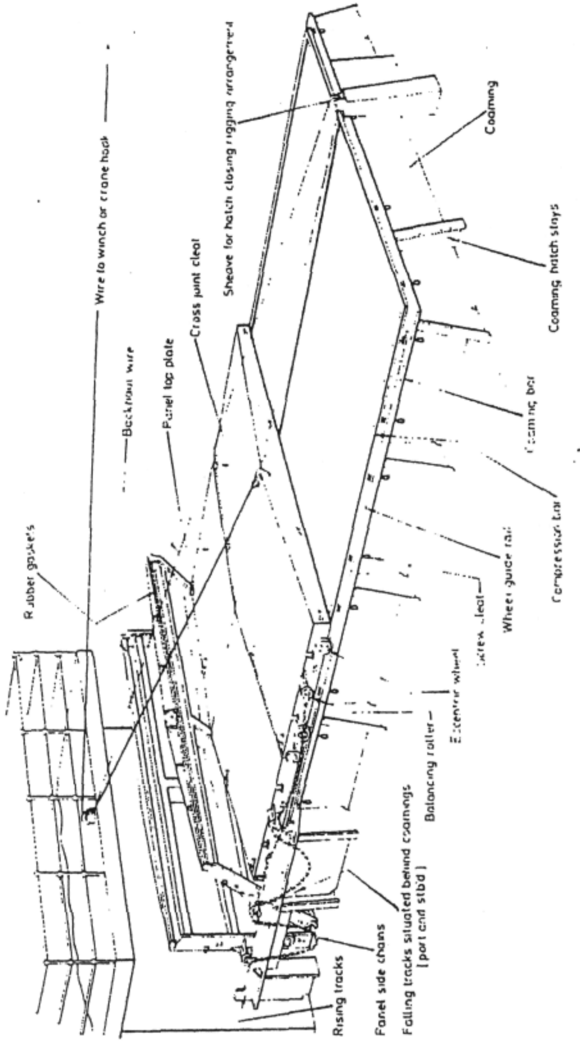


Fig 1.4 Hatchcovers.

Ship stresses and stability

Hogging and sagging

On long ships, such as very large tankers and bulk carriers, those responsible for loading the ship have to take care to avoid straining the vessel's hull. If too much weight is placed amidships, the vessel will sag (see Fig 1.5). As the vessel cannot submerge her loadline mark amidships, she will not be able to load her full cargo.

If excess weight is placed at the ends of the ship and not enough in the middle, the vessel may hog. If a vessel in such a condition were loaded with a full deadweight (dwt) cargo, her loadline marks amidships would indicate she could carry more cargo. In the 'bad old days' it is said that this was done deliberately.

With large modern vessels this distortion can be feet rather than inches, and apart from the obvious strain on the hull and the problems already mentioned, it may also increase the draft – which is often critical for large ships getting in and out of port.

Ships are fairly flexible structures and the bending may not do much permanent harm. If bent severely, however, the ship may become permanently distorted – which is obviously undesirable from many points of view.

To help ship's officers and those responsible for making the necessary calculations to avoid this bending, they must of course be supplied with the necessary information, gadgets and calculators. Any such longitudinal stresses will be aggravated by the vessel *pitching* when end-on to the waves.

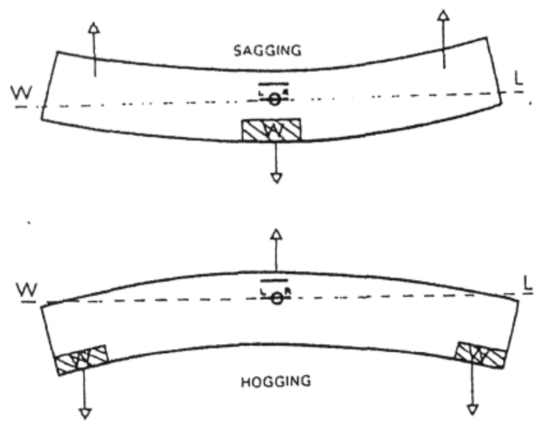


Fig 1.5 Sagging and hogging.

Stability

With smaller general cargo ships the problem of hogging and sagging is not so likely to be serious, but that of stability can well be.

Ship stability can be defined as the ability of the ship to return to the upright when slightly inclined, and instability can result from too much top weight – or, conversely, too little bottom weight. For the sake of argument, consider all the weight of the ship and cargo to act at a single point G (the centre of gravity) (see Fig 1.6) and the upward force of buoyancy to act at a single point B (the centre of buoyancy). Unless the cargo shifts, the point G will be fixed as the vessel rolls. The point B, on the other hand, will move out to the side as the vessel heels over. The point where the upward force of buoyancy cuts the centre line of the ship is known as M, the metacentre. M can be considered stationary for small angles of heel.

Without going into the mechanics of the situation, it can be seen that as long as M is above G, the vessel is stable, ie returns to the upright. Were the cargo loaded or bottom weight (such as bunkers) used so that G moves up above M, it can be seen that the ship becomes unstable. Should by chance G and M coincide, the vessel's stability is neutral and the ship just *lolls* over at any angle she is moved to.

The ship's GM, known as the *metacentric height*, is therefore a measure of the ship's stability.

The *completion* of loading of the ship with a safe GM is a prime consideration to the ship's officer and others responsible for stowing the cargo. With large modern container ships, the loading plan of which the stability is part will often form part of the terminal service.

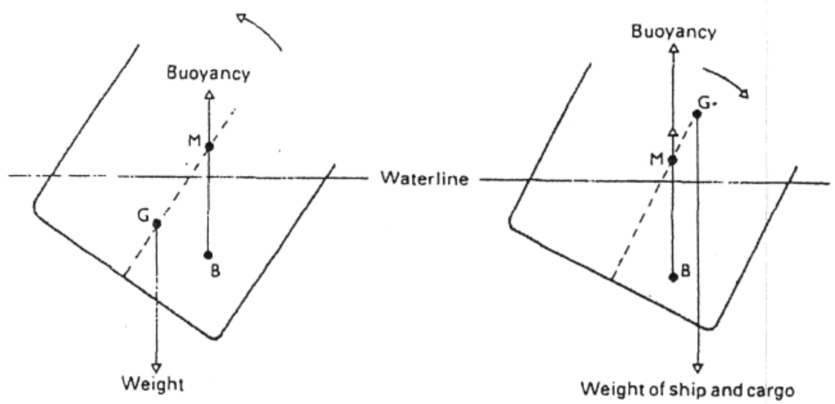


Fig 1.6 Stability of a ship.

An empirical formula connecting GM and the ship's period of roll T (T is the time it takes to roll from starboard to port and back to starboard again) is:

$$GM = (0.8\ \text{Beam}/T)^2 \text{ or } T = 0.8\ \text{Beam}/(GM)^{.5}$$

From this it can be seen that if GM is small, the period of roll becomes large and the vessel is said to be *tender*.

As GM becomes larger the period of roll becomes smaller, and the vessel is eventually said to be *stiff* – ie the period of roll becomes excessively fast.

With fast vicious rolling the cargo is more likely to shift, the ship to strain herself, and the crew to be extremely uncomfortable. (The 1986 IUMI Conference noted the dangers of deck cargoes of logs shifting if the GM was too large.) There is also a greater possibility of 'isonchronous' rolling – ie the ship's rolling getting into phase with the passing waves and resulting in increased rolling amplitude.

Example: Assume a vessel of 23 metres beam with a GM of .08 metres, 0.6 metres and 5 metres respectively:

$$T = (.08 \times 23)/(.08)^{.5} = 65 \text{ seconds}$$
$$T = (.08 \times 23)/(0.6)^{.5} = 23.8 \text{ seconds (about right)}$$
$$T = (.08 \times 23)/(5)^{.5} = 8.2 \text{ seconds (too fast)}$$

It can be seen that in this case a GM of about 0.6 metres would be a good level of stability to aim for when loading the cargo, as 65 seconds would indicate that the vessel is verging on instability, and at 8.5 seconds the 'accelerations' would be dangerous.

To reduce the amplitude of rolling there are various expensive devices, such as fins, that can be projected out of the side of the ship under water. They are automatically tilted as the sea tries to push the vessel over and thus the vessel remains upright. Another method is to use liquid in tanks and cause it to flow quickly from one side of the ship to the other, thus cancelling out the tendency to roll caused by the sea.

Another danger to stability is 'slack tanks' – in other words, if liquids are allowed to surge from side to side across the vessel while it is rolling. This causes a virtual rise of G with a consequent reduction in stability. In tanks designed to take liquids, wash plates and bulkheads are constructed to reduce this hazard, but it can be overlooked at such times (eg in firefighting) when water is free to move across the decks.

Should G move off the centre line of the ship due to an excess weight on one side of the ship, the ship is said to *list* (as opposed to *heeling* and *lolling*).

Markings on the ship

The name

This is marked clearly on each bow and across the stern.

Draft marks

These are printed on each side of the bow and stern, and sometimes also amidships. The draft marks are each 10 centimetres high with a gap of 10 centimetres between each mark – ie draft is shown in decimetres for ships registered after January 1974. Marks should be clearly painted using lines 2 centimetres thick. All measurements are taken from the top edge of the load line marks, but the bottom edge of the draft marks (see Fig 1.7).

$$\text{Draft(in metres)} = (\text{dwt}/1,000)^{.5} + 5$$

Load line marks

T Tropical

S Summer

W Winter

F Fresh water mark

TF Tropical fresh water mark

FWA Fresh water allowance (this is simply the difference between the summer and fresh water marks)

LR Lloyd's Register, or the abbreviation for the Society that the vessel is classed with.

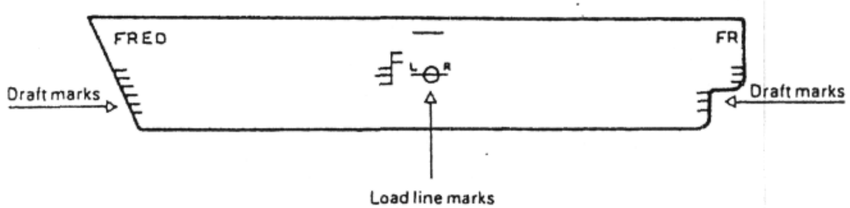


Fig 1.7 Markings on the ship.

Notes on markings

- The summer freeboard and the FWA are not marked as such on the vessel, but are shown in Fig 1.8 to clarify this point.
- As can be seen from Fig 1.8, the freeboard is the distance between the uppermost continuous deck, marked by the deck line, and the waterline. The larger it is, the more reserve buoyancy the vessel has and the less chance there is of waves breaking over the deck.
- The load line marks show the minimum freeboard allowed in certain seasonal areas, ie in a winter zone the vessel has to have a larger freeboard to enable her to cope with the worst weather that can be expected. A chart showing where and when these zones are to be observed is published by the Admiralty.
- There is also a mark and zone for winter North Atlantic (WNA), which must be marked on and used by ships up to and including 100 metres in length.
- The fresh water allowance is for use when the vessel is loading in fresh water, which has not the same buoyancy as sea water (assumed to have a density of 1,025 oz per ft^3). So, if loaded down to F in fresh water, the vessel would rise to S by the time it reaches the open sea. The person responsible for loading the vessel therefore must know the density of the water at the loading berth.
- If the vessel has a TPC of 60 tons and uses 30 tons of fuel and water a day, then it will reduce its draft by half a centimetre a day. (TPC = tons per centimetre, ie the number of tons required to sink the vessel 1 centimetre.)

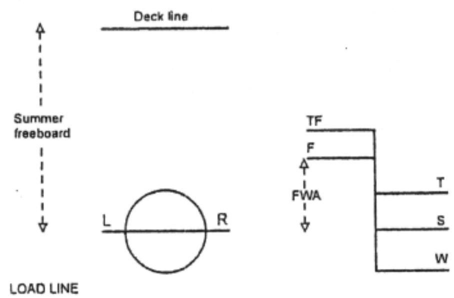


Fig 1.8 Calculating loaded draft.

Although load lines were used by the Italian Republics right back in the Middle Ages, the first record of an assigned freeboard in England is an entry in Lloyd's Register in 1774.

In about 1835, the Committee of Lloyd's proposed that a freeboard of 3 inches per foot depth of hold should be used for safe loading, and this was known as *Lloyd's Rule*.

Samuel Plimsoll brought in legislation concerning freeboard in 1876, but his rules had many loopholes and it was not until 1890 that the Load Line Act came into force. This made it compulsory for sea-going ships to be marked with a load line in a manner decided by the Department of Trade. However, such legislation was not universal, and American ships did not have obligatory load lines until 1917. The 1930 International Load Line Conference instigated an internationally accepted method for calculating load lines.

The latest International Load Line Conference was held in London in March 1966 and the substance of this conference came into being in the UK when the Merchant Shipping (Load Line) Rules 1968 came into force on 21 July of that year.

Tonnage

This word derives from the fact that a 'tun' was a barrel that held 252 gallons of wine – hence 'ton' in shipping can denote both weight and capacity. We can break down 'tonnage' into 'ship tons' and 'cargo tons' (Fig 1.9).

Ship tons

- *Loaded displacement tonnage* is the actual weight of the ship and cargo.
- *Light displacement tonnage* is the actual weight of the ship. The difference between the loaded *displacement* and the light *displacement* is the weight that the ship can actually carry and is known as the *deadweight* (dwt) tonnage.
- *Gross tonnage (GT)* is, very simply, a measure of the total enclosed volume of the ship in cubic metres multiplied by a constant.
- *Net tonnage (NT)* (or register tonnage) is the total enclosed volume available for cargo in cubic metres multiplied by a constant.

Displacement tonnage has little or no commercial use, and the size of tankers is usually expressed in dwt tonnage – ie a 250,000 ton dwt tanker means it can carry 250,000 tons of oil, bunkers and stores at its summer draft. It is more convenient when transporting liquids to charge for the ton weight carried – not only because it is a relatively heavy cargo, but the

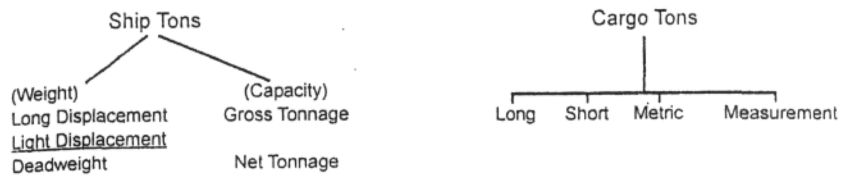


Fig 1.9 Ship tonnage.

volume of 250,000 tons of oil can appreciably change with, say, a 10° variation in temperature.

Most general cargo ships, though, are usually full before they are down to their marks, so a shipowner is usually concerned with selling space and he is more interested in the volume of his ship rather than the weight it can carry. Hence one always talks of a cargo ship of, for example, 9,000 gross tonnage (9,000 GT).

Until the introduction of the Universal Tonnage (UT) measurement in 1982, the whole question of GT and NT had been a complicated one from the point of view of a precise definition because port dues, canal dues and various government dues are often levied on these measurement tonnages. So shipowners, who were naturally anxious to keep the dues they paid down to a minimum, instructed their naval architects to study the rules carefully so as to build a ship of a certain capacity with the smallest GT possible.

In order to encourage safety, governments would offer various exempted spaces as an inducement to good building practices – ie the double bottom was exempted from GT if it was used only for water ballast. Therefore, by this time the precise definitions of measurement tonnage had become long, detailed and fairly complex.

To add to this seeming confusion, different countries had developed different rules for making these measurements. Prior to 1982 there were about five basic systems in use – ie British, American, most other maritime nations, the Suez Canal Authority and the Panama Canal Authority. However, up until 18 July 1994, ships built before 1982 were allowed to retain their original GRT (gross registered tonnage) and NRT (net registered tonnage) if the owners so wished.

It is generally believed that the Chinese were the first people to see the potential of levying tax on ship tonnage, but that Henry V was the first Englishman to think of it. Throughout the ages, there have been many variations as to how tonnage might be estimated. Often the term 'Tons Burthen' is used, which can be considered a crude estimate for dwt. The following are some significant dates in relation to tonnage:

- **In 1694, the Thames Tonnage Measurement was first used.**

- In 1849, a Royal Commission originated the basic concept that assessment of dues should be based on the vessel's potential earning capacity. This was known as the 'Moorsom system' after the secretary of the Commission, George Moorsom. This came into force in 1854.
- In 1873, an International Tonnage Commission was held at Constantinople. However, its findings were only followed by the authorities of the newly opened Suez Canal.
- In 1930, the League of Nations tried to get universal agreement on tonnage. The principles proposed were not followed by either the British or Americans, though they were adopted by most other countries.
- In 1967, the Merchant Shipping (Tonnage) Regulations were passed.
- In 1969, the UN Agency, the *IMO* (the *International Maritime Organisation*), held an International Convention on Tonnage Measurement of ships. This convention at long last brought in a universally accepted system of GT and NT on 18 July 1982.
- As these tonnages are independent of the nationality of the ship, they no longer need to be linked to the registration of the ship, so their official title is gross tonnage (GT) instead of gross registered tonnage (GRT). Likewise, since 1982 *net tonnage* is abbreviated to NT instead of NRT (net registered tonnage).
- When initially measured, ships are issued with an *International Tonnage Certificate* (1969).

Tonnage definitions and abbreviations

$GT = K_1\ V$ where V is the total volume of all enclosed spaces in cubic metres

$K_1 = 0.2 + .02 \log_{10}\ V$

$NT = K_2\ V_c(4/3 \times d/D)^2$ where V_c = volume of cargo spaces in cubic metres

d = Summer draft of the ship

D = Depth of the ship

$K_2 = 0.2 + .02 \log_{10}\ V_c$

- The smaller d is in relation to D, then the smaller the NT will be. This allows a similar benefit to the shipowner as the now out-of-date tonnage marks and shelter deck ships did in their era, in that a shipowner knowing that he is going to carry light bulky cargo could declare a small d (draft). NT can only be changed once a year.
- The purpose of the multipliers K_1 and K_2 is to ensure that the new tonnages are similar numerically to the previous tonnages, though some ship types, such as Ro/Ros, have found their measurement tonnages increased.
- For passenger ships the formula for NT becomes more complex.
- Phrases such as tonnage deck, exempted space, alternative tonnage, modified tonnage or tonnage mark no longer apply under these rules.

There is no direct mathematical relationship between these tonnages, whereby with the aid of multipliers you can convert one to the other. However, Appendix A does contain some empirical conversion formulae arrived at by statistical analysis. These will give approximate solutions for typical ships. For example:

The relationship between NT, GT and dwt for a typical traditional cargo ship is such that if NT were one unit, its GT might be 1.5 units and the dwt 2–2.5 units. We need to note, though, that with different ship types and sizes these relationships vary. Some examples are given in Table 1.2.

Although GT and NT are measures of capacity, those actually concerned with shipping space prefer to use the *grain space* and *bale space* figure (see Fig 1.1) as these give the actual volumes available for cargo.

- *Grain space* is the space available for a liquid-type cargo such as bulk grain which can flow into every corner.
- *Bale space* is the space available for solid cargo. Bale space is usually about 7–10 per cent less than grain space.

Paragraph ships Various government regulations concerning manning, safety appliances etc are determined by the vessel's tonnage; ie a vessel of 499 GT may be a lot cheaper to run than one of 501 GT.

Ships built to take advantage of such limits are known as *paragraph ships*. They are usually of the small coasting or short sea trade variety, but *Aframax* tankers could also be considered a type of paragraph vessel.

British tonnage measurement before 1982 Although this is now largely a matter of history, this system does illustrate the inventive nature of shipowners and designers in their constant attempt to find 'loopholes' in the system and the administrations' endeavours to maintain safety and raise taxes and revenue.

Gross registered tonnage (GRT) was the total internal capacity below the uppermost continuous deck (the 'tonnage' deck for most ships), plus all permanent enclosed spaces above this deck, less exempted spaces. Examples of exempted spaces were double bottom tanks if used only for water ballast, and crew ablution rooms above the upper deck.

Net registered tonnage (NRT) was the GT less deducted spaces. Examples of deducted spaces were machinery spaces, crew accommodation, chart room, radio room, etc.

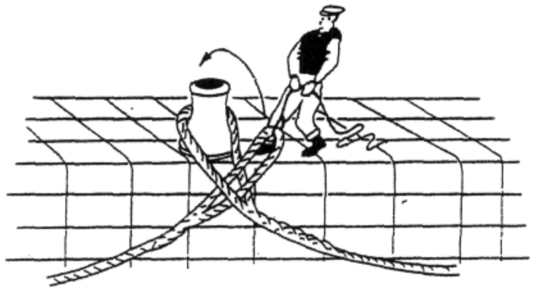
SEA TRANSPORT CHAPTER 1

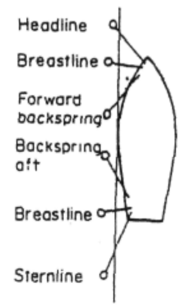
QUESTIONS

1. What is a liner?
2. What is a tramp?
3. How can we categorize ships?
4. What are the constraints that bind naval architects when designing ships?
5. What is the expected working life of a ship?
6. What does a shipowner need so as to convince an insurance underwriter that his ship is seaworthy?
7. Name some of the Classification Societies that you know.
8. What must a shipowner do to obtain Lloyd's class of ✠ 100 A1 for his vessel?
9. How can a vessel maintain class?
10. How many anchors are there and where are they on a ship?
11. What is the name of the special winch that raises and lowers anchors?
12. What are the Greek words for 'chain locker', 'bilge' and 'peak tanks'?
13. What are bulkheads?
14. What are the facilities deep tanks have which can be used for the carriage of liquid cargoes or water ballast?
15. What is the use of derricks and cranes?
16. What is the purpose and use of double bottom tanks?
17. What is 'dunnage'?
18. What is 'flare'?
19. What is 'hatchway'?
20. What is a 'shaft tunnel'?
21. What is 'hogging'?
22. What is 'sagging'?
23. What is 'stability'?
24. When does a ship become unstable?
25. When is a vessel said to be tender?
26. When is a vessel said to be stiff?
27. What is 'isonchronous rolling'?
28. What are 'slack tanks'?
29. How is the instability problem caused by slack tanks reduced?
30. Which are the markings on a ship?
31. What do the initials T/ S/ W /F /TF /FWA /LR stand for?
32. What is 'Freeboard'?
33. What do loadline marks show?
34. When is 'fresh water allowance' used?
35. What does TPC stand for? Explain what it is.
36. What is 'loaded displacement tonnage'?
37. What is 'light displacement tonnage'?
38. What is 'deadweight tonnage'?
39. When is the double bottom exempted from gross tonnage?
40. What do the initials GT/ GRT/ NT/ NRT/ D/ stand for?
41. What is 'grain space'?
42. What is 'bale space'?
43. What is a measurement ton?

ead this passage and do the exercises as you come to them.

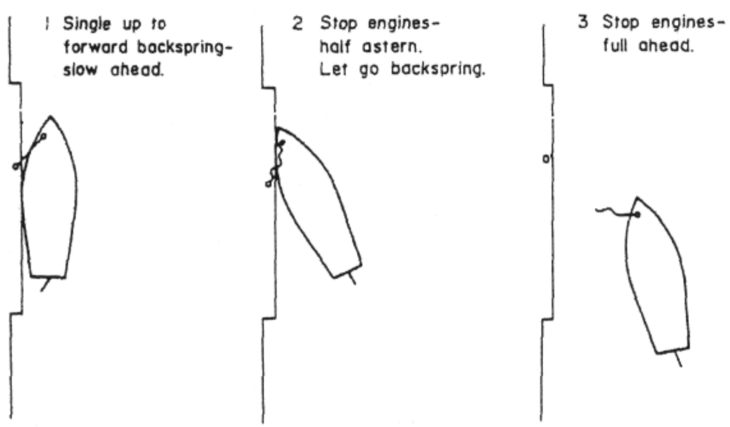
A ship is made fast to the quayside by mooring lines. The standard mooring lines are shown below. They consist of a headline, a breastline and a backspring forward, a stern line, a breastline and a backspring aft. Any of these lines may be doubled. Each line has a large eye spliced in the end. The eye is placed over a bollard on the quayside. If there is another line already on the bollard, the eye of the second line should be taken up through the eye of the first line before placing it over the bollard. This makes it possible for either line to be let go first.





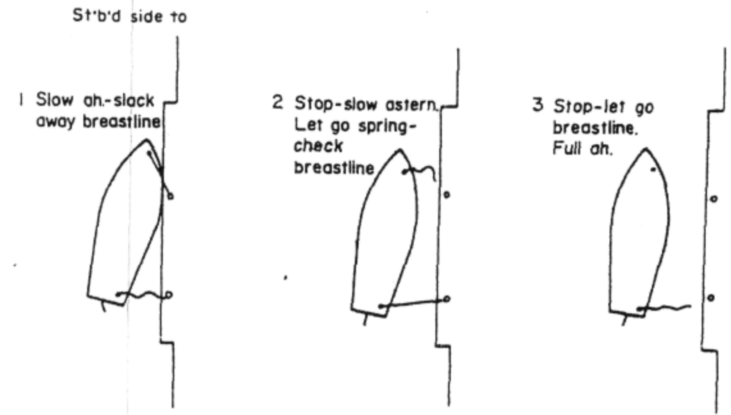
Putting eye on bollard

Leaving berth port side to (*no wind or tide*). Single up to a backspring forward and put engines to slow ahead. Put rudder hard to port (1). This cants the stern out away from the berth (2). When about 30° out, stop engines and put rudder amidships and engines half astern. Let go the backspring as the vessel moves astern off the berth (3). The effect of the transverse thrust is to take the stern to port and the bows will swing to starboard clear of the berth. Stop engines and then go full ahead.



Leaving berth (port side to)

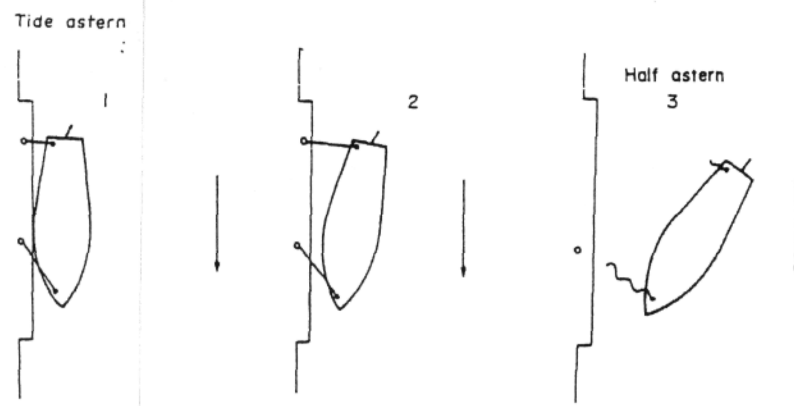
leaving a berth, starboard side to, with no wind or tide.



Leaving berth (starboard side to)

Leaving berth starboard side to (*no wind or tide*). Single up to a .... forward and a .... aft. Put the engines to .... and the rudder hard to .... (1). Slack away on the .... until the stern is clear of the berth (2). Stop engines, then go ...., put the rudder .... Let go the .... and check on the .... The action of the .... is to prevent transverse thrust taking the stern to .... and consequently forcing the bows onto the quayside. When all is clear .... engines and let go the ....(3). Then put engines ....

Complete the description using only the diagram to help you.



Leaving berth tide astern

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