"ENGLAND'S PRIDE—
THE CARGO-BOATS"

BY

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The Liner she's a Lady, and if a war should come,
The Man-o'-War's 'er 'usband, and 'e'd bid 'er stay at home ;
But, oh, the little Cargo-Boats that fill with every tide !
'E'd 'ave to up and fight for them for they are England's Pride.
Rudyard Kipling (1865-1936)

At the end of a recent appointment overseas the Author had the good fortune to travel home in a typical cargo ship, the S.S. *Livorno*, of Ellerman's Wilson Line Ltd., Hull. An article in the *Journal* of April, 1951, described the training of Merchant Service engineer officers, and it is thought that these short notes, based on one small ship, may also be of interest.

Ship Owners and Shipping Agents

As far as possible all repairs and dockings of merchant ships are carried out in home ports, and wherever convenient at the home port, where it can be supervised by the owners. It is usual for them to appoint superintendents to supervise the deck organization, the engine room, the cargo and the catering sides; where necessary there will also be a passenger superintendent. These officials are generally appointed from senior seagoing officers of the company and these jobs therefore represent the highest step in promotion, which the firm can offer.

The superintendents and their assistants deal with all aspects of their ships, in exactly the same way as the Admiralty controls the Navy, and their aim is to keep the ships in service as continuously as possible, with the minimum of repairs and delays, and with full cargoes.

When a shipper requires shipping space in which to send merchandise to one of his overseas customers, he may approach the ship owners direct, if they happen to be near to his factory, but as a rule he will deal with a shipping agent. The duty of these agents is to represent the owners in all respects in ports at home or overseas, other than those in which the owners have their own offices.

Acknowledgements

The Author gratefully acknowledges the ready help and advice given by the Master and Officers of S.S. *Livorno* in the compilation of these notes.

Reference was also made to :—

Know Your Own Ship, by Thomas Walton (Charles Griffin & Co. Ltd., London, 1927);

and to a number of makers' handbooks and instruction books.

hands being available for daywork. The seamen work in three watches, three to each watch—one on the wheel (in 1 or 2 hour stretches) and two available if required ; thus there are normally only one officer and the helmsman on watch on the bridge at sea, unless the Master is present.

Apart from watchkeeping, the mates are responsible for the loading and discharging of cargo, though most of this devolves on the Chief Officer. He is also responsible for all painting, anchors and cables, overtime pay, organization of the crew, and so on. The second mate is usually the ship's navigating officer and looks after the logs, voyage reports, and pay accounts, including P.A.Y.E. The third mate is responsible for the lifeboats, life-saving and fire-fighting gear. The 2nd and 3rd mates also assist the Mate with the loading and other ship's duties, as required.

The Second Engineer organizes the engine-room department in exactly the same way as the Senior Engineer of a warship. He and the junior engineers are the only skilled men available and do all maintenance and repair work when away from home ports ; in emergency, the Chief Engineer may also help, but this is entirely up to him. No workshop facilities are available in most merchant ships and hence all repair jobs have to be done by ship repair men at the major ports. In some ports the ship's engineers are not allowed to do any work while shore repair men are on board.

The Radio Officer keeps no watches in harbour, but at sea works two hours on and two hours off from 0800 to 2200 G.M.T. In large passenger ships, and in all ships in wartime, continuous watches are kept by three or more radio officers. Most shipping companies hire their radio officers and equipment from one of the big firms, for example, the Marconi International Marine Communication Co. Ltd., London, though a few large companies are entirely independent.

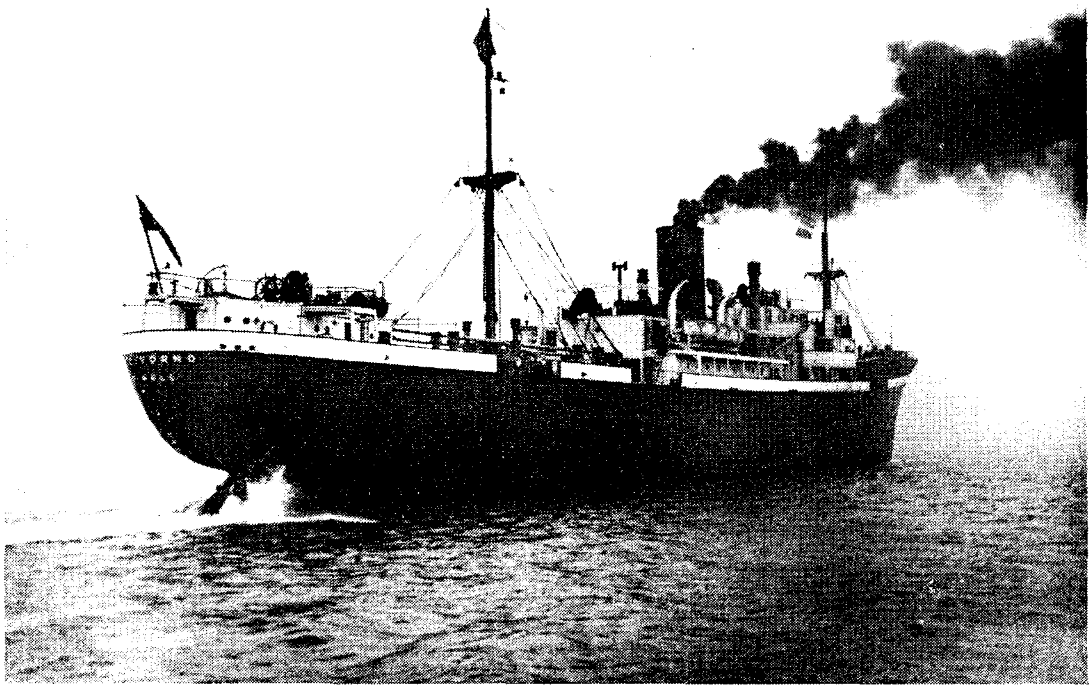
Most shipping lines hire their deck and engineer officers on a two-year contract, usually with the option of renewal, and this ensures that they receive pay continuously, whether employed or not. No overtime is payable to officers working on this basis. The Chief Steward may be retained on the same conditions.

The deck and engine-room hands are signed on at the beginning of the voyage and signed off at the final port of discharge in the United Kingdom ; if the latter is different from the port of origin of the crew, they are eligible for travelling expenses. In harbour and on daywork all ratings work on the basis of an eight-hours day for five days, five hours on Saturday. At sea, eight hours watchkeeping per day is allowed seven days a week, but only such jobs as washing paintwork may be done by watchkeepers. All other work above this is classed as overtime and paid accordingly, and is one of the headaches of the Mate at the end of the voyage.

It is laid down by law that every member of the crew, including the Master, must sign on for each voyage, and pay, taxes and allotments are worked out accordingly. This is quite independent of any contracts made with the Owners.

Officers are usually allowed to keep their wives on board when in port, and in some lines certain officers may keep them on board all the time.

As in so many jobs ashore, the standard of men signing on nowadays as crew-men in merchant ships is very poor, particularly in cargo ships. This situation is aggravated because the merchant service is allowed as an alternative to doing national service in one of the armed forces, provided that the men remain at sea until they are twenty-seven. Although this means going to sea from seven to nine years, many men appear to prefer it to national service, but few take it up as a career, and as a result very few show any real interest in the job, except as a means of earning pocket money.



S.S. 'LIVORNO'

THE SHIP

Specification

(*a*) *General.* Official Number 181285. Registered at Hull in 1946.
International Code Letters and Call Sign—G.P.W.F.
Gross Tonnage 2,957 tons. Nett Register tonnage 1,464 tons.
Length Overall 355 ft. 6½ ins. Length B.P. 335 ft.
Beam 50 ft. Depth 23 ft.
Sheers—Aft 4 ft ; Amidships nil ; Forward 8 ft.
Summer Draught 22 ft 1 in. giving a freeboard of 1 ft 1½ in.
Winter Draught 21 ft 7½ in.
Light Draught 8 ft 11 in.
Loaded Deadweight—Summer 4,560 tons ; Winter 4,391 tons.
Light Displacement—2,469 tons. T.P.I. Immersion 30·99 tons/in.
Loaded Displacement—Summer 7,029 tons ; Winter 6,850 tons.
Built by William Grey and Co. Ltd., West Hartlepool.

(*b*) *Machinery.* Two Scottish Marine Boilers, 4-furnaces, oil-fired, 35¼ tons each. Steam Pressure 225 lb/sq in. W.P., 600° F. S/H.

One 3-Cylinder Triple Expansion Engine (23 in × 38 in × 65 in diam. ; 48 in Stroke) driving a single right-handed propeller (16 ft 6 in diam : 16 ft Pitch ; weighing 8½ tons).

Horse Powers at full speed—b.h.p. 2,340 ; i.h.p. 2,600 ; Nominal h.p. 619 (for registration purposes).

Nominal Speed of Ship 12½ knots at 80 r.p.m.

Three Electric Generators—50, 22·5 and 15 kW. at 110 volts D.C.

Engines by the Central Marine Engine Works (Wm. Grey & Co. Ltd.), West Hartlepool (*c*) *Cargo Spaces and Handling Equipment*

Five Holds with Shelter 'Tween Deck Spaces above.

	Capacity			*Capacity*			
Holds	*Gross cu ft*	*Nett cu ft*	*'Tween Decks*	*Gross cu ft*	*Nett cu ft*	*Hatch Sizes*	*Derricks*
No. 1	24090	21452	No. 1	21037	20246	22′ 3″ × 16′ 0″	2,7 Ton
No. 2	53003	49419	No. 2	27841	26007	32′ 6″ × 18′ 0″	2, 10; 1, 25T.
No. 3	28942	27116	No. 3	21423	20665	20′ 0″ × 14′ 6″	2, 5 Ton
No. 4	40501	37393	No. 4	22711	20115	27′ 6″ × 16′ 0″	2, 7 Ton
No. 5	24005	21428	No. 5	14668	13611	20′ 0″ × 16′ 0″	2, 7 Ton
Totals	170541	156808	*Totals*	107680	100644		
			Tonnage Well ..	1618	1520		
			Fo'c's'le T.D. ..	2425	1985		
			Casings 3/4 ..	8129	7473		
			Totals ..	119852	111622		

Grand Totals:—290,393 cu ft Gross (Grain Cargo)
268,540 cu ft Nett (Bale Cargo)

The gross capacity includes the space between the ship's frames.

Each derrick, except the 25-ton, has its own steam winch.

Each hold is provided with $\frac{3}{4}$-h.p. propeller type supply and exhaust fans for use when carrying a fruit cargo.

The forepeak tank (capacity 54 tons) and afterpeak tank (23 tons) are provided with heating coils and a special pump in the engine room to enable edible oils to be carried.

(*d*) *Crew and Passengers*

Officers :—	Master ; Mate, 2nd and 3rd Mate ; 2 Apprentices. Chief Engineer, 2nd, 3rd and 4th Engineers Radio Officer	11
Petty Officers :—	Boatswain ; Carpenter. Donkeyman. Chief Steward	4
Men :—	9 Seamen. 1 Donkeyman/greaser ; 1 Greaser ; 4 Firemen (inc. Dayman) & 2 Stewards ; 1 Pantry Boy ; 2 Cooks	20
Passengers :—	1 Single and 1 Double Cabin	3
	Total (inc. Passengers)	38

(*e*) *Lifeboats*

Two 30 ft × 9 ft 6 in × 4 ft lifeboats of capacities 64 and 67 persons respectively. No. 1 lifeboat is driven by a Morris petrol engine. No. 2 is provided with oars only.

Plan of the Cargo Shipped on board the Vessel "LIVORNO"
at ANTWERP AND LONDON. for PATRAS, PIRAEUS, SALONIKA, IZMIR, AND ISTANBUL. 4TH JULY 1953
ELLERMAN'S WILSON LINE, LIMITED, Owners

PORT	Nº 1		Nº 2		Nº 3		Nº 4		Nº 5		DECK	TOTAL
	T. D.	HOLD	T. D.	HOLD	T. D.	HOLD	T. D.	HOLD	T. D.	HOLD		
PATRAS	—	—	1	—	—	—	136	—	11	—	1	149
PIRAEUS	10	47	122	53½	2	—	12	70½	153	—	2	472
SALONIKA	¼	3	1	—	28	20	83½	—	—	6	—	141
IZMIR	123½	—	4½	—	12	—	—	—	—	—	—	140
ISTANBUL	11	167	47	615	86	331	—	548	11	117	—	1933
	144	217	175½	668½	128	351	231½	618½	175	123	3	2835
	361		844		479		850		298		3	2835

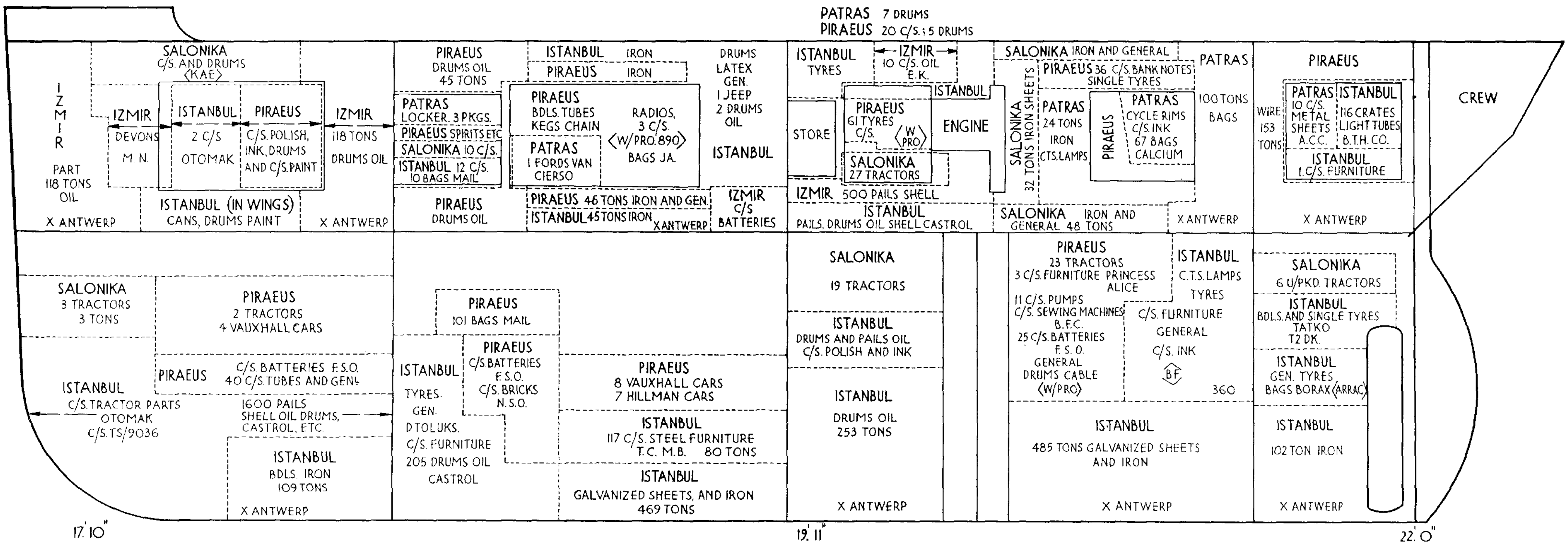


FIG. 3—THE FAIR CARGO PLAN

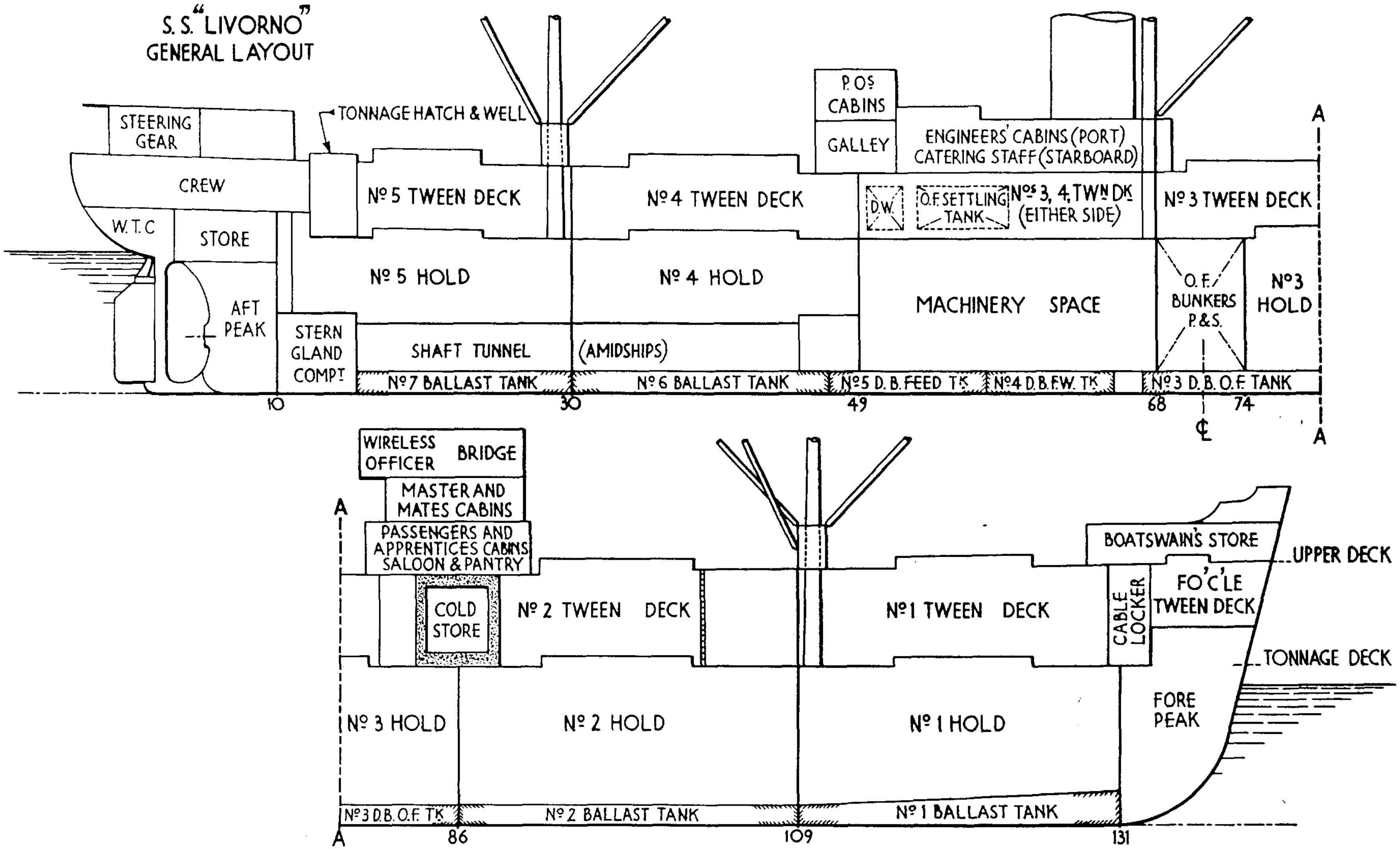

S. S. "LIVORNO"
GENERAL LAYOUT
STEERING GEAR
TONNAGE HATCH & WELL
CREW
W.T.C
STORE
AFT PEAK
STERN GLAND COMPT
Nº 5 TWEEN DECK
Nº 5 HOLD
SHAFT TUNNEL
Nº 7 BALLAST TANK
Nº 4 TWEEN DECK
Nº 4 HOLD
(AMIDSHIPS)
Nº 6 BALLAST TANK
P. O's CABINS
GALLEY
ENGINEERS' CABINS (PORT)
CATERING STAFF (STARBOARD)
D.W.
O.F. SETTLING TANK
Nºs 3, 4, TWN DK (EITHER SIDE)
MACHINERY SPACE
Nº 5 D. B. FEED TK
Nº 4 D. B. F.W. TK
Nº 3 TWEEN DECK
O. F. BUNKERS P. & S.
Nº 3 HOLD
Nº 3 D. B. O. F. TANK
A
10
30
49
68
74
℄
A
WIRELESS OFFICER
BRIDGE
MASTER AND MATES CABINS
PASSENGERS AND APPRENTICES CABINS SALOON & PANTRY
A
COLD STORE
Nº 2 TWEEN DECK
Nº 1 TWEEN DECK
BOATSWAIN'S STORE
UPPER DECK
CABLE LOCKER
FO'C'LE TWEEN DECK
TONNAGE DECK
Nº 3 HOLD
Nº 2 HOLD
Nº 1 HOLD
FORE PEAK
Nº 3 D.B. O.F. TK
Nº 2 BALLAST TANK
Nº 1 BALLAST TANK
A
86
109
131

Fig. 1

(*f*) *Navigational Equipment*

Standard Magnetic Compass (dry card). Helmsman's Magnetic Compass (spirit-filled). Echo Sounder. (Marconi Sounding Device Co.).

(*g*) *Radio Equipment*

One Main Transmitter. Approx. 300 Watts. 110 v. D.C. or 24 v. Battery.

One Battery-operated Receiver, 24 v.

One Emergency Receiver.

One Radio Direction Finder.

All the above equipment by the Marconi International Marine Communication Co. Ltd., London.

New regulations, which will shortly come into force require an additional emergency transmitter and an additional receiver. One Lifeboat Transmitter, approx. 20-30 Watt (Nominal 50 Watt). One lifeboat Receiver. Both these units are made by the Rees Mace Manufacturing Co., London. Both units will float without the batteries and are intended to be thrown overboard when abandoning ship. The batteries should be stowed in the lifeboats.

The Tonnage of Merchant Ships

Many different figures are used in referring to the 'tonnage' of a merchant ship and those usually quoted give little or no idea of the actual size of the vessel. Tonnage is one of the most confusing subjects associated with merchant ships, but an attempt will be made to give a brief explanation.

In warships, only the displacement tonnage is used for different conditions of loading fuel, water, stores and ammunition. When loading a merchantman, the ship's officers are concerned only with the displacement tonnage, as on this and on the relative positions of the various loads carried, the stability, trim and safety depend.

However, for purposes of insurance and harbour dues, it is not found possible to use displacement tonnage, as the displacement depends on the type of cargo and on its volume. It has, therefore, '. . . been a traditional usage of all maritime countries to submit merchant vessels to a measurement, the result whereof known under the general name of " tonnage ", serves as the basis of the taxation to which a ship is, or can be made, liable everywhere and under any circumstances.' This quotation is from the report of the International Tonnage Commission, held in Constantinople in 1873. Under this agreement it became the duty of every country participating to prepare a ' Certificate of Registry ' for each new ship. Every ship over 15 tons in weight must be registered, and certain conditions must be fulfilled before registration is allowed. A Register Book is kept by the Chief Officer of Customs in each port of any size and the owner may register his vessels at any port where such a book is held. Before a ship can be registered it must be surveyed by a Board of Trade surveyor, who issues to the Registrar of Shipping a certificate specifying the ship's tonnage, build and other particulars peculiar to the ship. It is also compulsory for the name of the ship to be clearly marked on each bow and the name and port of registry to be painted on the stern.

The register tonnage is that used by international agreement as a basis for all dues levied on the ship. There are, however, three main exceptions to this : Sweden, and the Panama and Suez Canals, which each issue their own tonnage certificates. In general, these differ only slightly from the register tonnage.

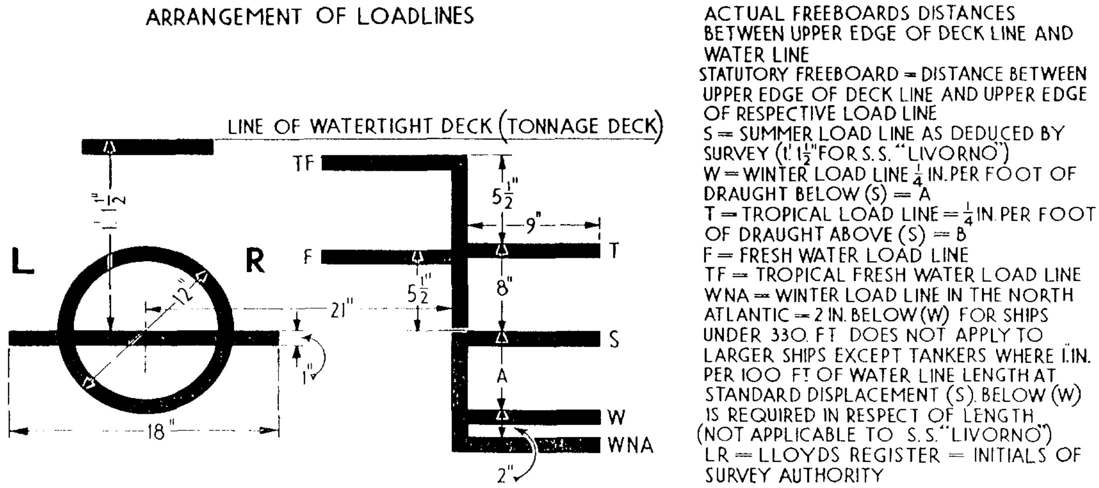


FIG. 2

The register tonnage gives no idea of the size of the ship, nor does it enable a comparison to be made between different ships. The basis on which register tonnage is calculated is the internal volume of all cargo and freight-earning spaces. While it might be less confusing to speak in terms of volume, it has become the universal practice to use ‘ volumetric tons ’ and one volumetric ton = 100 cu ft of cargo space. Thus a ship of 1,000 register tons has a nominal cargo-carrying capacity of 100,000 cu ft. The register tonnage is derived from the gross tonnage, after various deductions have been made to allow for machinery spaces, crew's accommodation, etc. The method is by no means perfect, but a better, which will also satisfy the strict needs of the law, has yet to be found.

The gross tonnage includes the cubic capacity of the spaces below the ‘ tonnage deck ’ : the holds, the 'tween deck spaces above the tonnage deck (but see below), the accommodation, the store-rooms. However, machinery spaces on the upper deck, capstan, steering gear or donkey boiler deck houses, are exempted from inclusion in the gross tonnage, as are the volume between the frames and ship's side, the double-bottom spaces, the wheel-house, the galley, the lavatories, and certain other non-watertight spaces. Where the 'tween deck spaces are not completely watertight, they may be exempted from inclusion and various ingenious methods are employed to retain this exemption, while making the 'tween deck spaces as useful for cargo-carrying as possible. The usual method is to provide what is known as a ‘ tonnage hatch ’, which is non-watertight, at the after end of the ship, and the 'tween deck spaces are all nominally inter-connecting, though it is usual to keep the openings in the main transverse bulkheads closed and watertight while the ship is in service. When this exemption is claimed, the cargo in the 'tween deck spaces is subject to a customs levy.

Certain spaces are included in the gross tonnage, but can be claimed as deductions for the purpose of the nett register tonnage. These are the main and auxiliary machinery spaces, if not already claimed as exemptions, the crew's accommodation, the master's accommodation, the boatswain's store, the chart room, and ballast spaces, other than double-bottoms.

Various modifications to the above are required for the canal tonnage certificates. For example, open forecastle and poop spaces are exempted from dues providing they are not used for cargo-carrying. In the case of the Suez certificate, such spaces have to be marked with a special brass plate to indicate that exemption is claimed. Canal dues for warships are based only on the displacement tonnage at the time of entering the canal ; for this purpose British and not metric tons are used.

It will be seen from the above that the gross and nett register tonnage of merchant ships are very complicated figures to derive and there are many loopholes by which the owner can keep them down, even in large ships.

The International Loadline Certificate

Having built a ship and kept the register tonnage to a minimum, the owner is naturally anxious to load the ship to the maximum possible extent, since every increase in displacement represents an increase in his profits. In the last century, many unscrupulous owners overloaded their ships to such an extent that they were unseaworthy, and then over-insured to cover themselves. Many ships were lost with much loss of life and eventually, as a result of a great deal of public agitation led by Mr. Samuel Plimsoll, M.P. (1824-98), various Acts of Parliament were passed to limit and regulate the loading of ships.

The famous ' Plimsoll or load-line ' was introduced by the Merchant Shipping Act of 1876. The purpose of this line is to ensure that sufficient freeboard is left when the ship is loaded, to give a reasonable degree of safety and seaworthiness under any normal conditions of sea and weather. Under the 1876 Act the owner chose the position of the load-line, but this was unsatisfactory and further legislation, the Load-line Act, was passed in 1890 ; this was later considerably modified in the light of experience, by another Act in 1906. The purpose of the Load-line Act is to lay down clear-cut rules by which the position of the load-line can be determined accurately for any ship. The Statutory Rules were formulated by the Load-line Committees and these set out to define the minimum freeboard required in the light of a ship's strength and reserve of buoyancy, and of the necessity for a margin of clear side or height of platform above the water. It is to be noted that no direct mention is made of stability, but this is naturally taken into account in estimating the position of the load-line, the position of which is fixed relative to the highest watertight deck in the ship. In a ship with a tonnage deck and non-watertight 'tween deck, the datum deck is the tonnage deck, not the upper deck.

Freeboard is defined as the height of the side of the ship above the waterline at the middle of the length, measured from the top of the deck at the side, neglecting the effect of any water ways or scuppers. The freeboard of British ships is determined by the rules laid down in the official Tables of Freeboard. These rules limit the permissible stresses in the ship's structure to those required by Lloyd's Rules of 1885 for a first-class ship. Reserve buoyancy is required to ensure quick recovery of a ship in rough weather ; otherwise she would be uninhabitable, and there would be a real risk of damage in rough weather. The tables of freeboard lay down minimum percentages of reserve buoyancy required for any particular size of ship, the percentage varying with the size. To ensure safety a minimum height of the weather deck above the sea is laid down, to prevent seas sweeping over it and endangering life, watertight hatches, boats, and the like. The good effects of deck houses and superstructure and of sheers are also taken into account in determining the freeboard. It is normally prudent to reduce speed in rough weather, but where any substantial reduction is undesirable, for example, in a passenger ship, a greater freeboard is required.

The freeboard calculated as a basis for the issue of the International Load-line Certificate is based on the conditions likely to be met in normal summer weather (FIG. 2). However, the freeboard required for operation in winter weather is increased and if the ship is to operate in the north Atlantic in winter, a further increase is made. Conversely, if the ship operates in the tropics, it is allowed to load deeper than in temperate climates. The ship will also float deeper in fresh water than in salt and it is usual to provide marks to show to what depth the ship can be loaded in fresh water, so that it will not float above the normal load-line on returning to sea water. The various drafts depend on the tons per inch immersion for each individual ship.

The Handling of Cargo in Merchant Ships.

The principal duty of the Mate or Chief Officer of a merchant ship is to receive, stow and discharge the cargo in the most convenient manner consistent with maintaining the stability, trim and safety of the ship. A great deal of experience is involved in carrying out these duties and great vigilance is required to ensure that the stevedores stow each consignment or ' lift ' in the required place and in the right way.

To assist the Mate in loading the ship correctly, he is provided with information on the trim and stability of the ship under typical conditions of loading, for example, in the light condition, in ballast, or with a homogeneous cargo at full displacement. He also has information on the effects of fuel, water and stores, and must know the capacities of the holds and the hatch sizes. Added to this, he must know the stowage factors for different types of cargo and the characteristics of different cargo.

It used to be the common practice for a ship to be loaded according to certain rules-of-thumb, which had been learned by experience, but nowadays accurate calculations are made to determine the effects on stability and trim of each batch of cargo. These calculations are assisted in most modern ships by an ingenious instrument known as the Ralston Stability and Trim Indicator. This consists of a duralumin plate on which is engraved a profile of the ship, using information obtained from the drawings. The position of the centre of gravity of each hold and space is marked and small weights are provided to represent cargo : 1 oz weight represents 100 tons of cargo. These weights are placed on the plates at the points where the cargo is stowed. Balance weights of suitable sizes are provided to represent full fore and after peak tanks and slacker flaps are fitted on the plate to represent full or empty ballast and double-bottom tanks. The plate is mounted as a balanced tray on special levers. By operating the appropriate levers, the plate may be balanced fore and aft to obtain the longitudinal trim or vertically to obtain the metacentric height G.M. A weight is moved along the appropriate scale to bring the bubble in a spirit level into balance, either for trim or for metacentric height. The appropriate figures are read off the scales, and the values of the trim by the stern, and of the metacentric height, are obtained from graphs.

Because of the Mate's responsibility for stability, he is also responsible for the stowage of fresh water, feed water, fuel oil (in conjunction with the Chief Engineer) and stores, as well as for water or other ballast. It will sometimes occur that the Chief Engineer must keep the double-bottom fuel tanks full throughout the voyage, on account of stability, and care may also be necessary in using fresh water. As an example of this, a case occurred recently where a ship developed a loll of 17 degrees, as the double-bottom fuel tanks were emptied during the voyage. In this connection it is interesting to note that the stability of a coal burning ship improves as the coal is burnt, while that of an oil burner may deteriorate if proper precautions are neglected. This is because coal is normally stowed in the 'tween decks and down both sides of the boiler rooms, and it is normal practice for the centre of gravity of the coal to drop as it is used. With oil and water, however, it is always coming out of tanks low down in the ship and free-surface effects must also be taken into account.

As cargo is accepted and loaded, the Mate prepares a rough ' cargo plan ' showing how and where each lift is stowed, its weight and its ports of origin and destination. It is usual to colour or shade the blocks on the cargo plan to show the port of destination, and care and ingenuity are often required to ensure that the lifts are so stowed that other cargo does not have to be moved to enable it to be unloaded at the port of destination. It is usually fairly easy to arrange this when lifting cargo from home ports for delivery overseas, as the details of all cargo to be carried will generally be available before any loading starts. However, conditions are much more difficult on the homeward voyage, as cargo must frequently be lifted at one port before any details are available of what, if anything, is to be lifted at other ports of call.

As far as possible, all cargo is stowed right across the ship and carefully trimmed to prevent any shifting in rough weather. Dunnage and securing ropes are used as necessary to separate and protect cargo from damage. Care has to be taken that fragile cargo is not stowed under other lifts where it would be crushed. When some of the cargo is to be lifted in one port and some in others, care may be necessary in the distribution of the first lift so that undue stresses are not placed on the ship's hull during the voyage between ports. It is also necessary to trim the ship so that the propeller is kept submerged as far as possible.

Before leaving the final port of call, the drafts forward, aft and amidships and the freeboard are noted and the metacentric height is calculated. This information is entered on the rough cargo plan and from this a 'fair' cargo plan (FIG. 3) is prepared and handed to the agents for despatch to the owners or to the agents in the first port of discharge. The ship's discharge programme can then be planned before she arrives and the necessary gangs of stevedores can be arranged.

Most loading and discharging is done with the aid of the ship's derricks and winches, except where adequate dockside cranes are available, or in cases where special cargoes such as bulk grain or very heavy lifts are involved. The ship's winches are operated by the stevedores, but a donkeyman of the ship's crew is always in attendance to see that the machines are not abused, and to oil them. In modern ships, electric winches are becoming increasingly popular, but steam winches are still preferred by many because of their great reliability in the face of constant use and misuse by all and sundry, and their comparative immunity to salt water.

THE MACHINERY

While diesel engines are becoming increasingly popular in the merchant service, it is still true to say that the steam reciprocating engine, in conjunction with coal or oil fired fire-tube (Scottish) boilers, is the most common for the main propulsion of cargo vessels up to about 14 knots. Steam turbines are used for the larger and faster ships, particularly if passengers are carried as a substantial part of the earning capacity, but these have not been particularly popular or successful in normal cargo ships, though a combination set has been very successful. Gas turbine machinery has now been fitted successfully in one large commercial tanker and it seems probable that these will become increasingly common as experience is gained.

The notes which follow apply only to a typical steam reciprocating engine installation, as fitted in S.S. *Livorno*.

> 'Steam engines are very human. Their very weaknesses are understandable. Steam engines do not flash back and blow your face in. They do not short-circuit and rive your heart with imponderable electric force. They have arms and legs and warm hearts and veins full of warm vapour.
>
> 'Give us steam every time. You know where you are with steam.'
>
> from *A Six-Hour Shift* by William McFee (born 1881).

Boilers

Two $35\frac{1}{4}$-ton Scottish marine boilers with four furnaces in each are fitted. These boilers were originally designed for coal burning, but were converted to oil during building. Air is supplied direct to the boiler casings by a centrifugal fan giving a normal air pressure of about 2 in water gauge at full power. Tubular air preheaters are fitted in the uptakes. Oil fuel is supplied by an oil transfer pump from one of four tanks, two double bottom and two deep tanks—to a settling tank of 16 tons capacity in the 'tween deck above the engine room. From here the whole oil fuel system is primed by gravity as far as the oil fuel service pump suctions. A heated oil separator is fitted in the line between the settling tank and oil fuel pumps. A conventional oil fuel system supplies heated oil to the Tod-type sprayers and registers, one for each furnace. If excessive water is present in the fuel, it may be passed through the Comyn oily-water separator of about 15 tons/hr capacity. This is a heated tank, with three concentric chambers in which gravity separation takes place, the clean oil being removed from the top and the water from the bottom.

One major difficulty is met in burning oil fuel in this type of boiler. Whereas in a water-tube boiler several registers are fitted to each furnace, there is only one for each furnace of a Scottish boiler and it is bad practice to run for long with one or more furnaces shut off. Thus, to obtain variations in power the only satisfactory methods available are to vary the oil fuel pressure and the size of the atomizer plates used in the sprayers. As a result the boiler is inflexible in operation, quite apart from the great size, which necessitates 24 hours' notice for raising steam from cold ; it is also found that excessively low oil fuel pressures and temperatures have to be carried to maintain a clear funnel, even when using the smallest atomizer plates available. Daily fuel consumption at full power is about 24 tons and 12 tons at economical speed ($9\frac{1}{2}$ knots).

Steam is generated at a working pressure of 225 lb/sq in (gauge) and supplied to the main and auxiliary steam systems. Main steam is supplied via superheaters, the tubes of which are situated in the fire tubes, and the headers on each side on the front of the boiler. Each superheater tube passes from the wet side of the header in and out through four or five tubes and back to the dry side of the header. A maximum steam temperature of 600° F. is attained. In order to reduce the wetness of the auxiliary steam, a bleed-off from the main to the auxiliary steam system is provided.

Main Engine

Steam is supplied to the triple expansion main engine via a lever-operated manoeuvring valve of the Cockburn-MacNicoll double-beat type. All main engine slide valves are operated by normal eccentrics and a Stephenson's link reverse gear, weigh shaft and reversing engine. However, the H.P. cylinder valves are of the Andrews and Cameron quadruple-opening balanced type. In this arrangement separate steam and exhaust valves are fitted for each end of the cylinder. The eccentric rod operates an oscillating cam shaft on which are mounted slotted cams which drive each of the four valves through individual rocker arms and rollers. The arrangement is designed to reduce valve wear to a minimum and is claimed to make better use of the steam as regards cut-off and expansion than more normal types of slide valve ; in practice wear of the cams and rollers is considerable and its effect is magnified by the arrangement of the operating levers.

The I.P. and L.P. cylinders are fitted with Andrews and Cameron valves of the match-box type. This type of valve is rectangular in cross-section and may be thought of as a rectangular piston valve. It has all the advantages of the latter, but occupies no more space longitudinally than a simple ' D ' slide valve.

All the moving parts of the engine are lubricated either by hand or by a pressure lubricator driven from the H.P. crosshead. The crossheads and eccentrics are salt water cooled, the water used being led into the bilge from which it is continually pumped overboard by a ram pump driven through levers from the L.P. crosshead.

Self-lubricating Michell type thrust and Plummer blocks are fitted on the main shaft. A worm-wheel and steam turning engine are fitted on the shaft between the main engine and the thrust block. The 4-bladed propeller is made of manganese bronze and a cast iron spare is carried in No. 3 hold.

A comparatively modern development, which is being fitted in some ships, is an exhaust turbine between the L.P. cylinder and the condenser ; this is connected through double-reduction gearing and a Vulcan clutch to the main shaft for steady steaming. This arrangement, which is known as the Bauer-Wach combination, increases the work done by the steam and also makes for smoother running of the engine. An increase of 1½ to 2 knots in speed has been achieved with no increase in fuel consumption.

Boiler Feed System

The feed system is shown diagrammatically in FIG. 4. Steam from the engine is condensed in the two-flow surface condenser, supplied with water by a centrifugal circulating pump. The air pump and the ram pump are both driven through levers from the L.P. crosshead and have a stroke of 24 in. It is therefore necessary to start the engine with no vacuum, but the capacity of the air pump is such that only a very short time is required before the required vacuum of 26 in is obtained, in conjunction with the vacuum-augmentor air ejector.

The Edwards air pump has no suction or bucket valves. When the plunger is at the top of its stroke, the bottom of the cylinder fills with water. The head clearance is very small and a high vacuum is created in the cylinder on the down stroke. When the plunger reaches the bottom of its stroke, ports are uncovered above it through which air and water are drawn from the suction line ; at the same time the water in the bottom of the cylinder is forced round the plunger, as the latter reaches the bottom of its stroke. Both the air and the water are trapped as the plunger rises and are forced out through the discharge valves in the cylinder head. To ensure the tightness of these valves, a weir is provided so that the valves are always covered with water. Water passes over the weir and away by gravity to the filter and scum and drain tank. The air is released to atmosphere through the vent.

It is to be noted that the scum and drain tank is only a collector for all the water returning from the main engine and all the auxiliaries. It is not a main feed tank and no such tank is fitted, as the capacity of the boilers is such that the reserve can be carried there. Make-up feed is obtained by suction from the R.F.T.s (port and starboard), through a small line connected to the air pump suction line. This is opened for about 20 minutes each watch and the average feed water consumption is about 8 tons per day for all purposes.

Water is drawn from the scum and drain tank by the ram pump and passed to the direct contact feed heater and deaerator. From here it is withdrawn by a main feed pump and passed via the pressure filters, which contain Terry towelling, the pressure feed heater, where the temperature is raised to about 290° F., and the main feed check valves, into the boilers. The direct contact feed heater and deaerator is fitted high up in the engine room to provide an

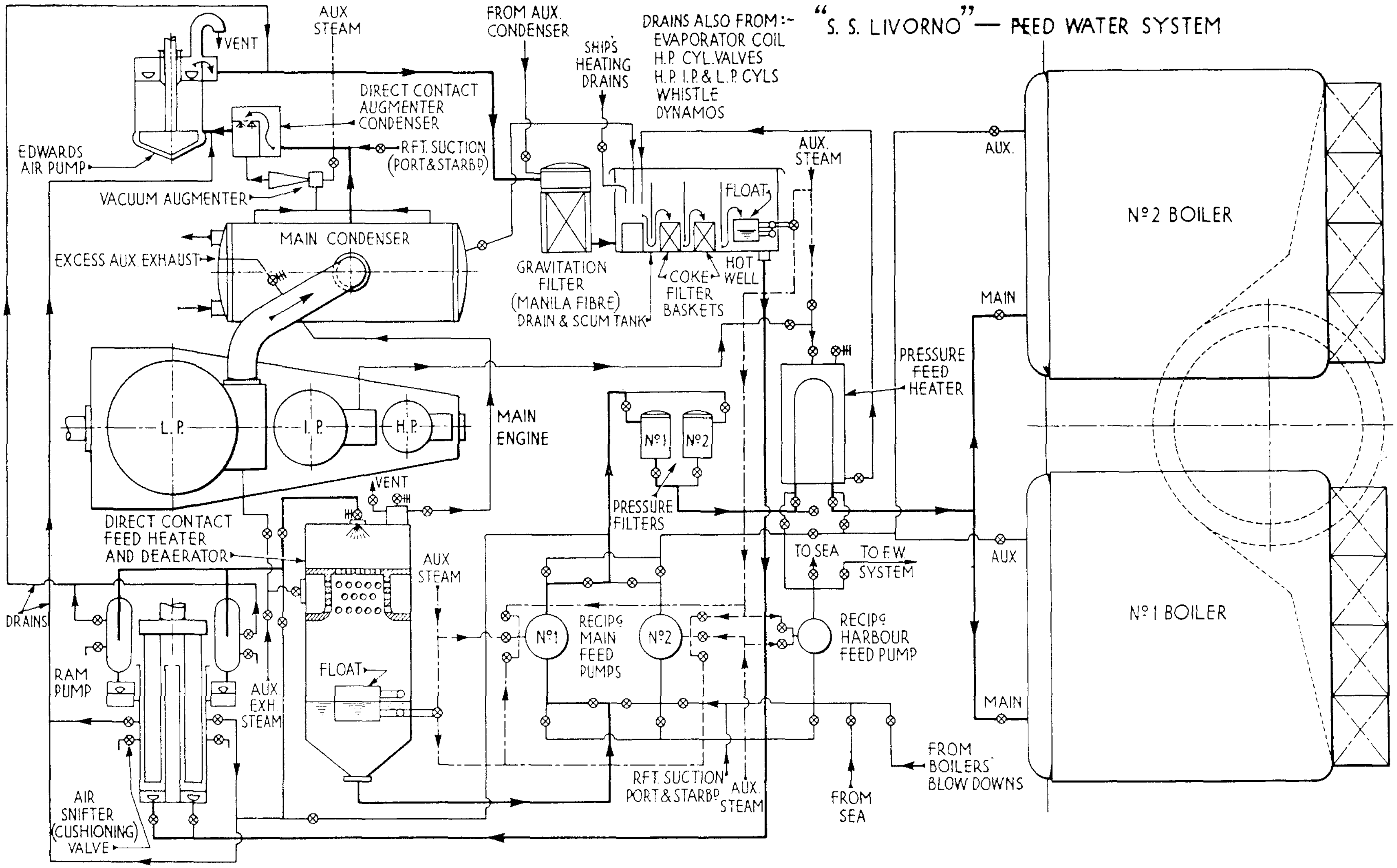


FIG. 4—DIAGRAMMATIC ARRANGEMENT OF THE FEED WATER SYSTEM

adequate head on the feed pump suction and so prevent steam locking, due to water flashing to steam on the suction stroke. The steam supply to the feed pump is controlled by the float-operated valve to maintain a constant water level in the direct contact feed heater and deaerator. In harbour, or for emergency use, a similar float-operated valve is fitted in the hot well of the scum and drain tank to control either main feed pump or the harbour service feed pump. The ram pump or the general service pump may be used as emergency feed pumps.

Auxiliary Machinery

Three main generators are now fitted, with a combined output of 87·5 kW. at 110 volts D.C. Two of these have only recently been added to cope with the additional load of the cargo space ventilating fans, which were fitted at the same time, and with the load of the degausing coil, when fitted in wartime. The main switchboard is fitted in the engine room close to the generators.

A single shell evaporating and distilling plant of 25 tons/day nominal output is provided, but is only used in emergency. No distiller is fitted and the made vapour has to be condensed in the auxiliary condenser (at atmospheric pressure) in harbour, or in the main condenser at sea. Normally ordinary shore water is used in the boilers and sufficient can be carried for all normal circumstances.

The steering gear is of the quadrant type driven by a twin-cylinder vertical non-expansion engine, and controlled from the bridge by a telemotor system and differential valve. By Board of Trade rules, the steering engine is made twice as powerful as is necessary for any likely conditions that will be met.

The windlass on the cable deck is driven by a twin-cylinder horizontal steam engine and each of the ten winches is driven by a similar engine, but of a smaller size.

A 4-h.p. automatic direct expansion methyl chloride refrigerating plant is fitted to cool a cold room, a fruit and vegetable room and a lobby. An automatic motor driven centrifugal circulating pump for the refrigerator condenser is fitted in the engine room.

A diesel driven emergency fire pump is fitted in the 'tween deck below the tonnage hatch.

THE PERSONNEL

Duties and Organization of Personnel

As in all ships, the Captain (Master) is in general charge of all departments. He deals with the shipping agents and with the ship's correspondence. Similarly the Chief Engineer is in general charge of his department and is responsible for the engine room register, the abstracts, fuel consumption reports, and so on ; in some ships, particularly on the short trades, for example, to the Baltic or the Continent, the Chief Engineer is also required to keep a watch at sea.

The mates and engineers keep watches at sea, which are usually divided as follows :—

Morning and Dogs (4 to 8)	Mate, 2nd Engineer.
Middle and Afternoon (12 to 4)	2nd Mate, 3rd Engineer.
Forenoon and First (8 to 12)	3rd Mate, 4th Engineer.

The engineers also have to keep watch in harbour if main steam is available. A donkeyman and fireman are also on watch with the engineer, one as greaser in the engine room and the fireman in the boiler room. In harbour two donkeymen and two firemen work 12 hours' watches continuously, the remaining three