A CHAPTER
ON SHIP CONSTRUCTION AND FITTINGS.

Questions on ship construction and fittings now form one of the most important parts of the examinations for **all** grades of certificates.

This chapter will give some idea of the questions that have been asked, and those likely to be asked, at the examination.

While **specially useful for examination purposes**, it is also meant to give candidates a general interest in the subject, and lead them on to further study.

The terms used and the subjects chosen have been made as simple as possible.

The drawings are only rough sketches. They are intended to indicate the proper names of different parts of vessels, rather than to give full detailed explanations of them.

☞ **All candidates** should get the following books on this and allied subjects:—

"The Modern Practice of Shipbuilding." By Thearle. 15s. net.
"Know your Own Ship." By Thos. Walton. 7s. 6d. net.
"Ship Construction and Calculations." By Nicol. 12s. 6d. net.
"Present-day Shipbuilding." By Thos. Walton. 7s. 6d. net.

These can be obtained from any nautical bookseller, or direct from James Brown & Son, 52 Darnley Street, Glasgow.

The first thing to be done in connection with the building of a ship is to prepare the various drawings which are required to work from, and to get ready a complete specification describing in detail the various different parts of the ship, her construction, and fittings.

This is the work of a naval architect. It will not be attempted here. We will presume that all the necessary drawings are completed, and at hand.

The "scantlings," or sizes of the various plates, frames, angle bars, stringers, and other parts of the vessel are shown upon the specification, and are generally in accordance with the Rules of Lloyd's Register of British and Foreign Shipping. They are governed by the "First" and "Second" scantling numbers, not by the tonnage of the vessel.

All steel worked into "classed" ships is tested at the steel works by the Surveyors to Lloyd's Register, and if found satisfactory is stamped with a brand, thus:—

The fact of a vessel being classed at Lloyd's is a guarantee not only that her materials in the first case were good, but also that her scantlings (*i.e.*, the actual sizes of her various component parts) have satisfied the Surveyors to Lloyd's Register that they are satisfactory and suitable for that particular ship.

Classed ships also have to undergo periodical surveys to retain their class, thus when a vessel is four years old she has to undergo her No. 1 survey; when eight years old her No. 2 survey; and when twelve years old she must undergo her No. 3 survey, which is a very thorough one.

In each survey the vessel is to be placed in dry dock on blocks of a suitable height, and opened up for survey in any places where the surveyor may require. There are various classes of vessels in Lloyd's Register, the class A1 indicating that both hull and equipment are in first-class order.

The shipbuilder also prepares a **model in wood** of the ship he is going to build, upon which he shows the arrangement of the edges and butts of the shell plating, and draws lines showing the positions of the frames. This model is generally made upon a scale of ¼ inch to the foot, but sometimes on a larger scale for small vessels. The particulars can, however, be got from drawings.

In most shipbuilding yards the lines of the vessel to be built are expanded to full size upon a **mould loft floor.** The mould loft is simply a large building or shed having a suitable floor to work on

When the vessel has been laid off upon the mould loft floor, or upon paper, the lines are transferred to the **scrive board.** The scrive board consists of a number of seasoned deals secured edge to edge by clamps at the back, the edges being close jointed, and the area of the board large enough to receive a copy of the body plan to full size. The lines required to be shown are razed or scratched into the surface of the scrive board, and some of them are distinguished by paint marks of various colours.

A set iron (a bar of soft iron) is bent to the curvature of any required frame on the scrive board, the various frames, etc., being bent to the corresponding shape by means of it and a **bending slab** or other appliance.

Before any of the actual building of the ship can be done, the materials required must of course be obtained and the keel blocks on the building slip prepared. A great deal of preparatory work is therefore required before any of the actual construction of the ship can be begun.

The foundation of the building slip must be solid and strong enough to bear the weight of the ship before launching. When a very large and heavy vessel is to be built, special care is taken with regard to this by means of piling, etc.

It must also be seen that there is sufficient depth and breadth of water for launching.

The keel blocks are usually spaced about 4 or 5 feet apart, and should be stout and substantial baulks of timber, the bottom ones in each tier being the larger.

Large vessels are always launched "end on," and the keel blocks are laid with a declivity down to the water. This declivity is somewhere in the neighbourhood of $\frac{5}{8}$ of an inch to the foot, and the **launching ways,** which are afterwards laid for launching the vessel on, sometimes have a declivity of $\frac{3}{4}$ of an inch to the foot.

It must be remembered by those who have never had the pleasure of seeing a vessel launched, that though the keel is first laid (of course, a part at a time) and the vessel built upon it, she is launched from the "launching ways," and that her keel is quite free of the keel blocks at the time of launching. This is accomplished by "wedging her up," and thus taking her weight on the "launching ways," the keel blocks being all knocked away from under the keel before launching.

Small vessels, such as steam trawlers, tugs, etc., are often launched broadside on.

The first part of the actual construction of the ship is the laying of the keel on the keel blocks.

The most common form of keel is the **flat plate keel.** Flat plate keels are usually made from a single thickness of plate, but sometimes a double thickness is adopted.

For small vessels of 100 tons, Lloyd's Rules require that the keel plate shall be 30 inches wide, increasing to 36 inches or so in large steamers. The thickness varies from $\frac{8}{20}$ of an inch in small vessels to over an inch in large vessels. In each case this extends for three-fifths of their length amidships, being somewhat reduced at the extremities. Sometimes it is doubled for one half of the vessel's length amidships.

A flat plate keel is always associated with an **intercostal keelson or centre through plate keelson.**

It is called an **intercostal keelson** when it is fitted down **in between** the floors.

It is called a **centre through plate keelson** when the middle line keelson plate is continuous throughout its entire depth. The floors are then consequently in two lengths, butting against it.

Bar keels, as the name implies, are formed of an iron or steel bar standing on its edge. They are generally made in forged lengths of about 40 feet, the different lengths being joined together by vertical scarphs.

Lloyd's Rules require a bar keel 6 inches deep by $1\frac{1}{8}$ inches for a small vessel of 100 tons, while for one of 6,000 tons it is required to be 12 inches deep by $3\frac{3}{4}$ inches.

Side bar keels are not often used, chiefly in consequence of the expense of workmanship, but the system is a very good and strong one. There are several forms of side bar arrangement, but the distinctive feature of the system is a continuous vertical plate extending from the under side of the keel to the top of the floors, and sometimes continued so as to form a part of the main keelson. A bar is riveted on each side of this plate at its lower part, the collective thickness of the middle line plate and the side bars being at least equal to the thickness of an ordinary bar keel.

Part of the keel being laid, generally near the midships part of the vessel first, the work is then carried on towards the bilges, the frames and floor plates being got into position. The keel is also continued towards the extremities of the vessel, and the number of men increased as the work of construction proceeds. The frames having been erected, the beams are next got into position, though sometimes beams are connected to the frames before they are erected, in which case the frames and the beam are sent up together. There are also various tie plates, stringers, and the deck stringer plates, which run along both sides of the vessel on top of each tier of beams, pillars, bulkheads, etc.

Shell plating.—This is the most important part of the structure of an iron or steel vessel, not only because it is essential to her flotation, but because **it is the chief source of her strength,** and is the largest item in the weight of her materials.

There are several different arrangements of shell plating, the most common being the "**raised and sunken plate system.**" An example of this is shown on Plates III., IV., and V., which are half midships sections of steamers.

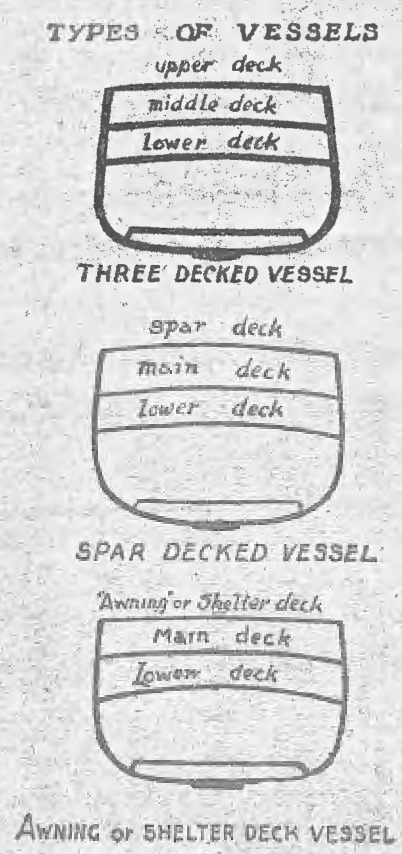
After launching, the vessel is towed to a convenient place to have her engines and boilers put in, hull structure finished, and her many and varied fittings installed. When completed and trial trips have been satisfactorily made, she is handed over to her owners and becomes another unit in our great mercantile fleet.

A few drawings are given on the following pages to show some of the principal types of vessel and parts of the hull construction and fittings. They are arranged in all cases with the drawing on one page and the explanatory matter on the page immediately facing it. This method will be found handy for reference and will save a lot of turning pages over.

Following these are a number of questions such as are frequently given at the examinations, with simple and practical answers.

NOTES.

PLATE I.



REMARKS ON PLATE I.

Types of Vessels.

The first drawing is a section of an ordinary three-decked vessel. This type is a strongly-built vessel of full scantlings, suitable for carrying all ordinary and heavy cargoes.

The upper deck is the "main" or "strength" deck, all bulkheads and frames extend to the upper deck, and where poops, bridges, or forecastles are fitted, the frames extend to the height of their respective stringer plates.

The reverse frames are sometimes fitted so that each alternate one stops at the middle deck.

The **sheer strake** is at the upper deck, from which the freeboard is measured.

The second drawing is a section of a spar-decked vessel. It very much resembles an ordinary three-decked vessel, but is of lighter construction than vessels of the same dimensions built to "three deck rule." The spar deck is the "strength" deck. The **sheer strake** is at the spar deck, from which the freeboard is measured.

The third drawing is a section of an "awning" or "shelter deck" vessel.

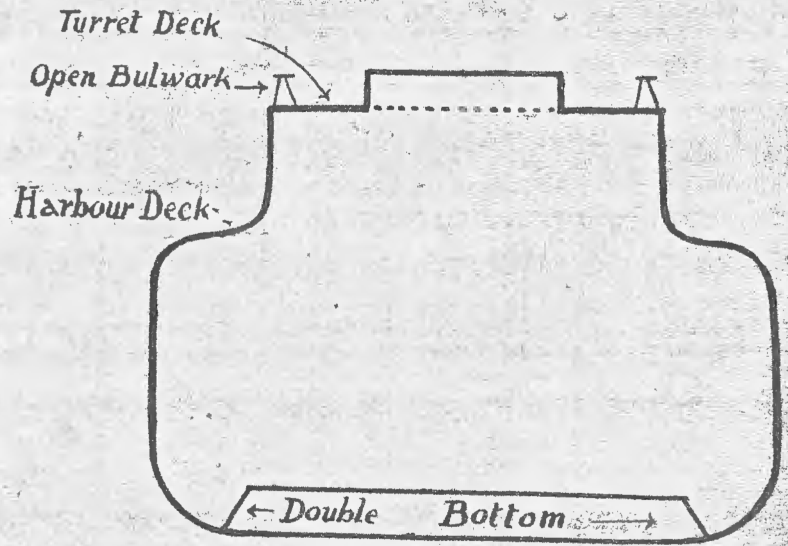
The hull construction from the main deck downwards is much the same as for a "spar-decked" vessel.

In old vessels the "main deck" is the "strength" deck. The modern practice, however, is to make the awning or shelter deck sheer-strake and stringer plates thicker than those of the deck below. The awning or shelter deck then becomes the "strength" deck.

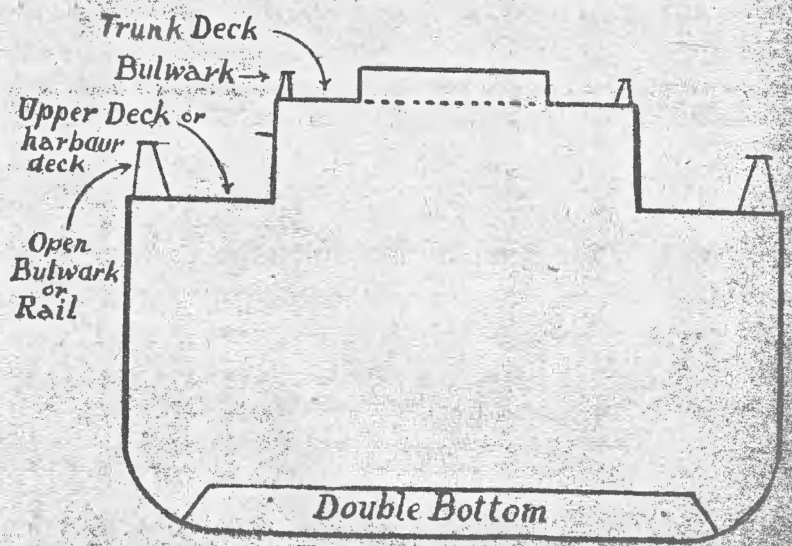
"Awning deck" and "shelter deck" vessels somewhat resemble each other, the difference being that an "awning-decked" vessel has a comparatively light deck structure continuously from stem to stern, the whole enclosed space being measured for tonnage, while a "shelter deck" vessel is fitted with openings through the shelter deck, which may extend from side to side of the deck, or only resemble small hatchways. The whole of the space between the main and shelter deck is not measured for tonnage. The shelter deck is suitable for carrying some descriptions of light cargo and cattle.

PLATE II.

TYPES OF VESSELS.



TURRET DECK STEAMER



TRUNK DECK STEAMER

REMARKS ON PLATE II.

The rough illustration facing this matter (the upper drawing on the opposite page) serves to give a rough idea of a turret deck steamer. The lower part is much the same, but the upper part of her construction differs considerably from the ordinary types of vessel shown on Plate I.

Note the curvature at that part of the vessel called the **harbour deck,** and the much reduced breadth of the vessel at the **turret deck.**

These are strong vessels, generally built without any sheer, and are said to be good sea boats. They are very suitable for grain carrying, as the upper or "turret" part of the vessel is an excellent feeder for the lower holds. Should there be any shift in the "turret," it will not make very much difference to the trim of the vessel. This remark also applies to the **trunk deck** steamer shown underneath.

The **turret deck** steamer is a speciality of Messrs. Doxford of Sunderland.

The **trunk deck** steamer has some features in common with the **turret deck** steamer. For trimming purposes the "trunk" has the same value as the turret. The deck and side, however, meet at an angle, there being no curvature as in the "turret" vessel. Bulwarks are fitted at the junction of deck and side. These differ somewhat from ordinary bulwarks, being designed to allow free egress of water from the upper deck. Sometimes a "rail" only is fitted.

The "trunk" system is due to Messrs. Ropner & Son of Stockton-on-Tees.

An excellent detailed description of these two types of vessel is given by Thomas Walton in "Present-Day Shipbuilding"

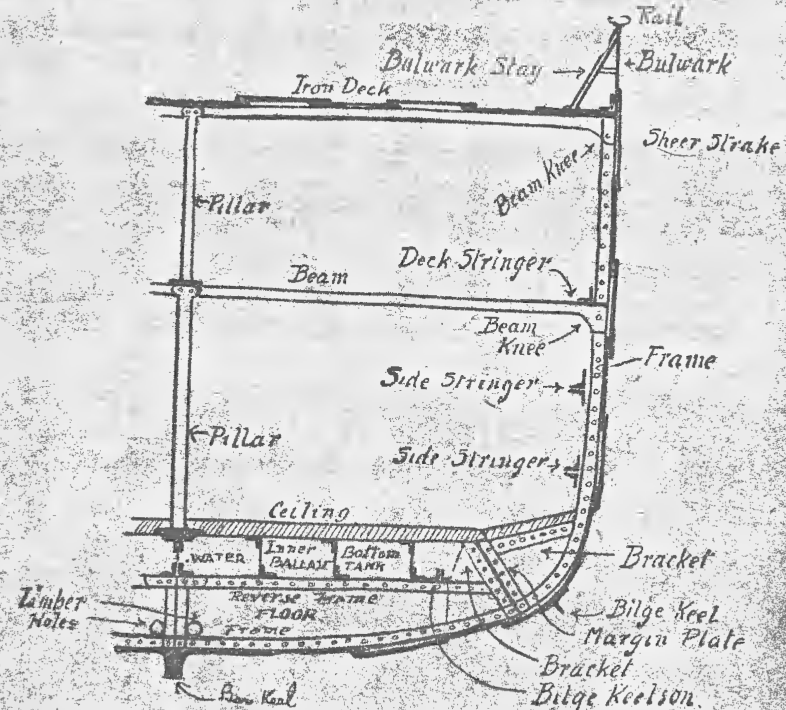
PLATE III.

HALF MIDSHIP SECTION.

ORDINARY FRAMING.

MACINTYRE TANK.

BAR KEEL.



REMARKS ON PLATE III.

This is a rough illustration of a half midship section of a small cargo steamer, with ordinary framing. The size of the frames might be about $4\frac{1}{2}$ by 3 inches by $\frac{7}{16}$ of an inch thick and the reverse frame, a little smaller, but they will, of course, vary with the size of the vessel.

The shell plating is the raised and sunken strake system—that is, each alternate strake is an inside and outside one.

One of its special objects is to give an idea of a M'Intyre water ballast tank, named after Mr. M'Intyre, who devised and introduced it.

The "margin plate" forms the side boundary of the tank, and the water ballast is of course carried in between the inner and outer bottoms of the vessel.

The frames and reverse frames are cut at the margin plate, but the transverse strength of the vessel is maintained by the two brackets; which are well riveted up.

The inner bottom of the ship, which forms the top of the ballast tank is supported by longitudinal girders on top of the reverse frames and floors.

PLATE IV.

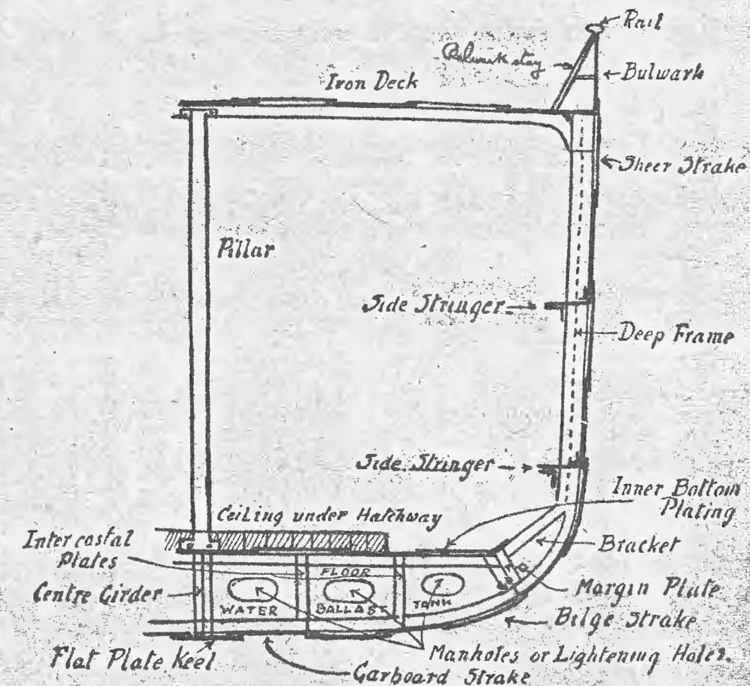
HALF MIDSHIP SECTION.

NO HOLD BEAMS.

DEEP FRAMES.

CELLULAR DOUBLE BOTTOM.

FLAT PLATE KEEL.



REMARKS ON PLATE IV.

This is a rough illustration of a half midship section of a steamer without hold beams. The loss of strength caused by the absence of beams being compensated for by "deep frames." These frames, as the name implies, are wider, and therefore stronger, than ordinary frames, but not as deep or as strong as "web" frames. Their depth might be about 10 inches.

The ballast tank arrangements are also different to those shown in Plate III.

In this vessel the water ballast is carried in the double bottom—that is, between the inner and outer bottoms. There are several different designs and arrangements of double bottoms.

In most cases the floors are continuous from the centre girder to the margin plate, and the longitudinal plates are fitted down intercostally between them, the longitudinal plates are then called intercostal plates.

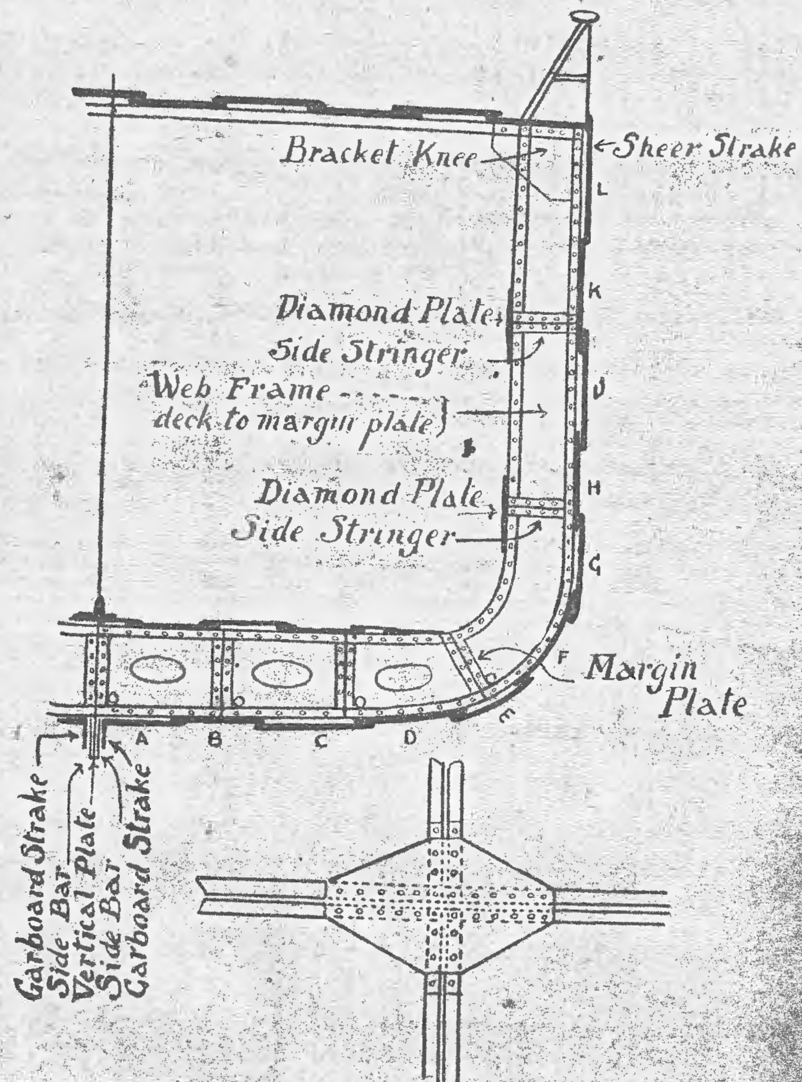
This arrangement divides the vessel's bottom into squares or cells, hence the name "cellular double bottom."

It will be noticed that oval-shaped holes are cut in the floors. These holes serve a twofold purpose. By taking some of the plate away, the structure is made lighter in weight. The holes are also necessary to make the double bottom accessible throughout.

The flat plate keel, as the name implies, consists of a flat plate, about an inch thick in large vessels. It is not so strong as a bar keel, but has the advantage of giving the vessel less draught. The longitudinal strength of the vessel is maintained by the "centre girder" or "centre through plate."

PLATE V.

HALF MIDSHIP SECTION.
WEB FRAME.
CELLULAR DOUBLE BOTTOM.
SIDE BAR KEEL.



REMARKS ON PLATE V.

This drawing shows a half midship section of a vessel without hold beams, fitted with "web" frames and corresponding "web" stringers, and diamond plates.

A "web" frame consists simply of a wide plate attached to the shell plating by a frame angle bar, and stiffened on the inner edge by a single or double reversed angle bar.

The width of a web frame varies from 14 inches in small vessels to 42 inches in large vessels.

When the vessel has a cellular double bottom, the web frame is efficiently connected to the margin plate. In other cases it is lapped against the floor plate, or connected to it by a "butt strap."

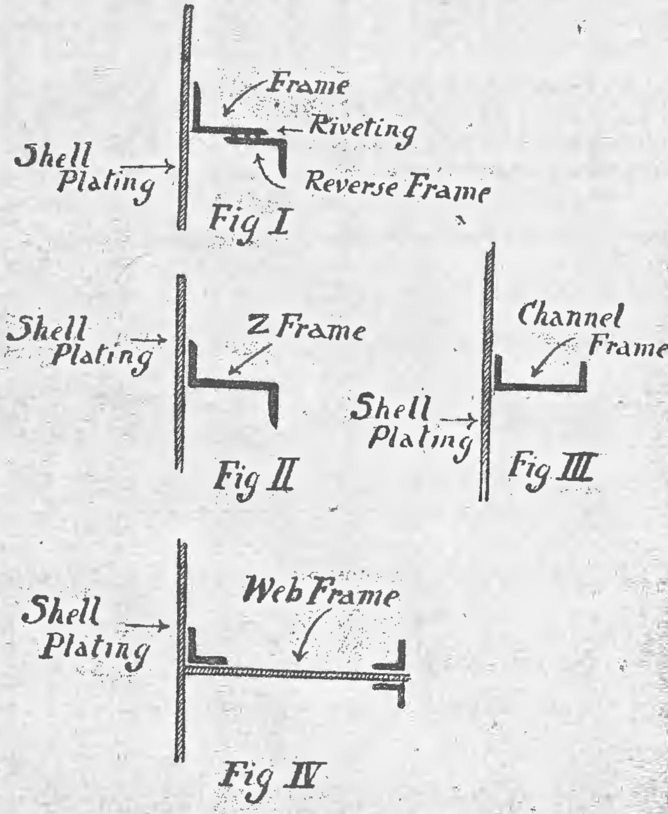
Web frames and stringers are connected at their junction by a "diamond plate." This is a diamond-shaped plate of the thickness of the web frame. It varies in size from 24 by 18 inches to 30 by 24 inches. If the web frame is continuous and the side stringer intercostal, the long diameter of the diamond plate is placed horizontal, and *vice versa*. Sketch of diamond plate on opposite page.

Recently the use of diamond plates has been largely discontinued, and straps of a different shape have been fitted instead.

A "side bar keel" consists of a continuous vertical plate extending from the under side of the keel to the top of the floors, and sometimes continued so as to form a part of the main keelson. A bar is riveted on each side of this plate at its lower part, the collective thickness of this middle line plate and the side bars being at least equal to the thickness of an ordinary bar keel. The garboard plates are bent and riveted to the side bars and vertical plate. There are thus five thicknesses riveted together. This is a very efficient arrangement, but not often adopted, chiefly in consequence of the expense of workmanship.

PLATE VI.

TYPES OF FRAMES.



REMARKS ON PLATE VI.

Figure I. gives an idea of an ordinary frame and reverse frame, showing them riveted together.

The shell plating is riveted to the frame, and the stringers are riveted to the reverse frame.

The flanges of the reverse frames point forward in the fore body, but aft in the after body of a ship, the flanges of the two midship reverse frames therefore pointing away from each other.

In ships of recent construction the necessity of riveting frame and reverse frames together has been overcome by using Z bars (Fig. II.) and channel bars (Fig. III.). They come to the same thing as frames and reverse frames rolled in one, and save weight and workmanship.

The **frame space,** that is the distance between the frames, varies between about 2 feet in small vessels to 3 feet in large vessels.

A "web" frame (Fig. IV.) is simply a wide plate attached to the shell plating by a frame angle bar or bars. In large vessels it is generally attached by two angle bars, but sometimes by only one of heavier make, and double riveted. In big ships it is as much as 42 inches wide, and over half-an-inch thick.

The inner edge is stiffened by single or double angle bars.

The object of a "web" frame is to give extra transverse strength to the vessel, to further stiffen the shell plating, and to give increased rigidity to the whole structure. In vessels of ordinary framing, each 4th, 5th, or 6th frame is sometimes replaced by a "web" frame. They are put closer together in the wake of engine and boiler-rooms, and large hatches.

"Web" frames are always associated with "web" stringers. These, as the name implies, are wide stringer plates, also stiffened at their inner edges by angle bars, and strongly connected to the "web" frames by "diamond" plates or other efficient means and angle bars. They contribute longitudinal strength and extra rigidity to the vessel. See sketch of web stringer, web frame, and diamond plate on Plate V.

PLATE VII.

Types of Beams.

Fig I

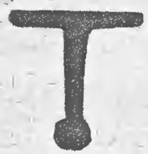


Fig II

Fig III

Fig IV

Fig V

Fig VI

REMARKS ON PLATE VII.

Beams, in conjunction with their supporting pillars, though sometimes without pillars, are put in a vessel to support the different decks, to give transverse strength, and to act as "struts" and "ties" to the frame heads.

Some of the different types are shown on the opposite page.

Figure I. represents a **bulb angle bar.** It is simply an angle bar finished with a bulb. Beams are sometimes constructed of angle bars without the bulb.

Figure II. represents a T angle bar finished with a bulb. It is, of course, heavier and stronger than the single angle bar.

Figure III. shows a beam of the **bulb plate and double angle** type. It consists of a steel plate finished with a bulb at its bottom edge and two angle bars at its upper part, the whole being riveted through.

Figure IV. shows a beam composed of a steel plate finished at top and bottom with double angle bars, the whole being riveted through.

Figure V. represents a beam rolled in one piece. This beam, also the one shown in Fig. IV., is very strong, and is used in special cases where heavy weights have to be borne.

Figure VI. represents a **channel bar** beam. It is now much used in large vessels.

Deck beams have usually a "round up" or "camber," both for the sake of the strength thereby obtained as well as to assist in freeing the deck of water. The round up of the midship beam is generally about ¼ inch per foot of its length.

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PLATE VIII.

TYPES OF STRINGERS.

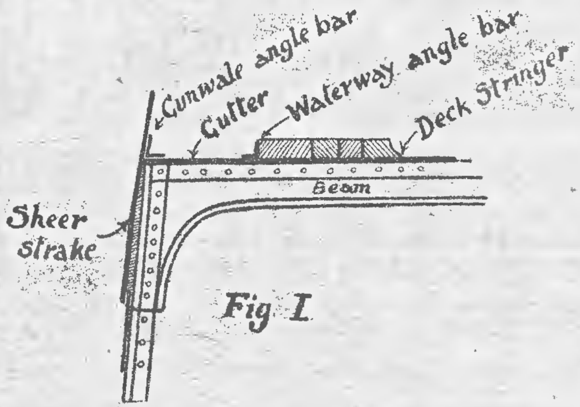


Fig. I.

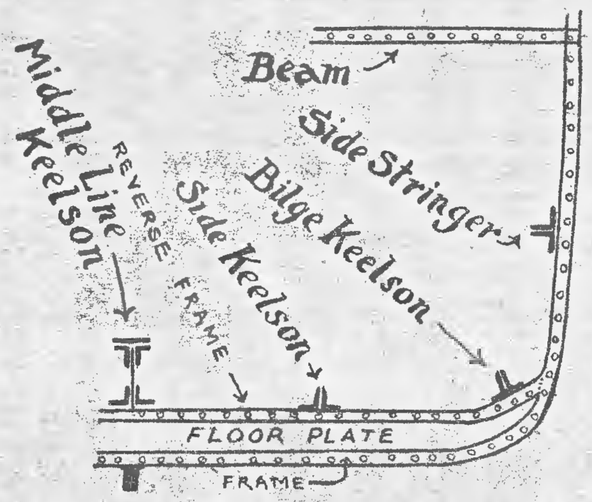


Fig II.

REMARKS ON PLATE VIII.

A deck stringer is a flat plate fitted round the sides of the vessel on the top of each tier of beams, and riveted to both the beams and the shell plating.

The functions of a deck stringer are to assist in connecting the deck beams to the side of the vessel, and to stiffen the shell plating. It also contributes with its angle bars some longitudinal strength.

The upper deck stringer, with its two angle bars, serves also to form a gutter and watertight boundary to the deck, and provides the means of efficiently fastening the deck ends and margin planks. (See Fig. I. opposite.)

Side Stringers are formed by an angle bar or two angle bars riveted back to back. They are fitted on the inside of the frames or reverse frames between the lowest tier of beams and the bilge keelson. The function of a side stringer is to stiffen the transverse frames, to hold them in their correct relative positions, and to prevent any tendency to tripping. If of large size, they also contribute some longitudinal strength to the vessel.

Bilge keelsons and **side keelsons** are practically the same thing as side stringers.

Bilge keelsons are fitted at the lower turn of the bilge on each side.

Side keelsons are fitted on each side of the middle line keelson, about midway between it and the bilge keelson. Figure II. opposite shows side stringers, etc., in a small vessel. In large vessels they are generally associated with an intercostal plate.

For **web stringers** in conjunction with web frame, see Plate V.

PLATE IX.

TYPES OF SHELL PLATING.

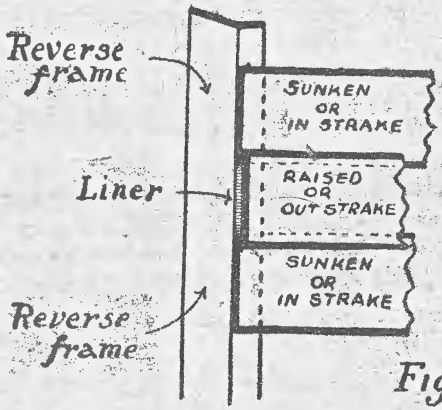


Fig. I

RAISED AND SUNKEN STRAKE SYSTEM SHOWING LINER

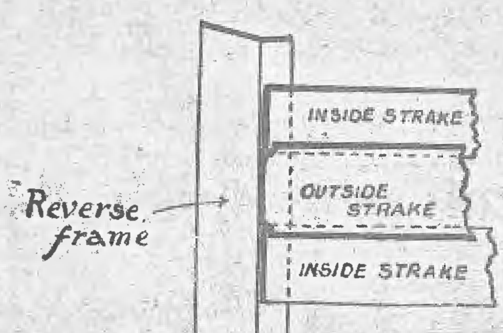


Fig. II

RAISED AND SUNKEN STRAKE SYSTEM JOGGLED PLATES NO LINER

REMARKS ON SHELL PLATING.

The most common form of shell plating, called the **raised and sunken plate system,** or the **in and out plate system,** is clearly shown in the half midship sections on Plates III., IV., and V. It is repeated here (Figure I.) to make the work more complete. This system, in the case of flush flanged frames, requires the fitting of **liners** to fill in the spaces between the edges of the inside strakes. A **liner** is a piece of steel fitted between the frame and the outside strake close up to the edges of the inside strakes, thus filling up the vacant space there would otherwise be, and making a solid job. (See Figure I. opposite.)

The ends of the plates are connected with a **butt strap,** generally on the inside, or by "**lapping.**" They are said to be "lapped" when the end of one plate overlaps the next, the two plates being secured together by single, double, or treble riveting, according to the size of the vessel.

Figure II. represents shell plating fitted on the raised and sunken strake system as in Figure I., but the plates are **joggled**—that is, the outside strake is bent at its edges where it lands on the inside strake, so that the plate may lay close to the frame, and thus do away with the necessity of fitting liners.

Sometimes the **frames are "joggled"** and the **plates flat.** In that case also, a "liner" is not required. The joggling is, of course, made of a depth equal to the thickness of the plating, so as to leave a flush surface on which to fit the outer strakes.

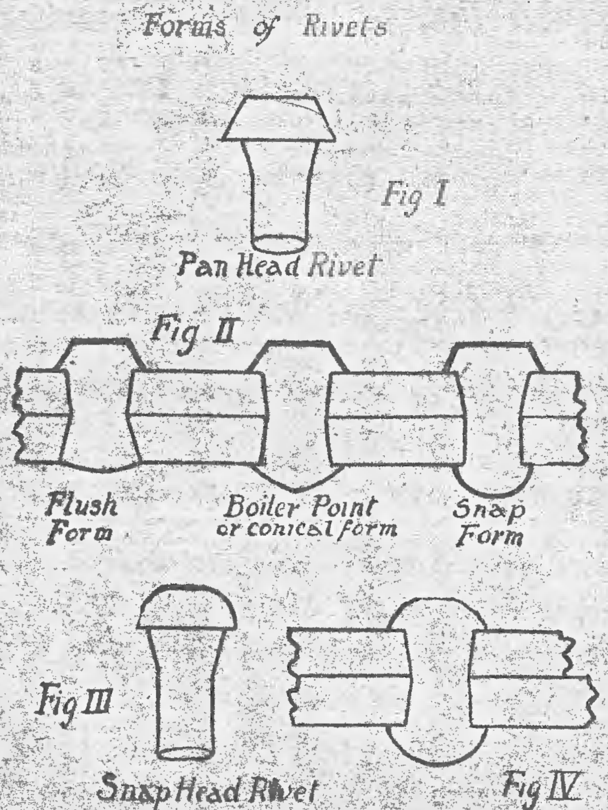
The practice of joggling is a growing one, as it has the advantage of saving weight, and diminishing the number of thicknesses to be fitted and riveted together.

Both the above systems are sometimes called **clencher systems** although they have raised or sunken strakes, and the plates are fitted differently to the planks in a clencher-built wooden boat.

Some of the old iron ships were plated clencher fashion, the plates being arranged in the same way as a boat's planks—that is, the lower edge of each strake of plating overlapping the upper edge of the next strake below it. This system involved the use of **tapered liners.** These tapered liners were more expensive to prepare, and were generally not so well fitted as liners of parallel thickness. This style of plating is very rarely seen nowadays.

PLATE X

FORMS OF RIVETS



REMARKS ON RIVETS AND RIVETING.

There are several forms of rivets employed at different parts of the ship, the most usual being the **pan-head rivet,** shown by Figure I. opposite.

Holes are punched in plates by a punching tool. The hole thus made is of conical form, being smallest on the side on which the punching tool first enters. Rivets for plating are therefore made of conical form under the head to efficiently fill the hole up.

They are inserted the opposite way to which the punching tool went, and their points are hammered up either to the "**flush,**" "**boiler point,**" or "**snap**" form as may be required. (See Figure II. opposite.) The point or hammered-up end of the rivet is termed the "**bat.**"

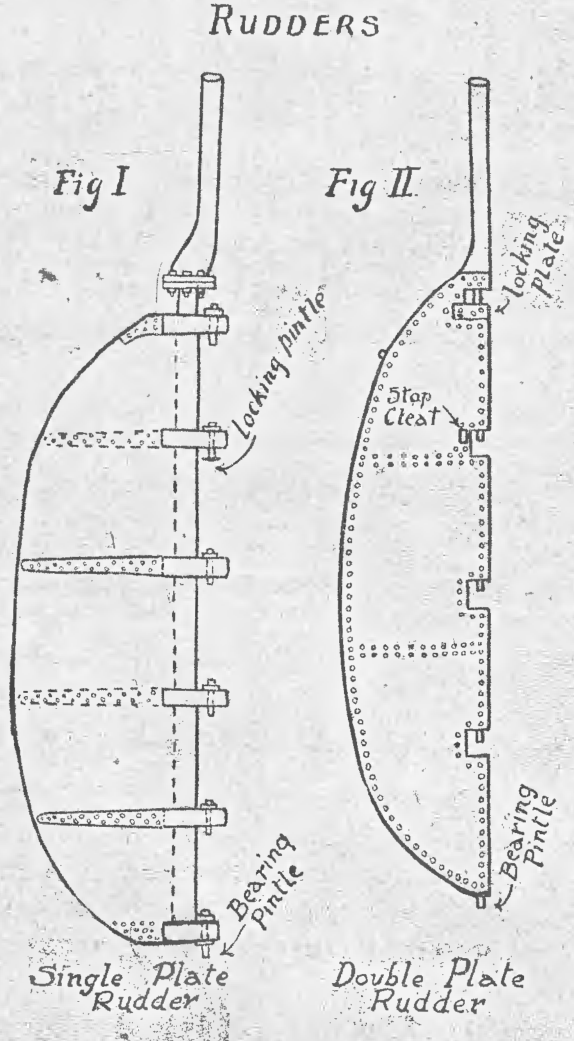
Figure III. shows a **snap head rivet.** This type of rivet is always used in connection with machine riveting, and the "bat" is always finished off "snap" form. Figure IV. shows the finished job.

The **diameters of rivets** vary with the thickness of the plates to be riveted together. In shell plating a ¾ inch rivet is generally used for ½ inch plates.

The **spacing of rivets** varies with different kinds of work. It is expressed in terms of the diameter of the rivets. The space between the rivets may vary between about 2½ and 5½ diameters. In single riveting the rivets are spaced closer than in double or treble riveting.

PLATE XI.

RUDDERS.



REMARKS ON RUDDERS.

Most modern ships are now fitted with **single-plate** rudders, which are often called **centre-plate** rudders. Some, however, have **balanced rudders.** (See Plate XII. on next page.)

The **single-plate rudder** shown opposite (Figure I.) consists, as the name implies, of a single steel plate, the plate being attached to the main spindle by means of strong **arms**, fitted alternately on opposite sides and securely riveted.

The plate of the rudder varies in thickness from about $\frac{3}{4}$ of an inch in small vessels, with a rudder head of $2\frac{3}{4}$ inches, to nearly $1\frac{1}{4}$ inches in large vessels requiring rudder heads 15 inches in diameter.

The distance between the arms varies between 45 and 75 inches.

The lower part of the rudder is coupled to the upper part by means of flanges and bolts, as shown on opposite page, or by other efficient means. The object of the coupling is to permit of the rudder being unshipped without the head being lifted or its connections to the after steering gear being disturbed. The **pintles** are removable, one of the upper ones being the **locking pintle.**

The **double-plate rudder** (Figure II.) consists of a frame, plated on both sides. The plates are riveted to the frame with through rivets, which should have full snap heads, for when flush riveted it is found that they soon become corroded and loose. It is usual to fill the space between the plates with wood.

The pintles are forged on the rudder frame, and a **locking plate** fitted on the rudder to fill up the space below the upper gudgeon, and thus prevent the rudder becoming accidentally unshipped.

The weight is borne by the **bearing pintle** at the bottom, which stands in the projecting heel of the stern post.