VESSEL DESIGN AND CONSTRUCTION

Prior to building, a commercial vessel is carefully designed for its intended purpose. Naval architects draw the plans; ship builders build the vessel; and government surveyors inspect the plans, oversee her construction and inspect the finished vessel to ensure that minimum standards are met.

FACTORS INFLUENCING VESSEL DESIGN:

- Nature of service;
- Area of operation;
- Regulatory requirements in terms of seaworthiness, stability and personnel safety;
- Stresses;
- Construction materials
- Commercial requirements.

Nature of service:
Is the vessel intended to carry passengers, cargo or fish? What are the required size, layout, accommodation, machinery and equipment for this service?

Area of operation:
Is she to operate in generally calm waters, seasonal cyclonic conditions or regular rough seas of high latitudes? Her area of operation would influence her design. To cope with rough weather her hull may be strengthened, she may be constructed larger in size and her decks may be located sufficiently high above the water to keep them reasonably dry. Vessels designed for longer voyages must have larger fuel and water capacity.

Seaworthiness and stability:
Vessel must be sufficiently seaworthy and stable at all times with additional measures to cope with rough weather and damaged condition. This would influence her hull shape, weight distribution and location, operation and protection of hull openings.

Stress:
Vessel's structure should be able to withstand operational stresses of:

- Water pressure,
- Weights on board such as cargo and machinery,
- Action of wind and waves and
- Operation of machinery.

Survey Requirements
Commercial vessels are designed, constructed and operated in accordance with regulations contained in a State Marine Act or the Commonwealth Navigation Act. The detailed legislation is contained in the Uniform Shipping Laws Code (USL) and the National Standards for Commercial Vessels (NSCV), discussed in Chapter 12. Vessels are surveyed by the relevant marine authority (in some States by private surveyors), during construction, on completion, and then periodically during vessel's life to ensure compliance with regulations.

Personnel Safety
Vessels must have safe accommodation, safe working areas and safe access to and from the working areas. In the event of accidents and breakdowns at sea, emergency safety measures must be available as per statutory requirements.

Construction Materials
Vessel's carrying capacity, propulsion power and construction method will be influenced by the choice of construction material. See chapter 5 for advantages and disadvantages of various construction materials.

Commercial Requirements
A commercial vessel must meet the owner's commercial requirements in terms of cost of construction and operation. This would influence vessel's design.

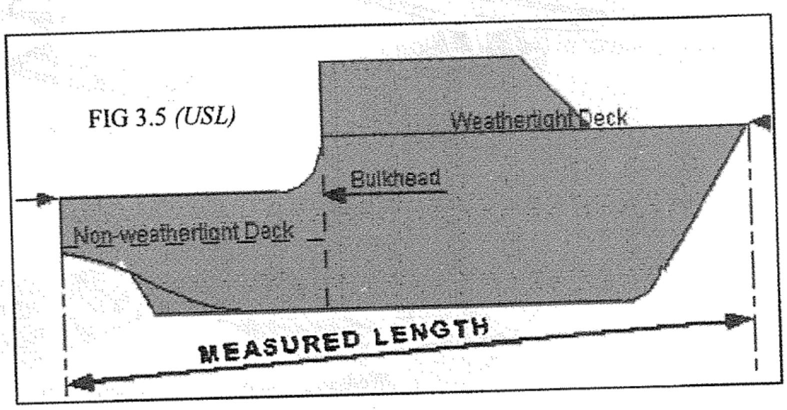


FIG 3.5 *(USL)*

VESSEL DESIGN FEATURES & MORE TERMINOLOGY

Measured Length – As shown here and in Chapter 12, measured length is the distance from the fore part of the hull to the after part of the hull, measured at the upper side of the uppermost weathertight deck, or, in the case of open vessels, at the height of the gunwale. The figures below show two examples. This measurement is used for most of the length-based application of USL and NSCV regulations.

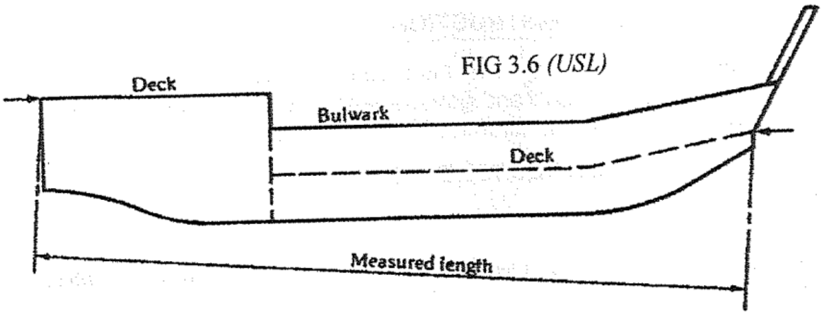


FIG 3.6 *(USL)*

Length Between Perpendiculars (LBP) - is the length from the forward perpendicular to the after perpendicular. The forward perpendicular is a vertical line drawn through the point where the load waterline cuts the stem. The after perpendicular in most cases is a vertical line drawn at the after end of the rudderpost.

Length Overall (LOA) – is the distance measured parallel to the designed (loaded) waterline from the foremost part pf the hull to the aftermost part of the hull. See 'nautical terms' for more details.

Load Waterline (LWL) or Design Waterline - A vessel's permissible loadline.

Freeboard – the distance from deck to waterline.

Depth - the distance from deck to keel, usually measured at the side and amidships

Beam or Breadth - is the greatest width from one side of the vessel to the other, measured at the widest part of the vessel.

Load (loaded) Draught or Service Draught – is the vertical distance from loadwater line (LWL) to underside of keel. (deepest point of hull).

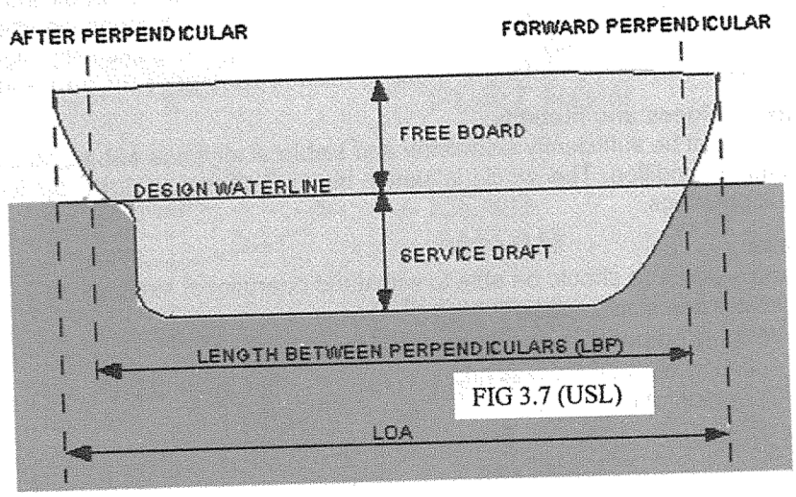


FIG 3.7 (USL)

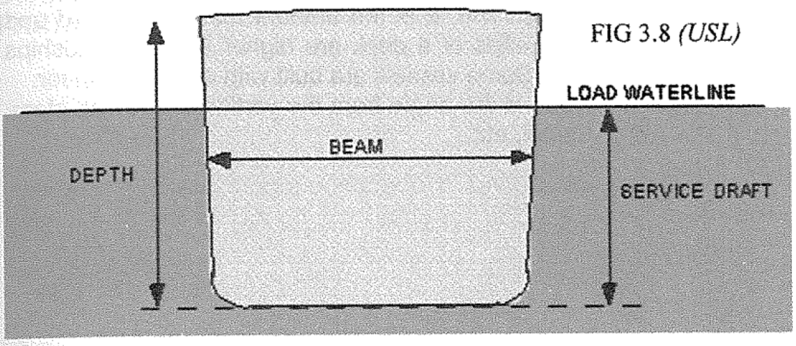


FIG 3.8 *(USL)*

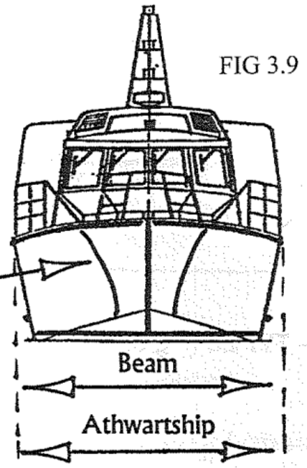


FIG 3.9

Rake (declivity) of keel – As shown in chapter 13, some vessels have their keel parallel to the design waterline, others at an angle to it. The latter are said to have a rake or declivity of keel.

Longitudinal – movement, measurement or a component along the length of a vessel.

Transverse - movement, measurement or a component across the vessel.

Flat of Bottom - in some vessels, the area of the hull near to the *keel* is flat, this is called Flat of Bottom.

Deadrise (Rise of Floor) - if the bottom of a vessel rises from the centre line to the turn of bilge, there is said to be a Rise of Floor.

Camber – see also 'nautical terms' above

Tumblehome - see also 'nautical terms' above. Monohull tumblehomes are no longer considered desirable. They have a poor righting arm due to decreasing water plane area as the ship heels. The tumblehome shape reduces reserve buoyancy (buoyancy above waterline needed to cope with damage). It reduces the usable deck space and the superstructure space.

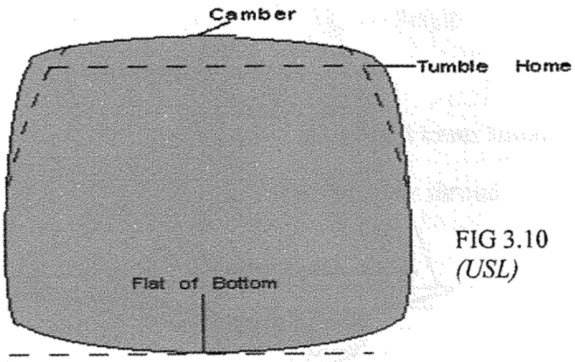


FIG 3.10 *(USL)*

Flare - see also 'nautical terms' above

Bow Rake (raking stem) -similar to flare, reducing waves coming on deck in rough weather.

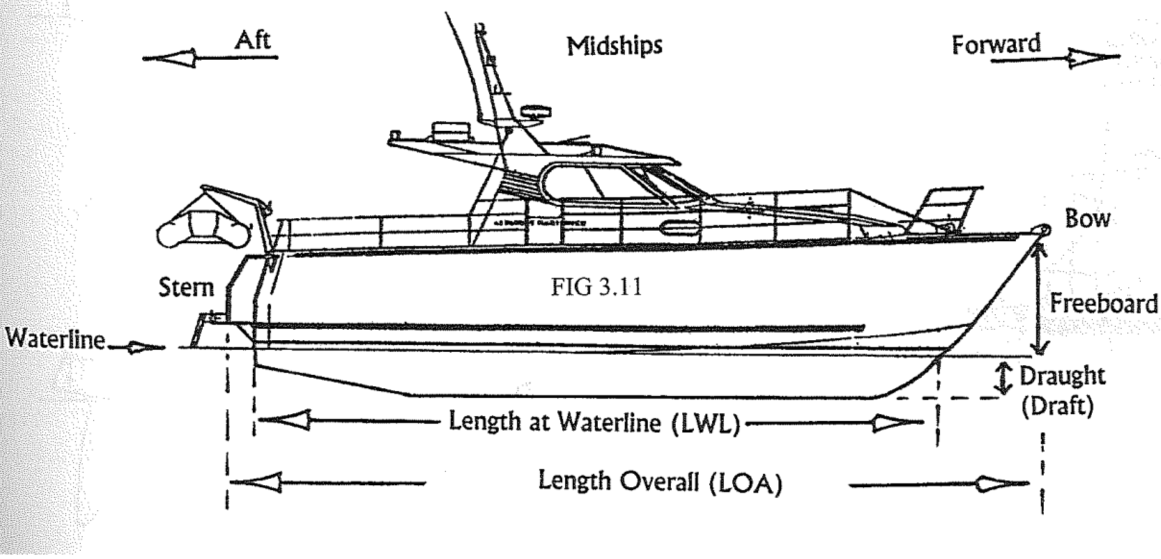


FIG 3.11

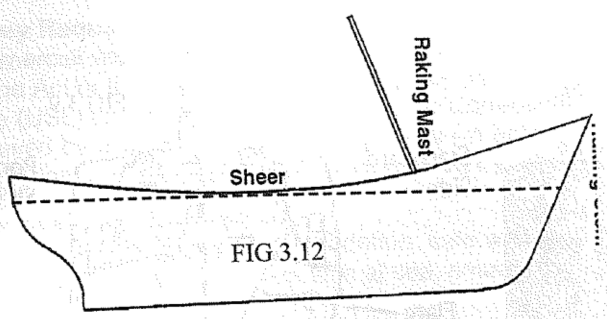
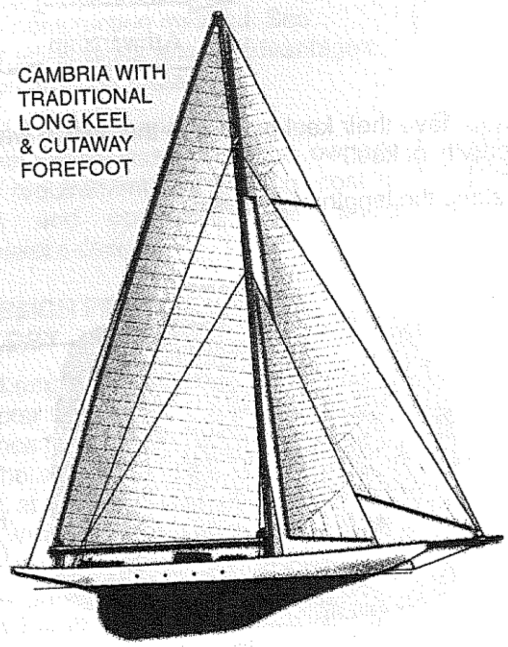


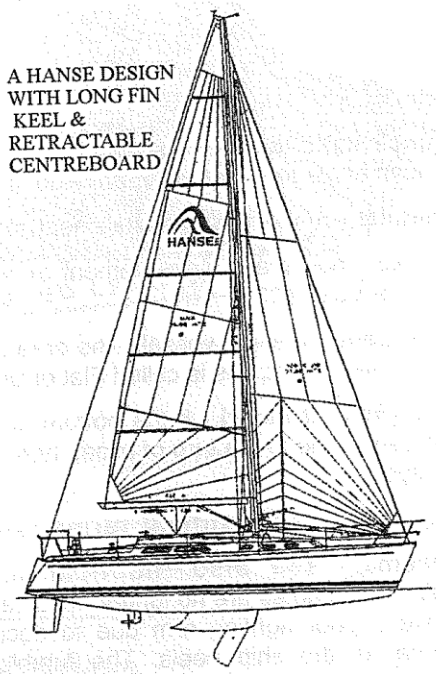
FIG 3.12

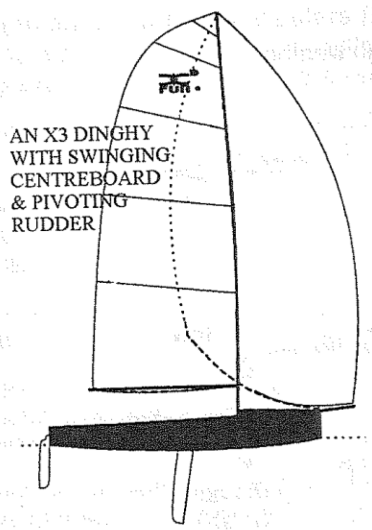
SHEER & RAKE

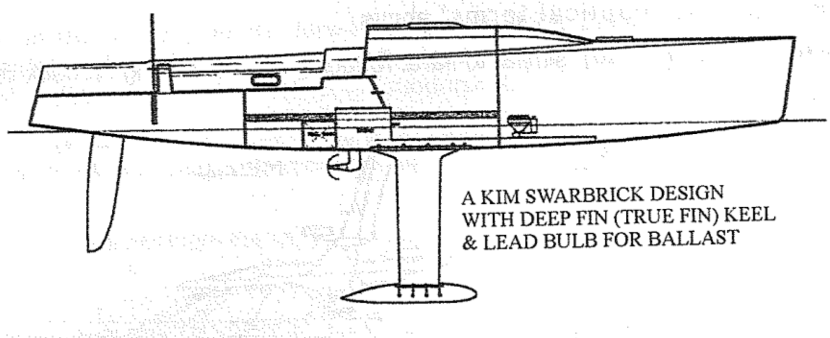
Sheer is the dip in the middle of the boat in the fore and aft line. It is the amount that the forward and after ends of a deck are higher than the midships part. Some vessels are built with a reverse sheer.
Rake is the angle from the vertical of a mast, stem, funnel, etc.

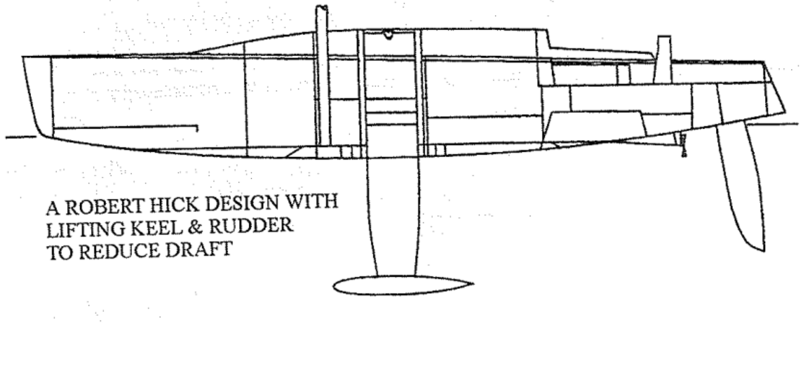
KEELS – TYPES (Fig 3.13)



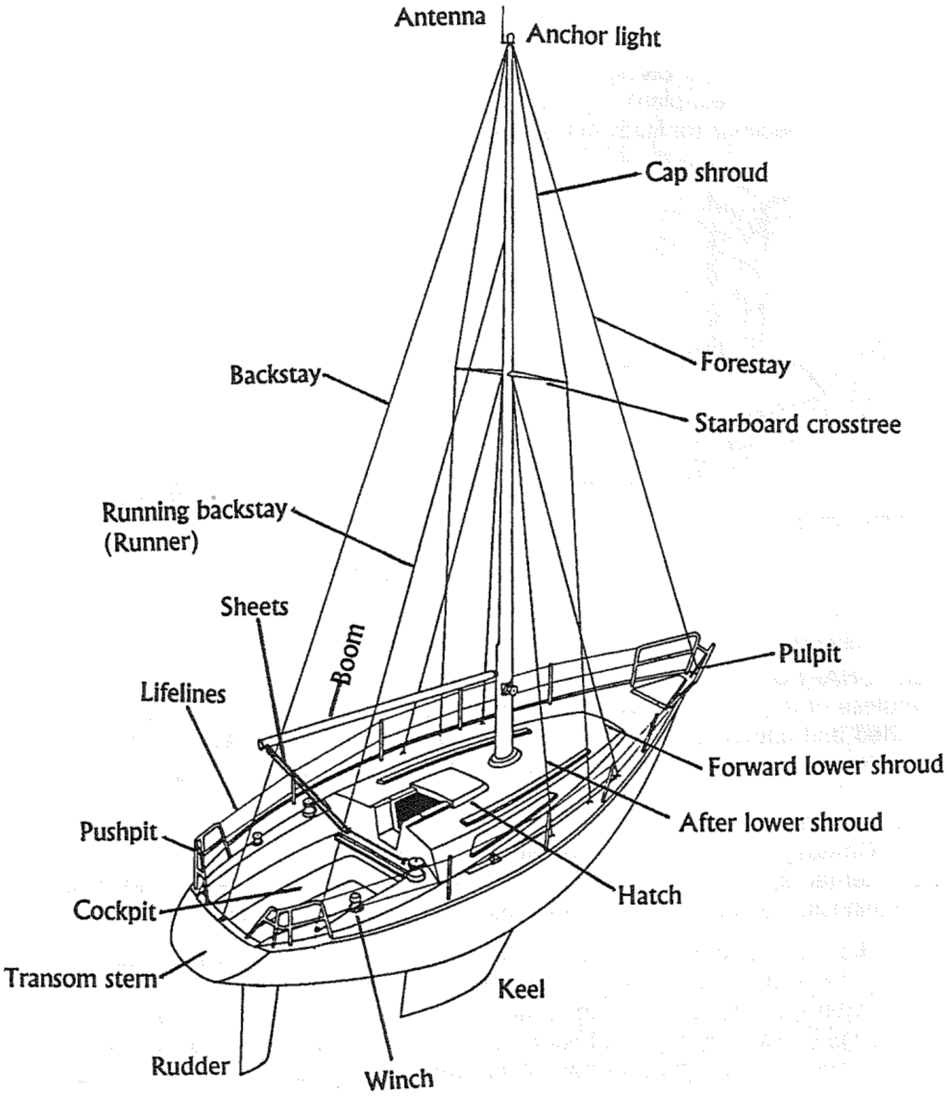








SAILING VESSEL: STANDING RIGGING & PARTS (Fig 3.14)



SAILING VESSEL: LAYOUT

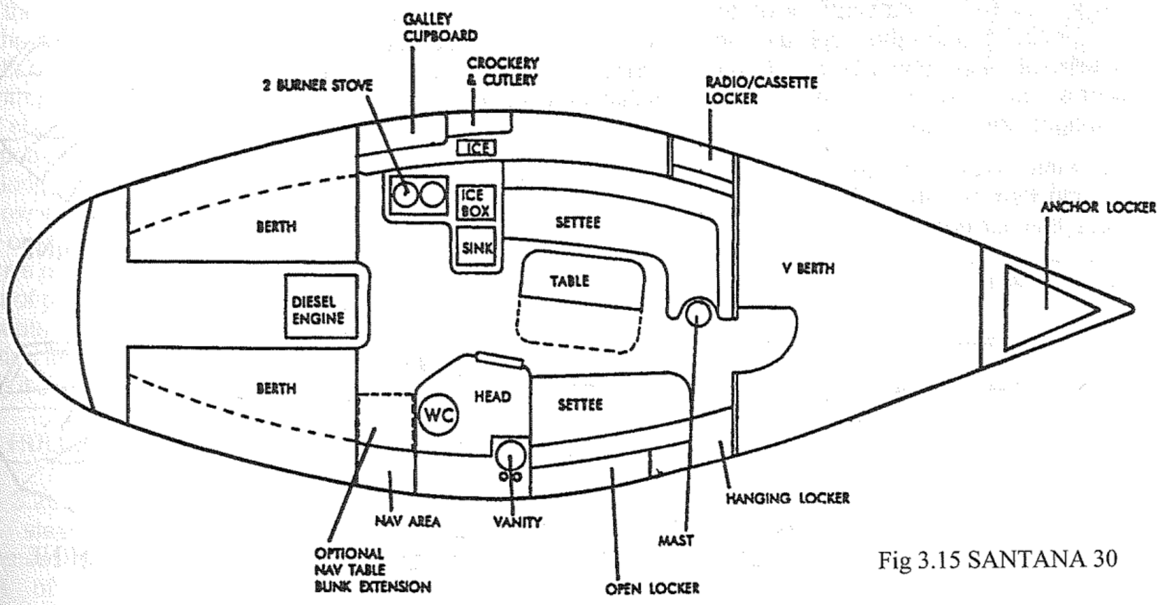
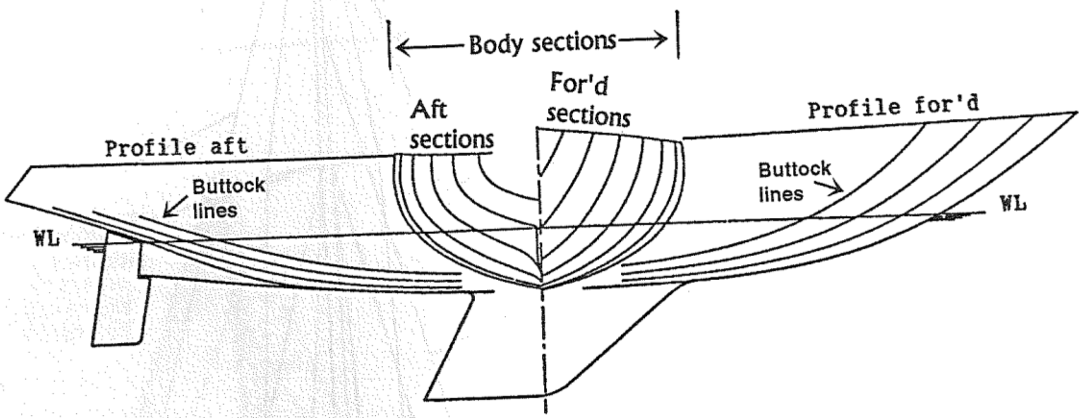


Fig 3.15 SANTANA 30

LINES PLAN (Fig 3.16)

This is a scale drawing showing the form of a vessel in two (or three) planes of reference:

- Profile (or sheer plan): It gives the general outline of a boat, and her buttock lines and the designed waterline.
- Body Sections (or Body plan): It is the end elevation of a boat showing the above information.



HULL - SHAPES

Regardless of the shape and material used in hull construction, their layouts are similar. A hull is a watertight shell supported and obtaining its strength from a series of internal stiffeners, usually in the form of frames (ribs). The hull may be transversely framed (frames running from side to side) or longitudinally framed (frames running fore and aft).

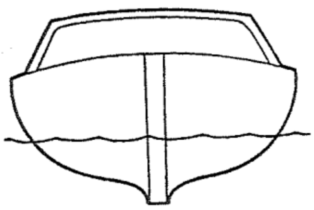
HULLS –TYPES (Fig 3.17)

Cruising boats are designed with a round hull, which provides a softer ride, more internal space, efficient speed for a given engine power, and better seaworthiness. However, these hulls roll more than the other shapes.

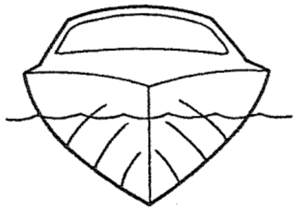
High-speed boats are fitted with a chine (or Vee shaped) hull for planing. A chine can be "soft" (topside meets the bottom in a curve) or "hard" (topside meets the bottom in compound curves or at angle). A Soft Chine usually gives a faster ride in rough weather, but it is not very roomy inside. A Hard Chine provides more internal space. It is designed to have less 'wetted' area but can be expensive to fabricate.

Hulls can be a combination of the above shapes: one type forward gradually changing to the other type aft. Other types of hulls include flat bottom, and multihulls such as catamaran and trimaran.DISPLACEMENT HULL: Whether underway or at rest, it achieves its buoyancy by displacing a volume of water equal to its own weight (light ship) and that of its load (deadweight).

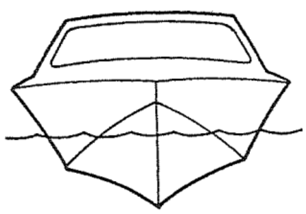
PLANING HULL: When underway, its load is mainly supported by a dynamic action between the underside of the hull and the surface of the water. When at rest, this hull reverts to displacement buoyancy.



ROUND BILGE



SOFT CHINE



HARD CHINE

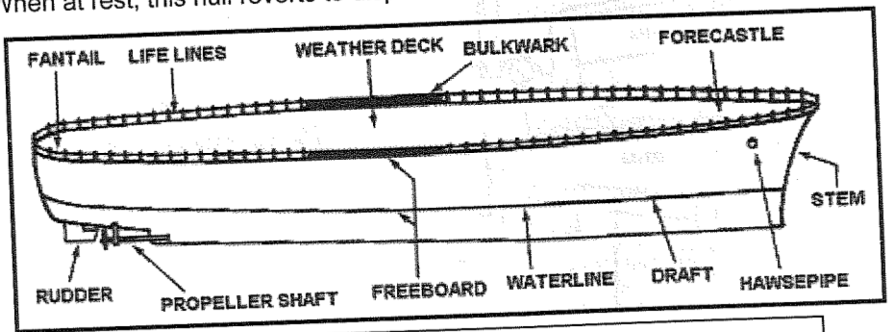


FIG 3.18 EXTERNAL PARTS OF A HULL *(Global Security)*

HULL - PARTS

The hull consists of a backbone (the keel), ribs (the frames) and skin (the shell plating). The keel runs from the stem to the sternpost. Fastened to the keel are the frames, running athwartship and giving the hull its shape and strength. Deck beams and bulkheads support the decks and give added strength to resist water pressure on the hull.

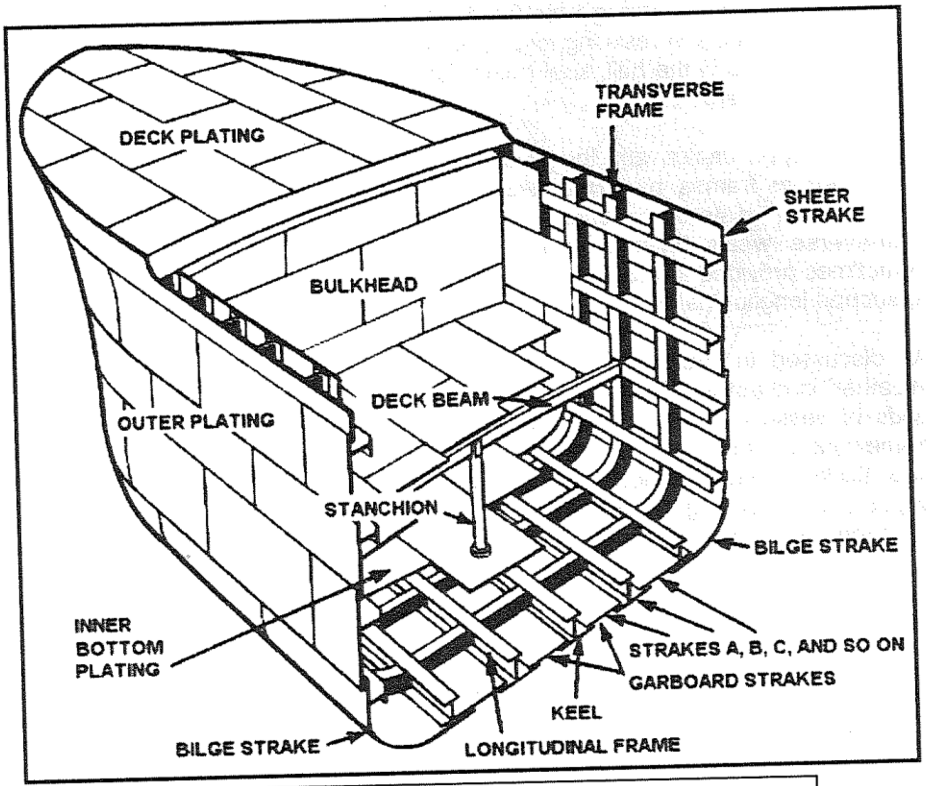
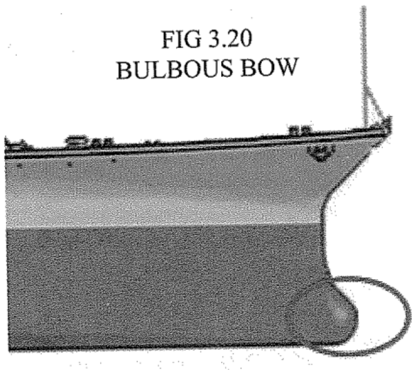


FIG 3.19 CONSTRUCTION OF A HULL (Global Security)

The shell plating provides watertightness and more strength. In a steel hull, the plates have different thickness at different parts of the hull. The heaviest plates are amidships. The others taper toward both ends of the ship and from the keel toward the bilge and from the bilge toward the upper deck. This method of construction reduces the weight of the material used and gives the vessel additional strength at her broadest section. These horizontal rows of plates are called **strakes**. They are lettered consecutively, starting with the bottom row (**garboard strake**) on each of the keel. The garboard strake on each side of the keel is strake 'A'. The strake at the turn of the hull (where ships bilges are) is the **bilge strake**. The strakes between the garboard and bilge strakes are called **bottom strakes** and the topmost strake on each side of the hull is **sheer strake**. The upper edge of the sheer strake is the **gunwale**.

FIG 3.20
BULBOUS BOW



BULBOUS BOW:

The water pushed aside by a displacement hull forms a wave starting near the bow. The length of this wave is proportional to the speed of the hull through the water - the faster the hull, the longer the bow wave. At some speed, the length of the bow wave increases to the point that it matches the length of the hull, and the hull starts to operate in the trough of the wave, with peaks (crests) near the bow and the stern. This speed is called the "hull speed" and it is approximately 1.34 times the square root of the waterline length of the hull. The purpose of bulbous bow, usually fitted only on long ships, is to change the nature of this bow wave to reduce the drag it induces on the hull The bulbous bow creates it's own wave that is farther forward and "out of phase" with the natural bow wave created by the hull, effectively subtracting from the normal bow wave and reducing it's drag-inducing effect.

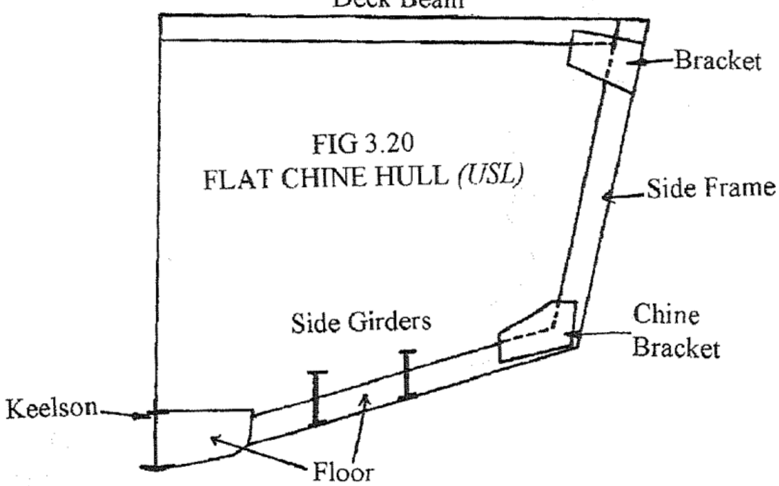


FIG 3.20
FLAT CHINE HULL *(USL)*

METAL HULLS

Figures 3.20 & 3.21 show typical sections through steel hulls. Note the stiffening arrangement of bottom shell plating. It consists of vertical plates. Transverse plates are called **floors** and longitudinal are

side girders. The **centre girder** fitted on the keel plate helps in resisting longitudinal bending stresses in the hull, keel being the backbone of vessel's hull.

Beams support **decks**, and the beams are connected to frames by **brackets**, which resist hull distortion during rolling. **Transverse webs** (built up frames) are sometimes provided for additional rigidity or to support longitudinal frames.

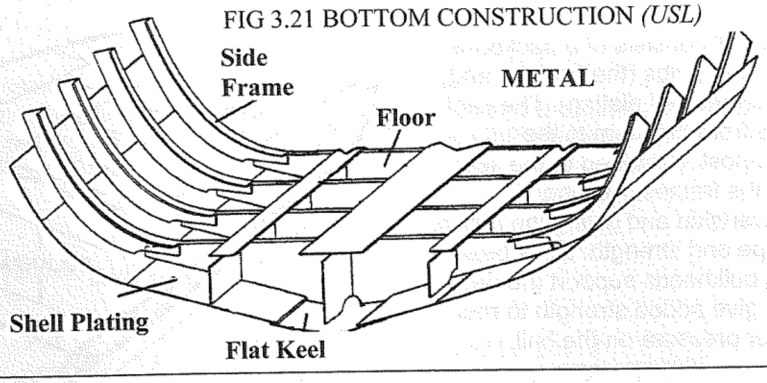


FIG 3.21 BOTTOM CONSTRUCTION *(USL)*

As discussed in 'Hull Stresses in Heavy Weather" in chapter 8, the forward and after ends of vessels are also strengthened with a framework of additional beams and stringers and thicker bottom plates to cope with the impact of pounding and panting and the vibrations and stresses caused by propellers and rudders.

TIMBER HULLS

Figures 3.22 to 3.24 show typical chine hulls, and figures 3.25 & 3.26 show typical round bilge hulls. You will notice that stress-resisting arrangement of various parts is similar to a metal hull. Major structural members running fore and aft such as the keel, **hog piece**, **stringers** and hull planking provide the longitudinal strength. **Floor timbers**, **gussets** and **hanging knees** that tie the whole structure together, maintain the shape of the transverse section.

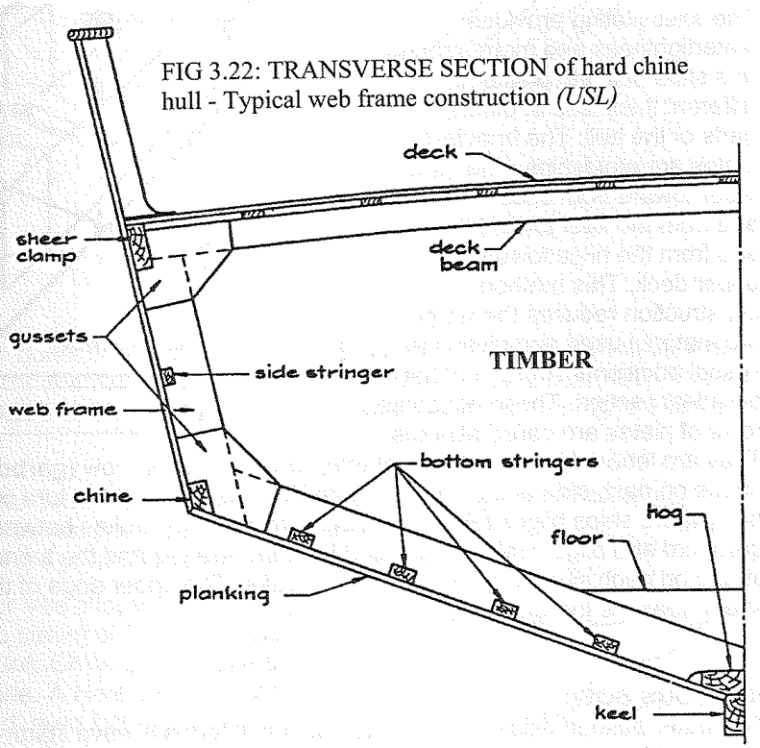


FIG 3.22: TRANSVERSE SECTION of hard chine hull - Typical web frame construction *(USL)*

Sheer clamp, Gusset, Web frame, Chine, Stringer, Floor, Hog, Deck beam,

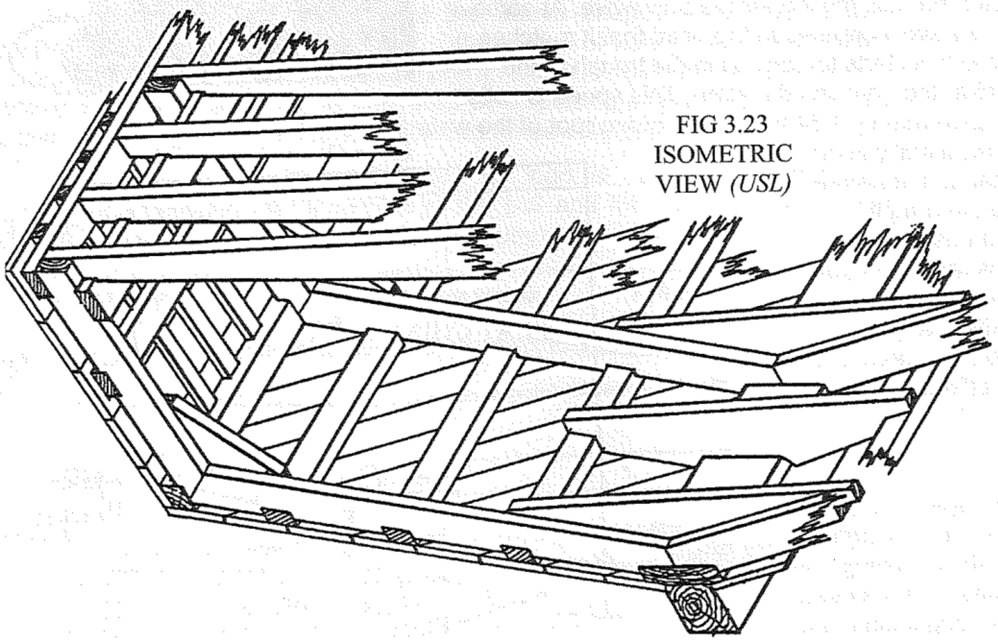


FIG 3.23 ISOMETRIC VIEW *(USL)*

TIMBER

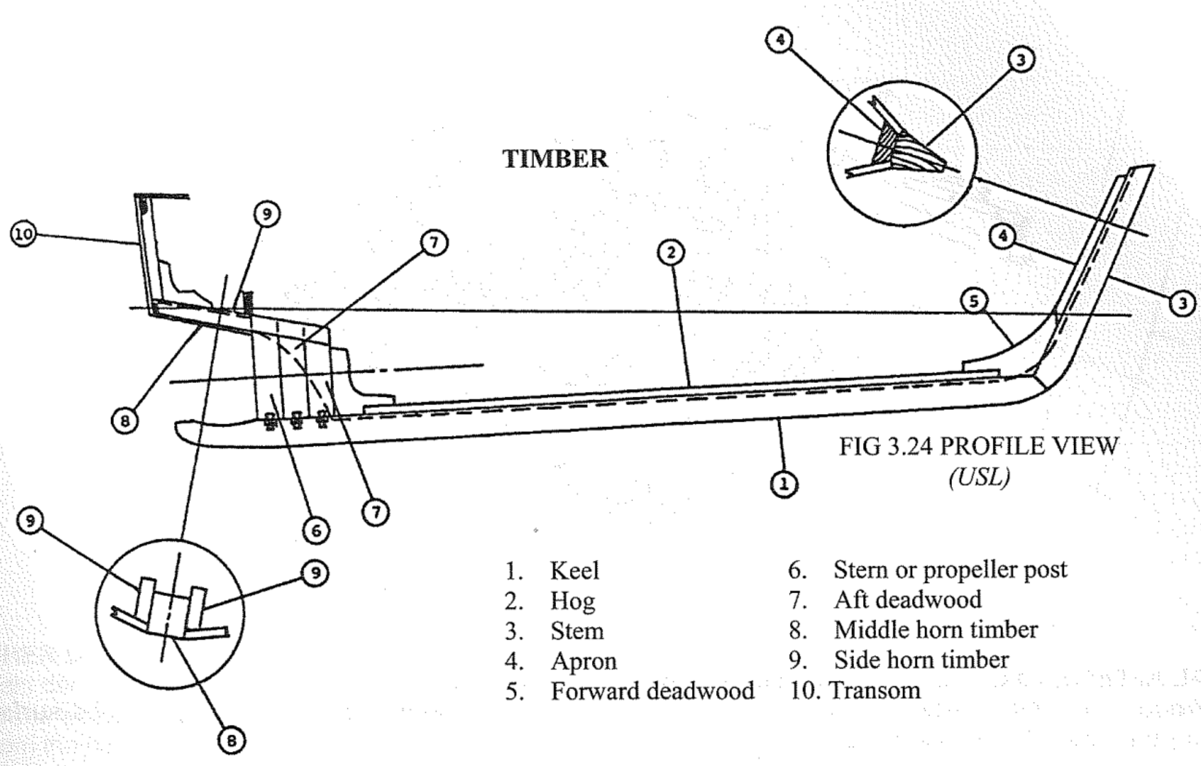


FIG 3.24 PROFILE VIEW
(USL)

1. Keel
2. Hog
3. Stem
4. Apron
5. Forward deadwood
6. Stern or propeller post
7. Aft deadwood
8. Middle horn timber
9. Side horn timber
10. Transom

TYPICAL SECTION OF A ROUND BILGE HULLS (FIG 3.25 & 3.26) *(USL)*

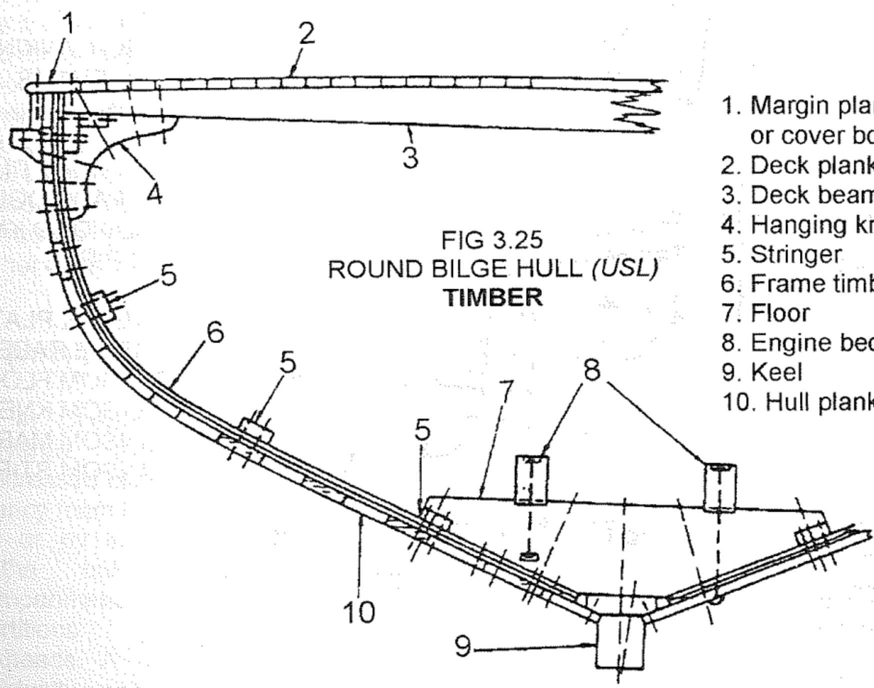


FIG 3.25
ROUND BILGE HULL *(USL)*
TIMBER

1. Margin plan
   or cover board
2. Deck planking
3. Deck beam
4. Hanging knee
5. Stringer
6. Frame timber
7. Floor
8. Engine bed
9. Keel
10. Hull planking

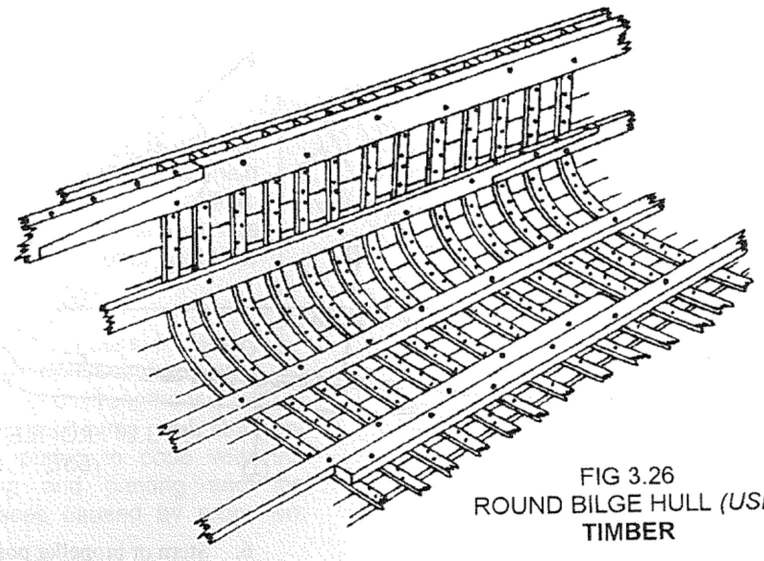
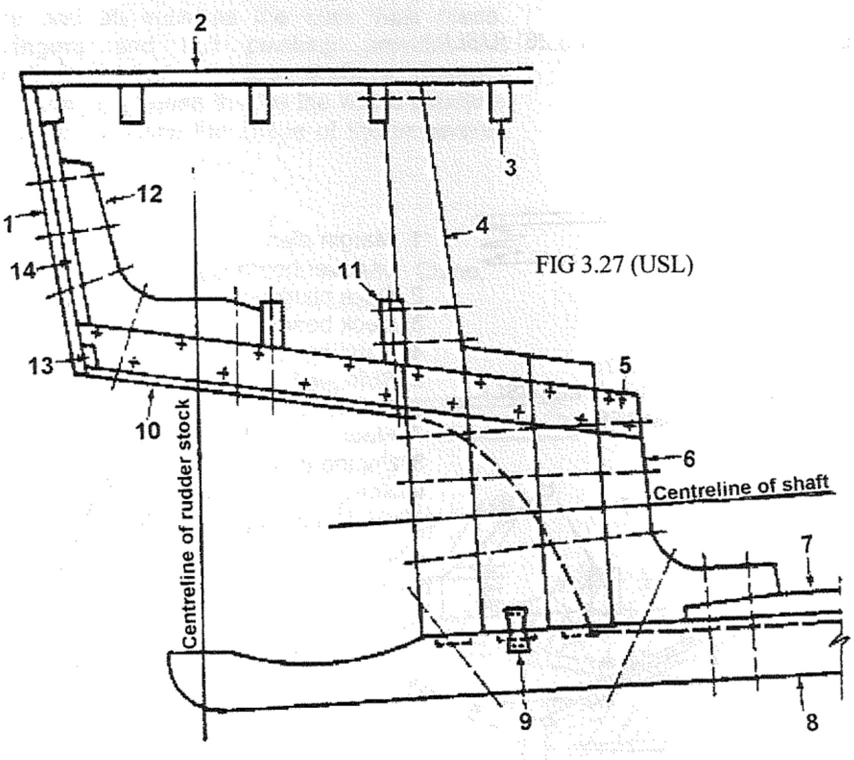


FIG 3.26
ROUND BILGE HULL *(USL)*
TIMBER

TYPICAL AFTER END OF TIMBER VESSEL (SHOWING DEADWOOD AFT) *(Fig 3.27) (USL)*
Dead Wood is the flat vertical timber used at each end of keel in some vessels to provide solid surface for fastening the bow and the sternpost.



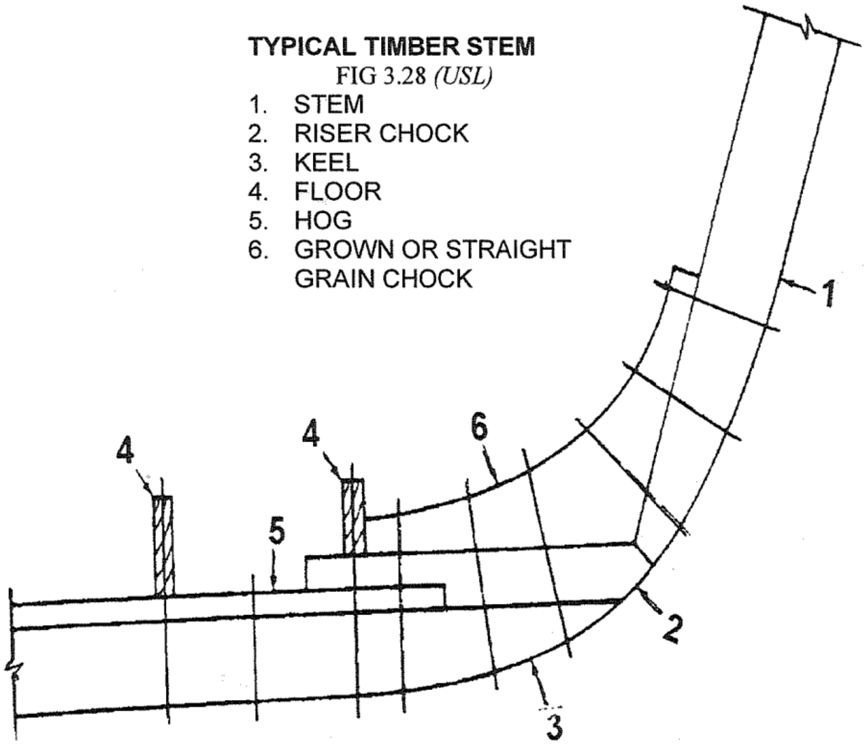
KEY TO AFT END (TIMBER HULL)

1. PLANKING
2. DECK PLANKING
3. DECK BEAMS
4. STERN OR PROPELLER POST
5. SIDE HORN TIMBER BOLTED TO DEADWOOD
6. DEADWOOD KNEE
7. HOG PIECE
8. KEEL
9. DOVETAIL PLATE
10. OUTSIDE RABBET LINE
11. TRANSOM FLOOR
12. TRANSOM KNEE
13. TRANSOM MARGIN
14. TRANSOM STIFFENER

TYPICAL TIMBER STEM

FIG 3.28 *(USL)*

1. STEM
2. RISER CHOCK
3. KEEL
4. FLOOR
5. HOG
6. GROWN OR STRAIGHT GRAIN CHOCK



WEATHER DECKS

The main deck is the first continuous watertight deck that runs from the bow to the stern. In many instances, the weather deck and the main deck may be one and the same. Any partial deck above the main deck is named according to its location on the ship. At the bow it is called a forecastle deck, amidships it is an upper deck, and at the stern it is called the poop deck. The term weather deck includes all parts of the forecastle, main, upper, and poop decks exposed to the weather. Any structure built above the weather deck is called superstructure.

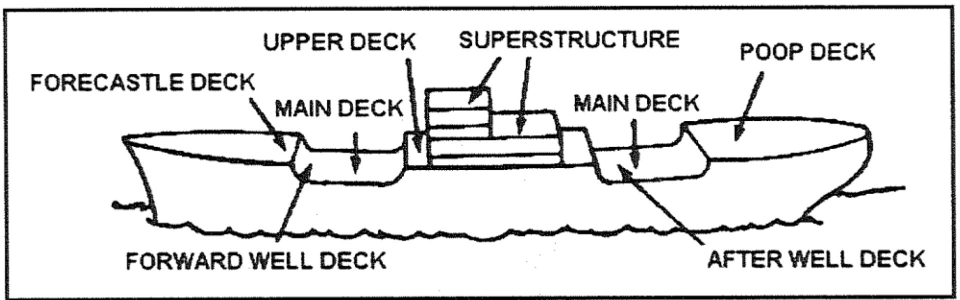


FIG 3.29 WEATHER DECKS (Global Security)

WATERTIGHT (W/T) BULKHEADS

As discussed in Chapter 13, vessel's buoyancy (reserve buoyancy) is increased either by installing buoyancy foam (in very small vessels) or by internally subdividing the hull into watertight compartments with vertical partitions called watertight bulkheads. A vessel can be made virtually unsinkable by dividing it into enough compartments with decks and bulkheads. But too many compartments would interfere with the installation of machinery

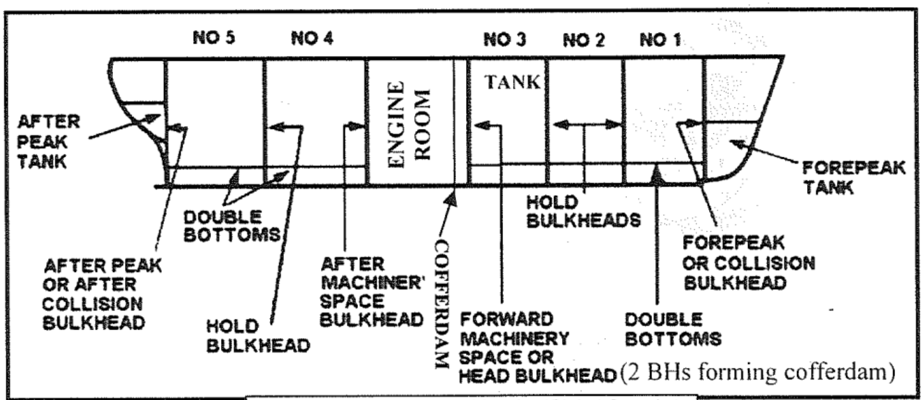


FIG 3.30 Bulkheads and Decks (Global Security)

and the operation of the ship. Engine rooms need to be large enough to accommodate bulky machinery and cargo spaces must be large enough to hold large equipment and containers. Therefore a set of rules is followed:

- In vessels of measured length 16 metres or more, a special watertight bulkhead called a ***Collision Bulkhead*** is fitted near the bow (See illustration).
- In vessels of measured length 12.5 metres or more, a watertight bulkhead is fitted at each end of the machinery space except where the machinery space is located at one end of the vessel. If the machinery space is located at the after end, it has the protection of the **after peak bulkhead.** It therefore requires only a bulkhead at the forward end. The after peak bulkhead is a collision bulkhead at the after end of the vessel.

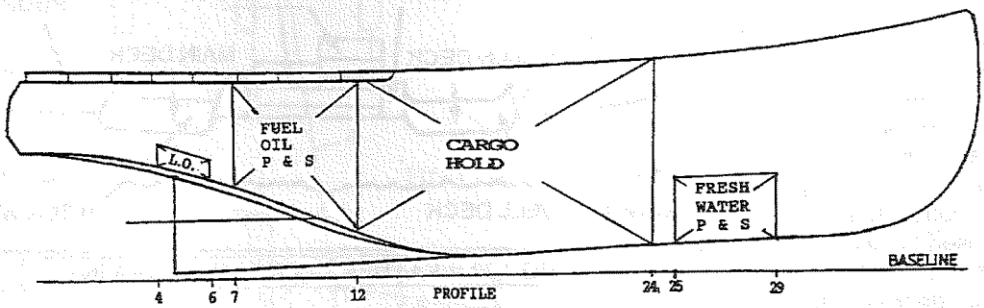
The additional number and placement of W/T bulkheads is determined by the measured length of the vessel such that the flooding of a single compartment would not sink a cargo vessel and the flooding of any two compartments would not sink a passenger vessel.

W/T bulkheads that divide the hull into tanks for carrying different types of liquids, or bulkheads separating a tank from a machinery space (engine room, pump room, etc), are constructed in pairs with void space between them, known as ***cofferdam*** *(see illustration)*. This is a precautionary measure so that leakage in one bulkhead does not contaminate different liquids or create a fire hazard in a machinery space. Tanks carrying the same liquid do not need to be separated by a cofferdam.

TANKS ARRANGEMENT

As illustrated above, ship's hull is split into tanks and compartments in order to store liquids carry cargoes and provide second skin (ranging from double bottom to double hull). Therefore many tanks, especially double bottom tanks, also provide watertight subdivision against flooding and fire.

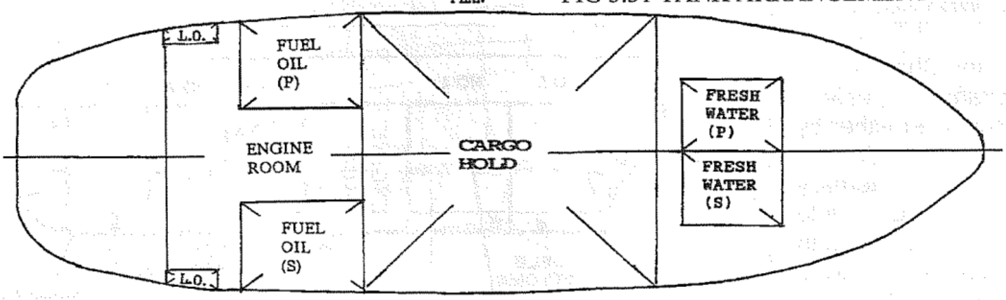
As also shown in MV Threesuch, each tank is nominated for specific storage of cargo, fuel, lube oil and fresh water. Tanks also might exist for sewage, ballast and oily bilge water. Some tanks are interconnected, while others are separated by a pumping system. In the case of MV Threesuch, the lube oil tank is between frames 4 & 6, fuel oil between frames 7 & 12, cargo hold between 12 & 24, and freshwater between 25 & 29. The frames are numbered aft to forward. In some vessels they are numbered forward to aft.



M.V. "THREESUCH" - LOCATION OF COMPARTMENTS - SCALE 1:100

PLAN

FIG 3.31 TANK ARRANGEMENT



WATERTIGHT INTEGRITY

A ship is a watertight container or storage compartment with its own means of propulsion. Its purpose is to load and carry cargo, whether the cargo is passengers, fish, or other commodities. Each type of ship is specialised for the trade in which it will operate. Ships are designed to ensure that water does not enter the hull and cause

progressive flooding. This characteristic of a vessel is called ***watertight integrity.***

The naval architect must design the vessel watertight, the shipbuilder must build her watertight, the surveyor ensures compliance with watertight regulations (by initial and periodic surveys) and the master must operate her in watertight state. The master must thus be thoroughly familiar with the locations and closing mechanisms of all openings, and not neglect to maintain, test and check their efficiency.

WATERTIGHTNESS

- **Margin line** or **margin of safety line** is a line drawn on shipside at least 3 inches or 75mm below the upper surface of the bulkhead deck. (**Bulkhead deck** is the uppermost deck to which watertight bulkheads are carried).
- In relation to fittings such as hatch covers, manhole covers and air pipes, located above the margin line, watertight means that the fitting is so constructed as to effectively resist the passage of water, except for slight seepage, when subjected to a hose test with water at a pressure of 210 kPa from a nozzle of 18 mm bore, or to an equivalent test.
- In relation to the structure of the vessel, watertight means being capable of preventing the passage of water through the structure in any direction under the head of water up to the margin line.
- Flooding is controlled by watertight bulkheads, watertight doors and vent pipe flaps.
- Watertight doors and openings should be marked on each side with bold permanent lettering "this door is to be kept closed and secured at sea"

Definitions

Watertight:

- The term watertight, when applied to an above-deck fitting, means that it is capable of resisting the passage of water under pressure, except for slight seepage.
- The term watertight, when applied to the structure of a vessel, means that it is capable of preventing the passage of water in any direction with the head of water up to the main deck (freeboard deck).

Weathertight means that the structure or fitting will prevent the passage of water through the structure or fitting in ordinary sea conditions.

In general, vessels are required to be watertight below the main deck (freeboard deck) and weathertight above the main deck. This means that the shell plating must be intact and the closures to all openings leading to the hull should be in efficient working order. No alterations should be done to any structure that would adversely affect the watertight integrity of the hull without the approval of the appropriate survey authority.

HULL WATERTIGHT INTEGRITY

In steel and aluminium hulls, watertightness is achieved by welding the shell plates to each other and to the frame. Sometimes the frame is built upside down and the shell plating is welded onto the inverted frame. The hull is then righted and the internal welds are completed. This procedure allows for a better weld and improved water tightness since all welds are 'downwelds'.

Fibreglass and Ferro-cement hulls and their deck/hull connections are continuous with no joints. They are therefore inherently watertight.

Timber vessels are not normally totally watertight but rely on seepage of water to swell the planking and thus make them watertight. Caulking and sealing compounds are also used to improve watertightness.

OPENINGS IN WATERTIGHT (W/T) BULKHEADS

In order to maintain the integrity of W/T bulkheads, any pipe passing through a bulkhead must be flanged to the hole cut in the bulkhead and not passed through it. The valve on the pipe shown in the illustration controls the filling of a tank on the other side of the bulkhead. This valve is operated from the main deck by way of a long spindle. The valve is sited outside the tank to minimise its corrosion and easier maintenance.

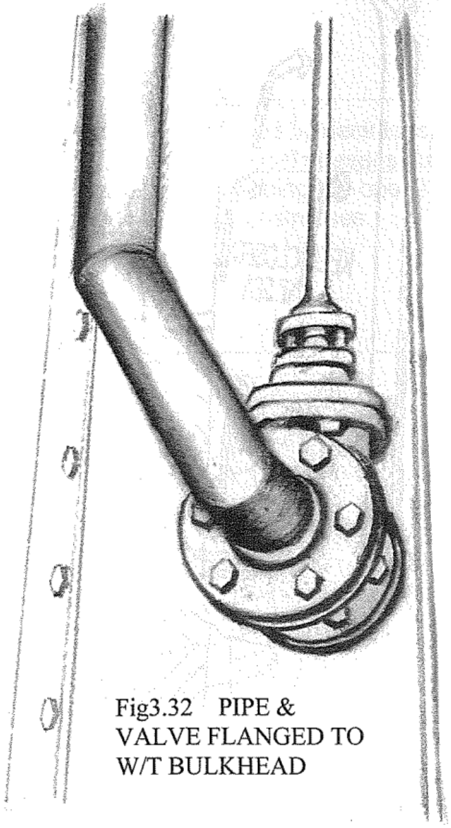


Fig3.32 PIPE & VALVE FLANGED TO W/T BULKHEAD

INTERNAL WATERTIGHT (W/T) DOORS

A door in a W/T bulkhead must also be a W/T door. It can be a sliding or hinged type door, and must be capable of operation from both sides of the bulkhead.

HULL AND DECK OPENINGS

VENTILATORS & AIR PIPES

Ventilators must be a minimum height above the deck and must have some means of making them watertight. This may be metal flaps, or in smaller vessels, wooden plugs and canvas covers. Air pipes, where exposed, should be of substantial construction and if the diameter of the bore exceeds 30mm then the pipe should be provided with means of closing watertight.

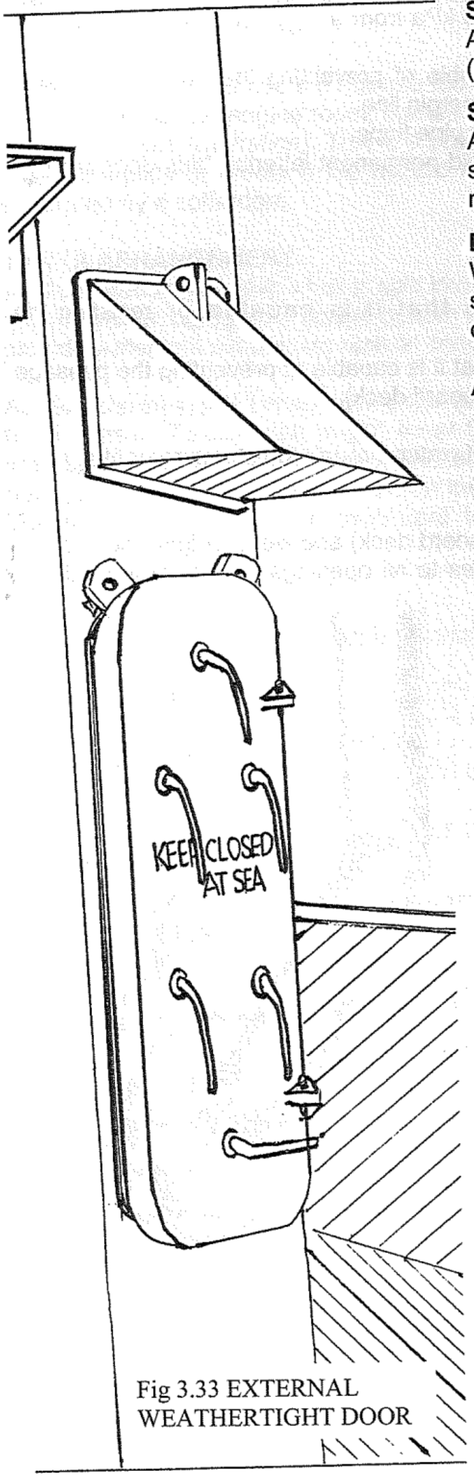


Fig 3.33 EXTERNAL WEATHERTIGHT DOOR

SIDE SCUTTLES (PORTHOLES)

All portholes below the main deck should have hinged metal covers (deadlights) that can be closed watertight.

SCUPPERS, SEA INLETS & DISCHARGES:

All sea inlets are to be fitted with valves of steel or material of equivalent strength attached direct to the hull or approved skin fittings (in case of non metal hulls).

DRAINAGE ARRANGEMENTS FROM WEATHER DECKS

Weather decks are to be provided with freeing ports, open rails or scuppers capable of rapidly clearing the deck of all water in all weather conditions.

ACCESS HATCHWAYS

- Hatchways must have a raised coaming to reduce the amount of water that could enter the ship should a wave wash over the deck while the hatch was opened. The height of the coaming varies according to the ship's length.
- Hatchways have rounded corners to reduce stress in the deck opening.

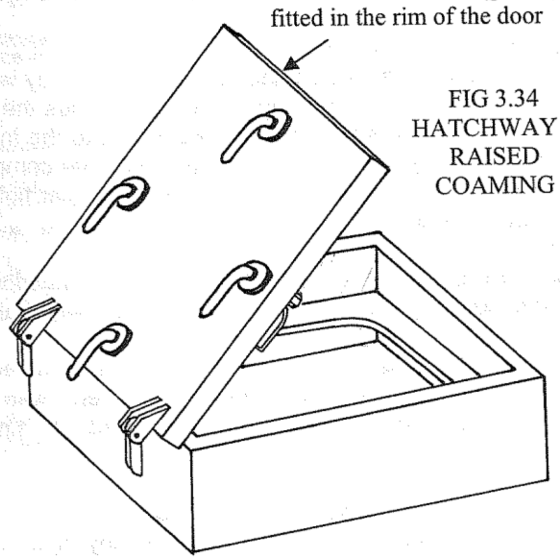


FIG 3.34 HATCHWAY – RAISED COAMING

EXTERNAL WEATHERTIGHT DOORS

Access doors from main deck to lower compartments must have sills, which serve the same purpose as hatchway coamings. The sill heights are the same as for hatch coamings. Access doors can be hinged and should be marked "THIS DOOR IS TO BE KEPT CLOSED AT SEA".

ACCESS OPENINGS & LOADING RAMPS IN THE HULL

Any openings, loading hatchways or ramps fitted in the side or bow and stern of the hull must be bolted and secured while at sea. An alarm system is fitted at these doors to automatically sound on the bridge if the door is opened.

MAINTENANCE OF WATERTIGHT INTEGRITY

- Do not leave hatches, doors and vents open;
- Do not block freeing ports and scuppers. Check that freeing ports are in a satisfactory condition, e.g., shutters are not jammed, and hinges are free and the pins are of non-corroding material, and the securing appliances, if fitted, work correctly.
- Look out for cracks in welds in metal vessels and loss of caulking in timber vessels.
- Maintain all access openings to enclosed structures. Check manholes and flush scuttles for capability of being made watertight;
- Check all cargo hatches and access to holds for weathertightness;
- Ensure that all air pipes, with a diameter exceeding 30mm bore, are provided with permanently attached closing device;
- Check that all ventilator openings are provided with efficient weathertight closing devices;
- Regularly inspect all machinery space openings on exposed decks;
- Maintain door clips, clamps, screw threads and hinges free and well greased.
- Maintain gaskets and watertight seals crack-free. Never paint seals.
- Ensure that W/T doors open from both sides.
- Guard against collisions, groundings and heavy weather;
- Ensure good operating condition of all non-return valves on overboard discharges;

HOSE TEST & CHALK TEST OF DOOR SEALS

The efficiency of closures can be tested with a simple "hose test" or "chalk test".

Hose test: With the door closed and secured as you would at sea, direct a jet of water at the joint between the door and the opening, and check for leaks on the other side of the door.

Chalk test: With the door open, heavily chalk the rim of the opening. Close and secure the door, then open it again. The gasket (seal) in the rim of the door should show a continuous chalk mark as result of coming into contact with the rim.

If the door fails any of these tests, it is usually the seal that needs replacing.

HULL STRESSES

In addition to the dynamic stresses caused by heavy weather (chapter 8), localised stresses caused by deck loading and point loading (chapter 13), vibration stresses of engines (chapter 25), vessels are subject to local stresses such as openings in the hull (lack of continuity of hull) and localised loads of deck machinery. Strengthening the openings with doublers and fitting doublers under the anchor winch and cargo winches compensate for local stresses.

SAILS: TYPES & PARTS

(Head (of a sail), Foot (of a sail), Tack (of a sail), Leech (of a sail), Roach (of a sail), Battens (of a sail))

A boat may carry many sails of different sizes and cloth weights to suit different conditions of wind and points of sail. A mizzen sail on the aft mast may also be carried.

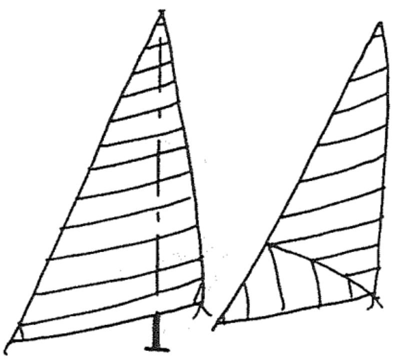


Fig 3.35 GENOA & JIB

MAINSAIL: The largest sail carried on the after side of the main mast. In very strong winds, the mainsail is either shortened by reefing (tying its bottom) or replaced with a *TRYSAIL* – so named to represent the sail set in trying conditions. Trysail is a small very strong loose-footed sail attached to the mast along the luff but not to the boom.

HEADSAIL: Any sail that is set forward of the main mast.

FORESAIL: Any sail set forward of the main mast except a spinnaker. A foresail on the forestay is a *GENOA* if it overlaps the mast and a *JIB* if it doesn't. A foresail set on a stay inside the forestay is a *STAYSAIL*, and a vessel carrying a foresail on the forestay and a staysail is said to be *CUTTER-RIGGED*.

A boat carries more than one foresail of different sizes and clothweight. She uses only one at a time to suit different conditions of wind and how close she can sail to it. For example:

- *GENOA* is the largest headsail, but made of the lightest material to catch the slightest breeze.
- *WORKING JIB* (referred to as *NO. 1 JIB*) & *HEAVY WEATHER JIB* (*NO. 2 JIB*) are in between the genoa and storm jib.
- *STORM JIB* is the smallest, and made of a heaviest cloth to withstand storm winds.

MIZZEN: The triangular sail hoisted on the after side of the aftermost (mizzen) mast.

SPINNAKER: A racing sail for downwind work. It is made of lightweight nylon or mylar, which is cut very full and sets on the opposite side of the boat from the main. Large boats carry several spinnakers of different weights of materials for use in different conditions.

BLOOPER: Offshore racing sail near the size of a spinnaker, but set on the opposite side and without a pole.

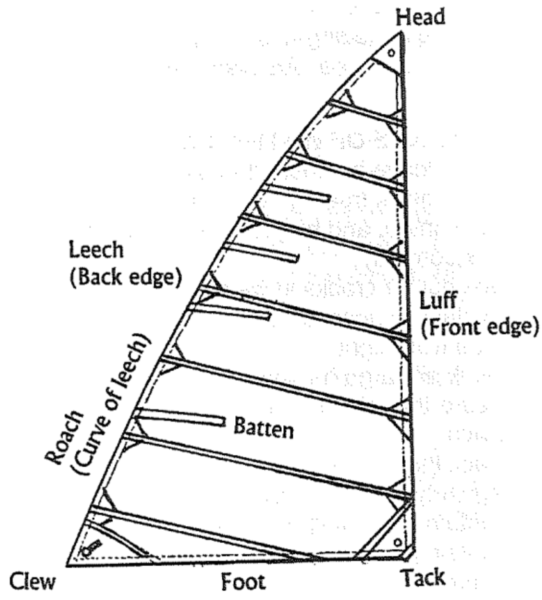


Fig 3.36: PARTS OF SAILS

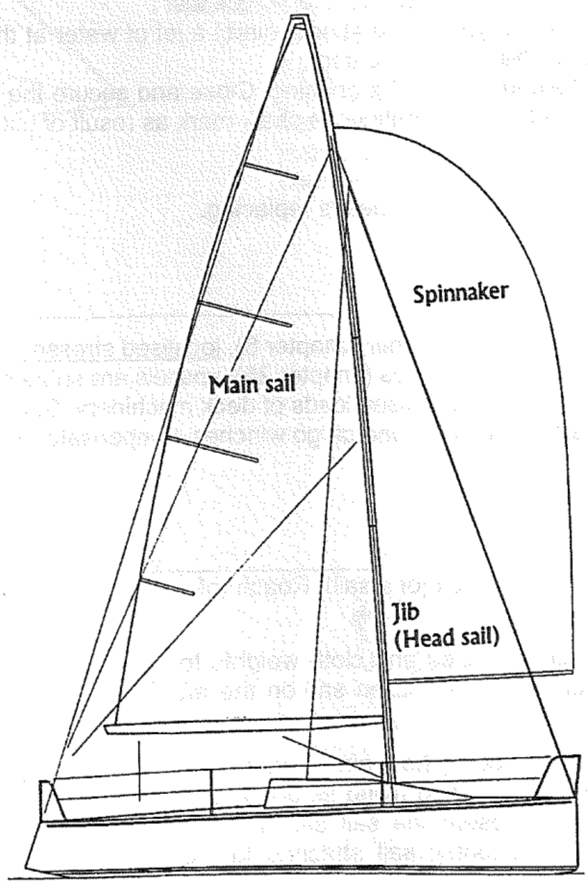


Fig 3.37: TYPES OF SAILS

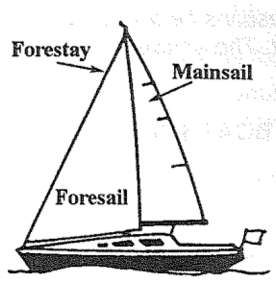
SAILING RIGS – TYPES (Fig 3.38)

BERMUDIAN RIG: A yacht with triangular mainsail and foresail. This is the modern rig.

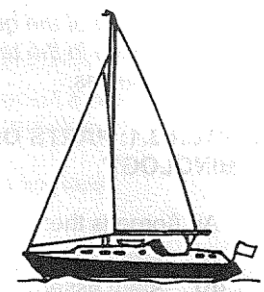
SLOOP: A single masted yacht with a forestay. Most yachts are sloops.

MASTHEAD SLOOP: The forestay extends to the top of the mast.

FRACTIONAL SLOOP: The forestay extends only part of the way up the mast. The most common fractional rig is three-quarter, where the forestay is attached three quarters of the way up the mast.

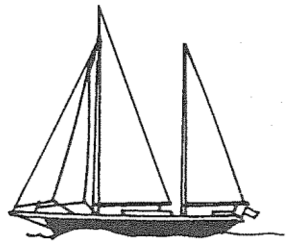


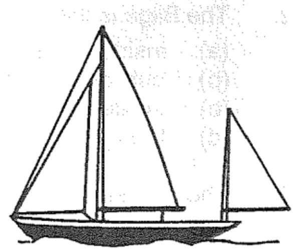
Masthead Sloop


Fraction Rig Sloop

KETCH: A yacht with two masts, where the main mast is higher than the mizzen mast, and the latter is stepped forward of the rudder post.

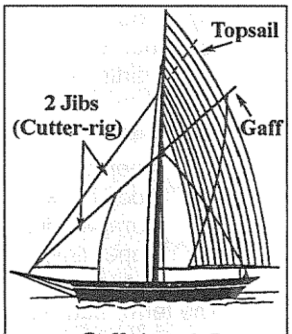
YAWL: A yacht with two masts, where the main mast is much higher than the mizzen mast, and the latter is stepped abaft the rudder post.


Ketch
(Main mast higher than Mizzen mast)

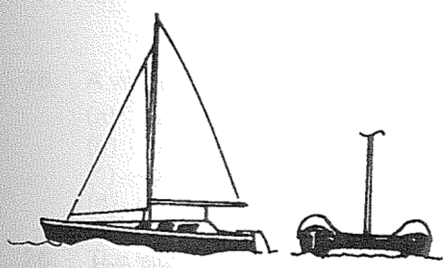

Yawl
(Main mast much higher than Mizzen mast. The latter stepped abaft the rudder post)

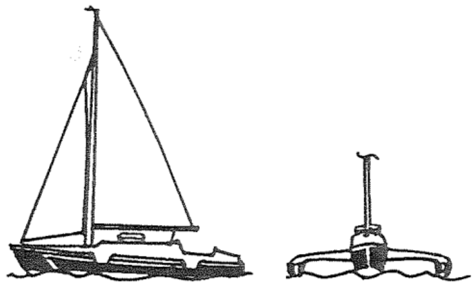
GAFF-RIGGED: A yacht with 4-sided mainsail. Gaff is the pole to which the top side of the sail is attached. If the spar is pulled almost vertical, instead of at an angle of about 30°, it is referred to as the GUNTER-RIG. A yacht may be a GAFF SLOOP, GAFF KETCH or GAFF YAWL.

CUTTER: A yacht with two jibs (foresails).

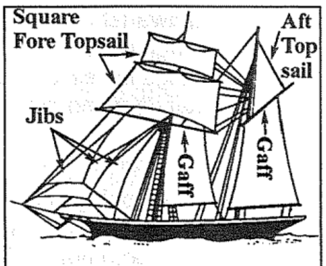


Gaff-rigged Cutter with Topsail


Catamaran


Trimaran

CATAMARAN: A vessel with two hulls.
TRIMARAN: A vessel with three hulls
SCHOONER: A fore-and-aft rigged vessel with two or more masts. When carrying a square fore-topsail, she may be referred to as square-rigged.
FORE-AND-AFT RIG: The sails hang in the same line as the keel.
SQUARE-RIG: The sails hang athwartship (Square sails set across the mast).



Topsail Schooner