5. DECK MACHINERY AND CARGO EQUIPMENT

5.1. Introduction to most common deck machinery and cargo equipment installed onboard

5.1.1. General design considerations

Broadly defined, hull machinery includes all the power-driven equipment located outside the machinery spaces that is not associated with the main propulsion plant. Included as hull machinery are such items as steering gears, anchor windlasses, all types of winches, cranes, capstans, elevators, cargo access equipment, thrusters, special rudders, and stabilizers.

a) Types of power transmission drives

There are, for most of practical purposes, only three types of drives for hull machinery:

a.1) Electric;

a.2) Electro-hydraulic;

a.3) Steam (seldom installed onboard).

Occasionally, other types of drives, such as diesel engines and manual, can be found onboard.

Steam-driven units are specifically installed aboard steam-powered tankers, and because they do not spark, they are sometimes used in the vicinity of hazardous cargoes.

Electric power is commonly used aboard as power transmission drives. Alternating Current (AC) has now all but replaced Direct Current (DC) as the standard supply for deck machinery installations. Since nowadays the use of AC also permits an accurate control and variation of the electric motor speed. The use of solid-state controllers for infinitely variable speed control has resulted in a more extensive use of a single-speed squirrel-cage motors for marine deck machinery.

b) Design Details

One of the obvious points to be considered in the design of hull machinery is that it is necessary to design for the pitch, roll, trim, and list of the vessel. All machinery should be designed for at least the following conditions:

Tab. 5.1 – Design conditions of hull machinery.

Ship motion or attitude	**Limit**
Pitch (bow up to bow down)	10º
Permanent trim (either the bow or stern)	5º
Roll (each side)	30º
Permanent list (each side)	15º

Note that no two of these conditions are considered to occur simultaneously. In addition to that, if the equipment is not used at sea under storm conditions (e.g. mooring and accommodation ladder winches), the design conditions listed in Table 5.1 apply only when the equipment is in the stowed condition.

In many cases, a common bedplate for the driving and driven equipment is preferable, in order that alignment may be more easily maintained. For heavily loaded deck machinery and for equipment with large "footprint", however, it is preferable to arrange the foundations (seats) to directly transfer the forces into the hull structure.

Motors or gearboxes exposed to the weather should be provided with watertight housing, while those located below deck or out of the weather may be provided with either totally enclosed fan-cooled or drip proof protected housing.

Rotating machinery should be aligned with the axis of rotation longitudinal to the vessel. This avoids high bearing loads, which would be experienced during ship's roll if mounted transversally.

When hydraulic fluids are used aboard as power transmission drives, an Hydraulic Power Unit (HPU) is usually installed that supply hydraulic fluid to a system of multiple loads or a group of electro-pumps each of these feeding a single load.

In general, all the hull machinery and deck equipment should be robust and designed to support heavy loads, which sometimes also might be rapidly varying (intermittent). These equipments comprise transmission gears, support bearings, wildcats, breaks and clutches, and flexible couplings subjected to traction forces. Provisions must be taken to assure alignment and adequate support of all these equipments.

The wear rating of gearing for hull machinery can be increased because of its intermittent usage. The range of wear load service factors that may be considered, that is, the factors by which the nominal gear working loads can be multiplied by to arrive at the design wear loads, is given in Table 5.2.

Tab. 5.2 – Wear load service factor for gears.

Equipment	**Factor**
Capstans	0.35-0.5
Crane machinery	0.7-1.0
Winches, cargo	0.7
, mooring	1.0
, other	0.35-1.0
Windlasses	0.35-0.5

Where flexible couplings are used, as between motors and pumps, they should be of the all-metal type, preferably steel.

All fasteners exposed to weather up to and including 12 [mm] diameter should be of nonferreous material, preferably all steel. Larger fasteners may be cadmium plated or galvanized steel. Breathers and drain check valves should be of nonferreous material or stainless steel. Dowels and taper pins should be of stainless steel. Aluminum should not be used for watertight enclosures.

The rope contact surface of capstan, warping, and windlass heads should be hardened to a depth of at least 1.6 [mm] to a minimum of 300 [BHN] to provide an abrasion-resistant surface.

The main rams for steering gears are hydraulic cylinder rods, but because they are invariably located below deck and out of the weather, they need no surface protection other than that provided by the hydraulic oil that adheres to them as they move in and out of the cylinders. All other cylinder rods, including those located in cargo holds where dust may be present, should be plated. The outer layer of plating should be of chromium because of its fine finishing.

A large number of deck machinery equipments (such as capstans, windlasses, and mooring winches) have mechanical breaks installed. Brake linings should be of incombustible, non-asbestos material that is not adversely affected by heat, salt atmosphere, or moisture. In the past, asbestos was the most commonly used brake lining material, but for health reasons regulatory agencies in several countries no longer allow its use. Apart from mechanical breaks, electro-magnetic breaks of the disc type and remotely actuated by means of solenoid control valves are also used. These are usually designed for loads corresponding to 200% the nominal working loads, and operation tests should be conducted to confirm these limits.

Depending on the type of application (load), there are two different types of load control systems: constant-flow and constant-pressure hydraulic system. As mentioned before, a constant-flow hydraulic system has a fixed-delivery pump, and is well adapted for a single load application. On the other hand, the constant-pressure hydraulic system uses a HPU which includes one or more variable-delivery pressure-compensated pumps that supply hydraulic fluid at a substantially constant pressure to either a system of multiple loads or to a single load.

Finally, stress analyses should be made during the design of all hull machinery. These should include calculation for gearing, bearings, shafting, structural components, foundation bolts, etc. For merchant vessels, the normal-duty stresses should not exceed 40% of yield point of the material and maximum stresses should not exceed 75% of the yield point; however, other design criteria regarding stresses may be required by the approval authority.

Where automatic or oil-bath lubrication is not furnished, pressure gun grease lubrication should be supplied.

5.1.2. Distinction between hull equipment and deck machinery

As previously mentioned, hull machinery includes all the power-driven equipment located outside the machinery spaces that is not associated with the main propulsion plant. However, this group can be further sub-divided into two other specific sub-groups:

c.1) Deck machinery:

  c.1.1.) Hoisting anchor;

  c.1.2) Mooring;

c.1.3) Cargo handling;

c.1.4) Cargo-hold handling;

c.1.5) Hatchcovers actuators.

c.2) Hull equipment:

c.2.1) Rescue boats;

c.2.2) Liferafts;

c.2.3) Emergency and distress;

c.2.4) Watertight doors;

c.2.5) Roll stabilization;

c.2.6) Bow thrusters, etc.

5.2. Anchor Windlasses

5.2.1 Introduction

The ship specifications usually require that a windlass be capable of hoisting the anchor at an average speed of not less than 5 to 6 fathoms per minute (1 fathom = 6 feet) from a depth of 30, 60 or more fathoms. The required chain pull thus is dependent not only on the weight of the anchor (see Figure 5.2), but also on the weight of the chain (see Figure 5.1) to the specified depth, with an appropriate deduction for the water buoyancy effect.

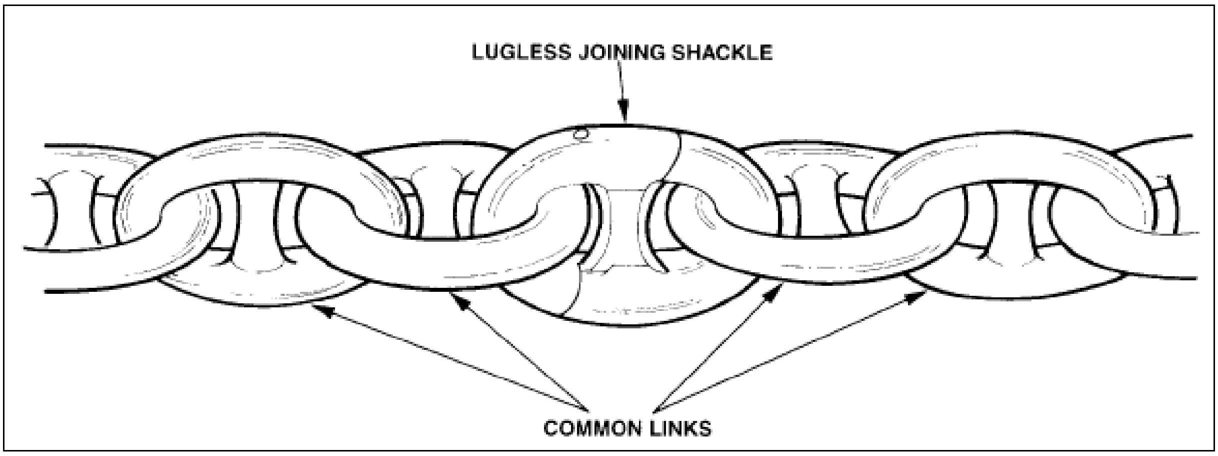

Fig. 5.1 – Schackles of a chain cable joined by a lugless joining shackle.

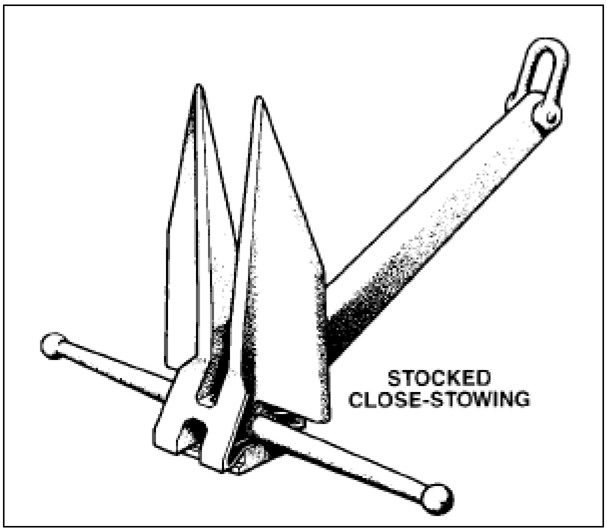

Fig. 5.2 – Danforth anchor.

Even though the windlass may be constructed as a sophisticated machine, it must be built to perform the crudest task on shipboard. The anchor chain is heaved in through a hawsepipe in which the friction loss averages from 35 to 40% in good designs, and sometimes exceeds 55%; however, a roller in the end of the hawsepipe can reduce friction to as little as 20%. The chain is engaged by a wildcat, which is hardly comparable in efficiency to the sprockets used in refined chain drives; the wildcat is usually made with five whelps (comparable to a 5-tooth sprocket), causing the chain to move with a jerkiness, which is aggravated by its tendency to turn over or “slap” in the hawsepipe and to slip on the wildcat. Windlasses, therefore, require more ruggedness of construction than any other machine on board ship.

The rules of the Classification Societies contain tables of required equipment consisting of anchors, chain cable, towlines, and hawsers. These items are identified by, and sized in accordance with an “equipment number” or “equipment tonnage” included in the tables. The number or tonnage figure is calculated by substituting in empirical formulas certain dimensional and displacement measurements of the vessel for which the equipment is desired. This has become standard mode of equipment selection for oceangoing merchant vessels.

The basic dimensions and scantlings of an anchor windlass depend on the anchor weight and chain size. These follow, therefore, from the equipment selection to suit a given case.

The size of the vessel, the nature of the service, and the desired anchor-handling and stowage arrangements are also contributive in the choice of the anchor windlass. In many cases, the windlass is used only in emergencies. However, in some cases the windlass may be used regularly (e.g., some operators set an anchor in a “flying moor”, approaching a dock, far enough offshore to warp the bow into the stream when preparing to get underway, thereby reducing or eliminating the need for a tugboat). Also, it is usual to install capstans or warping heads, driven by the windlass power plant, off the windlass gear train. The windlass may be used for normal warping duty. Combination windlass mooring wing/warping head systems have been supplied for large container, tanker, RORO, and passenger ships.

As with the other items of hull machinery, anchor windlasses are available from specialty manufacturers who can provide machinery to suit a variety of requirements. Their recommendations are very helpful in the ship design stage.

5.2.2 Windlass types

Two fundamental configurations of anchor windlasses have evolved from the “winding log” and capstan of earlier times, namely, the horizontal arrangement and the vertical arrangement. The horizontal windlass is a specialized winch that is powered by a hydraulic or electric motor. The motor is connected to a train of gearing that drives one or more chain sprockets, called “wildcats”, through sliding-block “locking heads” or comparable jaw clutches. Figure 5.3 is a schematic diagram of a horizontal electro-hydraulic windlass. A photograph of a horizontal windlass that is driven directly by an electric motor is shown in Figure 5.4.

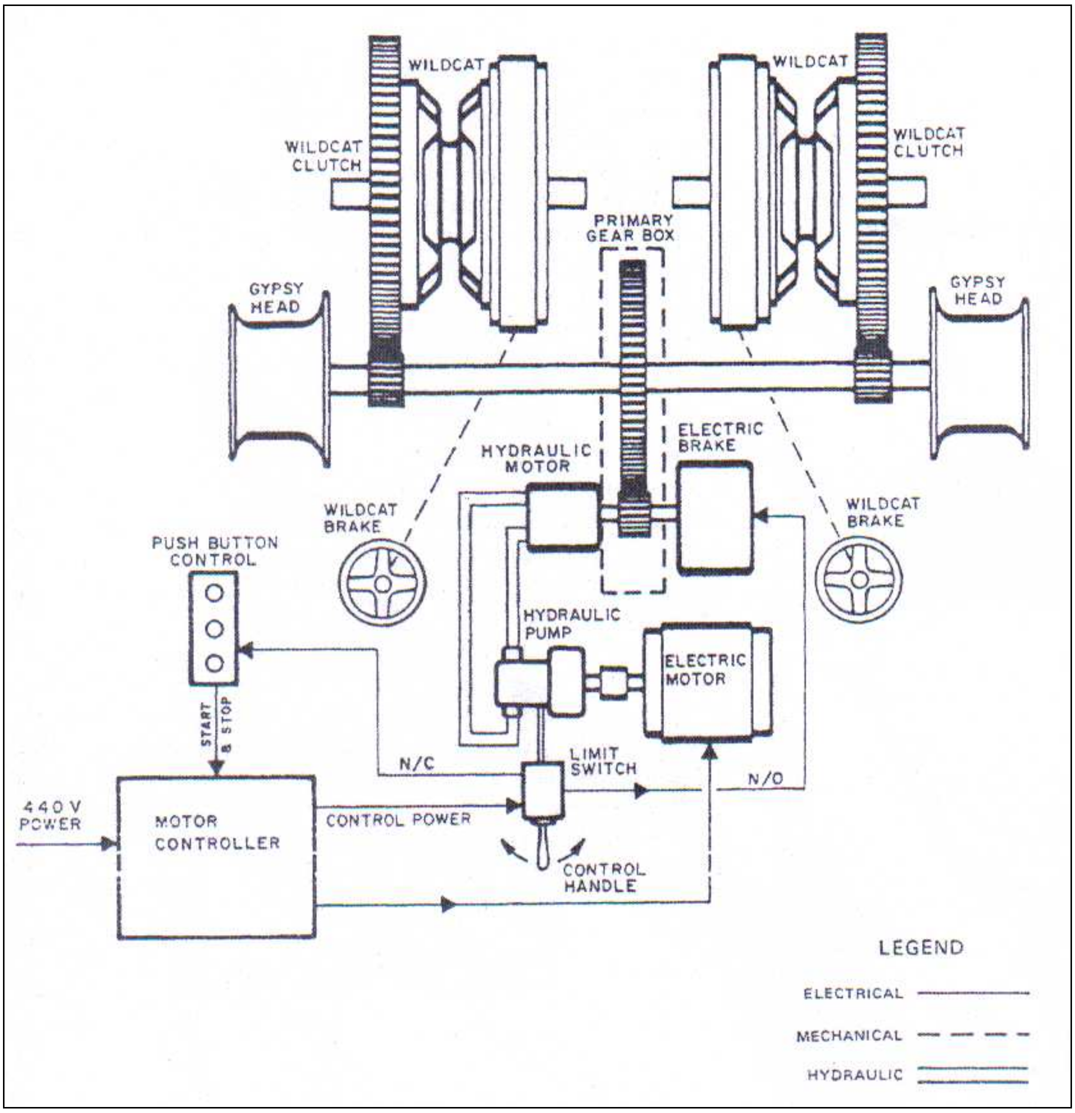

Fig. 5.3 – Schematic diagram of a horizontal electro-hydraulic windlass.

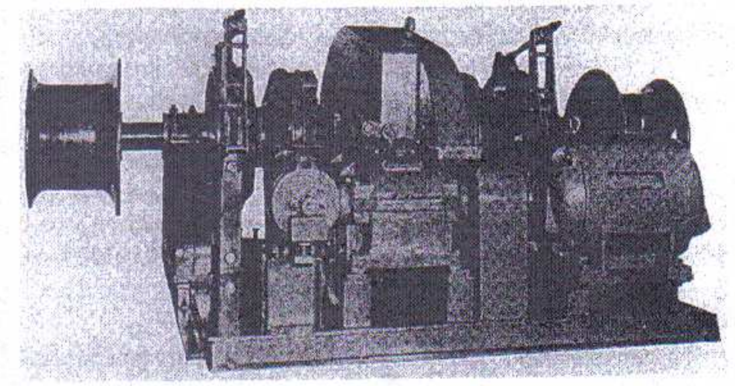

Fig. 5.4 – Horizontal-shaft, double-wildcat windlass driven by electric motor.

The specifications for cargo vessels often require the combination of a horizontal mooring winch with a clutched drum driving a chain wildcat through an auxiliary gear reduction and sliding pinion or jaw clutch. The chain lifting unit consists of a rigid framework holding an axle for support of the integral gearwheel wildcat brake rim and the pinion shaft with bearings. Although enclosed gears running in oil bath are preferable on deck from a maintenance point of view, an open gear protected by a guard is generally accepted on a chain lifting unit. The large gear teeth are not especially sensitive to corrosion, and the open gear allows transfer of the torque directly from the gear rim to the wildcat, which allows the design of a simple rigid chain lifting unit of moderate weight. An automatic grease lubricator for the gearwheel simplifies the operation and maintenance procedures. One or both pinion shafts ends are fitted with couplings for connection to mooring winches.

Each wildcat and mooring-winch rope drum, in the case of combination units, is provided with a brake of the band type. The wildcat brake is used to restrain the chain when the anchor is let go under controlled drop, for veering chain to the desired scope, and for holding the chain while the chain stoppers are being attached. One or more warpings heads are usually keyed to the winch drum or intermediate shafting. The gear train through which warping head is driven usually affords a line pull in the order of one quarter of the available wildcat chain pull, at four times the normal chain speed.

A self-contained horizontal type of windlass is the least expensive in terms of installed cost. However, it requires more maintenance than does the vertical type because the windlass machinery is completely exposed to the weather and to the spray and waves that break over the bow during storm conditions.

In the preliminary design stage of a vessel, it is good practice to develop the anchor-handling arrangement to the extent that the chain leads are confirmed to be satisfactory. In the case of ships with large bulbous bows, the anchors must be located farther aft or closer to the rail so that the anchor will not hit the bulb when they are dropped. This usually requires that two separate windlasses be provided with each set at an angle to the ship centerline in order to obtain proper leads to the hawsepipes. Figure 5.5 shows a forecastle without hawsepipes, and an anchor on deck arrangement. A well rounded fairing plate serves as a guide for the chain and anchor. The arrangement is integral with the deck structure and has a means for securing the anchor at sea and for holding the breaking load of the chain when anchored.

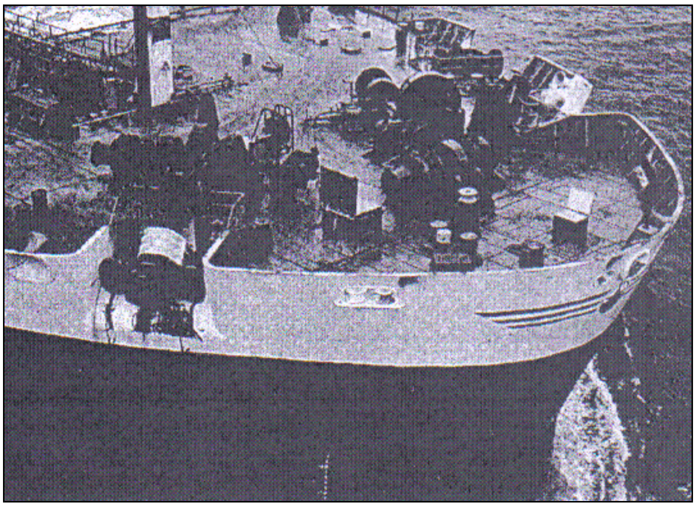

Fig. 5.5 – Forecastle with two combined mooring winch/windlass/fiber rope handling gear units; mooring drums are of the split type.

A vertical windlass consists essentially of a wildcat mounted on a vertical shaft that is carried in a rugged set of main bearings in a casting or weldment, which is bolted or welded to the deck, as typically illustrated by Figures 5.6 and 5.7. The strengthening of the deck and supporting ship structure in way of this assembly is usually made adequate to sustain all anticipated loads due to the chain pull, independently of the main shaft extension to the deck below.

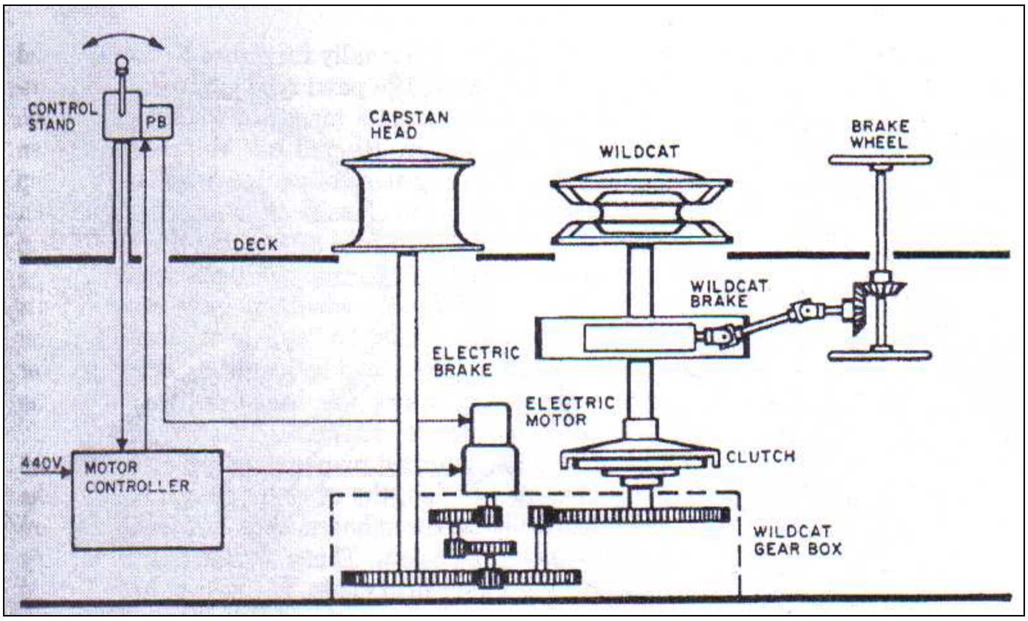

Fig. 5.6 – Schematic diagram of a electric driven vertical windlass.

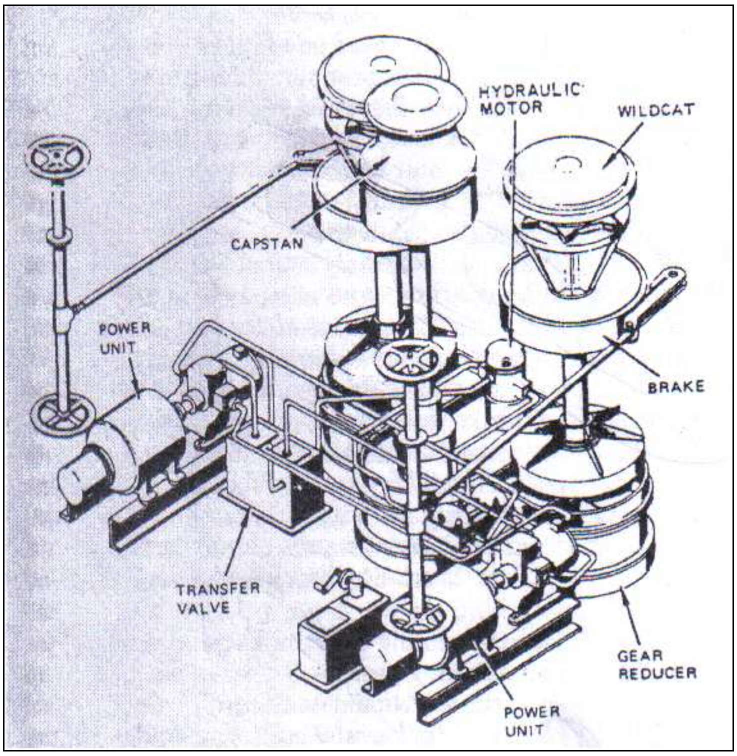

Fig. 5.7 – Vertical electro-hydraulic windlass.

The wildcat is brought as close to the deck as possible in order to minimize bending moments due to the chain pull. The chain is wrapped approximately 180º around the wildcat, and then enters a chain deckpipe leading to the chain locker.

The shafts from vertical wildcats and associated capstans are often extended from one or more decks below where they are coupled to main and intermediate shafts, respectively, of transmission gearing. Vertical windlasses with the gearbox and clutch supported under the deck on which the wildcat is mounted have been used on naval vessels. This arrangement minimizes the problem of relative deck deflection and simplifies the installation and alignment of the windlass as the wildcat, transmission, and brake band are supported from a common structure.

The gears in vertical windlasses are usually completely enclosed. The shaft couplings are of the type that allows limited relative vertical motions between the decks, if necessary. The preferred design locates the break drum and locking head (clutch) below the weather deck where they are protected from the weather.

For handling warping lines, a capstan head may be keyed to the main shaft, above the wildcat. However, unless there is a speed change in the gearing or hydraulic transmission, the light-line hauling rate may be unsatisfactory slow. Another arrangement is one in which a capstan is located adjacent to the wildcat and is driven from the windlass gear train by a separate shaft, which revolves about four times as fast as the wildcat; the equipment for such an arrangement is illustrated by Figure 5.6.

5.2.3 Design considerations

Detailed practices recommended for the design and testing of anchor windlasses can be obtained from the Classification Societies rules. There are, however, some basic design considerations that have a large effect on the performance of a windlass, and therefore will be briefly discussed in here.

The links of stud link anchor chains are almost invariably made with inside length equal to four times the nominal chain size (i.e., four times the "wire diameter"). Since 10 links will warp around a 5-whelp wildcat, the wildcat circumference = 10 x 4 x the nominal chain size. From this, the mean pitch radius of the wildcat is readily found.

Wildcats should be made of a reasonably hard grade of cast steel.

The fittings of wildcats and chains are important. Usually, the final dimensions of a chain are attained as a result of stretching in a proof test. A new chain may be within the minus allowance of the tolerances on length (measured over six links) in order to allow for stretching and wear in service. However, such a chain will not run properly on a wildcat made to fit the nominal chain size. The pitch diameter of the wildcat is a function of the depth of the pockets between the whelps, in which alternate links lie substantially flat. If the pitch circle is somewhat small, there will be large movements of the chain in the pockets. These movements will cause wearing of the chain and the wildcat.

The chain deckpipe, which leads to the chain locker, for a horizontal windlass should be located well under the wildcat. The vertical centerline of the deckpipe should project upward through the axis. The chain pipe lip must be flared to assure that the chain will be hauled into the locker by gravity.

Chain stoppers are normally furnished by windlass and chain manufacturers. The pawl type is favored in merchant practice as a means of securing the chain when riding at anchor. Hinged bar stoppers are often combined with chain guide rollers for installation on top of the hawsepipe. Some Classification Societies require a chain stopper which can hold 80% of the minimum chain breaking load without permanent deformation of the stressed parts, unless the windlass brake can hold this load.

Pelican hooks (see Figure 5.8), modified turnbuckles or devils' claws are used as stowing stoppers. These should align as closely as possible with the run of chain. The wildcat brake should not be used to hold the anchor in the stowed position, because if the brake should slip, the anchor will back out and pound in a seaway.

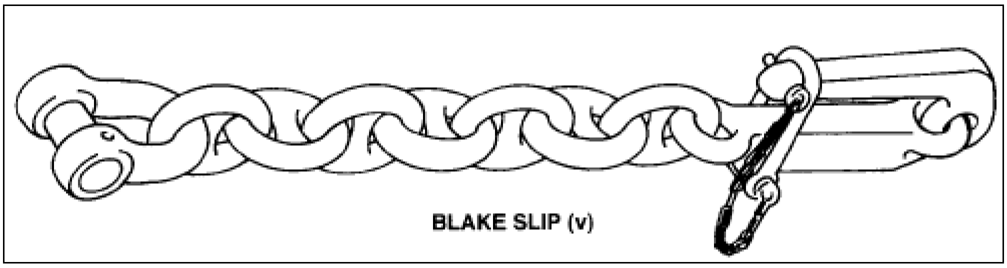

Fig. 5.8 – Cable chain stopper.

The wildcat band brake design and the selection and treatment of brake-lining material are critical in windlasses, which must be subjected to the free drop tests required by the regulatory bodies. Typical specifications stipulate a single drop from 45 to 60 fathoms, under control of brake. Anchor windlass brake tests must be conducted with the utmost respect for the magnitude of the masses, velocities, and forces involved. These tests can be extremely hazardous, especially in the event or a runaway. Test observers should stand well clear of the windlass, with only those responsible for operating the brake and recording data allowed to be near.

Anchor windlass brakes are usually of the lined band type. For maximum effectiveness, these brakes should warp around the drum as near as 360º as possible. The features of a typical band type break are shown in Figure 5.9. Auxiliary power-assist mechanisms for setting the brake have also been used to advantage on very large windlasses.

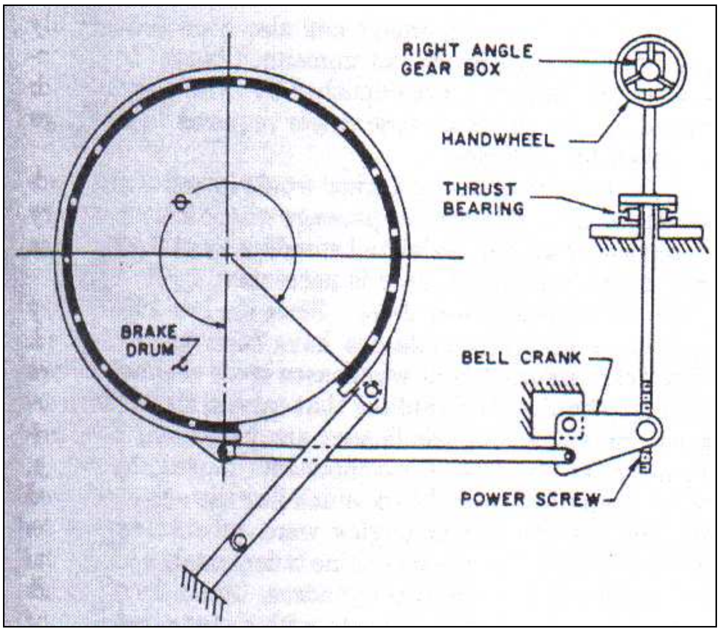

Fig. 5.9 – Schematic of band of anchor windlass brake.

5.2.4 Windlass power units

The two commonly used powering systems for windlasses are direct-connected electric motors and electro-hydraulic systems. Electro-hydraulic systems permit complete control over the hoisting speed and also provide protection (by relief-valve action) against shock loadings in the transmission shafting and gearing in the event that the anchor is inadvertently housed to abruptly.

When an electric motor is directly connected to the windlass, it may be either a squirrel-cage or wound-rotor AC motor or a DC motor. A DC motor provides sufficient speed-control to house the anchors safely. If a squirrel-cage motor is used, it should be of either the two- or three-speed type with the slowest speed usually one quarter of the full-load speed and slow enough to house the anchor satisfactorily.

In an electro-hydraulic windlass, the pump, or A-end, is usually located below deck and driven by an AC motor; and the hydraulic motor, or B-end, is mounted on the input shaft of the windlass gear reducer. When the windlass is of horizontal-shaft type, the B-end is mounted in the weather. When the windlass is of the vertical-shaft type, the B-end is mounted below deck out of the weather.

Some vertical-shaft windlasses, particularly those on naval vessels, have two completely separate power plants, one for each wildcat or wildcat and capstan combination. These are arranged so that, in the event of a casualty to one power unit, the other unit may be engaged (usually hydraulically) so as to operate both vertical shafts; such an arrangement is illustrated in Figure 5.7. A more common arrangement on merchant ships is a single, double-ended, electric motor driving two pumps with each pump discharging to a hydraulic motor, or simply the electric motor directly connected to two clutched drums of the two wildcats of the windlass.

In each of the hydraulic arrangements described above, the hydraulic transmission would consist of a positive-displacement, reversible-flow, variable-stroke pump piped in a closed circuit to a fixed-stroke hydraulic motor. The first pinion in the gear reduction should be coupled to, rather than mounted on, the B-end output shaft. The hydraulic circuit should include an auxiliary, positive-displacement, replenishing pump. The pumping unit bedplate is usually built as a storage tank, and it should be large enough to contain 110% of the oil in the system so that all oil may be drained to the tank for servicing or maintenance.

The procedure followed in determining the powering requirements of an electro-hydraulic windlass with an attached capstan is given in Table 5.3. The procedure for a direct-electric windlass is similar.

Tab. 5.3 – Power calculation for electro-hydraulic windlass.

Parameter, [unit]	***Symbol***	**Value**
Number of anchors hoisted	n	2
Anchor depth at beginning of hoist, [m]	h	55
Anchor weight, [Kg]	$W1$	5760
Anchor chain size, [mm]	C	62
Chain weight (each anchor), [Kg]	$W2$	4500
Buyancy factor	b	0.87
Weight per wildcat = $b.(W1+W2)$, [kg]	$W3$	8926.20
Hawspipe efficiency	$e0$	0.6
Pull at each wildcat = $W3/e0$, [kg]	$P1$	14877
Outside length of one chain link, [mm]	G	372
Pitch of links = $G-2.C$, [mm]	p	248
Number of whelps on wildcat	a	5
Wildcat pitch radius = $a.p/pi$, [mm]	r	394.70
Torque at each wildcat = $P1.r$, [kg.m]	$T1$	5872.02
Electric motor speed, [rpm]	$N1$	1150
Hydraulic pump speed, [rpm]	$N2$	1150
Hydraulic motor speed, [rpm]	$N3$	1110
Gearing ratio: first reduction	$R1$	7.83
second reduction	$R2$	7.4
third reduction	$R3$	4.55
Chain hoisting speed = $2.pi.(r/1000).(N3/60)/(R1.R2.R3)$, [m/s]	S	0.17
Specified chain hoisting speed, [m/s]	$S1$	0.15
Hydraulic pump and motor efficiency	$e1$	0.75
Gearing efficiency: first reduction	$e2$	0.97
second reduction	$e3$	0.97
third reduction	$e4$	0.97
Wildcat efficiency	$e5$	0.96
Torque per hydraulic motor = $T1/(R1.R2.R3.e2.e3.e4.e5)$, [kg.m]	$T2$	25.42
Hydraulic pressure, [kPa]	pr	106.676
Total electric power required = $n.(P1.g).S/(1000.e1.e2.e3.e4.e5)$, [kW]	$H1$	77.32
Electric motor power provided, [kW]	$H2$	75
Capastan diameter, [mm]	D	609.6
Capstan rope diameter, [mm]	d	64.77
Gearing, B-end to capstan:		
efficiency = $e2.e3$	$e6$	0.94
reduction = $R2.R3$	$R4$	57.94
Capstan speed = $N3/R4$, [rpm]	$N4$	19.16
Rope speed = $pi.((D+d)/1000).(N4/60)$, [m/s]	Sc	0.68
Permissible rope pull = $e1.e6.(H2*1000)/Sc$, [N]	F	78241.94

5.3. *Mooring and warping winches*

Mooring winches are used to hold a ship in position alongside a pier. As illustrated in Figure 5.9, a six-point mooring arrangement with one head (1), two breasts (2, 5), two springs (3, 4), and a stern (6) line is preferred for most ships, but the size of the shore bollards limits the rope size in some harbors. A high-capacity brake that can hold a load approaching the breaking strength of the mooring line, but which can be set to slip at a lower tension to avoid line breakage, is an important part of the mooring winch. ISO standard for mooring winches, specifies a minimum of 80% of the breaking strength of the line for a mooring winch drum brake.

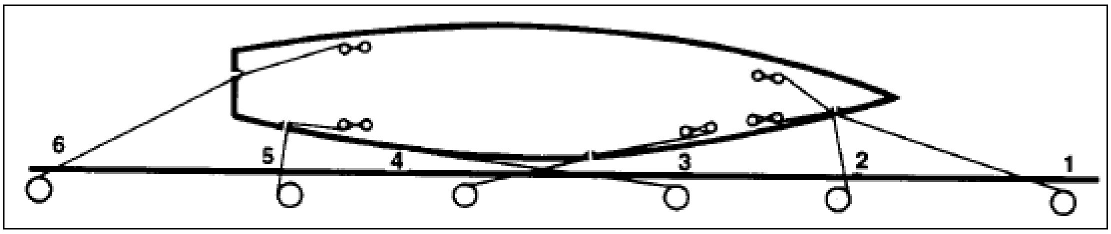

Fig. 5.9 – Typical berthing hawsers.

Automatic or self-tensioning mooring winches can be set to automatically render or recover mooring line using the prime mover when the line tension varies outside of preset adjustable limits. A "constant-tension" mooring winch is an automatic mooring winch with only a small difference between rendering and recovery tension.

Many mooring winches are equipped with a warping head. The mooring drum must then be declutchable to allow it or remain stationary when the warping head is used for rope handling. Synthetic line is used on the warping head, while wire rope is normally used in the mooring drum. During berthing, the mooring drum can be used for warping the ship toward the pier, and with automatic mooring winches this operation can be made "self-tensioning" by setting the winch for the proper mode. Normally, two of the forward mooring winches are combined with wildcats to accomplish the windlass/mooring function with a single unit.

A frequent problem with mooring winches is caused by the fact that the rope is generally spooled on the drum in a slack condition during the mooring operation. Unless special precautions are taken, the underlying layers will be loosely spooled when the mooring line is being tensioned at the top layers. Mooring lines are often damaged because the top layers wedge into the underlying layers. This problem can be avoided by using a split mooring drum, which is illustrated in Figure 5.10.

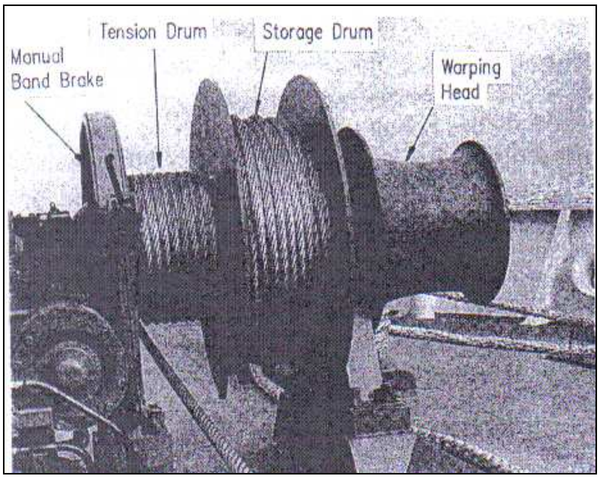

Fig. 5.10 – Split-drum mooring winch.

A warping winch is typically used to warp a ship alongside a pier or to move a ship from a place to another, by means of hawsers, without other assistance. The warping head on a warping winch is similar to the head on a capstan, except that the warping head or heads are mounted on a horizontal shaft. In some instances, the heads are mounted on extensions of the main shaft so that they may be at considerable distance from the power unit, as in Figure 5.11.

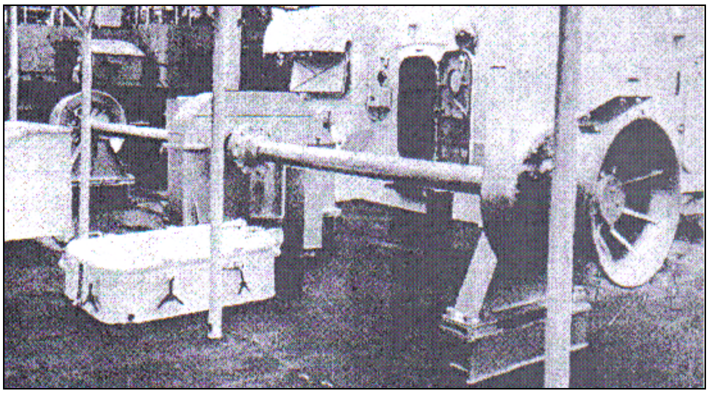

Fig. 5.11 – Warping winch with extended shaft.

As shown in Figure 5.12, sometimes a drum traction winch is driven from a mooring winch. One traction winch with a storage reel on each end of the ship is preferable.

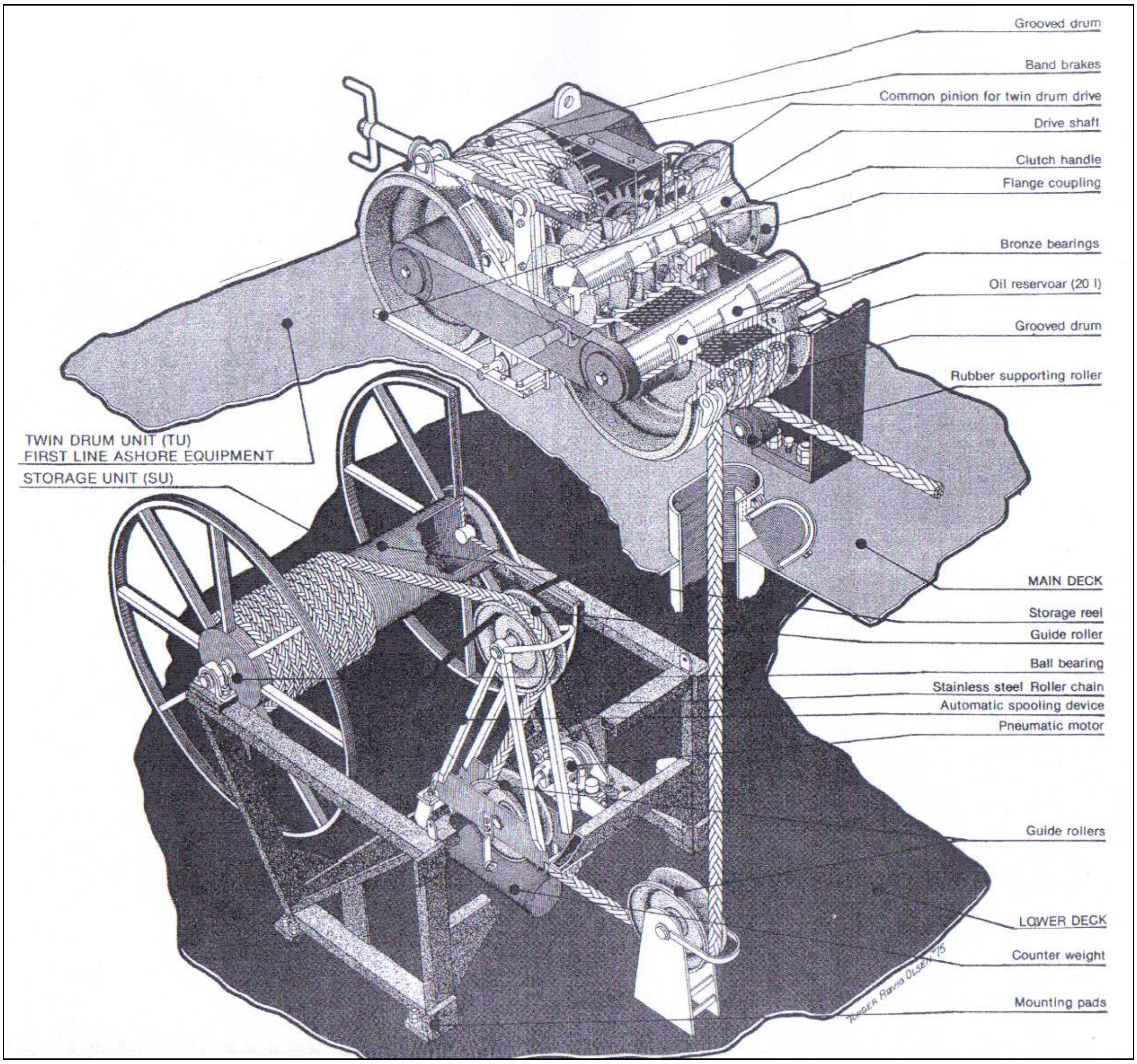

Fig. 5.12 – Drum traction winch.

The rope capacity of a storage reel or a drum depends on the volume of revolution available for the stowage of the rope. For a given drum, the length of rope that can be wound varies with the diameter of rope to be used. For a given rope, the drum dimensions can be ascertained to suit any required length of rope. The total length of rope that can be spooled upon a drum is given by:

$$L = \frac{(A+B).A.C.\pi.10^6}{d^2} \qquad (5.1)$$

, where variables A, B, C are expressed in meters and d in millimeters, as shown in Figure 5.13.

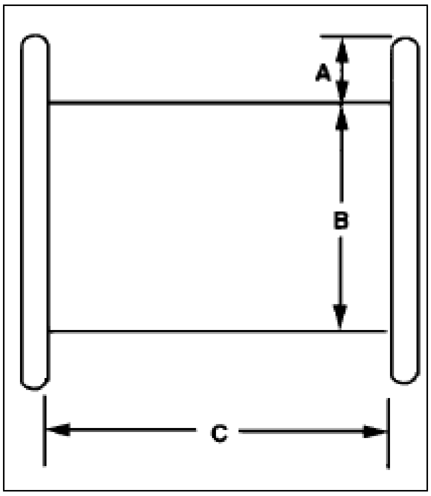

Fig. 5.13 – Calculation of drum capacity.

5.4. Winches for cargo-handling

The simple rigging arrangement shown in Figure 5.14 has the capability of performing the three basic functions required to handle the boom and the cargo. One function is the ability to top the boom, i.e., raise the boom head to the proper elevation. A second function required for the rigging arrangement is the ability to swing (or slew) the boom so as to control the transverse location of the boom head. As shown by Figure 5.14, the upper vang pendants, which are secured to the boom head, are used to swing the boom. Vang lines are required on both sides of the boom head. Lastly, the rigging arrangement must be capable of hoisting and lowering the load. The load would be secured to the cargo hook shown in Figure 5.14 and would be hoisted and lowered by means of the cargo hauling part that goes to the cargo (hoist) winch drum. As illustrated in Figure 5.15, a double hoist block is fitted on top of the cargo boom providing 1/3 of the cargo load to the winch drum.

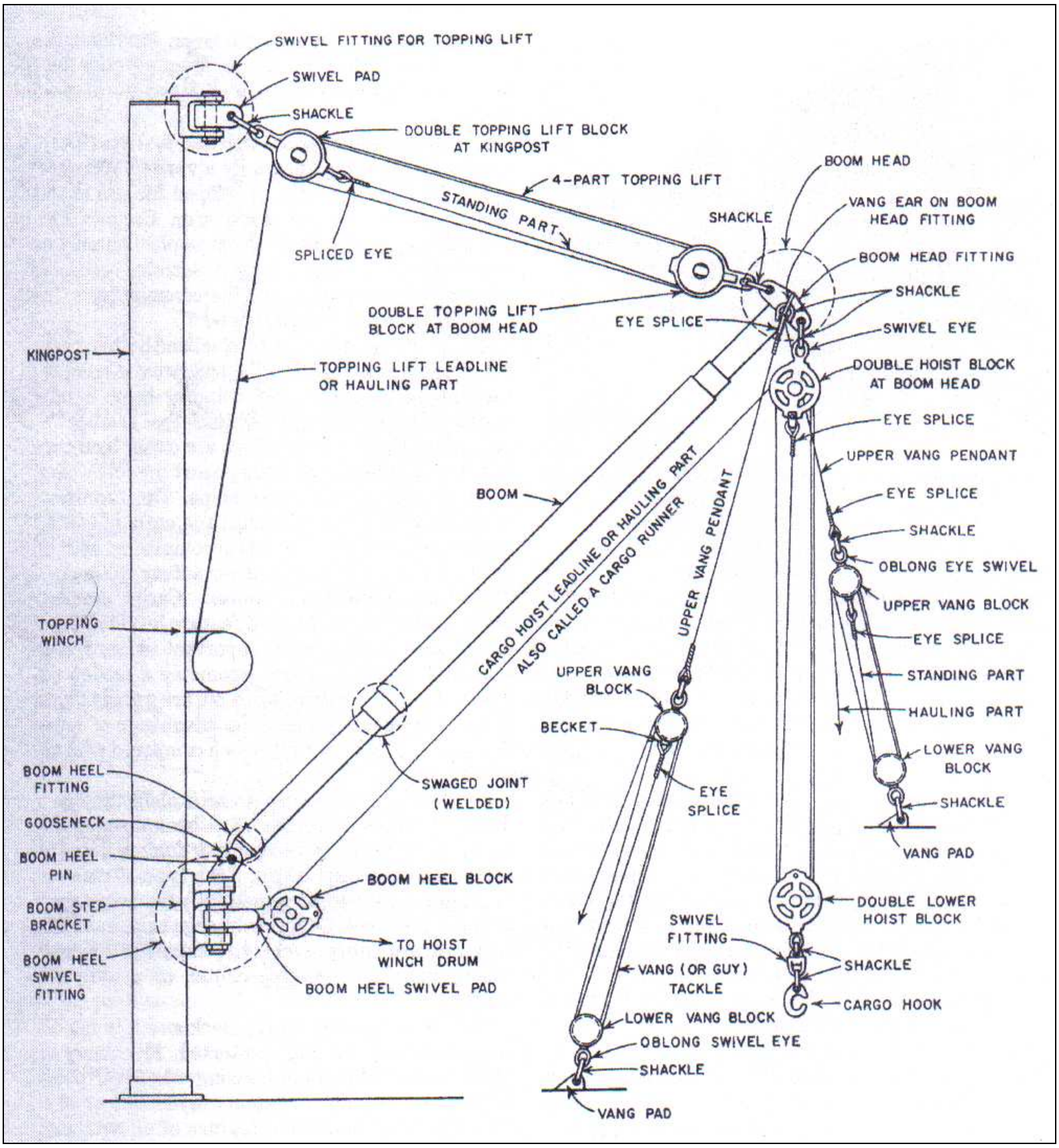

Fig. 5.14 – Nomenclature for cargo gear rigged for swinging or slewing.

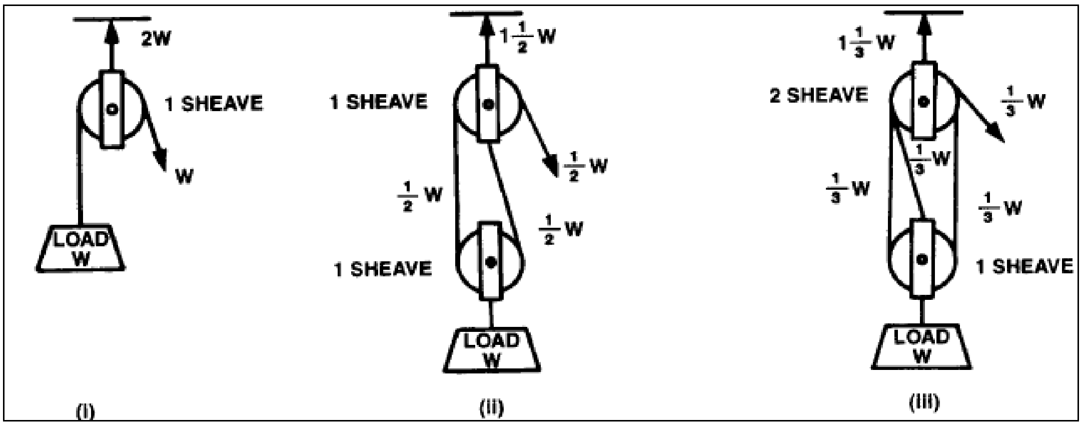

Fig. 5.15 – Calculation of different loadings on a block.

Most cargo winches are driven by 50 [HP] electric motors and have a double gear reduction so that different ratings at different line pulls are obtained. The mechanical band brakes provided on cargo winches are intended to be holding devices rather than stopping devices. As a substitute for the band brakes, it is frequently possible to use a simple locking device, such as a bar or pin that can be inserted on a hole in the flange of the winch drum.

5.5. Cargo-handling cranes

A typical marine cargo crane is shown in Figure 5.16. Many different types of cranes have been developed including those designated as telescoping or folding boom types, and overhead or gantry cranes, as shown in Figure 5.17 to 5.20. Each type of crane offers its own advantages.

Cargo cranes are predominantly wire luffed and feature level luffing as standard. Level luffing is an important safety feature and is achieved through proper geometry selection during design stage. The drive systems are principally electro-hydraulic. Hydraulics offer the advantage of lower weight and higher power density when compared with alternative drive systems.

The primary factors influencing the selection of the correct crane type are:

a) Cargo to be handled;

b) Lift capacity;

c) Lift weight;

d) Outreach;

e) Weight;

f) Centre of gravity;

g) Ambient temperature;

h) Drive system;

i) Visibility;

j) Duty cycle.

Cranes are placed on the deck and it is important that the machinery be well protected. Machinery should be placed inside the crane housing whenever possible. Preheating of the drive systems (hydraulic or electrical) is important and must be a feature of all equipment placed on deck. The heating system should be arranged in such a way that it can be energized independent of the main supply. The hydraulic system should have the capability to pre-heat the oil. Electric motors and cubicles must be equipped with heaters to avoid condensation.

The generator capacity on board is often determined by the number and sizes of cranes. When determining the generator capacity, the crane supplier should be consulted because regenerated power must be considered.

The hydraulic system comprises three main circuits:

a) Hoisting;

b) Luffing;

c) Slewing.

Sometimes a boost circuit is added to the three circuits above.

The control circuit can be either hydraulic or electric/electronic (solenoid valves). The main circuits are either closed loop or open loop, with open loop being preferred. Each circuit has a pressure relief valve installed as a safe feature. The relief valve is also used to limit the lifting capacity of the crane. To assure that the maximum safe working load of the crane is not exceeded, the crane should be equipped with a maximum-lift cut-out valve. When the cut-out valve is activated, the pump stroke should automatically return to zero and the brakes should be closed.

The pump unit is an integrated unit consisting of main electric motor, pumps, and gearbox. Preferably one pump is used for each main function (hoisting, slewing, and luffing). The alternative is to let one or more pumps serve the circuits, although in this case the speed of each function will be dependent on the number of motions driven simultaneously.

To guarantee safe operations, all motions must be governed by safety limit switches. These limits are primarily: safe working load cut-out, slack rope, full drum, empty drum, maximum outreach, and, when required, slewing limits. Further safety limits may be required upon specific applications.

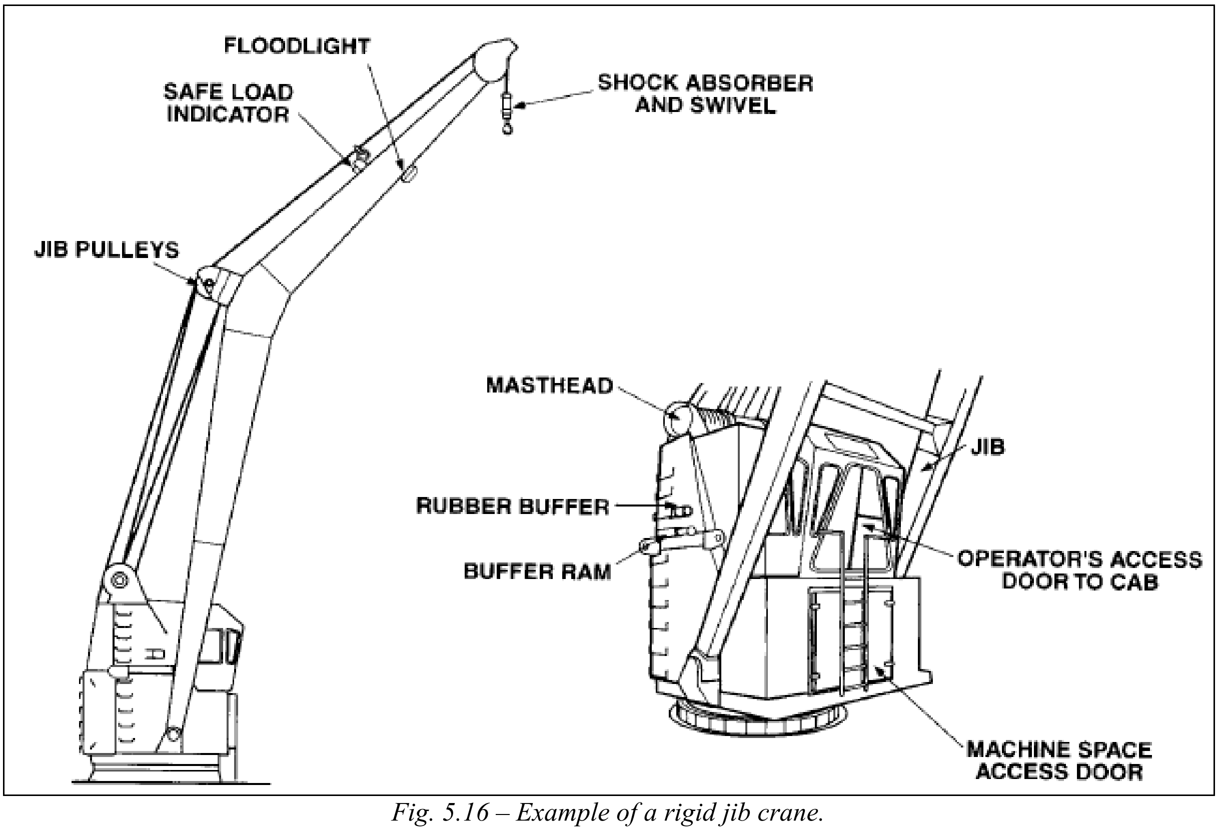

Fig. 5.16 – Example of a rigid jib crane.

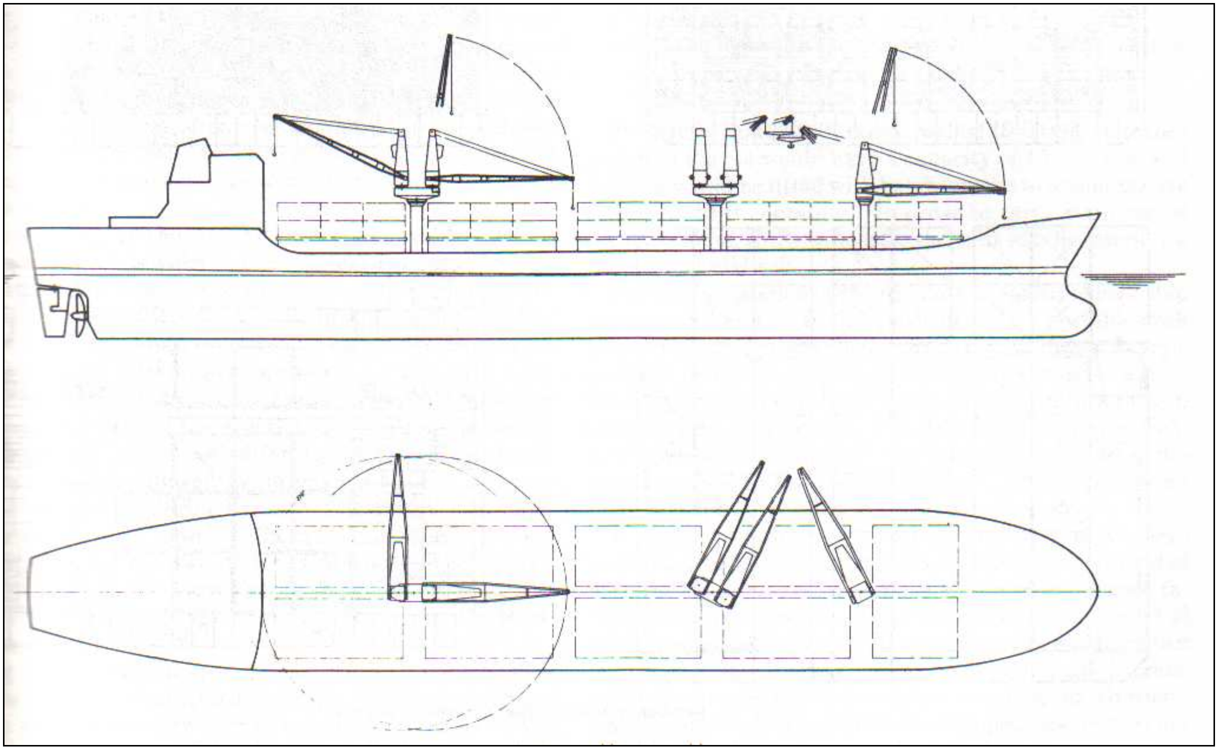

Fig. 5.17 – Neo-bulk on multipurpose ship fitted with rotating crane.

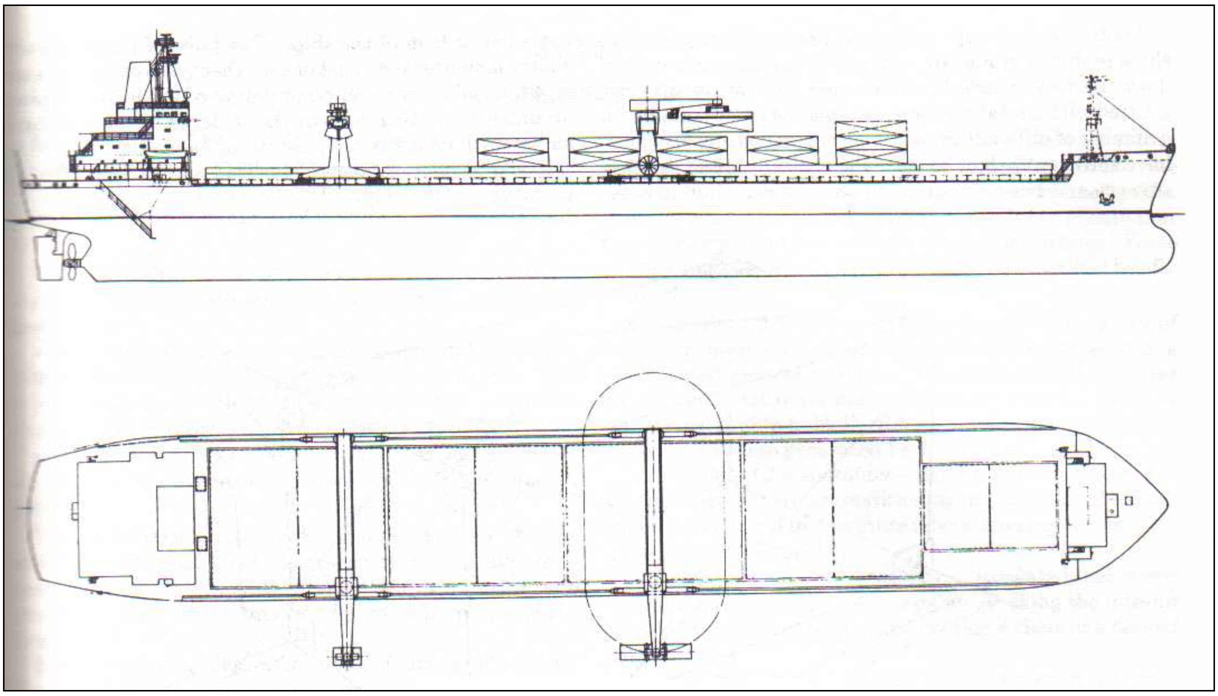

Fig. 5.18 – Multipurpose ship fitted with rotating gantry crane.

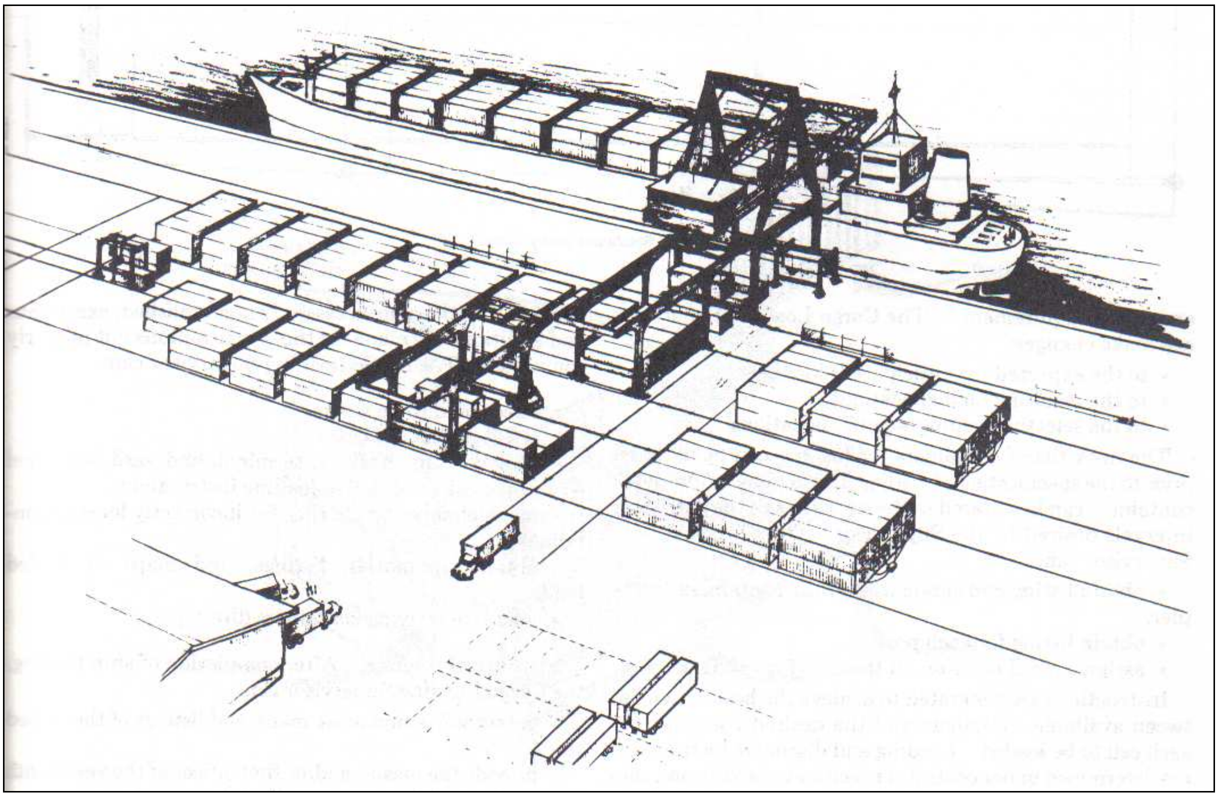

Fig. 5.19 – Example of a composite container terminal.

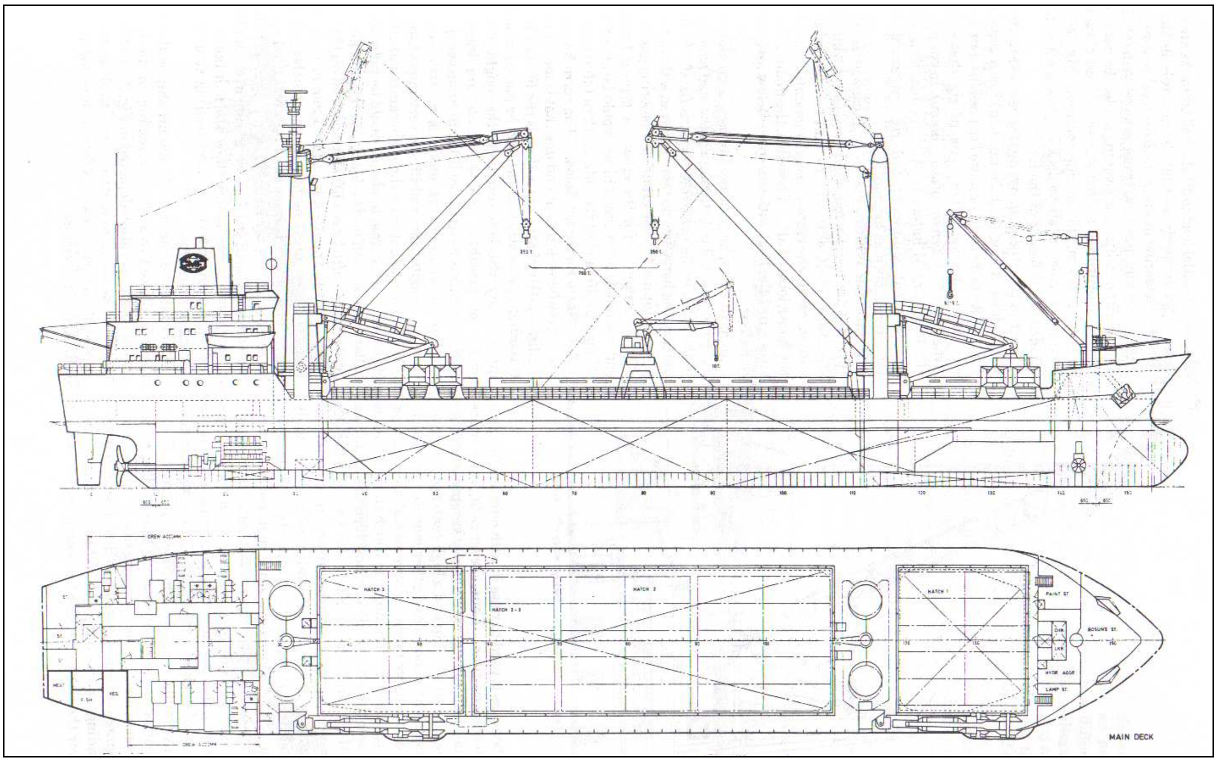

Fig. 5.20 – General arrangement of a heavy lift vessel.

Many other vessels such as fishing boats, coasters and naval vessels have hydraulic articulated-jib cranes for light-duty mechanical handling onboard. As illustrated in Figure 5.21, these cranes are single-man operation and have a fixed-point mounting.

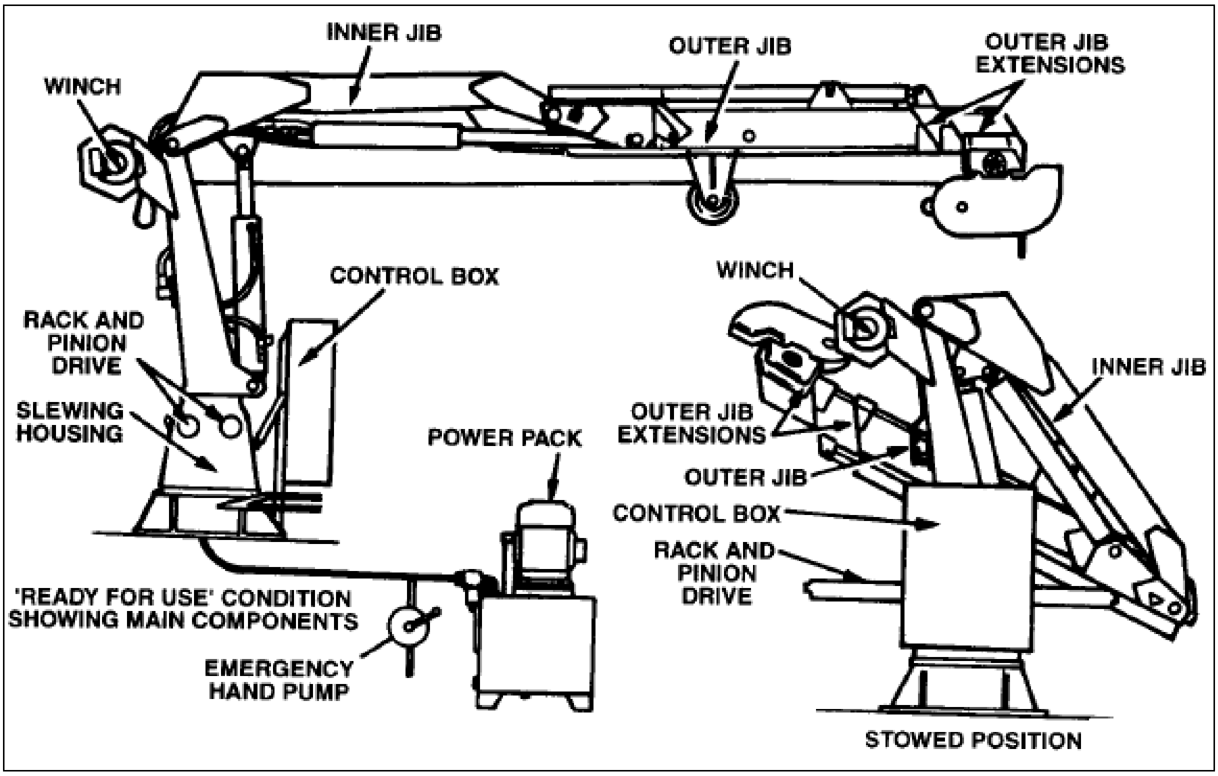

Fig. 5.21 – Example of an articulated, telescopic- jib folding crane.

5.6. Cargo-access equipment

Cargo ships must have cargo-access openings into their holds: either vertically in the weatherdeck or horizontally in the bow, stern or side as with Roll-On Roll-Off (RORO) vessels. Cargo-access closures are vulnerable to damage at sea and, thus, properly designed cargo-access closure equipment is vital to ship safety.

The hatch cover is the single principal piece of access equipment for vertically loaded dry-cargo vessels, and a number of different designs have been used. The decision as to which to install depends on ship type (e.g., bulk carrier, general cargo ship, multipurpose vessel, reefership) plus cargo type and considerations of space on board.

Typical cargo-access equipments are shown in Figures 5.22 to 5.24. Many different types of cargo-access equipments have been developed.

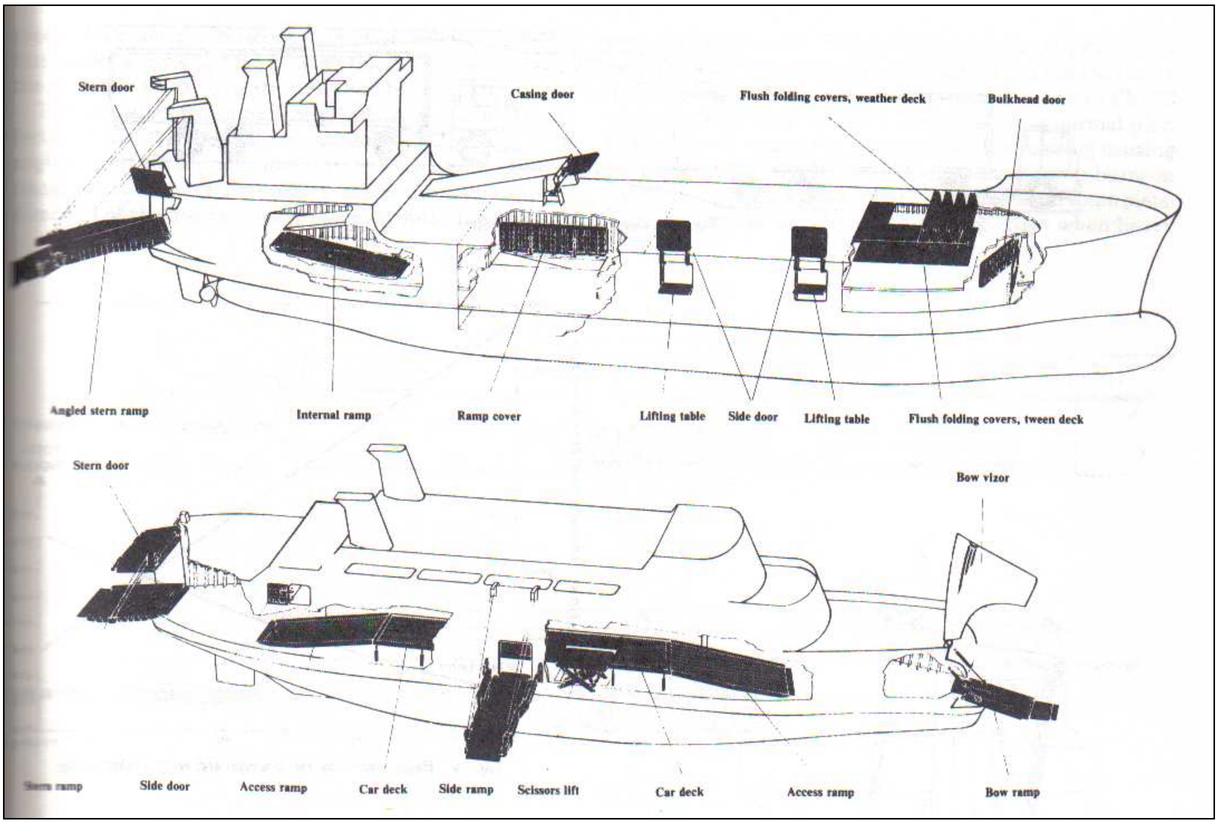

Fig. 5.22 – Typical cargo gear equipment for RORO handling.

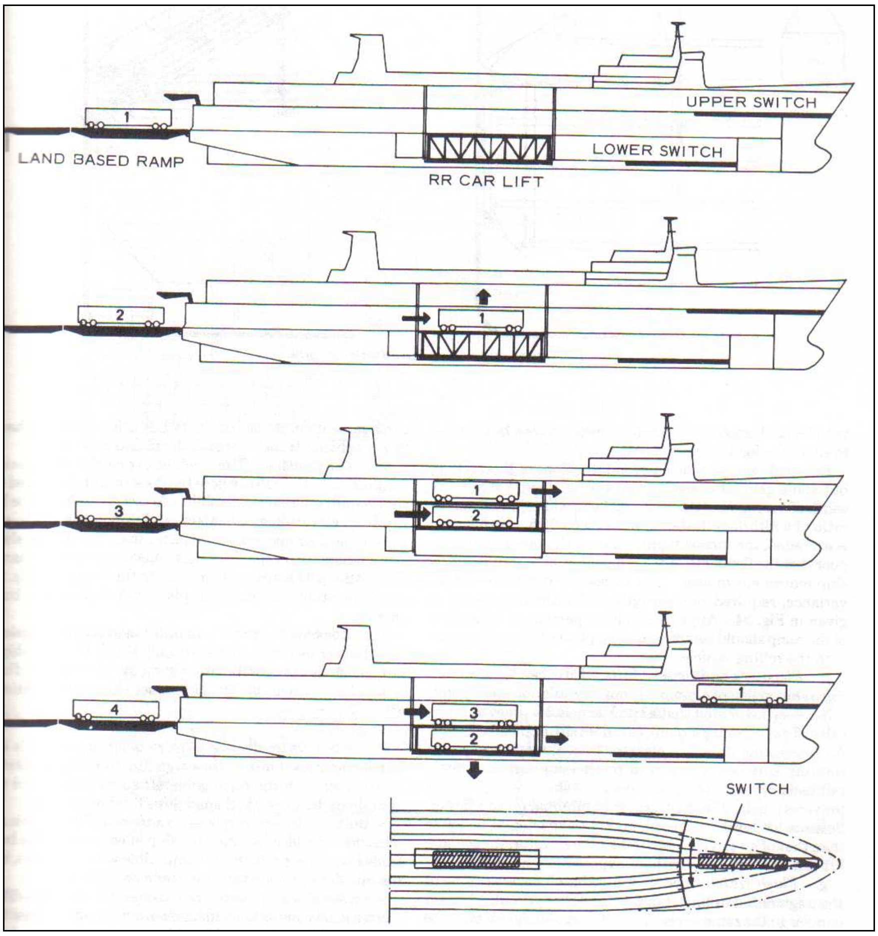

Fig. 5.23 – Railway ferry loading sequence.

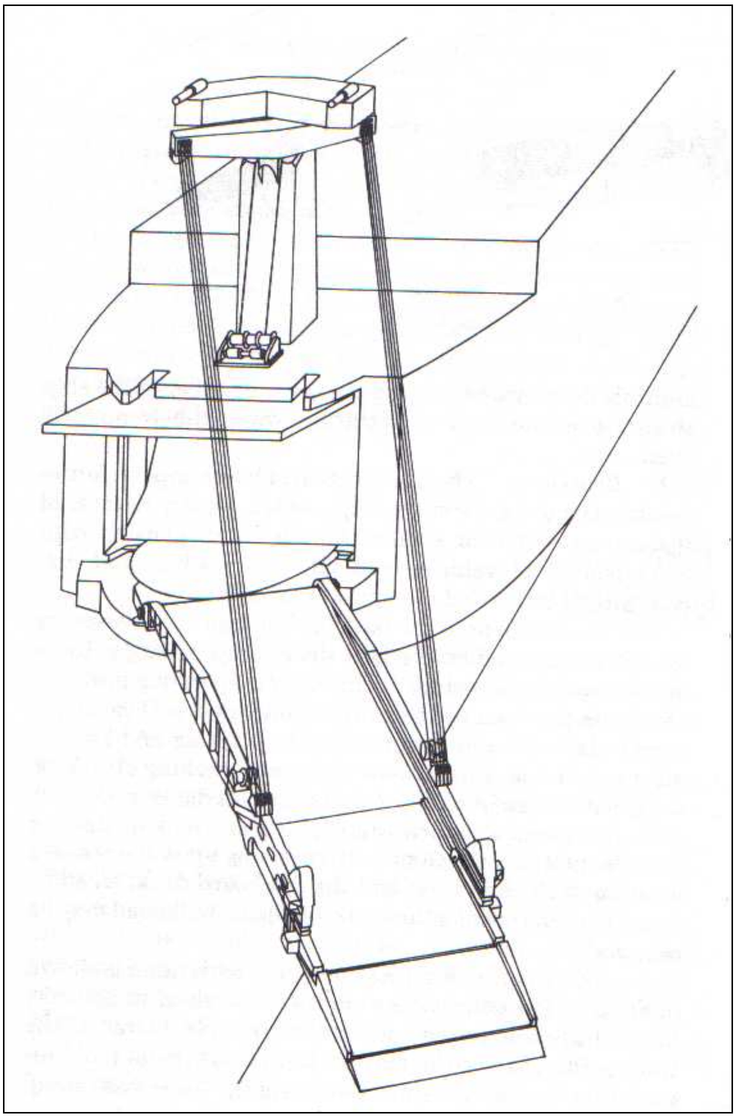

Fig. 5.24 – Slewing stern ramp on a RORO vessel.

Besides providing weathertight integrity during voyage, cargo-access equipment may also provide the means to move cargo onto or off the ship ant the means of its interdeck transfer. This latter operation is performed either on wheels via fixed or adjustable ramps, or by elevator.

5.7. *Elevators*

Many types of merchant and military vessels require elevators for the vertical movement of personnel, cargo, or weapons. Two primary types of elevators are in common use:

a) Hoistway (or trunk);

b) Open mounted.

Both types are usually operated by wire-rope hoisting cables in one of the following hoist arrangements:

a) Winding drum, which is powered by a hydraulic or electric motor;

b) Hydraulic engine, which consists of a traveling sheave on a hydraulic cylinder;

c) Traction drive, with a counter-balance weight and drum, which is powered by a hydraulic or electric motor.

Safety provisions for hoisting machinery and controls of elevators include:

a) Platform over speed or free-fall safety stops (often in the form or knurled rollers that wedge into the guard rails);

b) Slack-cable device, to stop the platform if any of the hoist ropes become slack;

c) Buffers below the platform (and counter-weight, if used) to decelerate a free fall;

d) Brakes on winding-drum and traction elevators, which are capable of holding the platform and 150% of the rated load for military applications (125% for commercial applications);

e) Interlocks, to prevent elevator operation when doors and hatches are improperly positioned;

f) Interlocks, to prevent elevator doors from being opened when the platform is not in proper position;

g) Speed governors to control platform speed.

To illustrate some principles associated with the design of elevators, the elevators that are used to transport aircraft between the hangar deck and flight deck on aircraft carriers may be considered. The arrangement of a typical aircraft elevator is illustrated by Figure 5.25.

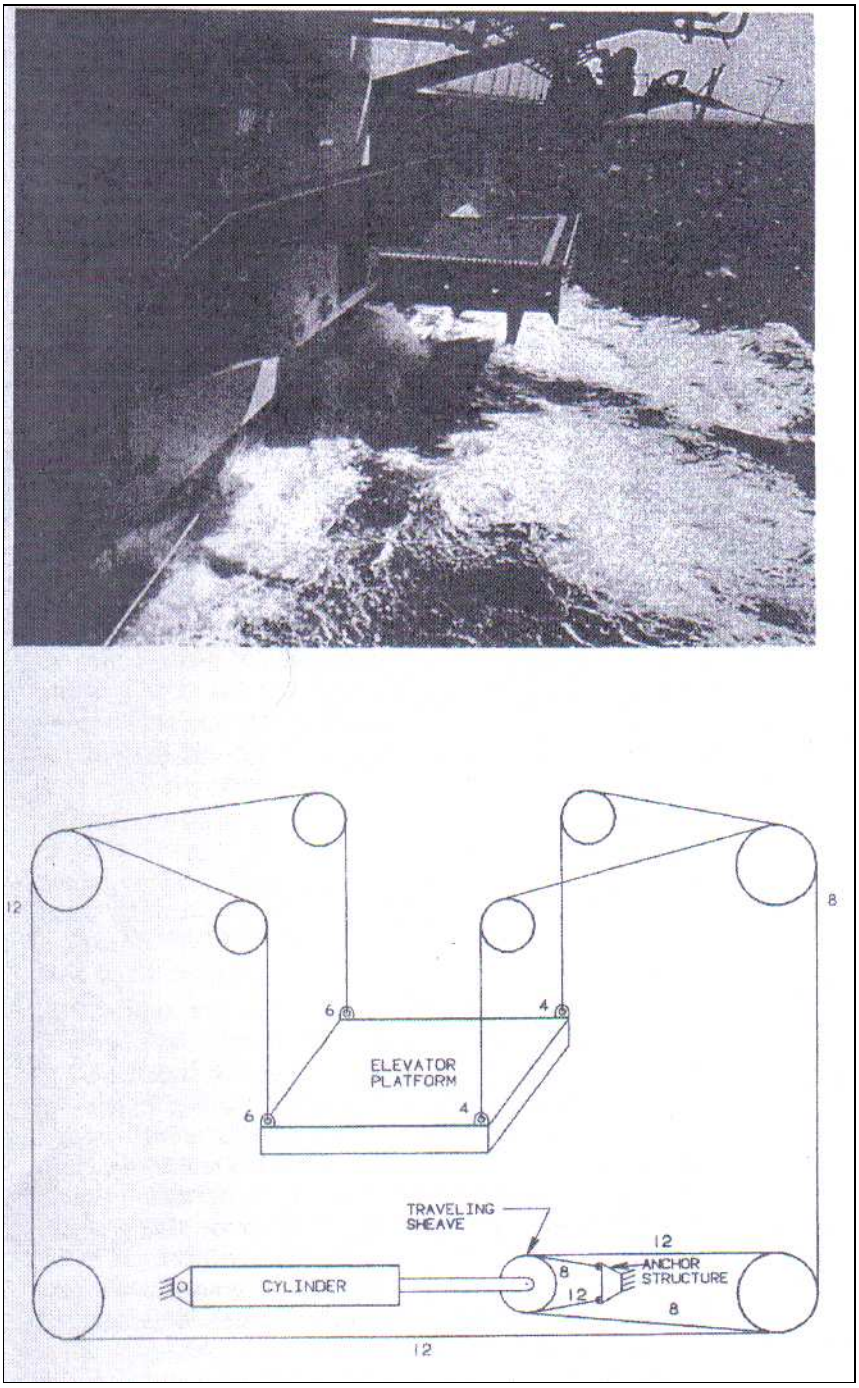

Fig. 5.25 – Example of an aircraft elevator.

5.8. Lifeboats

Lifeboats should be provided with sufficient capacity and so distributed that all the persons on board can be accommodated. These lifeboats should be launchable within the shortest period of time even if the ship machinery is not running and when adverse ship and environmental conditions exist. Lifeboats occupants should be protected when launching from great heights to minimize the danger of being thrown overboard. A typical lifeboat is shown in Figure 5.26. Gravity davits are designed to move lifeboats from their stowed position to an embarkation position, and subsequently to lower them to the water without the use of any power.

Fig. 5.26 – *Example of a lifeboat installed on a gravity davits.*

5.9. Liferafts and emergency equipment

Modern lifesaving equipment has been designed specifically to counteract the dangerous heat loss from the body. Additionally, in the event of consciousness being lost, it will give the individual the best possible protection against drowning. Good knowledge of lifesaving equipment, especially personal equipment, is essential in order to survive the rigors of a cold sea. Accounts of recent loss of life at sea, where modern equipment was available to men who did not know how to use it to the best advantage, reveal the importance of such knowledge and training. However remote may be the possibility of disaster from fire, collision, or stranding, seafarers should always be prepared to abandon ship when necessary and take to the liferafts. Every seafarer should also be prepared to rescue survivors from another ship.

Preparation for such eventualities includes the provision of lifesaving equipment and training in its use, but the best equipment is of little value without good organization and high standards of discipline, leadership and morale. The chance of survival after shipwreck is better today than at any time in the past. A lifejacket is designed to enable the wearer to jump safely into the sea from a considerable height and to keep the wearer's mouth and nose out of the water should they be unconscious or asleep. A survival suit keeps them dry, and an enclosed liferaft protects them from the elements and provides them with food and water until rescued. The prospects of rescue from liferafts have also been improved by radio beacons and other aids to detection. The following paragraphs give details of installation of the survival and safety equipment commonly used aboard.

The 25 men inflatable liferaft is fitted as standard equipment in all ships, and is supplied on a scale to provide liferafts for the full complement plus 10% spare. The liferaft is supplied packed in a weathertight GRP container and is fitted in a weather-deck stowage either singly or in pairs. The stowage is designed so that the liferaft(s) will fall unobstructed into the sea when released manually (Figures 5.27 and 5.28), or will release hydrostatically should the ship founder and sink. Associated with the liferaft and packed in the same GRP container are survival packs.

Each liferaft is packed in a GRP container and these are stowed on suitably designed platforms on the weather decks (Figures 5.27 and 5.28). Figure 5.27 shows a pair of GRP containers in a weatherdeck stowage: note that the lip (at the join of the upper and lower halves of the container) of the outboard container is above the lip of the inboard container. This method of stowage is essential to enable both containers to roll free of the stowage when released. The liferaft in its container is held securely in the stowage by two polyester webbing straps; the outboard ends of these straps are shackled to the stowage platform and the inboard ends are secured to a ‘coat hanger’ arrangement, Figure 5.27. A hydrostatic release mechanism is incorporated between the ‘coat hanger’ and the deck connection. Buckles are fitted in the straps to adjust their tension and ensure a secure stowage for the container. The end of the liferaft from which the operating cord protrudes must face aft to minimize water ingress; the operating cord is secured to a ‘weak-link’ line, which in turn is secured to a strong point in the ship, see Figure 5.28.

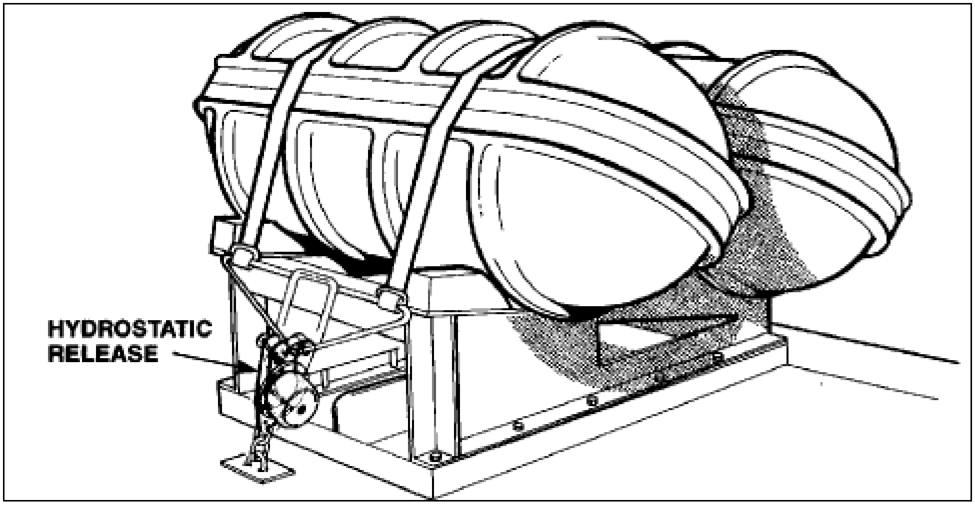

Fig. 5.27 – Weather deck double liferaft stowage.

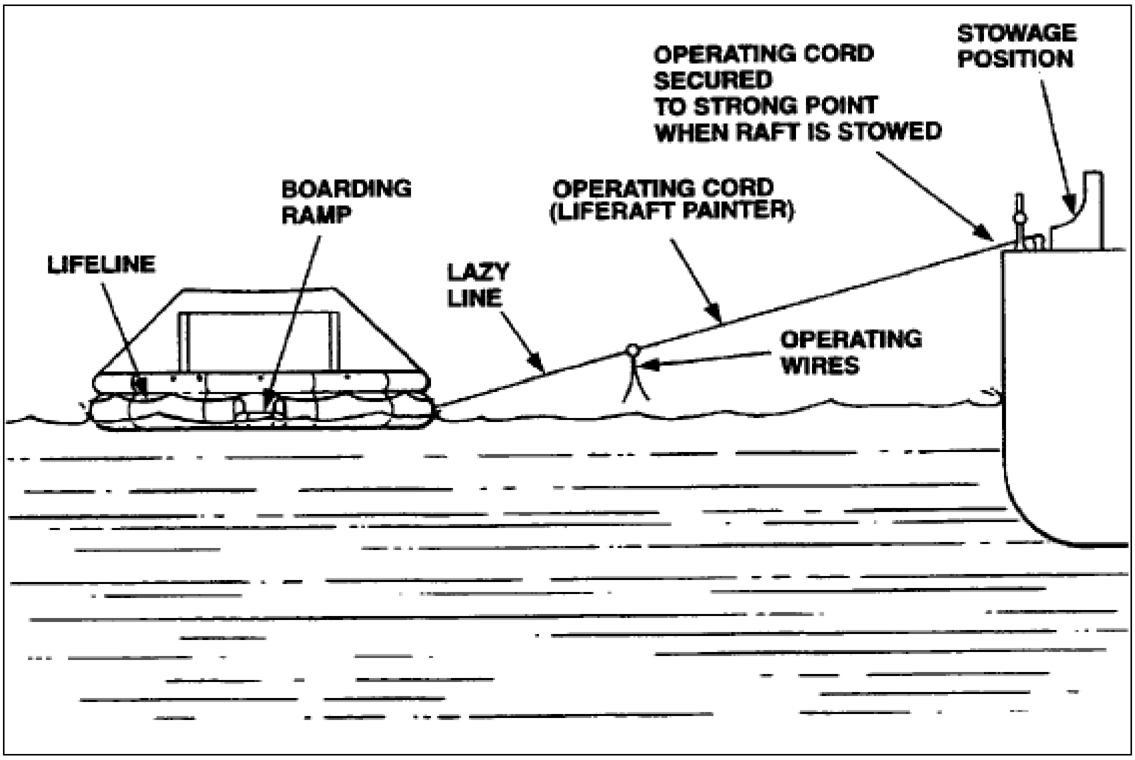

Fig. 5.28 – Liferaft launched, showing arrangement of operating cord.

The total weight of the GRP container and its contents is approximately 180 kilograms. The use of a dockside crane is required when containers have to be removed, shipped or unshipped. Only polyamide or polyester slings should be used for hoisting the containers. The containers should not be rolled during shipment or stowage and care must be taken to avoid bumping, especially on deck projections.

All oceangoing vessels are provided with Global Maritime Distress and Safety System (GMDSS) equipment to alert search and rescue services in the event of an emergency, and then guide them to your position. The system consists of the following kit:

a) Emergency Position Indicating Radio Beacon (EPIRB). An EPIRB (Figure 5.29) is installed on the upperdeck of all oceangoing vessels. A crew member is delegated to retrieve it and stow it aboard his liferaft. However, if your ship sinks or capsizes before the EPIRB can be manually removed from its stowage a hydrostatic release system will ensure it automatically disengages and activates.

b) Search and Rescue Transponder - SART (Shipborne Model). All oceangoing vessels carry at least one shipborne SART (Figure 5.29); certain ships in certain areas of operation carry two. Shipborne SARTs are stowed in canisters sited adjacent to escape routes and a crew member is delegated to retrieve it and stow it aboard his liferaft in emergencies. The SART is designed to help rescue services quickly locate your position.

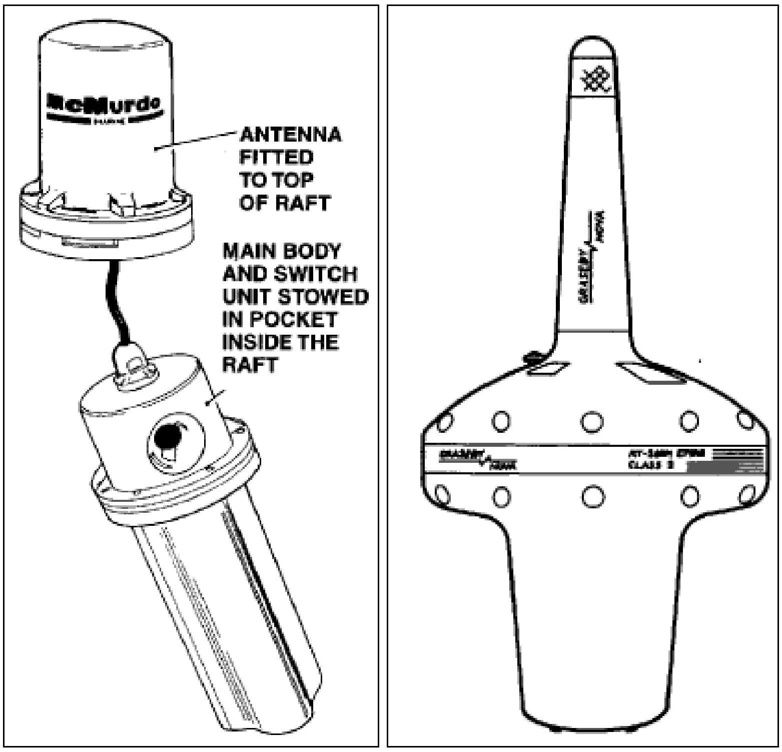

Fig. 5.29 – SART of Liferaft fitted version (left) and EPIRB (right).