him warm and dry but also provide protection against the sun's rays. His inner pockets should contain a change of underclothing and some spare pairs of socks. Clothing has the additional advantage of providing at least a quarter of an hour's buoyancy in the water. When space and time is available plenty of spare blankets should be stowed within the boat.

The officer in charge of the boat must be sympathetically strict, optimistic, cheerful, and confident. He should be provided, if possible, with a sextant, a watch set to G.M.T., a nautical almanac, details of the wreck's position, proximity of shipping lanes and land, and whether or not a distress call was transmitted and acknowledged. Each boat should preferably have a second officer to assist, and at least two able seamen.

If a call was sent out before the vessel was abandoned it is quite possible that it was received and not acknowledged before the wreck's operator closed down his equipment. For this reason, the survivors should at all times hope for rescue. If the call was acknowledged it will be unwise for the boats to move far from the area, but if no acknowledgement was received the near proximity of a coast may make a voyage in the boats a more attractive proposition than remaining stationary in the wreck area.

The officer in charge should arrange a daily routine within the boat, awarding each person a specific duty, however small, making sure that the work is carried out. He will take charge of distress signals to make sure that they are not used indiscriminately, all the rations, and all weapons potential or otherwise, including boat axes and spare crutches. The daily ration of food and water must be issued punctually to avoid grumbling and irritability, and each portion should be presented openly in full view of all hands so as to avoid bickering. Ideally, each person should have his own drinking vessel, however crude. The crew should be divided into three groups, one at each end with an officer, and the other amidships together with the ill and wounded. As soon as possible, the boat's stores and equipment should be checked and a logbook commenced.

If swimmers are found they should be hauled aboard (over the bows or quarters) only if it will not endanger the safety of the boat and the persons on board. Bodies should be stripped of clothing, putting personal effects aside, and the garments distributed among the boat's complement, particularly the ill and wounded. All useful flotsam should be recovered from the area, particularly pieces of canvas and tarpaulins, provided there is room available.

The boat should be kept dry and baled. Life-jackets may be removed if there is no danger of capsizing and used as cushions, or pillows for the helpless, to prevent sores and chafe. In hot weather it is most essential to keep cool. This is best achieved by rigging the protective cover

across the gunwales with a current of air below it and keeping clothing damp all day. Bathing should not be allowed, because it consumes bodily energy. In the late afternoon clothing should be dried out ready for the cool night.

Duties should be kept to a minimum, and in this way, observing all these points, perspiring will be kept low. The head, eyes, mouth, nose, and neck must be kept shaded from the sun's rays—this applies particularly to those who are unable to shelter beneath the screen by virtue of their lookout or steering duties.

In cold weather a protective cover should be similarly rigged to keep out rain, wind, and sea. All persons should huddle together for warmth and avoid removing wet clothing, as this action will induce frostbite and exposure. The arms, legs, feet, and hands should be exercised regularly to keep the circulation strong. The hands should be kept within the crutch, or thrust under the arms. To avoid frostbite to feet, the persons should be arranged in such a way that each one can place his feet on the bare abdomen of a neighbour within the latter's clothing.

The adult body normally contains about 45 litres of water. A man will lose 5 litres every 24 hours when resting in a temperature of 35°C. The maximum permissible loss before severe dehydration occurs is about 11 litres.

10 gal
1·1 gal
2·5 gal

Sea water must not be drunk. During World War Two, the mortality rate in lifeboats where salt water was drunk ranged between 700% and 800% higher than in boats where only fresh water was used.

Rain must be caught whenever possible in all available containers, such as cans, bottles and footwear. They should be washed overside first to remove encrusted salt. Clothing can be spread out and later wrung into a container.

It is a good plan to organise sing-songs, story-telling, and reminiscences in order to keep up morale. Smoking may aggravate thirst and can be dangerous in cold weather, assisting frostbite.

The food within a boat, biscuits, milk, and barley sugar or boiled sweets, is extremely nutritious and easily digested. It has a high content of fat, starch, and sugar, protein being avoided, since its digestion entails consumption of body water. For this reason, the stores should never be augmented with meat, fish, eggs, butter, or cheese, nor should fish or birds be eaten at sea, unless there is ample water available.

Water is given priority of boat space, because a man can exist without food for a month and longer, provided he is given sufficient water. Food, however, does provide energy, warmth, and helps to maintain good circulation of the blood. Generally, it is better to award a full daily ration rather than to reduce it so that the supplies last longer. A man should ideally have about 850 millilitres of water per day, with a minimum of about 425 millilitres. About 112 grammes of each food

1·5 pints
0·75 pint 3·5 oz

1·75 oz are desirable each day, with a minimum of 50 grammes of each per day. The minimum quantities quoted are those necessary to sustain life. Water should not be issued on the first day except to the ill or injured.

Seasickness wastes body water, and should be avoided if possible. Where a medical remedy is available, all persons must take it. It is essential to combat seasickness within the first two or three days.

A record should be kept of daily rations and existing supplies. All food should be eaten slowly and water kept in the mouth for as long as possible, finally gargling with it prior to swallowing.

As soon as possible after taking to the boats, the lifeboat radio transmitter should be used, if available. This should quickly guide rescue ships and aircraft to the scene of the wreck. If remaining within the area the sea anchor should be streamed in order to keep the boat head to sea and lessen her lee drift. If the seas are too heavy for this to be possible the boat should be run very slowly before the wind, streaming the sea anchor. If oil is available it should be used. In the absence of an oil bag the oil can be poured into punctured tins slung over the bows or quarters.

The four basic concepts of survival are control of fear, the will to survive, possession of some equipment and knowledge. Survival is more likely if the craft stay together, sharing their equipment and the expertise of personnel. They should be connected by painters and the occupants evenly distributed amongst them which will assist in attaining a uniform rate of drift. The exception to this may be in very cold weather when crowding together produces the advantage of *buddy warming*. If the boat is to proceed to land she should be headed on as comfortable a course as possible, which might involve some zig-zagging if the most direct course might result in shipping water. Oars should be used only to clear a ship in the event of engine failure, to manœuvre into the path of a rain shower and perhaps for landing on beaches. While in very cold weather their use may help to exercise limbs, it must be balanced against the loss of heat from bodies. Everyone should try to put his feet up for about five minutes each hour. A regular watch should be set, each having two lookouts or helmsmen to support each other during weariness. Any suspected sightings of other ships or aircraft should be reported to the Officer-in-charge who should then use pyrotechnics only when several people have agreed and confirmed the sightings. Sharks and large fish can damage inflatable craft. They should not be annoyed and nor should food be dumped near them. Elderly occupants of the craft may not be as aware of thirst as others and can dehydrate very quickly. Their consumption of rations should be carefully supervised.

A good indication of the proximity of land is afforded by low-lying,

stationary cloud in a clear sky, this being convectional or orographic cloud. The flight-direction of birds in the early evening is also a good indication of the bearing of the land.

The Recovery of Survivors

The rescue ship should bring the survivors aboard by any or several of the following methods:

(1) By hoisting the survivors' boats aboard together with their crews, using derricks. This is only possible if the boats are not too heavy and suitable lifting gear is available.

(2) Alternatively to (1), by lowering the vessel's own boats, transferring the survivors into these, and hoisting them inboard.

(3) Scrambling (cargo) nets and ladders may be rigged overside, and the survivors can climb these.

(4) In (3) the men may not have sufficient energy, and they must then be hoisted aboard in canvas slings, bosun's chairs, cargo baskets, or by means of whips rove through blocks on davit heads. It should be noted that in sea water of about 5°C a man can survive for about ½–2 hours depending upon his fitness and build. To preserve heat, he should not swim or take off clothes, except to fill them with air. In freezing water, the fingers become frozen in about 4 minutes, consciousness is lost after about 7 minutes and death generally occurs within 20 minutes. These time intervals are all taken from the initial instant of immersion.

(5) A floating stretcher capable of being hoisted is useful for bringing injured men aboard.

(6) A cargo net can be slung overside between davits, with its lower end partly submerged. The davits are swung out and whips, passing through blocks attached to the davit heads, are secured to the lower cringles of the net. Swimming survivors can then manœuvre themselves across the submerged net and the whips are then used to heave the net, together with the men, up the ship's side. This is called *parbuckling*.

(7) Survivors in the water cannot necessarily be rescued together, and to make the waiting period more comfortable, a side boom or a derrick should be swung overside in the horizontal position having a net attached to it. The net must be partly submerged. The survivors can then cling to this net and await their turn.

(8) An isolated swimmer might be recovered by careful use of line-throwing rockets, fired well overhead.

(9) Inflatable rubber life-rafts may be dropped by aircraft or by ships which, for any reason, are unable to afford immediate rescue.

2-3-in 100 fathoms

(10) To pick up survivors in the water who are grouped together, a very long length of, say, 25-mm rope—up to 200 m—may be streamed by the rescue vessel. The last few metres should have several life-jackets attached to it, and the end should ideally be secured to a rubber life-raft, however small.

In the absence of such a raft, two or three life-buoys will be sufficient, in addition to the life-jackets. The ship is then headed across the wind, i.e. with the wind on the bow, making a wide turn while streaming the line. As the turn downwind is completed, the headway is checked and eventually the ship will come abreast of the survivors, making about 1 knot only, and with the line fully streamed abeam, across the wind and with the buoyant end close to the men in the water. The ship will now be heading downwind. Once the men are safely clinging to the jackets, the line may be hove-in, taking care not to use the propellers.

The recovery of survivors must be carried out well clear of propellers and overside discharges. At night searchlights, signalling lamps, and cargo clusters, if available, may be used to augment the available lighting.

As soon as the persons are safely aboard they must be given first aid, a change of clothing, and warmth. Fuel oil is not particularly harmful to the skin, and is generally the least of a survivor's worries. It can be cleaned off with a detergent, but this treatment should not be used over burns, sores, or other wounds. A good drink will be the initial requirement of a survivor, and should be non-alcoholic. Both food and drink should be taken as slowly as possible, the food being light and readily digested. Exposure victims should be placed in warm rooms, with the emphasis on warming the torso before the limbs. Rapid heating may cause pain and injury. Frostbite should be thawed out in cold water, avoiding any type of massage. Future warming of the affected part must be very gradual, and re-cooling may be necessary for a while to reduce pain.

The officer or person in charge of the survivors must, as soon as possible, inform the owners of the wrecked vessel so that arrangements may be made for repatriating the crew and forwarding passengers to the original destination. On a British ship, the Department of Transport must be given a report of the accident. In all cases of wreck it is of great importance to salvage the Official and Deck Logbooks before final abandonment.

Rescuing the Crew and Passengers of a Disabled Ship at Sea

This operation depends upon several factors, namely the condition of wind and sea, the ability of the seamen to handle small boats, the urgency of required assistance, and whether any help is available from

the persons on board the distressed vessel. From the commencement of the rescue it is important for the Master of the wreck to allow himself to be directed by the rescuing Master, since this will avoid unnecessary hesitation and confusion. Communication should be established by radio, code flags, or by signalling lamp, and both Masters fully acquainted with the conditions and system of rescue.

If boats are to be used the rescue vessel should cruise the area to ascertain whether there is heavy wreckage and flotsam about which will hamper and endanger boatwork. The rescue vessel should, ideally, manœuvre into the wake of the drifting wreck and stop her engines. It is then an easy matter to determine the relative drift of the two vessels.

If the rescue vessel arrives during the hours of darkness the Master of the wreck should endeavour to hold on until daylight. If, however, the weather is steadily deteriorating, such an action may be either impossible or unwise. Both vessels should spread low-viscosity oil freely. If the wreck is unable to do this the rescue vessel should steam around the area and spread copious oil in the form of a circular *slick* into which the wreck will drift.

The lifeboat selected for the rescue operation should have all gear removed which is irrelevant to the rescue procedure, and have it partially replaced with life-jackets and lifebuoys, blankets, a line thrower, disposable ballast, VHF radio, and perhaps extra first aid gear and a loud hailer.

Before lowering the boat (fully manned with the crew wearing life-jackets), the vessel should create as good a lee for it as possible, bringing the wind on the opposite bow. This action will also serve to reduce rolling, which is an adverse factor in the launching of a boat. Oil should be spread freely from both sides. The rescue vessel should at this stage be lying to windward of the wreck. Mattresses should be slung overside between the davits and secured at, and above the water-level in order to prevent the boat being stove-in during an adverse roll. A cargo net, also slung between the davits and trailing in the water, will be of great assistance to the crew if the boat should capsize alongside. The painter is rigged and kept tight throughout so as to keep the boat in position below the falls. It is a very good idea to connect light lines to the two bottom fall blocks and man them on deck. As soon as the blocks are released they can be hauled clear of the boat's crew.

Just before the boat reaches the wave crests, the engine should be started and the plug checked. The fall-blocks are manned, and then in one rapid sequence the boat is launched, falls are released, the engine put into forward gear at full throttle, and the painter let go, using the tiller hard over towards the ship's side. Both lower fall-blocks must be released simultaneously, the men on board keeping the falls absolutely slack. If one block jams or cannot be released before the boat descends into a trough the engine must instantly be reversed to bring the boat under the davit heads again. Instead of the fast block heaving that end of the boat bodily out of the water, the weight of the boat will overhaul the fall because it is all slack on board. The crew must keep well down in order to avoid the suspended blocks as the boat clears the side. The operation is extremely tricky, and should preferably be carried out in absolute silence, with the officer in charge giving his orders clearly and concisely. If the vessel has very slight headway on at the time of launching the tight painter will enable the boat to take a very rapid sheer away from the side.

By now, a considerable slick will probably exist towards the wreck, and the boat may proceed downwind, spreading additional oil astern to prevent shipping seas in the sternsheets. The trim of the boat should be adjusted to suit the course relative to the sea. In a short sea the steering must be very competent, since the boat will tend to broach-to under the slightest provocation. If a big sea is approaching the temptation to take it on the bow should be resisted and the boat headed, as gently as possible, directly at it.

Generally, contact by boat with a wreck is to be avoided, but if it is inevitable the boat should on no account approach from the weather side of the wreck, where wave-battering will occur. Neither should she approach the lee side, where heavy wreckage may be accumulating and perhaps falling. Further, the drift of the wreck, which may be up to several knots, will usually prove to be a trap for the boat, and it will be extremely difficult to get clear. In addition to these problems, since the wreck, if centrecastle type, will be lying with the wind abeam or slightly abaft it, she will be rolling, perhaps heavily.

Fig. 9.1 shows a wreck lying in four different positions relative to the wind, with her likely direction of drift in each case. The boat should approach at her lee end as shown for each position, for then trapping of the boat is unlikely.

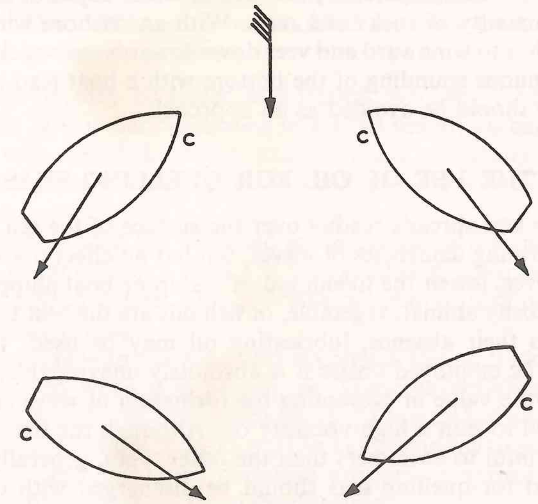
The boat may secure to the wreck, end-on, by means of a line, ready to go astern at a moment's notice should signs of broaching-to appear. A man should stand by the line with an axe, ready to cut it adrift in such an emergency. Once fast, the survivors may lower themselves down the line to the boat as rapidly as possible.

To avoid actual contact with the wreck, the boat may lie off head to wind and sea, streaming oil, and will then pick up the survivors from the water. The rescued crew and passengers must unhesitatingly enter the water wearing life-jackets. Under these conditions, a life-buoy having two, strong, buoyant heaving lines attached can be useful for heaving persons from wreck to boat, one line being aboard each craft, the buoy being passed backwards and forwards.

Occasionally, it may be preferable to drop a boat downwind to the

wreck on a 25–30-mm fibre hawser having only two or three men in 3- or 4-in
the boat. Plenty of spare line should be left in the boat so that its crew can control the boat to some extent should it suddenly become necessary to drop further downwind. A good method of signalling must be maintained between the boat and its parent ship. The boat is kept head to wind and sea by the hawser and steered with a steering oar. If the rescue ship is making a greater drift than the wreck she will have to use engines in order to maintain her distance. This calls for very efficient ship handling if the boat is not to be hampered.

Once the boat has been sent away to leeward, unless it is attached to



DRIFT OF A WRECK.
BOAT MAKES CONTACT
AT POSITION "C"

FIGURE 9.1

its parent ship the latter will steam to leeward of the wreck ready to pick up the boat again. This avoids any necessity for the boat having to make prolonged headway into the wind and sea.

When communication cannot be established by boat a raft may be towed across the line of drift of the wreck until the towline fouls that end of the wreck which would normally be approached by a boat. The survivors must then endeavour to get hold of the towline, and board the raft. For this purpose, an inflatable rubber life-raft is better than a decked, makeshift type, which will have a very small range of stability, and from aboard which survivors are easily washed off. A raft may be similarly dispatched after establishing communication by rocket-line.

Another method is for the rescue vessel to drift broadside on to the wreck (their fore-and-aft lines being parallel), but in such an attitude that they will pass clear and end-on. In this way, the ships may safely approach very closely for the purpose of establishing contact by line. In all cases, the rescue ship can try steaming around the other vessel in a circular path, streaming oil on each windward pass.

Many other methods are possible, each depending upon the prevailing conditions. The above text applies equally well to vessels which are stranded. There is the advantage that one vessel is stationary, and therefore only the rate of drift of the rescue vessel need be considered. Boatwork is, however, hampered by the lack of water adjacent to the wreck and the proximity of rocks and reefs. With an onshore wind the boat should anchor to windward and veer down towards the wreck, maintaining a continuous sounding of the bottom with a boat lead-line. Again, the lee side should be avoided as an approach.

THE USE OF OIL FOR QUELLING SEAS

Oil floats and spreads readily over the surface of the sea. It reduces the crest-forming tendencies of waves, but has no effect upon a swell. It does, however, lessen the likelihood of a ship or boat shipping seas.

Low-viscosity animal, vegetable, or fish oils are the best types for this purpose. In their absence, lubricating oil may be used, but fuel oil should not be employed unless it is absolutely unavoidable. Petroleum is of very little value in preventing the formation of wave-crests, but it may be used to thin a high-viscosity oil. Although the first-named oils are less harmful to swimmers than the other types, generally speaking, all oils used for quelling seas should be discharged with care and in
45 gal moderation. As a rough guide, it has been found that 200 litres of lubricating oil discharged slowly just above the level of the sea surface while steaming at slow revolutions has effectively reduced breaking
48 000 ft^2 seas over an area in excess of 4500 m^2. In terms of ship waterplanes, however, this is not as large an area as it would at first appear, for it amounts approximately to the area occupied by two vessels each of
500 ft 50 ft 150 m in length and 15 m abeam.

(In view of the deteriorating effect of oils upon the buoyancy of life-jackets, kapok is now required to be enclosed within sealed polyvinyl-chloride (P.V.C.) envelopes, and no other buoyancy materials are allowed to be used unless they are immune from this trouble.)

In cold weather oils should be warmed in order that their distribution may be made more easy, but it should be borne in mind that certain oils, including coconut oil and some fish oils, will congeal on the sea surface in low-temperature conditions, and they are then of no value.

The oil may be distributed in several ways as follows:

(1) By filling an old, specially punctured hose with oil, sealing both ends, and trailing it overside in a position close to the horizontal in order to obtain as wide a coverage as possible.

(2) By filling large, punctured, and weighted canvas bags loosely with oakum, kapok, or cotton waste, filling the bags with oil, sealing, and trailing them overside.

(3) By placing a 5–10-litre tin filled with oil, and punctured at its base, into a wash-basin, bath, shower, or water-closet pan. The 1–2-gal
oil is then steadily flushed overside by means of water running through the soil-pipes. This method is most effective. In all cases the amount of puncturing of the oil container will regulate the flow. This will have to be modified on ships fitted with septic tanks or similar devices. 1½-gal

In (3) the tin may be sealed and trailed overside. When streaming oil from the bow under conditions of a head sea an oil bag is liable to be tossed well out of the water, and it should be heavily weighted. If forward soil-pipes are available they will provide a better means for distribution.

When running with the wind and sea astern or on the quarter, the oil should be streamed from right aft, the weather or *both* bows and the weather or *both* quarters. This provides protection from quarterly seas in the event of yawing.

When running with the wind and sea ahead, the oil is streamed from both bows, and when it is abeam, or when the vessel is hove-to or drifting, it is distributed from along most of the weather side, preferably at intervals of not more than 15 m. The vessel will make greater leeway 50 ft
than the oil, and the latter therefore appears to spread upwind, so providing protection from the right direction.

When at anchor a block and endless whip is secured to the cable, the latter is veered and an oil bag hove out to the block and the water's edge, giving oil distribution from well ahead of the ship.

Oil may also be used to advantage when crossing a bar, manœuvring boats through surf (although the innermost surf will not be affected by oil), and when working boats alongside in heavy weather. Its use has already been mentioned in connection with wreck. American ships are compelled to carry an amount of storm oil, depending upon the gross tonnage of the ship. British ships are only required to carry such oil as part of lifeboat equipment.

SURVIVAL IN COLD WEATHER

In many respects, this presents a greater challenge than surviving extreme heat. In the latter case, the modern survival craft provides ample protection from the sun. Cooling of the body is easy by dowsing with sea water, albeit with some discomfort from salt sores. The main problem will be thirst. In cold weather, however, the only solution is for the body to be warmed, and if everyone is in a similar condition, the outlook is poor.

In a properly managed liferaft, or totally-enclosed lifeboat, it should be possible to exclude many of the outside influences, huddle together and maintain a reasonably warm atmosphere, allowing for periodic ventilation. It is when the situation is less ideal that serious trouble arises. *Do not smoke. It reduces the blood supply to hands and feet.*

Hypothermia

This can occur at temperatures above freezing. The body's metabolic temperature control becomes unstable at around 34°C and may be completely lost below that level. The victim, or *hypothermic*, is pale, very cold to the touch, has a weak pulse, is confused in speech and movements, no longer shivers and as he drifts into a comatose state, his pupils dilate. Death can occur even before the body temperature drops to 31°C. Hypothermia, and indeed any consequence of cold weather, is likely initially to affect heavy drinkers, people with poor circulation and anyone in poor health. Those in charge in survival craft must be alert to the above symptoms and commence rapid treatment where possible. The hypothermic is no longer able to help himself and will die if he does not obtain warmth. Others must huddle against him and try to impart their own body heat to him. If a hypothermic is brought aboard a ship, it is most important to warm his torso before his limbs. Warming the latter will bring a rush of icy blood to the heart causing *afterdrop* and perhaps death. Remember that hypothermics are most susceptible to frostbite and that 10% of body heat can be lost through the head. Cover the ears and nose if they are exposed to extreme cold.

Frostbite

The freezing of skin and surface tissues is sometimes called *frostnip* or superficial frostbite. Deep frostbite occurs when the freezing extends to nerves, muscles, cartilage and bone. The affected area can become frozen (as hard as wood) quite suddenly after an intense stinging pain or a prickling sensation. Sometimes the onset is not felt at all. Certainly it is unlikely that the spread of frostbite will be felt. The appearance is opaque, of a waxy-white colour and may be of varying severity. This is not always known until thawing occurs and blisters appear. If these are present, they may burst up to ten days later. If dry gangrene sets in, the affected part turns from grey to black and may become detached. To avoid frostbite, keep exposed parts covered, especially hands, feet, cheeks, ears and nose. Keep the

face mobile to prevent freezing. Place cold hands in the armpits or crutch. Warm icy feet inside other people's clothing. Do not apply ointments or massage, nor direct heat from stoves or fires. Loosening clothing may help circulation. Rapid warming brings on intense pain and may need to be aided with morphine. Most medical opinions regard the outlook as being most favourable when the affected area is thawed out as fast as possible. Again, survival leaders must encourage people to look for symptoms in each other.

Immersion foot or hand

This is brought on by prolonged exposure to water, wet clothing or wet footwear. Damage occurs to the skin, nerves and blood vessels and the appearance is white with numbness. Toes and fingers are hard to move. The situation worsens and swelling begins. There may be blisters, dark patches and broken skin. The victim must rest with no walking or standing and the affected area dried and warmed. On a ship, a warm stream of air from a fan heater is ideal. Apply clean dry dressings and perhaps give penicillin.

MAN OVERBOARD PROCEDURE

Assuming the accident to be observed, it is most important for the observer to cry, 'Man overboard to port (or starboard).' The officer of the watch should then carry out three simultaneous actions: he should ring stand-by, put the wheel hard-over towards the side from which the man fell, and release a life-buoy to which is attached a self-igniting flare or a water-activated electric light. By day, the use of one also equipped with an orange-smoke float, burning for 15 minutes, will be to great advantage. Lookouts should be posted as high as possible, preferably supplied with binoculars, emergency stations sounded and a boat prepared for lowering, and a general urgency signal transmitted to all ships in the vicinity. In busy waters International Code flag 'O' is hoisted. The Master should be notified as quickly as possible, though doubtless the above procedure will already have alerted him.

The releasing of a second life-buoy is of questionable value, since the man may only sight the more distant one and become helpless before reaching it. Further, when the ship returns to the area it will be difficult to detect which buoy was initially released unless they are provided with different types of light.

The man, who initially sinks, loses the beneficial action of the bow-wave wash and comes under the immediate effect of propeller suction. If he is able to determine the direction of the ship's side upon becoming submerged he will instinctively strike out towards it, which will aggravate his danger. Whenever possible, he should swim rapidly away from the ship. A vessel of length 122 m travelling at 12 knots will travel its 400 ft own length in 20 seconds, and if the man falls over forward of amidships it will take between 10 and 20 seconds for him to reach the propellers. During this period, an alert engineer may be able to stop the appropriate propeller from revolving, but this will be out of the question in a ship equipped with turbine-driven shafting, which will take up to 5 minutes to run down, or in a Diesel equipped vessel.

Again, the stopping of engines and the use of immediate helm is of questionable value in protecting the man in the water, for so little time is available. However, if he rises to the surface before reaching the propeller, he will invariably float clear, even though he may pass directly over it. If the ship is rolling or pitching, causing the propeller to break surface or approach it very closely, then he is in grave danger.

If the engines are maintained, as far as possible, at full revolutions and the wheel is kept hard-over, the vessel will then folow a turning circle, taking as much as 30 minutes to return to the area where the man is situated. If the ship is high-powered and quick-turning she will probably arrive within a ship's length of the man. The circular path will naturally be governed by the existing weather conditions, particularly in a heavy sea, when it will be necessary to reduce speed as the vessel heads up into the waves.

If recovery is to be made using a boat this may safely be done in most sea conditions while the ship has headway on her of up to about 3 knots. A lee should be made for the boat, and if the seas are breaking oil should be distributed in small quantities.

If the vessel is stopped under the action of reversed engines as soon as the man is clear, in moderate weather a boat may immediately be lowered and manœvred towards him, guided by radio or morse signals from a lookout aloft. If the man is lost from sight the boat should proceed back along the ship's track on a compass course. In reversing her engines the ship will have made little lateral way over the ground, but any lee drift must be allowed for when using such a compass course.

There are, among others, three useful methods in which the ship may be handled so that she returns to the man in the water. Methods (*a*) and (*c*) have automatic-return features, and all are illustrated in Fig. 9.2.

(a) The Williamson Turn

This was devised and demonstrated by Commander J. A. Williamson of the United States Naval Reserve in 1942. A man in the water faces three hazards: drowning, mangling by the propellers, and abandonment due to non-location. This turn was originated in order to reduce these dangers to a minimum. In darkness, poor visibility, or bad weather, and when the time of the accident is unknown, the execution of this turn may be relied upon to bring the vessel as closely as possible back to her original track.

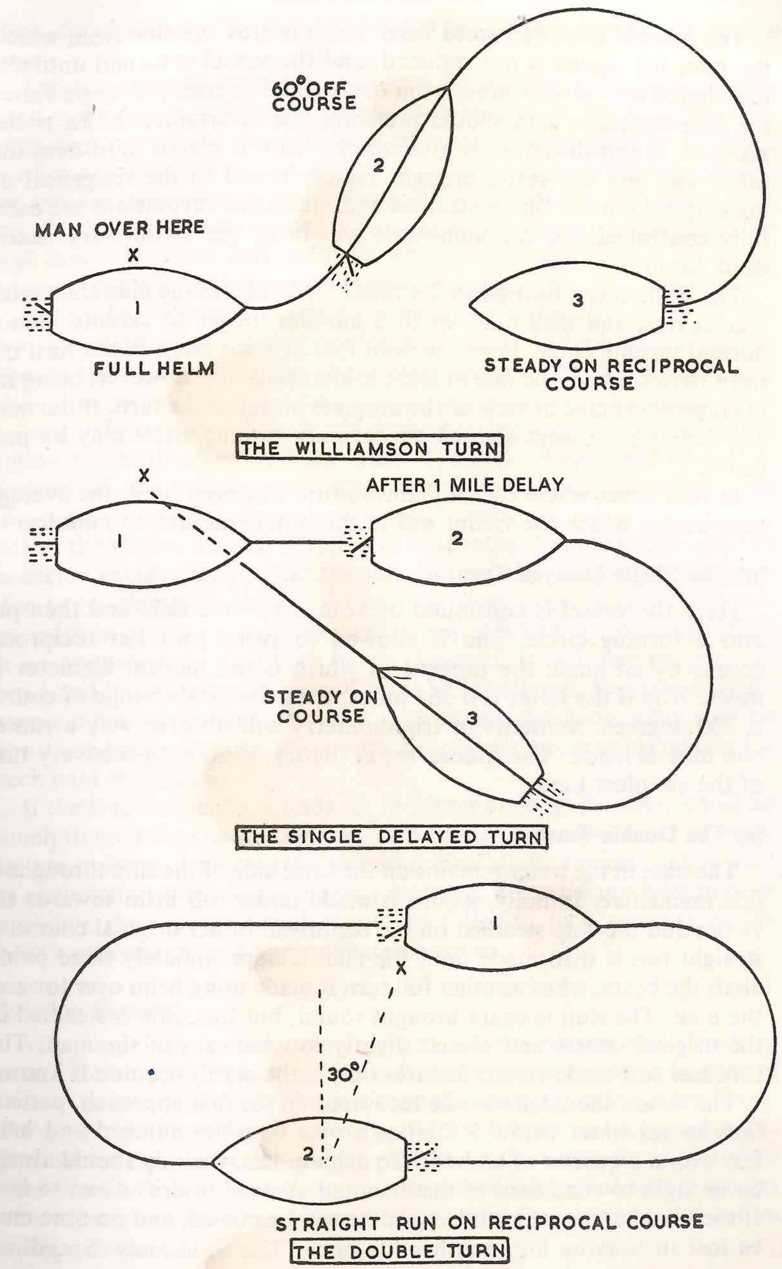


FIGURE 9.2

The helm is initially placed hard over towards the side from which the man fell, speed is not reduced, and the vessel is turned until she has altered course 60 degrees from the original course. The angle varies for different ships, and should preferably be determined at sea trials. As soon as this deviation is attained the helm is placed hard-over the other way and the vessel brought rapidly round to the reciprocal of her original course. She is steadied and the engine revolutions are carefully controlled, for the manœuvre will bring the victim very nearly dead ahead.

The Williamson turn takes the vessel farther from the man than most manœuvres, and may take up to 5 minutes longer to execute than a normal turning circle. It will be seen that at some stage in the turn the stern passes across the line of sight to the man, this, however, being no great disadvantage in view of the ultimate object of the turn. If the man can definitely be kept sighted an ordinary turning circle may be preferred.

In four cases where the Williamson turn has been used, the average time during which the victim was in the water was sixteen minutes.

(b) The Single Delayed Turn

Here the vessel is continued on course for one mile and then put into a turning circle. She is allowed to swing past her reciprocal course by an angle the tangent of which is the tactical diameter in miles. E.g. if the latter is 0·364 miles, then the total change of course is 200 degrees. Students of trigonometry will observe why a run of one mile is made. The manœvre, in theory, is an auto-recovery turn of the simplest kind.

(c) The Double Turn

The man in the water remains on the same side of the ship throughout this manœuvre. Initially, a turn is made under full helm towards the victim and the ship steadied on the reciprocal of her original course. A straight run is then made until the man is approximately three points abaft the beam, when another full turn is made using helm over towards the man. The ship is again brought round, but this time is steadied on the original course and placed slightly to windward of the man. This turn has automatic-return features only if the man's position is known.

The victim should always be recovered on the first approach, particu-
40°F larly in sea-water below 5°C when a man becomes numbed and helpless within a quarter of an hour. To achieve this, the ship should always be brought to windward of the man and allowed to drift down to him. If the vessel approaches to leeward he will be missed, and no time must be lost in heaving him another life-buoy. The Schermuly 'Speedline'

Unit, fitted with the buoyant head to the rocket, may be useful in such a case.

Ladders and nets should be rigged on the lee side, attended by volunteers wearing life-jackets and safety lines secured to the ship, who are prepared to enter the water in order to help the man ascend or to secure a whip or safety belt to him. Astern movements close to the man should be avoided, since the propeller wash will tend to throw him away from the ship's side. When lowering a boat, or approaching a victim, the ship will invariably have lost headway when the propeller wash from the reversed propellers abreasts the amidships position.

In fog the Williamson turn is the most preferable manœuvre. If this is not used the vessel should be stopped quickly and a boat lowered. It should steer back along the ship's track using a compass course, and should be equipped with a megaphone, a foghorn, a radio and a radar reflector. The parent ship should make her fog signal frequently, and follow the boat's movement by radar. The megaphone, held to the ear instead of the mouth, provides a useful means of ascertaining the direction of sounds, particularly a man's cries.

For the victim, the best advice is to float rather than swim, in order to conserve energy; realise that the ship will rapidly disappear from view due to his negligible height of eye; never lose hope of rescue; remain as calm as humanly possible, and when reaching a life-buoy, strike it on one side only with both hands clenched. It will then tip over his head and he can support himself on it by his elbows. Professional life-savers advise swimmers to strike a persistent shark on what may be considered to be its nose, the resultant rapid retreat being his reward for such cool courage.

If the ship frequently sounds 'O' in Morse code on the siren it will do much to raise the victim's morale, even though the vessel is out of sight. Its use in foggy, traffic waters should preferably be avoided unless used in conjunction with a radio urgency message. When using a boat in poor visibility, the urgency signal should be followed by a warning of the boat's movements and approximate position.

Missing Persons

When a person is reported missing at sea, the Master may decide to search the ship before turning back. If the person is found to be aboard then of course no time has been lost on the voyage. On the other hand, if the person is not found, then the ship will have to be turned back. Because of this delay, the person will be in the water for a period of time equal to twice the duration of the search compared with a similar case where the ship is turned around at once. Clearly the latter action is to be preferred.

The ship should be searched by as many people as possible, looking in the most unlikely places. I once found a missing man in a cattle pen on the poop, another hiding in the chain locker, and a third crouched under gratings in the shaft tunnel over which the search party was walking! There can be no hard and fast rules on the subject. On a passenger ship the Officer on watch used the public address system at full power at 3 a.m. and located a missing boy asleep in a toilet. The sheer volume of sound awakened the boy.

When the person is missing in heavy weather, thick fog, darkness or freezing conditions or where many sharks are about, or where it is known that the person cannot swim, the Master is faced with a serious dilemma. However, people have survived for great lengths of time in the water regardless of their age. It is an occasion where the personality of the person virtually governs his survival. There is a report of an Australian naval seaman surviving for 17 days in the Pacific Ocean, having fallen overboard wearing a lifejacket. It must not be assumed of course, that because a person was last seen say 4 hours ago, that he or she fell overboard 4 hours ago.

HEAVY WEATHER

A wave which is breaking is more dangerous than one which is not, although the latter can become equally hazardous if it is unnaturally broken upon impact with the ship. A breaking wave is higher and steeper than one which remains unbroken, and while the motion within the latter is generally in the vertical plane only, the former wave projects a large volume of water downwards and ahead of itself, causing sudden horizontal motion of a buoyant object, such as a boat. In almost all sea conditions there tends to be a cycle of wave development and deterioration which is usually sufficiently regular to enable a seaman to predict a short period of moderating sea.

In open, deep waters where the wind has a long *fetch*, i.e. a large, smooth area over which it may blow without meeting obstructions, waves are higher and their successive crests are farther apart, the distance between two such adjacent crests being known as the *wavelength*. When the wavelength increases, so does the time interval between the passage of two successive crests past a fixed point, i.e. the true *period* of the waves. If the period remains constant, then the velocity of the waves must increase.

Large vessels behave best in a short sea, while smaller craft are more comfortable in a long sea, i.e. one having a large wavelength. A long vessel, supported only at her ends or amidships by wave crests, is subjected to severe bending stresses, and a shorter wavelength is therefore preferable. The seaman can estimate the wave characteristics once he has

found the true period because: The velocity in knots is roughly equal to three times the period measured in seconds. The wavelength in metres feet is roughly equal to the square of the period (in seconds) multiplied by 1·5, e.g. a 5-second wave system has a velocity of 15 knots and a wave- 5 length of 37 m. These very closely approach the observed characteristics. 125 ft

The period of roll of a ship is the time taken to roll from, say, port over to starboard and back to port. It may similarly be described as the time interval between three successive transits of the mast through the vertical plane. This period is largely governed by the metacentric height, a short roll and an uncomfortable motion being associated with a centre of gravity positioned low down in the vessel. Such a vessel is described as being *stiff*, her counterpart with a long period of roll and high centre of gravity being known as *tender* or *crank*. The latter's motion is more easy, but both extremes are undesirable. The period of roll is increased by distributing weights farther away from the fore-and-aft line of the ship, the process being known as *winging-out* weights.

In a similar way the period of pitch of a ship is the time taken to ascend from the lowest position and return to it, or the time between three successive transits of a fixed point on the stem through a horizontal plane. The *apparent period* of the waves is the time interval between the passage of two successive crests relative to a shipborne observer. It is sometimes called the *period of encounter*. When a ship is running before a sea the apparent period exceeds the true period, and vice versa when the ship heads the sea. The period of encounter is the interval with which the seaman is most concerned.

Synchronism

When the roll period is equal to the apparent wave period each roll is boosted by the waves and a condition of synchronous rolling is set up. Within a minute or so the vessel rolls to large angles, which progressively increase. Shifting of the cargo may occur, but in cases where the range of stability is small the vessel may capsize. The condition must be recognised immediately and course altered rapidly in order to change the apparent wave period. The vessel is most vulnerable when the sea is abeam, and in this situation the true and apparent wave periods are equal. An increase in metacentric height (or lowering of the centre of gravity) will increase the amplitude of synchronous rolling.

Synchronous pitching occurs when the period of pitch is equal to the period of encounter and causes excessive racing of the engines as the propeller emerges from the water or approaches the surface, longitudinal straining of the hull, and heavy damage due to the shipping of seas. Alteration of speed will destroy the condition. The water resistance to pitching is greater than to rolling, and the pitching angle does not become abnormally large.

A vessel broken down and lying helpless in the wave trough is extremely vulnerable to synchronous rolling, and means should be adopted to bring the vessel head to wind and sea as soon as the engine failure occurs.

General Behaviour of the Ship

A vessel heading into a bow sea heels over towards advancing wave crests, and this part of her roll is damped. When running before a quarterly sea the reverse is true and she heels away from oncoming seas. In this condition the resistances to rolling are least and larger angles of roll are attained, in addition to which the waves traverse the ship's length more slowly than if they approach from ahead. The combination of these two factors renders the ship liable to ship heavy seas aft, a process known as *pooping*.

From the previous text, we now see that the ability of a ship to ride comfortably depends upon her course and speed relative to the waves, her strength, her range of stability, her weight distribution relative to the fore-and-aft line, her period of roll, and the period and wavelength of the seas.

When steaming head to sea the ship is subjected to pitching, racing of engines, longitudinal stresses, slamming and pounding at the fore end due to wave impact, and the shipping of water. Ideally, the ship should be trimmed a little by the stern so that the screws and the rudder are immersed to the maximum and the bow resists a tendency to bury itself. All the hazards of pitching are reduced by lowering the speed of the vessel. Occasionally, such a reduction in speed may adversely affect pitching, for it may cause the period of encounter to approach closely the period of pitch, setting up synchronism. From this, it follows that on rare occasions an increase in speed will reduce pitching, but this action will inevitably produce dangerous slamming of the forefoot.

The tendency of a vessel to pound her forefoot is most marked in light, flat-bottomed ships, particularly when the forefoot becomes emerged. It is decreased by reducing speed, but in very short waves extremely low speeds may prove a reverse effect. Certain slamming occurs even when the forefoot is buried deeply or ascending, and is due to the rapid variations of the pressure system which always surround a hull. These variations are caused by the ship's speed, and have been used in past hostilities to detonate certain types of mine.

When running before the sea a vessel usually experiences difficulty in steering, particularly one having a high counter stern which is easily lifted by the sea, producing an alarming yaw. Under these conditions with the sea astern, if the vessel is situated in the trough of a sea which is overtaking her and breaking she is likely to be pooped. If the ship and waves have equal velocities and the vessel is lying on an advancing wave

slope, i.e. *surfing*, she is likely to be slewed violently, heeled over, and swamped. The process of slewing is known as *broaching-to*. The sudden addition of top-weight water when heeled over to a large inclination may reduce the angle at which positive stability disappears to the *existing* angle of heel, and capsizing is then likely.

If the sea has a wavelength considerably greater or less than the ship's length, i.e. a long or short sea, her motion will be safest, and it follows that the greatest danger from a quarterly or astern sea arises when the sea has: (*a*) a wavelength closely approaching the ship's length, and (*b*) a velocity equal to or greater than the ship's speed.

In these circumstances it is wise to reduce speed so that the seas overtake the vessel rather than run the risk of surfing and broaching-to. Ideally, the speed should be found at which the danger of pooping is also least.

With a sea abeam, allowance must be made for lee drift, which may have a rate in excess of 2 knots. If the wake is sighted and its direction compared with the course steered the angular difference will give a close approximation to the necessary upwind alteration of the ship's head. Alterations of speed will have little effect on behaviour in a beam sea, but course alterations will reduce the amplitude of rolling. Whether the alteration is made into or away from the sea will depend upon the wave characteristics relative to the ship's length and speed, and on her known preference for a bow or quarterly sea. The use of weather-side storm oil will produce a valuable slick spreading to windward, in which the breaking of seas is minimised.

Turning a Vessel in Heavy Weather

This requires the utmost accuracy of judgement and a knowledge of the ship's characteristics in answering helm and engine movements. The engine and catering departments of the ship should be informed and the decks cleared of men. Before turning, a study should be made of the wave-development cycles and the arrival of a moderating sea predicted.

When turning downwind away from a head sea it is desirable to experience the relative calm when the vessel is lying in the trough and commencing the last half of the turn, for this is the period when she is likely to be swamped. The latter half of the turn must be executed as rapidly as possible.

When running before a sea and wishing to turn upwind it is desirable to experience the relative calm during the latter half of the turn when the vessel is swinging up into the wind and sea. If this swing is executed in very heavy seas the ship may suffer extensive damage. For this reason the latter half of the turn should again be carried out as quickly as possible, so that the ship is fully prepared to meet oncoming seas while steady.

In both cases speed should be reduced before turning and bold helm used. The turns must be carried out with the minimum of headway, and the rudder is rendered operational by using short bursts of full-ahead revolutions. The ordering of full ahead and full helm has everything to recommend it providing: (*a*) the minimum of headway is gathered, and (*b*) the rate of swing kept low if misjudgement causes the arrival of heavy seas at a critical stage. In this event it may be preferable to resume course and make a second attempt. The use of storm oil is of great value in these manœuvres.

Heaving-to

A vessel heaves-to when, due to the stress of weather, the voyage is temporarily discontinued and the ship is manœuvred so as to ride out the storm in the most comfortable position. Generally, a ship will behave best in one of three positions: (*a*) with the sea on the bow and steaming at a reduced speed sufficient only for steering, (*b*) with the sea abaft the beam and at a similarly reduced speed, or (*c*) stopped and drifting to leeward.

In (*a*) the dangers of pitching and slamming are present, but the vessel will probably make little way over the ground, and the attitude is therefore a wise one when there is little sea room to leeward. It is a difficult position to hold when in light condition if the bow shows a tendency to pay off. In (*b*) considerable way is made to leeward and the danger of pooping exists. The attitude is therefore recommended only when a ship has plenty of leeward sea room and good steering qualities in such a condition of quarterly sea and low speed. In (*c*) a lesser amount of drift is made to leeward, but despite this a recent case showed a particular vessel, in light condition, to experience a rate of 5 knots lee drift in this attitude, so that again ample lee sea room is desirable. The vessel will probably roll heavily in this position, and synchronism may occur, so that at all times the vessel should be capable of being swung rapidly. The risk of a shifting cargo is present, and rolling may be very violent if the vessel is stiff. The method is often employed in low-powered vessels which are unmanageable in position (*b*) and which are incapable of turning head into the existing wind. This may be due either to a large wind surface forward or the inability to gather sufficient headway in the circumstances.

In all cases when hove-to the use of storm oil will do much to reduce hazards.

Preparing the Vessel for Heavy Weather

The vessel must be made as seaworthy as possible before the onset of

bad weather, paying particular attention to the following points:

(1) The checking, and doubling-up if necessary, of all deck lashings.
(2) The tightening of boat gripes.
(3) The battening down of hatches. Locking bars, where fitted, should be tightly set up and consideration be given to the stretching of extra tarpaulins.
(4) Where the admission of continual fresh air to cargo holds is unnecessary or may be temporarily dispensed with, ventilators should be covered to prevent the admission of sea-water. This applies particularly in the case of a cargo of wood pulp, where expansion due to wetting can be up to 50% and rupturing of the ship's side or deck can occur. Wet grain provides a similar danger, though not having such a great expansion.
(5) Lifelines of 25–30-mm fibre rope should be rigged and set up tightly throughout the exposed decks. Where a long unsupported span is inevitable the line should be stopped to the adjacent distant strong points by short lengths of line of preferably equal strength to the lifeline. 3–4-in manila
(6) If time permits, unprotected accommodation storm doors should be hose-tested and any deficiency of watertightness made good with the use of waxed caulking felt.
(7) The securing of all derricks must be absolute.
(8) The existence of water or oil fuel which is loose, i.e. it is able to wash from side to side of the ship, produces a *free surface effect* reducing the stability of the ship. It should be reduced to a minimum, preferably by filling tanks, for this adds bottom weight and lowers the centre of gravity of the ship. Any flooding or pumping must be done well beforehand while the ship is steady, for the filling of an empty tank in itself produces a free surface effect in addition to any list which may be caused by off-centre loading. The deliberate introduction of free surfaces while the ship is in a seaway is a practice to be avoided, unless the vessel is light, in which case her margin of stability is usually high.
(9) If the stability of the ship is dangerously small due regard should be paid to the jettisoning of deck cargoes if the flooding of double-bottom tanks proves insufficient. The filling of a deep tank will have little effect in lowering the centre of gravity of the ship. Otherwise, the deck cargo should be securely lashed, and in the case of livestock, ample protection be given to the animals. A large supply of food and water should be provided in case men are unable to reach the animals at the height of the storm.
(10) The watertightness of the spurling pipes, leading to the chain locker, should be ensured. Some officers prefer to remove

hawse-pipe *storm plates* in bad weather. They have been known to come adrift with great force and fly about like scythes.

(11) All loose gear, including ropes, should be cleared from the decks.

(12) Signal halliards may be slackened in anticipation of their tautening when wet.

(13) All doors on exposed decks should be tightly closed except for accommodation accesses.

(14) Deadlights (metal screens) should be fixed in place over portholes and scuttles.

(15) A swimming-bath should be drained, since this, when full, adds top-weight and free surface effects.

(16) A heavy weather routine should be adopted by the Chief Officer to ensure the minimum of men (if any at all) being on deck during the storm.

(17) All life-rafts and other buoyant apparatus should be checked for freedom of jettisoning.

(18) Should the cargo be tommed or shored in any way, this should be checked before the storm to make sure it is in place and tight.

(19) In an older ship with wooden hatches, all spare hatchboards should be made ready for immediate use in anticipation of a hatchway being stove in.

(20) Awnings must be taken down, otherwise they will be ripped apart and the spars damaged.

Duties of the Officer of the Watch

He must avoid steaming too rapidly into a head sea, and reduce speed early in all attitudes where hazards are increasing despite the fear of being considered over-cautious. He must be satisfied that the ship is thoroughly seaworthy and at all times keep a close watch for synchronism. Only the best helmsmen should be employed during the storm, and if conditions arise where it is necessary to meet each wave with the helm he must consider the necessity of relieving the helmsman every ½ hour to avoid weariness. The clear-view screens should be tested beforehand, together with the fog-signalling apparatus in anticipation of poor visibility. Distress rockets should be to hand.

HANDLING DISABLED VESSELS

A vessel which has shipped considerable water will be more deeply laden, and she may be both listed and trimmed by the head. Chapter III

should be referred to at this stage, where the handling abilities of ships in these conditions are fully discussed.

A twin-screw ship will handle quite well with her rudder and one propeller. If both screws are available for use she can be steered, in the event of rudder loss or damage, by varying the port and starboard engine revolutions. A single-screw ship without the use of her rudder will be temporarily helpless unless a jury rudder is rigged (Chapter VII).

Any ship having no motive power is completely helpless unless a towing vessel is available. The vessel should be brought head to wind and sea as rapidly as possible in order that she may ride comfortably and with the minimum of lee drift. This necessitates the use of:

Sea Anchors

In anchoring depths the easiest and quickest way of bringing a vessel head to wind is to trail a length of chain cable along the sea-bed. The anchor is detached from the cable to minimise the risk of it fouling. If one cable proves insufficient the other should also be used, but it is preferable to keep one anchor ready for use in the hawse pipe in case of an emergency. The cable should be ready for slipping and buoying should it foul an underwater obstruction, and this is best achieved by locating a joining shackle just abaft the upper end of the hawse pipe.

Since the weather entailing this procedure will be very bad, no attempt should be made to hang off the anchor, since this involves sending a man overside in a bosun's chair. The anchor is therefore lashed in its stowed position within the pipe and the cable is eased. The spare joining shackle just abaft the anchor shackle is broken, and the cable is manhandled out through a forward fairlead, the Panama Canal type being ideal. In the absence of such a lead, a mooring chock will have to be used, but any damage to it will be of small moment if the ship is saved from major damage or stranding. Three, or even more, shackles should be ranged along the sea-bed. The use of the weather cable, if only one is to be used, will prevent a continual bad nip at the stempost. This method of sea anchoring is used frequently by some Masters of short-sea traders when encountering bad weather in the North Sea.

In waters of all depths other methods are feasible, provided time and suitable gear is available. In past days a very effective sea anchor was made by lacing a trysail to a boom, weighting it at its lower apex—the tack of the sail—and streaming it ahead on a rope bridle. Nowadays, such an appliance would have to be made from spare canvas, or tarpulin, and a wooden spar. The latter is not always available. The canvas will take considerable time to prepare, and the strength of the finished appliance will be doubtful. The following are tried methods, but they may prove unsuitable for large vessels:

(1) The streaming, on a wire hawser, of several cargo baskets or empty oil drums rigged in a cluster, or even an empty container.
(2) The streaming of a wooden raft, weighted at its lower edge with spare chains.
(3) The streaming of a triangular-prism hatch tent having its apex removed and its base stretched open with two crossed awning spars. The strength of the spars will govern the life of the sea anchor.
(4) The streaming ahead of a waterlogged boat; the falls will probably have to be cut adrift and the boat may be non-recoverable. The use of life-saving appliances in this way may well be regretted at a later stage.
(5) The streaming of a wooden cargo slab hatch, i.e. five or six wooden hatches already strapped together with steel slats into a rectangle 8 ft square about 2·5 m square. It must be weighted at its lower edge so that it lies vertically in the water.
(6) The rigging of a makeshift mizzen sail to increase the wind surface aft.

All these methods take considerable time and trouble to rig, and their jettisoning involves danger to the crew in heavy weather. There are, however, cases reported where a vessel has been successfully turned head to wind by lowering one or both anchors to a considerable depth. The vessel makes leeway while her anchors tend to remain vertically above a fixed point. The bows are then slowly swung into the wind. The lower the depth to which the anchors are veered, the better will be the result, due to the increased water pressure. It is preferable therefore to attempt this method prior to commencing manufacture of an appliance of doubtful strength, life, and efficiency. Until the anchor reaches the level of the keel there is considerable danger of it damaging the hull plating as the vessel rolls. It would be unwise to veer more than about four shackles of chain on each anchor. In excess of this, the windlass might have difficulty in lifting the anchor and chain.

Running on to a Lee Shore

A *lee shore* is one towards which a strong wind is blowing. Occasions arise when a vessel is strongly set towards such a shore and is unable to turn head to wind in order to make favourable way out to seaward. This situation is most likely to occur in a low-powered vessel, particularly when in light condition. In addition to her leeway, the vessel comes under the influence of a surface drift current created by the wind, provided that the wind has blown unveeringly for more than 24 hours.

In high latitudes this drift current is likely to have an average rate equal to 2% of the wind speed, and 4% in the case of low latitudes. It is therefore possible to predict, in low latitudes, a drift in miles per day roughly equal to the wind speed in knots, e.g. a 30-knot wind may produce an approximate drift of 30 miles in one day in low latitudes and 15 miles per day in high latitudes. Exceptions to these frequently occur, particularly within the Indian Ocean at the time of the south-west monsoon, where daily drifts of 160 miles can occur. The western coasts of the United Kingdom are renowned lee shores after a period of south-westerly gales, and cautionary notes are printed on the appropriate Admiralty charts to this effect. Despite this, a vessel grounded in recent years after being swept to leeward, with the loss of all hands together with the crew of the local Royal National Lifeboat Institution craft. Total lee drift in excess of 4 knots is not unusual.

There are four basic ways in which a vessel may attempt to clear a lee shore:

(1) By rapid use of a sea anchor to swing the vessel head to wind.
(2) By letting go both anchors, when in suitable depths, snubbing the bows head to wind, and steaming out to seaward, weighing her anchors as she does so. If the act of weighing anchors is likely to swing the bows off the wind, then preferably one anchor only should be used on a long scope and slipped from the deck while proceeding out.
(3) By turning through 270° downwind under full speed and helm until the vessel heads the wind. In sailing ships this is known as a wearing turn. The method is hazardous, because if it fails the vessel lies much closer to the coastline and, further, the momentum of her swing must be maintained in order for it to be successful, and this involves bringing the bows very rapidly into a heavy sea. This is likely to cause extensive damage.
(4) Apart from (2), the method most likely to succeed in deep water is as follows:

The engine is reversed and the vessel, which is allowed to gather only the minimum of sternway, runs her stern into the wind's eye. This position is then held while flooding of the after compartments is carried out. The flooding of the after hold alone will, though immersing the rudder and propeller further, create an awkward trim producing an increased wind surface forward and any benefit may be lost. If only one hold can be flooded, the one abaft the vessel's tipping centre will give the best results. It is desirable, however, to flood as many aft compartments as possible. The holds should be flooded to just below the level of any shaft-tunnel top. The tunnel then acts as a washplate, and free-surface effects are reduced to a quarter value.

This action, then, sinks the vessel bodily, and the greater thrust of the screw together with the increased rudder sensitivity offsets any adverse effect of trim. The flooding is carried out by means of hoses, removing non-return valves and pumping through the bilge line with limber boards (bilge covers) removed, and/or flooding up through the double-bottom tanks with manhole doors unshipped. Any other available means should be used in addition. If the double-bottom tanks contain fuel oil only the first two methods are used. If possible, all loose timber and gear should be taken into the 'tween deck, but in an emergency nothing should be allowed to interfere with the rapid flooding. A case on record shows the two after holds of a vessel of 6000 tonnes D.W., in light condition, to have been sufficiently flooded in forty minutes.

Once this is achieved, a turn into the wind is again attempted, preferably to port in a single-screw ship to make use of transverse thrust.

It is most undesirable to gather too much sternway into the sea for: (*a*) the engines will race due to pitching, and (*b*) the rudder and propeller when under headway are protected to some extent from wave impact, but under sternway they are extremely vulnerable and are likely to be fractured. A case has occurred, however, of a vessel lying stern-to a heavy sea while maintaining her position off a lee shore, and with her screw turning over at very slow reversed revolutions for 36 hours. Oil was used to prevent breaking seas striking the blades, and no damage was suffered.

If the vessel has low astern-power, she may have little chance of avoiding stranding despite her following the above manœuvre. A vessel of 7000 tonnes deadweight was heading in a northerly direction off the Californian coast at light draught. At noon her position was fixed and conditions were calm. By 2000 hours the wind was gale force and freshening, with a heavy swell on the port beam. Her steering became difficult and at 2100 hours flooding of No. 5 hold was commenced, using four hoses. By 2200 hours the wind speed was about 55 knots and full helm had no effect. A wearing turn was attempted towards the land, to no avail. At 2300 hours the engine was reversed at full speed and the vessel ran her stern up into the wind. In this situation, due to low astern-power, she was unable to hold her position and virtually sailed before the wind. Visibility was approaching nil. At 0050 hours a reef was struck, tearing several bottom plates away adjacent to the forward engine-room bulkhead. At 0120 hours the bows struck and the vessel became fast on
150 yds a rock 150 m offshore. Both anchors were let go.

The sailing component of disabled ships

Considerable research has now been carried out on the sailing qualities of large tankers, as shown in Figure 9.1. When disabled, it is

not unusual for such ships to make a lee drift in excess of 4 knots. They are large enough to achieve a significant sailing component and the two influences produce a resultant movement to leeward slanted towards the downwind end of the ship. This resultant can be further influenced by changes to draught, trim and list, bearing in mind that a moving ship turns naturally towards her high side. The walking back of an anchor to say four shackles of chain might swing the bows towards the wind and alter her sailing direction yet again. Seafarers faced with the prospect of a certain stranding, or a drift towards an island or reef, should seriously consider whether influences as described above could be used to lessen the damage in a stranding or enable them to bypass the isolated danger.

A 150,000 tonne tanker with rudder amidships and a trim by the stern of 5 m, can drift in a 150° direction when heading east and stationary in a north wind. By heading west, the drift becomes 210°. By swinging the ship through 180° before motive power is lost, her drift direction can be changed by as much as 60°.

DANGERS TO NAVIGATION

A *derelict* is a vessel which has been completely abandoned but which remains afloat. Since their lights will usually be without power supply, collision is possible with them at night and will invariably be end-on at full speed. Extensive damage is likely. A derelict can be taken in tow and a claim made for a salvage award.

On sighting a dangerous derelict, the Master is bound to communicate the information to all ships in the vicinity and also to the nearest coastal Authority. It must be reported to the local Receiver of Wreck. The transmission will consist of a Safety signal and may be in plain language (preferably English) or in International Code. The message is free of charge to the ship concerned.

The same obligations apply to dangerous ice, any other direct danger to navigation, a tropical storm, severe ice accretion associated with gales and sub-freezing temperatures, and a wind of force 10 or above on the Beaufort scale for which no warning has been received.

The information transmitted should include, in the case of ice, derelicts and similar dangers:

(1) The kind of danger observed.
(2) The last observed position of the danger and the Greenwich Mean Time and date.

In the case of a tropical storm the transmission should include:

(1) A statement that the storm has been encountered, or that the Master believes one to exist or be developing in the area.
(2) The date and time (G.M.T.).
(3) The ship's position.
(4) The barometric pressure and whether it has been corrected.
(5) The barometer tendency, i.e. the change in the last 3 hours.
(6) The wind direction and Beaufort force.
(7) The state of sea and swell.
(8) The true course and speed of the ship.

The Master should then transmit further reports preferably every hour, and in any case at intervals of less than 3 hours for as long as he remains under the influence of the storm.

In the case of winds of force 10 and above for which no warning has been received the message should include all the above points with the exception of (7). Messages concerned with ice accretion should include:

(1) The position.
(2) The G.M.T.
(3) The air temperature and the sea temperature (if practicable).
(4) The wind force and direction.

The following are specimen messages:

TTT Ice. Extensive berg sighted 4600 N 5100 W 1200 GMT April 30.

TTT Derelict. Derelict sighted low in water heeled about 30 degrees. Name unknown. 3300 S 11014 E 0300 GMT Dec 20.

TTT Navigation. Mine sighted 5003 N 1023 W 0930 GMT June 15.

TTT Storm. Hurricane believed nearby due south. 1500 GMT July 22. 2002 N 4001 W. Corrected barometer 74 cm. Tendency down 5 mm. Wind E force 8 squally, Heavy southerly swell very rough sea. Course 252 speed 15 knots.

TTT Storm. Wind force 10 no warning received. 1400 GMT Feb 12. 5006 N 3005 W. Corrected barometer 74 cm. Tendency down 5 mm. Wind SW force 10 veering. Course 240 speed 9 knots.

TTT Severe icing occurring. 1100 GMT Feb 22. 70 N 12 W Air temp −10 Sea temp −1. Wind NNE force 9.

WRECK AND SALVAGE LEGAL ASPECTS

In the United Kingdom Officers of the Department of Trade supervise matters pertaining to wreck, and may appoint Receivers of Wreck, one

to be situated in each wreck area of the country. They are often Customs Officers.

Wreck as a term also includes *flotsam*, i.e. goods which have been lost overboard or jettisoned and which are recovered because they remain afloat; *jetsam*, i.e. similar goods which are washed ashore; *ligan* or *lagan*, i.e. goods which are jettisoned and buoyed for later recovery; and derelict. All wreck must, if found by a person other than the owner, be delivered to the Receiver of Wreck. This applies to wreck found outside the United Kingdom waters and brought into the country. If found by an owner a full report must be made by him. Wreck is usually kept for a period up to one year, but smaller goods which are not of sufficient value to be stored may be sold. Unclaimed wreck will become the property of the Crown.

The Receiver of Wreck must proceed to any vessel which is stranded or in distress, on or near the United Kingdom coasts, and take charge of rescue operations. He can interfere between a Master and his crew only if the former so requests. The Master can prevent by force any person boarding his ship without his permission unless it is the Receiver of Wreck, or his representative.

Salvage

If a ship, lives, or cargo on board are saved from a danger, *voluntarily* and successfully, the person so doing carries out a salvage service and is entitled to a reward.

In spite of the fact that a Master must, by law, assist any vessel that collides with him or which is in distress, he is still regarded as a volunteer for the purposes of salvage. A passenger cannot claim salvage unless he chooses to remain aboard and assist, in spite of the offer of rescue. A member of the crew is bound by his agreement to preserve his ship, and can claim salvage only if he is ordered to abandon his ship (the order being given with no intention of returning), but later returns to it.

The Royal Navy may claim salvage; Coastguards may do so if they provide a greater service than that to which they are bound; members of a R.N.L.I. lifeboat may claim salvage if they find that their life-saving services are not required and they choose to save property.

Every salvor who contributes to the ultimate success may claim a share in the reward, but initially the Master of the salved ship may select his salvors if several arrive upon the scene. Others may assist later if he decides that their services are necessary, but only with his permission. In the case of derelict, the first salvor to arrive has complete control and sole rights; others may interfere only if he proves to be thoroughly incompetent.

The use of Lloyd's Standard Form of Salvage Agreement between the

Master and his salvors saves time, bargaining, and refers all disputes directly to arbitration. No financial sum need be mentioned in the agreement, it being decided later by the Admiralty Courts. In the case of a salvage claim below £200 the Receiver of Wreck will probably deal with it himself.

Awards are usually paid for the salvage of lives only if property has been saved as well, because this then provides a source of finance. In United Kingdom waters life salvage in the absence of property salvage may be rewarded by the Department of Transport (D.o.T.) out of Treasury resources.

CHAPTER X

TOWING

THE type of towing discussed in this chapter is that employed in open waters by a vessel which is not a tug. In the text the vessel which is being towed will be referred to as the tow.

LEGAL ASPECTS

In certain circumstances a ship which requires to be towed may not necessarily be in distress, and for this reason, a Master proposing to tow her should ascertain that his Charter-party and/or Bills of Lading allow him to do so in such a case. If the vessel is in distress, then she could be towed to a place of safety, but the towing Master then has no right to continue towing for the purpose of completing a successful salvage operation unless the above documents permit him to do so.

Assuming that the towing Master is unrestricted, he should consider:

(*a*) The duration of the towing voyage.
(*b*) Any mail contract to which he may be a party.
(*c*) Whether he will be able to arrive at his original destination before the cancelling date of the Charter-party.
(*d*) Whether he has enough bunkers and a safe reserve.
(*e*) The effect of delay on his own cargo.
(*f*) The power of his engine(s).

In addition, he should:

(1) Notify his Owners, who will inform Lloyd's and the Underwriters, the latter possibly requiring a larger premium.
(2) Inform his charterer, if any.
(3) Enter into a Lloyd's Standard Form of Salvage Agreement.
(4) Preferably make for a port where the British law of salvage applies.

It has already been mentioned in Chapter IX that salvage claims are only admissible when a danger existed. The fact that a vessel may be disabled in calm weather does not detract from this, since as her stores are consumed, or the weather deteriorates, a peril arises.

On arrival at the destination the offer of assistance from tugs should not be rejected under the impression that extra salvors are then involved. If required, they should definitely be employed, because the towing Master must conclude the operation successfully in order to submit a claim. The tugs may be engaged under an ordinary towage contract, and this does not entitle them to make any salvage claim unless a new peril arises and the tugs perform useful work over and above that which is demanded by the towage contract.

THE TOWLINE

Little can be laid down regarding the method of towing, since this depends upon the types of ships, the duration of the towing voyage, the weather, the route to be followed, and very largely upon the urgency with which the tow must be commenced.

In some cases, where the towing ship is of a suitable type, one of her anchor cables is ranged right along the deck to the stern rail, where it is shackled to the anchor cable of the tow. The anchor is left in the towing ship's hawse pipe, preferably with heavy wooden pads between the flukes and the bow plating, to act as a toggle. The cable must be well racked to bitts and other strong points throughout the vessel's length. Timber and canvas should be used copiously to minimise chafe.

Probably the ideal towline is one made of manila fibre, for this possesses great elasticity, which is very necessary in towing, when sudden stresses are likely to be applied to the line. Such a line, however, would be very bulky, cumbersome, and subject to rotting and exceptional chafe. If storm oil was used the manila would deteriorate in strength once it had been in contact with the oil. Wire rope of equal strength is less bulky, easily stowed and handled, and is less susceptible to rotting and wear. It possesses negligible elasticity, however, and will part under a sudden applied stress. In order to provide elasticity, a composite towline of wire and manila may be used, the manila being of cable lay (three left-handed ropes laid up together right-handed), which is more flexible and watertight than a hawser. A simple hawser-laid rope should not be used, since it tends to unlay when under stress and develop serious kinks when the stress is relieved. This can, however, be prevented by using swivels at each end of the hawser.

A towline can be made by securing two heavy wire pendants to each
9-in end of a special strop. This strop is made endless, of 70-mm manila, and the two parts are well seized together, leaving two thimbled eyes at
ten fathoms the ends. Swivels are again recommended. The strop, forming the middle 20 m of the towline, provides valuable elasticity.

A very quickly rigged and frequently used towline is formed by securing the towing ship's towing wire to one anchor cable of the tow, the

latter vessel still retaining one anchor in the hawse pipe ready for an emergency. This necessitates those on board the tow disconnecting the anchor from the cable and preferably bringing the anchor on deck. Alternatively, the anchor may be hung off below the hawse pipe and secured by tackles leading from the deck. In an emergency consideration may be given to jettisoning the anchor in order to save time. The cable may now be led through the hawse pipe and shackled to the tow-wire. Naturally, the anchor could be lashed in the hawse pipe, and the cable led through a fairlead or mooring chock, but this may cause the cable to be badly nipped, quite apart from probable damage to the chock, which is not intended for cable use.

In such a composite towline the cable should be veered between three and, say, seven shackles. The weight of the chain causes the towline to lie in a shallow curve called a catenary, and this provides spring, for a sudden stress will be absorbed as the catenary becomes more shallow, and normally before the catenary disappears altogether the tow will be surged ahead, thus relieving the stress. In this way, two materials, neither of which possesses useful elasticity, may be combined to absorb shock. The longer the length of chain, the greater will be the shock-absorbing property of the towline. Using materials of equal strength, wire is about one-fifth of the weight of chain, the size of the wire (its diameter in mm) being roughly equal to the size of the chain (the diameter of the link bar in mm). To maintain a suitable catenary, the towline should never be allowed to close or break surface; on the other hand, it should never be so great as to foul the bottom, since the line may then part.

The towline is bound to be nipped at fairleads, and even if the leads are in fact fair, chafing will occur. The chafing part should be removed from the fairlead regularly either by veering or shortening the towline. This is called *freshening the nip*, and in this composite method is easily achieved by means of the tow's windlass, providing the tow is manned.

A minority are of the opinion that the use of the chain cable promotes link wear, but the weight of opinion is that the wear is considerably less than that caused by a ship yawing at a single anchor, and in any case the tow is more valuable than her cable.

Under Lloyd's Classification Rules, only vessels of less than 90 m in length are required to carry towing lines. Certainly larger ships might well be able to tow using synthetic fibre mooring ropes which are immensely strong and elastic. Two Royal Navy frigates engaged in a towing operation in the Mediterranean Sea using 1,800 metres of 88 mm braided nylon rope with a breaking load of 165 tonnes. A total distance of 3,000 miles was covered and a world record towing speed of 23 knots was claimed. The speed was attained in tests to determine the noise produced by towing a dead ship.

Other proved methods of towing include shackling the towing wire to both anchor cables of the tow, using the chains as a bridle. Sometimes, the towing ship provides a wire from each quarter, the ends being
30 ft shackled to the towing wire about 10 m beyond the stern. This is a bridle and avoids the towline exerting a stress on only one side of the ship, or exactly amidships, both of which have been found to hamper steering. The same result may be achieved by shackling the tow-wire to several parts of wire loosely secured across the poop deck or around the stern of the towing vessel. It is virtually a bridle, but is known as a *span*. Such a span may also be achieved by leading a heavy wire out from one quarter of the towing vessel, while the main towline is led aboard through the other quarter leads. The wire is shackled to the towline and hove-in so that the latter is bowsed in towards the opposite quarter to its lead. This again appears as a bridle, but is termed a span. By letting go the wire, the span is instantly removed.

When the tow has full motive power but is rudderless a method sometimes used is for her to tow the assisting ship, the latter sheering from side to side, as required, to steer the disabled vessel.

Nylon rope of equal size to top-grade manila is about twice as strong as the latter. For this reason, a manila rope can be replaced by a very
6-in much smaller nylon line to provide equal strength, a 50-mm manila
4½-in being replaceable by a 35-mm nylon line. Since nylon possesses elasticity, it is ideal for towing purposes, but as yet is used for such a purpose only by tugs, and as a pendant secured to a wire towline in larger ships. It is light, easily handled, does not freeze when wet, and is, to a very large extent, rotproof.

Fittings

The strength of these must be in direct proportion to the towing pull, which in turn is directly related to the motive power of the towing vessel, the speed of towing, the tow's displacement, and the inclemency of the weather. If the security of bitts is doubtful the lines should be belayed to several pairs of bitts, all as nearly as possible in one straight line. By backing up the first pair of bitts in this way, provided the belaying is done evenly, the stress on the lines is evenly distributed.

Other strong points include winchbeds, the bases of cargo-hatch coamings, deckhouses, superstructures, masts, and samson posts. These are more easily made use of if the vessel is flush-decked aft. When using any strong point, particularly in the case of bitts, they should be well shored up and stayed, to provide added resistance in the direction of stress. If the deck is considered too weak to withstand the applied stresses of towing, the hull of the tow is sometimes completely girdled with wires frapped to the deck edges and shackled to the towing wire. If the tow's cable is being used as a component of the towline her windlass

will not be subjected to undue stresses provided an adequate catenary is maintained. The cable should be held firmly on the brake, using devil's claws, Blake stoppers, guillotines, and all other available means to act as preventers to protect the windlass.

With regard to the towline, its size should be sufficient to provide an ample factor of safety under the towing conditions. In practice, the average merchant ship usually carries only one towing wire, and therefore has no choice, unless several parts of a smaller wire are used. These towlines, carried under Classification Rules, are often known as *insurance wires*, the origin of the term being obscure, for Lloyd's Classification Society is not an insurance company. A classed vessel will, however, no doubt earn reduced insurance premiums from her underwriters.

It is estimated that a tug equipped with steam reciprocating motive power can, in calm weather, exert a pull of roughly 1 tonne for every 75 kW of engine power. The force required to tow a ship is naturally increased if the tow is damaged, yawing heavily, badly fouled on her underwater plating, or in bad weather. In the case of a cargo vessel of 10000 tonnes displacement, in calm weather and with a fairly clean hull, a pull of very roughly 1 tonne per knot of towing speed is required up to speeds of 6 knots. Above this, the proportion disappears, and 11 tonnes are required to attain a speed of 8 knots. A ship of 200,000 tonnes when towed produces a towline stress of 100 tonnes on pick-up, 60 tonnes on average, but 184 tonnes when not steering.

When connecting wires, lugless or lugged joining shackles should be used in preference to shackles fitted with screwed pins. Cable shackles are ideal for this purpose. If screwed shackles must be used the pins should be securely wired to the shackle jaws to prevent them loosening. This type of shackle is liable to foul in fairleads due to its projecting pin, the cable shackles, on the other hand, are designed to prevent such an occurrence. A swivel may be used where chain is connected to wire, and this, like all other fittings, must be of equivalent strength to the towline, for the towing pull must always be confined to the safe working load of the weakest component.

The Length of the Towline

This basically depends upon the depth of the water, the state of the sea and swell, and the sea room available. The greater the length, the more able is the line to absorb shocks, and for this reason the length must be increased when the factor of safety is low, when the tow has a large displacement, or when the towline is light in weight.

The length should not be excessive, otherwise the deep bight, i.e. the catenary, may foul the bottom and part, or at the very least it will provide an added resistance to towing. Generally, a short, heavy tow-

line is better than a long, light one in that it enables the ships to have greater manœuvrability. As a guide, the centre of the catenary is best
20–30 ft 40 ft kept about 6–9 m below sea-level, increasing this figure to 12 m in rough weather.

Wear

Throughout the towing voyage, chafe must be kept to a minimum by parcelling hawsers with canvas, lining fairleads with soft wood and canvas, and using liberal amounts of soft soap or grease. Cable passing through a fairlead need only be lubricated. Nips of hawsers should be freshened about four times a day in calm weather, and those of cable about once a day. To avoid bad nips, the fairleads should be padded with metal or pieces of hardwood in order to lessen the angle of lead. Bollards should be of adequate diameter for the hawser being belayed, ideally at least 12 times the size of the line. Cable should not be belayed to bitts, since to prevent a nip a 1 m diameter bollard is necessary for a 50 mm cable, and this size of bollard is not usually fitted to merchant ships. Instead, the cable is racked to several pairs of bitts or around strong points, using hardwood padding to round off any sharp corners. If chain can be used in fairleads in place of wire, the amount of wear will be diminished.

Propellers

The resistance to towing offered by locked screws may, particularly in twin or multiple-screw ships, exceed the underwater resistance of the hull. Shafting should be disconnected in order that the propeller(s) may trail and revolve freely.

SUPPLYING POWER TO THE TOW

If this vessel is equipped with electric pumps and has no power available the towing vessel can sometimes supply electricity, providing the current and voltage of the two ships is identical. This may prove invaluable, because the engine-room staff of the tow are then in a position to correct any list or adverse trim which may otherwise cause severe yawing. The power supply should be through one length of cable, because joints are unlikely to be watertight. A 16-mm wire rope should be rigged between the two ships as a jackstay, continually adjustable for conditions of roll and relative drift. The electric cable must be stopped in loose bights to the jackstay, parcelling both lines where seizings occur.

MESSENGERS

These are usually fibre ropes used to send a heavier and more cumbersome line to a distant point. They are of sufficient strength to support

the larger line, but are sufficiently small in size to be easily used on a warping drum.

MAKING CONTACT

The method employed here must depend largely upon the types of ships involved and the weather conditions. If the weather is very bad and there is no immediate urgency to commence towing it is preferable to wait for a moderation, and in darkness it is wise to postpone contact attempts until daylight.

Much has already been discussed in Chapter IX regarding this aspect of seamanship. The engine(s) of the towing vessel should be stopped, her way run off, and her drift relative to the other vessel can then be estimated. This is probably best done while lying on the same heading as the other ship and with all masts in line. It must be remembered, however, that when manœuvring in the lee of a disabled ship one's own lee drift rate is slightly retarded due to the protection from wind afforded by the other vessel. Similarly, if manœuvring to windward of a drifting ship, her rate of lee drift is likely to be reduced. In these circumstances two ships having equal lee-drift rates when well separated may be caused to close each other. The manœuvring Master must therefore be prepared to use full revolutions and helm to correct any such tendency.

Methods used for making contact may include:

(1) Manœuvring close enough to the stern or bows of the tow in order to cast a heaving line. The end of the tow to be approached will be the same as that shown for a lifeboat in Fig. 9.1, since this will minimise risk of collision. If the vessels are tending to drift apart several linesmen should be standing by in case the first cast fails to establish contact.

(2) A buoyant line attached to a life-buoy may be streamed to leeward of the tow. The crew of the latter vessel can then grapple for the line as the ship drifts across it. In the absence of a grappling iron, a lifeboat anchor would prove a good substitute. The tow could similarly stream such a line to windward, as she drifts, and it can be picked up by the crew of the towing vessel, which will proceed past close to windward.

(3) If the weather is suitable, contact may be established using a lifeboat.

(4) The quickest method under all conditions will probably be to use the rocket line-throwing appliance from either vessel. The crew of the target vessel will greatly facilitate this operation if they lower the main radio aerials. The fouling of a rocket on such obstructions is an all too frequent occurrence, and valuable time is wasted. The rocket should be fired downwind.

In cases (1) and (4), if the rocket is fired, or the heaving line cast from the forecastle head, the Master will have better manœuvring control, since he will have a clear view of the attempts. Throughout the line-work between the two vessels, care must be exercised not to revolve the propeller(s) until the lines are clear of the water. The use of storm oil will greatly assist the manœuvring, particularly if a lifeboat is used, but lines which become oily will be difficult to handle.

When passing lines it is most desirable that neither ship should have any way on other than lee drift. Naturally, any dangerous closing of the two vessels must be instantly corrected, but nevertheless, the gathering of sternway or headway will considerably hamper line-work. Further, the development of sternway in conditions of wind will result in the vessel commencing a swing.

If, in case (1), the two vessels have differing rates of lee drift, they may be brought close enough for line-casting by using the principle shown on page 192. The towing vessel lies to windward or leeward of the tow according to whether the latter ship has a slower or faster lee drift rate. A vessel drifting is likely to have some headway or sternway due to her ability to sail through the water. This has already been shown in Fig. 9.1, to which the reader should refer, where the resultant motion is composed of leeway and sailing-way.

When casting a line, or firing a rocket from the towing ship, the line should be secured to a messenger, which in turn is led along the ship's side, clear of all obstructions, passed in through the towing fairlead and secured to the towline. This enables the towline to be passed between the two vessels extremely quickly.

Communication should be arranged between the two ships either by W/T, R/T or VHF, megaphone, loud-hailer, signalling lamp, or by the International Code of Signals. If the vessel is a derelict, it will be advisable to send the Chief Officer and Chief Engineer across by boat (weather permitting) in order to survey the possibilities of towing. Later a basic crew can be put aboard for steering and watchkeeping and tending navigation lights. A member of the Catering Department should be included.

SECURING THE TOWLINE

The heaving- or rocket-line will be secured to a carefully flaked messenger which will be passed to the tow as rapidly as possible. This is then led to a warping drum and the tow-wire, or a larger messenger, hove across. Ideally, when passing the messenger which is directly attached to the towline, an additional similar messenger should be sent across and kept secured to both vessels throughout the towing voyage. A situation may arise, such as the parting of a link, when this secondary line will save valuable time which would normally be lost in establishing

fresh contact. The line must be kept very slack and attended throughout the voyage so that it can be instantly veered as soon as the towline parts. If this is not done the messenger itself will break.

If towing on a chain bridle from the tow the length of each bridle leg should be as long as possible so as to reduce uneven stresses, which are bound to arise except when the tow is situated in the towing ship's wake. Usually the tow rides at a steady angle of sheer away from the wake. Such a sheer should not be corrected by shortening one bridle-leg, for a bad nip is bound to occur.

If the tow's windlass is damaged the cable should be well frapped to several pairs of bitts, making use in addition of other forecastle-head strong points. On the other hand, the chain cable need not be used, in which case the tow may use a wire bridle; the absence of any chain in the towline will necessitate a greater length of hawser in order to attain a suitable catenary. A wire bridle is often used when the vessel has to be towed sternfirst. If the tow is not equipped with many strong points on her forecastle head, or if the existing points are considered too weak, the towing hawser may be passed through her hawse pipes several times and finally shackled to its own part. Both anchors will have to be shipped on deck or securely hung off.

In an emergency, such as towing a burning vessel clear of others, a method sometimes employed is to pass the eye in the towing hawser (making such an eye as rapidly as possible if the existing one is too small) over a fluke of the tow's bower anchor.

When securing a heavy wire hawser it may be belayed to two or more sets of bitts on the same side of the ship. An efficient method is to take a round turn on each of the first pair of bitts and belay the hawser to the succeeding pairs. Each turn on a bollard must be securely hove taut and lightly lashed to the underlying turn before passing the next. If this is not done the wire will quickly spring off the bitts and prove unmanageable. Chain stoppers (or carpenters' stoppers) should be secured to each pair of bitts, and a chain check-stopper is rigged just inboard of the fairlead, for use in controlling the wire when it is being surged around the bitts. Whenever a hawser is secured to the bitts a turn should be passed around the bollard nearest the fairlead before belaying commences. Failure to do this will result in the first turn occurring at the far bollard, and the set of bitts may then be lifted from the deck.

TAKING UP THE TOW

This is probably the most critical phase yet discussed, for the towline has to be stressed at a very slow, increasing rate, and a dead load of some 10000–20000 tonnes started into motion by this stress. The towing tons
vessel should move slowly ahead and veer the towing hawser to the

required length, and at the same time the crew of the tow can veer the cable to the pre-determined scope. The vessel must be stopped dead in the water while the towline is secured, and when all is ready the engine is worked ahead in short bursts of slow revolutions, say five to ten. An officer is stationed on the poop to continually report the lead and state of the towline, for on no account must it be allowed to break surface. If it does, the use of astern revolutions may cause the line to foul the propeller. Great patience must be exercised until the tow begins to move, when speed may be gradually developed. Even at this stage of increasing revolutions, care is necessary to avoid losing the catenary and having to start all over again.

If the two vessels are on the same heading, as the tow is taken up, the stress on the line is used to move the tow bodily through the water. Some Masters, however, prefer to head about 90 degrees away from the tow's fore-and-aft line in order that the initial low stress is used to turn the tow, and full bodily motion is not achieved until the stress is sufficiently developed.

THE TOWING VOYAGE

The tow must be equipped with proper lights as laid down in the Regulations for Prevention of Collision at Sea, but if she is not manned and no power is available oil lamps will only burn for about 16 hours. The use of a searchlight, trained by the towing vessel to illuminate the tow, will be necessary in the vicinity of other shipping. The towing vessel must also be equipped with the proper lights, as laid down.

During the voyage the bight of the towline must be kept below the surface, and its length should be adjusted in a heavy swell so that the two ships are *in step*, i.e. they rise and fall simultaneously. The catenary must not be allowed to foul the sea-bed, particularly when towing across the wind and current, for if the ships are towing slowly and are brought up by the towline they will be set down wind or stream and will collide, unless the line can be quickly slipped. The nips should be freshened regularly, and grease applied to fairleads at least twice a watch. Any padding or canvas must be renewed as required.

If the towline tends to break surface speed should be reduced or the line lengthened. In heavy weather the tow (if using chain cable) may veer an extra shackle or so, in order to add weight to the towline. In heavy weather the forces necessary to heave-to, or steam head to wind, will be too great, and the ships should either temporarily run downwind or else the towline could be slipped and the vessels allowed to drift until the weather moderates sufficiently for the voyage to be continued. In shallow waters with a smooth sea-bed, if the towline is slipped from the towing ship the other vessel will have an admirable sea anchor.

Great care must be exercised in altering course, a swing being corrected at once. At the slow speeds of towing the effects of wind and current will be very noticeable, and for this reason the shortest route may not prove to be the quickest. Steering is likely to be difficult because the towline is not secured at the ship's pivoting point, and the stern is therefore reluctant to move away from the direction of the towline.

If the tow is unable to steer and her yaw is great, chafe, uneven stresses, and bad nips will arise. The effects of wind, sea, freeboard, trim, list, underwater projections caused by damage, draught, and superstructures all tend to cause yawing. Undoubtedly the greatest single factor is an adverse trim.

A deep-draught ship will yaw less than one which is lightly laden. The effects of wind and sea upon yawing can be partially diminished by altering course or speed. A vessel trimmed by the head will yaw very badly unless she is towed sternfirst. A listed vessel tends to sheer continually towards her high side, the tendency being corrected by a low-side wind. If the ship has underwater projections forward of the pivoting point the effect is that of a trim by the head; if they exist off the centreline of the ship she will sheer towards that side.

Yawing may be corrected by trimming the vessel by the stern, and this should be done by transferring weights rather than by loading water ballast, which will increase the stress on the towline. An increase of speed tends to correct a yaw directly caused by list, while a decrease in speed often reduces a yaw produced by adverse trim. If the tow has a constant angle of sheer to one side of the towing ship's wake it may be corrected by setting the tow's rudder at a fixed angle. This has the disadvantage, however, of creating an additional drag on the towline. In a twin-screw ship a yaw to one side can be corrected by trailing only one propeller, and in all ships such a sheer can be reduced by rigging a large awning as a sail, either at the bow or stern.

In rough weather the use of storm oil by both ships will assist in making conditions more comfortable.

SLIPPING THE TOW

Arrangements must be made for slipping the towline in an emergency. Such an emergency might be the foundering of the tow. In shallow waters, if time permits, the line may be buoyed first, using a buoywire sufficiently heavy to recover the end of the hawser.

Letting go the Hawser at the Destination

This is almost as difficult as taking up the tow. Speed must be reduced very gradually so that the tow does not over-ride the other ship. This danger is partly avoided by allowing the towline to drag on the sea-bed (if smooth) for it will check the tow's headway, particularly if the line includes a length of chain. The crew of the tow should be prepared to let go an anchor immediately this danger arises and use it to check the headway as described in Chapter I (Anchoring at High Speed).

Once the way has been taken off both ships, the towline may be cast off, taking care not to revolve propellers while heaving the line aboard. If the tow has been using cable as part of the towline this is hove-in on the windlass and the wire cast off.

PRACTICAL TOWING

525 ft A typical example occurred in May 1959, when *Trochiscus*, 160 m
tons in length overall, 16 500 tonnes deadweight, laden, and displacing some
tons 21 500 tonnes, on passage from Singapore to Rotterdam, experienced a complete breakdown of the main propulsion unit when in the Indian
556 ft tons Ocean. *Halia*, 170 m in length overall, 18 000 tonnes deadweight, in ballast, and bound for the Persian Gulf, proceeded to her assistance and successfully towed her, at an average speed of 6·5 knots, a total distance
95 fathoms 6-in of 1 222 miles to Trincomalee, using 190 m of her own 50-mm wire
105 fathoms towline connected to 210 m of anchor cable from *Trochiscus*.

While diverting to *Trochiscus*, *Halia* took on additional ballast to attain a full winter-ballast condition, so as to have a displacement similar to the vessel to be towed, and the following detailed preparations were put in hand to undertake the tow.

6-in The 50-mm towing wire was laid out on deck on the starboard side, with the ends at the after end of the poop and the bight along the main
16-in deck. One end of this wire was secured with six turns round the 40-cm
14-in towing bitts, with backing turns to the capstans and 35-cm mooring bitts, and it is of interest to note that it took over 2 hours to complete the first part of this operation, each of the six turns having to be hove taut with the capstans, and lashed, before commencing the next turn. The capstans were then backed on to the forward mooring bitts on each side of the poop and the towing bitts securely shored from the roller fairleads, see Fig. 10.2. The Panama lead, through which the eye of the towline was led, was also shored from each side.

3½-in At the same time, a 30-mm wire mooring rope was flaked down on the port side of the poop deckhouse, once again with both ends at the after end of the poop, and a chain stopper rigged to control the wire while paying out, see Fig. 10.1. One end was then led through the port quarter fairlead to the Panama lead on the centre line, where it was shackled to the towing hawser, just clear of the additional serving. This method of securing the towing hawser enabled it to be shackled on to the anchor
3½-in cable without first having to disconnect the 30-mm wire, see Fig. 10.3.

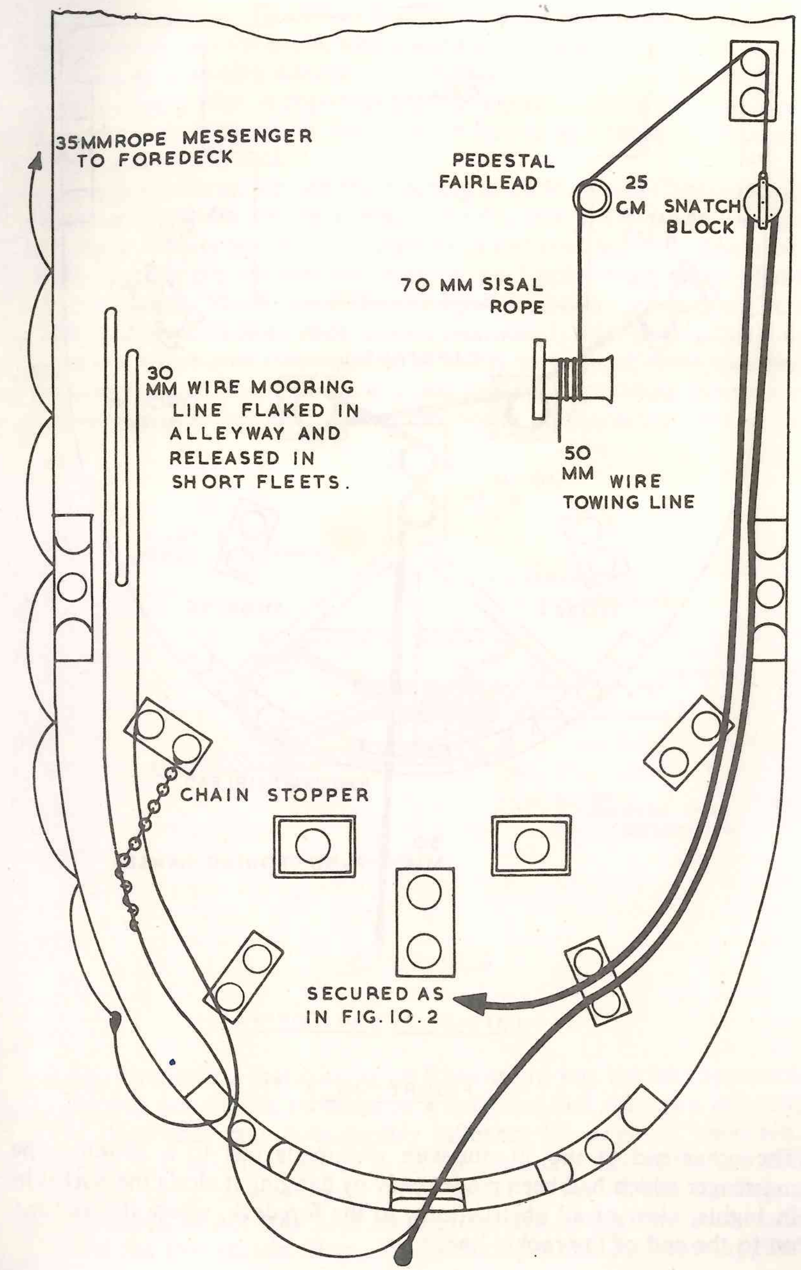
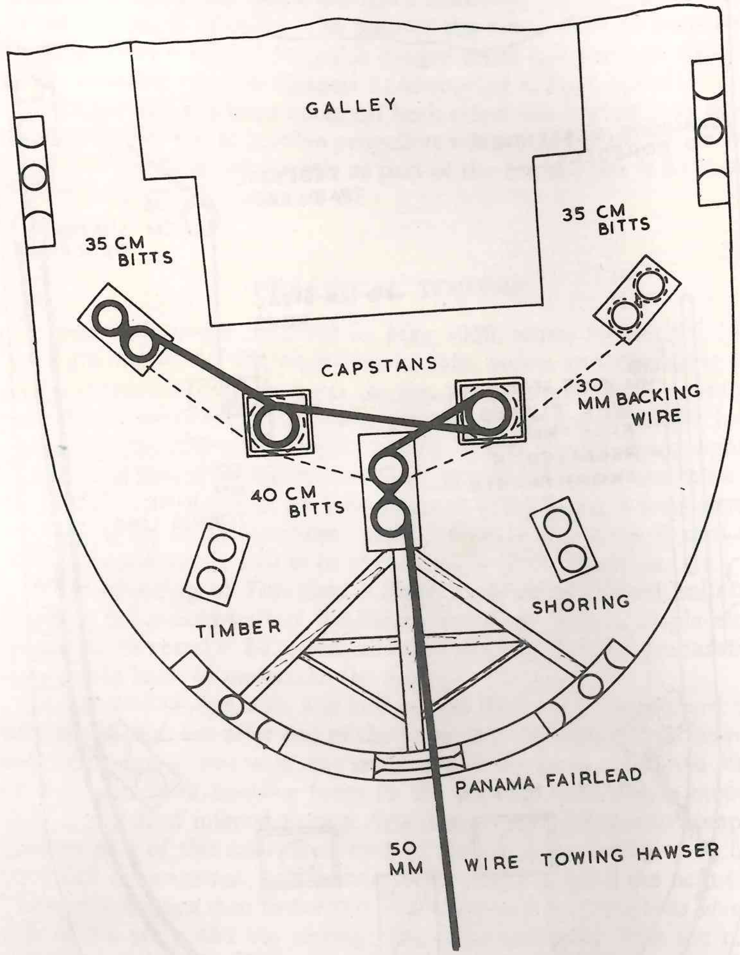


FIGURE 10.1 LAYOUT BEFORE TOWING



LAYOUT DURING TOWING

FIGURE 10.2

3½-in 4-in The other end of the 30-mm wire was made fast to a 35-mm rope messenger which had been made ready by hanging it along the port side in bights, clear of all obstructions, to the foredeck, where it was bent on to the end of the rocket-line.

In the meantime, *Trochiscus* had lifted her starboard anchor on deck and disconnected the cable, which was then hove-up through the hawse pipe, where a joining shackle was prepared for attaching the cable to *Halia*'s towing wire. A rope was made ready for heaving the messenger from the towing vessel up through the hawse pipe using the forward winch on the main deck.

Trochiscus was sighted on the morning of 23 May, and Captain R. R. Potter of *Halia* established contact with Captain J. Davison by radio-telephone, whereupon the procedure to be followed was fully discussed. *Halia* came in for an approach from some 3 miles dead astern of the disabled vessel, which was rolling and yawing beam-on to a long, low swell, and eased in close under her lee (starboard) side. During this run-in period, which was accomplished at a very slow speed, there was time to assess the handling qualities of *Halia* under the prevailing conditions, and also to observe the drift and movement of *Trochiscus*. In this in-

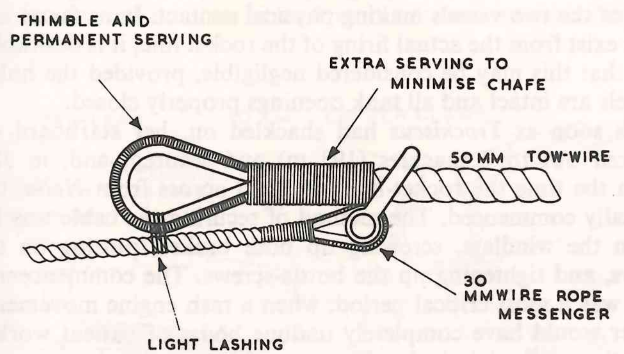


FIGURE 10.3

stance, it transpired that coming up from astern was the best approach course, but this cannot be taken as a hard-and-fast rule, as a different set of conditions may considerably influence the angle of approach.
Halia, in fact, passed about 20 m off the starboard side of the tow and 70 ft
eventually came to rest about 25 m ahead of her. While passing, a 80 ft
line-throwing rocket was fired from *Halia* and connection was made between the two vessels. Here, the forethought that had been applied

to the whole operation, and the care with which preparations had been made, became most creditably evident, and this will be readily appreciated in that 11 minutes after the rocket had been fired across the foredeck of *Trochiscus* the tow was shackled up.

As already mentioned, the towline was laid out along the starboard side of *Halia*'s main deck, and an ingenious method was devised of paying it out under complete control. The bight was rove through a
10-in 25-cm snatch block at the end of a mooring rope led to the winch on the after deck, and it was thus possible to ease it out to the towing length of
95 fathoms 190 m without fear of kinking or of taking charge, see Fig. 10.1. (*Author's Note:* I have drawn Fig. 10.1 with clarity in mind, but it must be appreciated that two different decks are involved. Where the towline crosses the break of the poop, heavy wooden pads were used to prevent chafing of the wire on the plate edges.)

Although *Trochiscus* was loaded with high-flash cargo, suitable precautions were nevertheless taken against fire, fire-hoses being rigged, portable extinguishers placed in strategic positions, and all personnel not required on deck keeping under cover, there being an ever-present risk of the two vessels making physical contact. In as far as any danger may exist from the actual firing of the rocket line, it is desirable to point out that this may be considered negligible, provided the hulls of both vessels are intact and all tank openings properly closed.

As soon as *Trochiscus* had shackled on, her starboard cable was
105 fathoms walked out to 7 shackles (193 m) and secured, and, in 38 minutes from the time the rocket-line was fired across from *Halia*, the towing actually commenced. The method of securing the cable was by leaving it on the windlass, screwing up both brakes, putting on the devil's claws, and tightening up the bottle-screws. The commencement of the tow was a most critical period, when a rash engine movement or helm order would have completely undone hours of patient work and preparation, and might in fact have caused irreparable damage or loss. This risk was avoided in this case and, from being stopped, the first order was 5 revolutions per minute (0·75 knot) gradually building up by steps of 5 revolutions at 5-minute intervals, to 50 revolutions per minute, which gave an engine speed of 7·5 knots. Similarly, course was altered not more than 10 degrees at a time and the tow allowed to settle down before any additional alteration in course was made.

Slight trouble was experienced initially with the towline wearing through the chafing pad in the Panama lead, but this problem was overcome by the design and production of a patent multi-sleeved clamp, see
$\frac{1}{16}$-in Fig. 10.4. This consisted of three cup-shaped sections of 1·5-mm hard
$\frac{1}{16}$-in copper sheet, one of 1·5-mm soft copper sheet, and an inner sheet of
$\frac{1}{16}$-in 1·5-mm lead, with all friction surfaces thoroughly greased. The clamp was first lightly secured round the towline on the inboard side, and the

towline raised clear of the lower side of the fairlead by means of a 4-tonne ton
chain tackle secured to the hose-handling derrick pedestal. The sleeve was then slid into position and the packing pieces placed underneath. Clamped on the wire over a foundation of three coir doormats and eight thicknesses of canvas, this arrangement was found to be eminently effective in reducing chafe.

The initial tendency of *Trochiscus* to yaw, putting an added strain on the towline, was nullified by steering in the wake of *Halia*, and this proved satisfactory at a towing speed of 6·5 knots, until a fresh quarterly breeze was experienced towards the end of the voyage, when it was found that the tow automatically settled down a couple of points on the quarter. This same tendency to yaw was observed when speed was reduced approaching Trincomalee Harbour, when cable was shortened, and experience showed that all phases of altering course and reducing speed had to be cautiously achieved, step by step.

Off port, the services of a harbour tug were obtained to prevent the disabled vessel overrunning the tow while the cable was hove-up and the towing wire disconnected. Slowing down a tow of this size requires considerable time and involves almost as much care as when getting

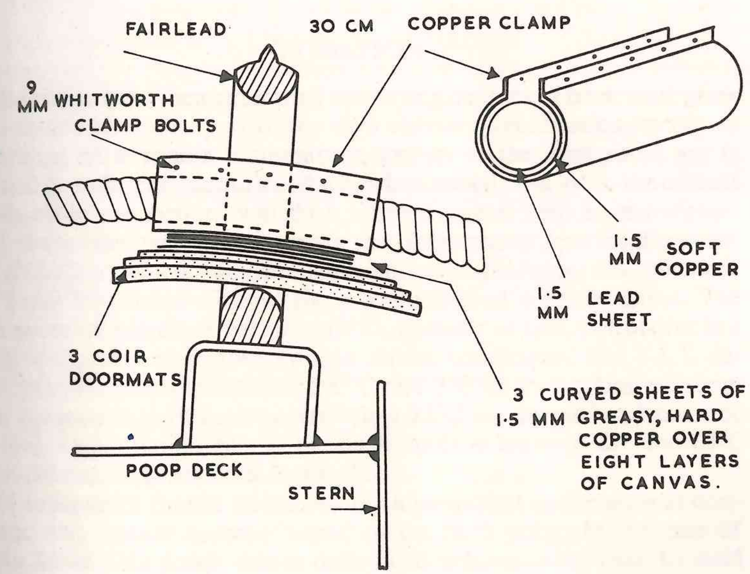


FIGURE 10.4

under way. After slipping, *Halia*'s tow wire was recovered by adopting a similar procedure, but in reverse, to that used when connecting up, and it worked smoothly and efficiently.

It must, indeed, have been a relief to both Masters to see their ships safely in port, and it is no small tribute to the seamanship and ability of all concerned that the voyage was completed with so little trouble.

(The above example is from the *Shell Magazine*, and is based by Nautical Division, Shell Tankers Ltd., on reports from the vessels concerned and is reproduced here by the courtesy of the Company.)

CHAPTER XI

FIRE

An outbreak of fire occurs when sufficient heat is applied to a flammable material within an atmosphere freely charged and supplied with oxygen. The fire will continue provided these three elements are present, and together they form what is known as the *fire triangle*. When one side or element is removed the triangle or fire can no longer exist. The process of fire-fighting involves eliminating one or more of these elements. Heat may be dissipated by cooling the area with water, flammable material may be physically removed and oxygen can be prevented from reaching the fire by placing a blanket of suitable material or gas between the burning substance and the atmosphere.

OXIDATION

All substances, when submitted to varying degrees of heat, emit gases from their surfaces as part of the slow chemical combustion known as oxidation. At a certain temperature, known as the *flash point*, gas is evolved in sufficient quantities which, when mixed with air in the correct combustible proportion, will flash when a naked light is introduced. Well above this temperature exists the *Spontaneous Ignition Temperature* (S.I.T.) at which, provided sufficient air is available, the substance will burst into flame without the introduction of a naked flame. The flash point of petrols is below −18°C. Because of this, petroleum is a highly dangerous substance even in Arctic conditions. The S.I.T. for most petroleum oils is between 260°C and 370°C. In the United Kingdom, substances with flash points below 23°C are deemed and must be labelled, *highly* flammable. If the flash point is between 23° and 60°C the substance is considered flammable.

500° and 700°F
73°F
73° and 141°F

All substances should be stowed in ships so that under normal conditions they cannot become heated to the flash point. In the case of highly flammable goods this is difficult to achieve other than by cold storage, and they should therefore be in airtight containers free from seepage. Provided air can be excluded from these substances, the vapour at their surfaces will be too rich for flashing to occur. If too much oxygen is combined, such as at a considerable distance above the fluid level, the mixture will be too weak to flash. It is only at some small distance above the surface that flashing conditions are possible.

DESTRUCTION OF THE FIRE TRIANGLE

1. Removing the Heat by Means of Water

For several reasons, water is the ideal material to achieve this purpose. It has a high *specific heat*, i.e. it requires a great amount of heat to change its temperature one degree and needs a further input of 540 times as much heat to change it from boiling fluid into steam. Under normal
212°F atmospheric pressures it cannot be heated above 100°C and can in fact be boiled in a paper bag because the latter requires to be heated to nearly double this temperature before it will burn. Provided the bag is porous and remains wet, combustion cannot occur. When using water to extinguish a fire it is therefore imperative to keep the burning materials saturated. If they are poor absorbers of water, such as hardwood or rubber, or non-absorbers, such as metals, the saturation will occur at the surface only, and a continuous spray is necessary in order to dissipate the heat. Certain metals will burn if they come into contact with water, such as sodium and potassium, and these must be immersed in paraffin (kerosene) in order to exclude water vapour.

In addition to its cooling properties, water used for fire extinguishing is continuously vaporising into steam. The volume of steam created is about 1700 times as great as the original volume of water, and since it is an inert gas, the fire is starved of oxygen.

The use of sea-water should be avoided where possible, since it will quickly spoil goods surrounding the fire zone, particularly foodstuffs. Not only will it corrode steels, copper, and electrical machinery but it is also slow drying and finally leaves a corrosive residue of salts. The chemical action of sea-water on a molasses fire will rapidly produce toxic fumes.

The use of water in the vicinity of acids is dangerous. Acids are diluted by adding *them* slowly to water until the desired mixture is obtained. If, however, the water, and particularly sea-water, is admitted into a large quantity of concentrated acid, rapid heating, spluttering, and the evolution of toxic fumes occurs.

Carbides in contact with water will generate explosive and flammable acetylene gas in addition to heat.

If water is applied to burning coal or coke the generated steam, unless released quickly, will cause the emission of dangerous and highly combustible gases.

An oil fire may be extinguished by applying a water spray, but the use of a water *jet* will scatter the burning oil, which will float and cause

isolated outbreaks of fire widely dispersed around the original fire zone. The use of water on an oil fire presents certain problems which are discussed in the subsequent treatment of liquid fuel fires.

When water is used to flood a compartment the following points should be borne in mind:

(1) Flooding high in the vessel reduces her stability.
(2) Flooding at the sides produces a list.
(3) Flooding low in the ship tends to increase her stability.
(4) All flooding, unless water is being transferred within the ship, reduces the freeboard and the reserve buoyancy, while it always creates a free surface effect which reduces stability.
(5) If the stability becomes zero or negative the ship will loll over to one side. If the fire zone is then situated on the high side of the ship it may become quite clear of the water level, enabling it to spread upwards throughout the ship on the high side. The high-side plating will then have to be cut open to admit further water and this, flowing to the low side, will further increase the list until capsizing may occur.
(6) If cutting holes in the ship's side to admit dock water, it should be remembered that the vessel can be flooded only up to the level of those holes. Once this is achieved, any further water applied by hose will level out with the dock water. The vessel is now in such a predicament that she may have to be flooded in other sound compartments in order to increase her displacement and immerse the holes.
(7) Any liquid fuels which are burning will float on the surface of the water and will gradually fire the upper compartments as the water level rises.
(8) If at sea, flooding may seriously impair the safety and manœuvrability of the ship.
(9) The suctions are likely to be choked with debris, and once the fire is extinguished, the problem arises of how to pump the compartment dry. In this connection, a pump can only create a complete vacuum, and since air pressure can be measured by a water
barometer 10·3 m in height, it follows that a pump can lift water 34 ft
to itself only if it is within 10·3 m of the water level. In practice, 34 ft
a high-efficiency pump may be able to develop a lift of 7·6 m 25 ft
while other pumps may achieve only 6·1 m. Thus, if the water 20 ft
level is more than 7·6 m below an efficient pump the latter will 25 ft
be of no value unless arrangements can be made to lower it and suspend it closer to the surface.

Once the pump is able to develop a lift of water into its body, it may then be used to discharge water at some higher level, and

in this connection it is interesting to note that a pressure of 100
1 lb/in² 2 ft grammes per cm^2 is necessary to raise the water 1 m in the
discharge hose. If, for example, it is desired to deliver the water
30 ft 10 m above the pump the pressure at the hose outlet will be
15 lb/in² 1 kg per cm^2 less than at the pump discharge.

(10) Water used to cool the bulkheads and boundary plating of a compartment, inside which a fire is being smothered by steam, will increase the rate at which the latter condenses on the inside of the plating. The steam, in condensing, will contract to one-seventeen-hundredth of its volume, and this original volume of occupation will tend to become a partial vacuum. The effect of this may be to induce air draughts through crevices which previously admitted no appreciable quantity of air. The fire may thus obtain a new oxygen feed.

Fire pumps, whether auxiliaries of the main propulsion unit or of independent Diesel type, are usually capable of supplying from 50 to 80
tons 50 lb/in² tonnes per hour. A hose, delivering water at a pressure of 3·5 kg per
tons cm^2, may pass about 15 tonnes of water per hour through a jet nozzle
and nearly double this amount through a spray nozzle due to the lower resistance in the latter case.

In a drydock full fire-fighting preparations should be made as soon as the vessel docks. Hoses are difficult to run from the dockside to the ship and the operation takes considerable time, so they should be kept permanently rigged. If pumps are under repair a supply of water should be arranged from ashore either through several rigged hoses or by means of one hose coupled to the ship's fire main or wash-deck line.

When flooding a fire in a drydocked vessel the effects of the added weight are very serious. The vessel is naturally unstable while on the blocks, and any flooding will aggravate this condition. In addition to this, high keel stresses are set up. The fact that the hull no longer has the cooling effect of surrounding sea-water means that a fire is likely to spread rapidly to adjacent compartments.

The fire main runs throughout the vessel, on both sides, and has hydrant outlets. The fire hoses, when required, are secured to the outlets
2½ in by means of instantaneous couplings of 6·3 cm diameter. Two jets of
water are capable of being directed to any one compartment by the fire main. The line is supplied by several pumps widely dispersed so that a fire will not render them all out of action. If the fire main is damaged the stop valves on either side of the fracture should be closed. The water is then by-passed by connecting a hose between two hydrants, each beyond the stop valves.

½-in The hoses are fitted with jet or jet/spray nozzles of 12-mm outlet dia-
meter. These should never be used for levering or hammering in an

emergency, and should be treated with respect at all times. The hoses are normally made of canvas, the use of rubber being prohibited. They are not to be used for any other purpose, must be drained and dried before stowage subsequent to firefighting or drill, and must not be left rolled up for long periods. They are drained by raising them to about shoulder height and then walking slowly forward, under-running the entire length. Walking on them will both drain and *damage* them very efficiently. They should not be painted, washed in strong cleansing fluids, or contaminated with oil or grease.

2. Smothering to Exclude Oxygen

The following are the substances normally used for this purpose:

(a) Steam. This gas is lighter than air, and will therefore seek to occupy the upper volume of the compartment. If the fire zone is situated at low level the steam will have to be injected for some considerable time before it will penetrate all the crevices within the fire. Its efficiency will be lowered if an air feed exists at low level, such as a damaged shaft-tunnel door. *Steam smothering is not allowed on ships built after 1980.*

In a fire area where packages are loosely stowed the steam may effec-
tively control flame, but due to the high temperature, which will not be
below 100°C, oxidation and slow combustion may continue, rendering 212°F
the compartment liable to flashing when opened to the atmosphere. Some cargoes, such as grain and wood pulp, may swell extensively under the hot, moist conditions of steam smothering.

In the early stages of steam injection continuous condensation will occur, and any re-vaporisation of this moisture will assist in cooling the fire zone. With regard to the condensation, goods which are susceptible to water damage will be harmed by the application of steam.

It has already been mentioned that steam injection provides little or no cooling effect, and heat conductivity will continue freely to adjacent compartments, where further oxidation and flashing may occur. For this reason, flammable materials in adjacent compartments should be removed or kept sprayed with water while extinguishing a fire with steam injection.

The injection of steam into a burning stack of coal or coke produces an explosive and highly combustible water gas such as is produced in the retorts of a gas works.

(b) Carbon Dioxide. This gas is heavier than air and is a non-supporter of combustion, so it will effectively blanket a fire and exclude the oxygen from the burning material. It has the advantage of causing no damage to goods, but it will rapidly become heated and therefore conduct heat to adjacent compartments. The gas will settle at the bottom of a compartment, increasing in depth as the supply continues. As its level rises, air in the vicinity is driven to the top of the compartment. If the zone has been closed to the atmosphere it is possible that the pressure of the carbon dioxide in the bottom will become equal to that of the air layer, and should the fire exist at high level it will burn until the air is exhausted of oxygen, during which time the smothering gas is of no value, neither can more be injected. In the case of a very hot fire, however, there will be sufficient turbulence to mix the gas with the air, and as soon as the mixture has a 30–40% concentration of carbon dioxide the fire will be unable to continue.

It is not advisable to inject carbon dioxide and steam together since the cool gas (−79°C) will condense steam, producing vacuum and carbonic acid. The two gases are not compatible in fire-fighting. The normal level of carbon dioxide in air is 0·033% by volume.

Starvation of Air. Generally, the use of carbon dioxide or steam as a smothering gas calls for a sealed compartment to complete the control of oxygen, but unless the compartment is a tank the best that can be hoped for is a partial stifling effect and a retardation of oxygen inflow. When firefighters are working in a compartment the stifled air flow may at times have to be increased in order to dissipate heat and smoke.

In compartments adjacent to a fire ventilation should be maintained normally or even increased in order to dissipate heat and prevent oxidation and flashing. This does not apply to tanks containing liquid fuel, which should preferably be pressed full in order to exclude all air.

(c) **High-Expansion and Detergent Foams.** These are manufactured from waste protein matter. Shore fire-fighting brigades are equipped with machines which can inject this type of foam through powerful fans, filling a large space within minutes. The advantage of this material is that it is unlikely to cause damage to cargoes. Complete blanketing of the fire is achieved. On tankers, detergent foam can be made by drawing controlled amounts of the basic detergent concentrate into branch pipes fed with high pressure water.

(d) **Chemical Foam.** This is generated by solutions of sodium bicarbonate and aluminium sulphate in combined activity, and will effectively
2-gal blanket a fire. It may be supplied direct from a 9-litre portable extin-
10- or 30-gal guisher, by hose nozzle from 45- or 135-litre extinguishers, or in very large quantities from a permanently installed apparatus, via perforated pipes. When used on a burning liquid fuel it should be very lightly sprayed to avoid scattering the fire, or else directed at a nearby surface so that the stream disintegrates and flows gently over the fuel.

(e) **Solids.** Fireproof blankets or quantities of sand may be thrown over small fires, such as burning oils or fats, in order to exclude the atmosphere.

The use of all smothering materials, whether solid, liquid, or gaseous, provides little cooling effect, and it is therefore imperative to maintain the smothering until the fire zone has cooled sufficiently to prevent re-ignition when starvation ceases. Breathing apparatus should be worn when entering a blanketed compartment, even when high-expansion foam has been injected. If a face mask should break, the firefighter should instantly switch to continuous air feed and escape as soon as possible. The body is used to breathing 0·033% carbon dioxide and a concentration of only 10% will induce rapid unconsciousness.

Once a fire has been controlled with the use of smothering gas, the inflow should be maintained, at a reduced rate if necessary, until all dangers of re-ignition are past. If the fire is prematurely considered to be extinguished, or the zone sufficiently cool, and injection of gas is ceased, a renewed fire may be an extremely difficult one to bring under control, particularly when supplies of carbon dioxide are running low.

3. Removing Flammable Material

This entails clearing the edge of the fire zone of all combustible material. It is not, of course, suggested that blazing material should be moved, since this is safer left to burn out, even if of an explosive nature. Firefighting is concentrated at the fire zone, and any scattering by explosion is far more easily dealt with in that area rather than elsewhere, where a brave man, attempting to jettison blazing explosive material, may cause loss of life, new outbreaks of fire, and division of the firefighting strength.

Providing the outskirts of the fire can be starved of material food, control will be certain, but by outskirts is meant not only the immediate vicinity but all adjacent compartments. Gas cylinders are likely to explode due to the expansion of their contents under heat, and should be removed from the area or continually sprayed with water.

SOURCES OF FIRE

These are too numerous, and often completely unexpected, to list extensively, but a few of the more common sources are included:

(a) Leakage of Oils on to Hot Surfaces, Particularly within the Engine- and Boiler-rooms

This sometimes occurs when settling tanks overflow, oil hot-filters or oil supply lines leak on to exhaust uptakes or boiler surfaces. Suitable overflow alarm devices, overflow gutters, screens, and adequate lighting will prevent many of these fires, which have caused the loss of several ships and many lives. Any boiler-room supplied with an oil feed should have as much access as possible from the engine-room to enable fire-fighting to be effective. No woodwork should be permitted in boiler-rooms or engine-rooms supplied with oil, tank tops and floor plates should be scrupulously clean, any oil should be soaked up at once and the oily waste destroyed, bilges should be kept as free as possible from oil, and all combustible material kept well away from oil-feed lines. Fire appliances should be regularly examined, all personnel made familiar with their use and location, and foam appliances kept away from high temperatures, which may destroy the properties of the ingredients.

(b) Welding and Other Repairs

These produce sparking, and portable extinguishers should be kept at hand, both in the repair area and on the *opposite* side of the repair work (when possible) where a fire is likely to break out due to local heating. The compartment should be inspected regularly between work shifts for signs of smouldering.

(c) Seepage of Flammable Vapours or Fuels into Adjacent Compartments where Welding is in Progress or where Men are Smoking

(d) The Use of Radio or Radar Equipment

This can induce currents at very high electrical pressures, and should therefore not be worked when loading or discharging inflammable substances.

(e) Spontaneous Combustion

Many fires tend to be attributed to this phenomenon, since no person is then involved in blame. Probably in nine cases out of ten the fire originated from some other cause, often careless smoking, the dangers of which cannot be stressed too frequently. Certain fibrous substances, when impregnated with suitable oils, such as jute with colza oil, cotton waste with fuel oil, or canvas with paint, do become heated and may catch fire, particularly if the heating is accelerated by local unlagged steam pipes or other hot surfaces.

This type of combustion may occur when oxygen is absorbed at the surfaces of coal, particularly when bituminous and finely broken, and in such cases the risk increases at temperatures above 80°C. The coal should be kept as cool as possible and all air supplies blocked off except for surface ventilators, which are used to remove the explosive methane gas. This gas is dangerous when concentrated 5% in air.

All materials which are liable to spontaneous combustion should be regularly tested for temperature, especially when carried as cargo. Risks are always minimised by local cooling.

(f) Electrical Fires

A short-circuit, the failure of an unscreened fuse, or overloading of wiring may result in a fire outbreak. Whenever a fire exists in a ship it is possible for insulation to become charred near the fire zone. The resulting short-circuit, i.e. a path of very low resistance for the current, results in a surge of excessive current which may overload the wiring and heat it sufficiently for it to burn. Such an outbreak may occur at the switchboard or even at places elsewhere and quite remote from the main fire zone.

While a fire exists, and for some considerable time after it has been extinguished, the switchboard should be closely watched for signs of overloading.

(g) Static Electricity

Many fires have started as a result of sparks caused by the discharge of static electricity at high voltage. An example occurs when friction within a filling hose produces static electricity, and the petrol or other fuel passing through it is ignited. Both the hose end and the filled tank should be securely earthed, as should all other equipment which is subject to static charging.

(h) Floating Oil or Petrol on the Surface of a Dock, the Sea, or a River

This may be ignited by a carelessly thrown cigarette end. The blazing fuel may be extinguished by means of a foam spray; or it can be driven clear of the ship either by powerful water jets or by the propeller wash of a small launch.

A vessel in collision may be surrounded by an area of burning fuel on the water surface. In a current the vessel may be brought quickly to anchor, and the stream will then carry the fuel clear of the ship. If no current exists, the vessel should, if possible, be moved rapidly clear of the fire zone.

(j) Steam Pipes

These should be regularly checked to make sure they are properly lagged. Such surfaces, if unprotected, may quickly start a fire among surrounding materials.

(k) Hot Bulkheads

These are equally dangerous if left uninsulated. A case occurred where a hot engine-room bulkhead ignited the cork insulation of an adjacent hold containing a full cargo of frozen butter. The only possible method of extinguishing was flooding of the entire compartment. Fortunately the permeability of the hold was very low, due to the compact blockstow of the butter, and the space existing for water was adjacent to the insulation. Only a small amount of water was needed to flood the hold, and the fire was quickly put out. The sea-water damage to the butter was less than 1 %, but the use of air sheathing on the engine-room side of the bulkhead, or fibre-glass insulation within the hold, would have greatly minimised the fire risk.

(l) Funnel Sparking

This can be avoided, or at least reduced, by regular cleaning of the exhaust uptakes. Burning of awnings, lifeboats, and other deck equipment is then less likely to occur.

(m) Timber

This is very combustible, and should be stowed well clear of hot surfaces and fuels.

(n) Galley Fires

These are not uncommon, and are frequently caused by the boiling-over on to hot-plates, or the ignition, of unattended cooking fats. Galley hoods should be cleaned regularly and not allowed to become caked with grease, which may be fired by heat uptake.

(o) Paint

This is very combustible, containing and evolving flammable substances. It should never be stowed other than in the official paint locker, which should be well away from heat areas. Isolated pots of paint left lying about the ship constitute a fire risk.

Ideally, painted surfaces should be maintained with the minimum of coats in order to reduce the amount of permanent combustible material. Paint will burn very rapidly indeed, and can quickly turn accommodation into an inferno. The use of heat-resistant plastic laminated materials is preferable to paint decoration.

(p) Batteries

These evolve an explosive and flammable gas and should be stowed in well-ventilated cool compartments containing a portable extinguisher.

(q) Leaky, Defective Packages Containing Flammable Materials

These are extremely dangerous, particularly when stowed in the holds on wooden dunnage. All such containers should be rejected.

(r) Smoking

This has caused the total loss of ships, and any regulations on board a vessel regarding this habit should be adhered to strictly. Cigarette

ends must be properly extinguished and not thrown on to the deck or over the side. In both cases they may be blown through doors, portholes, or ventilators, causing a fire. Smoking in bunks has caused loss of life through the smoker prematurely falling asleep. In no circumstances should smoking be permitted in holds, for a burning cigarette end may smoulder beneath sawdust and similar material for many days before the smoke is detected. It is for this reason that many fires, discovered when several days out of port, are thought to be due to spontaneous combustion, since few people realise the length of time which can elapse before a carelessly thrown cigarette end will start a *detectable* fire.

FIRE PATROLS

These are required to be carried out regularly in Class 1 ships. Great care should be exercised in selecting patrolmen, for they should be physically and mentally suited to the task and well trained in modern firefighting techniques. Each man should be provided with a whistle or other portable alarm-signalling device. Every part of the ship should be visited at least once in every hour, and patrolmen should report at a place which is manned at all times, where all detection alarm bells ring, and which is provided with adequate fire appliances.

DISPERSAL OF GEAR

The fire appliances should be widely dispersed throughout the ship and in such a way that they may be easily found in conditions of smoke or darkness.

GENERAL ACTION IN THE EVENT OF FIRE OUTBREAK

The person first discovering the fire should instantly raise the alarm and commence fighting the flames. If it is rapidly and correctly attacked it may well be restricted to a small outbreak, rendering major measures unnecessary. Alarm bells should, if necessary, be rung throughout the ship, a continuous ringing being the usual signal, bearing in mind that too many persons at the scene of the fire may cause confusion. At sea emergency stations should be sounded and the boats swung out ready for lowering if it is thought that the fire is, or will be, of major proportions.

It is imperative to gain rapid access to a fire, but in many cases this may be possible only from above, where movements are hampered by rising smoke and heat. Every endeavour should be made to discover whether the fire has an air feed at low level. If this is so, and a means of access exists, the fire should be fought from this level, where a cool, fresh air supply will benefit the firefighters. If no means of access exists, the air feed should be blocked. A hose can be lowered from above, on lines, and directed at the seat of the fire.

Cutting holes in plating to gain access causes an air feed and destroys the ship's watertight integrity. In an accommodation fire access may be obtained by lowering a hose-handler over the side on a boatswain's chair so that he can direct a water jet through a porthole.

Generally, the Officer in charge of firefighting operations should not take part in the actual fighting, but should attend the entire perimeter of the fire zone and keep himself fully informed so that he is the ideal person to direct personnel.

He should:

(1) Make sure that the fire is stifled as efficiently as possible and that ventilating fans are switched off.
(2) Alter the course of the vessel so that the apparent wind force on board is nil, unless dense smoke is hampering operations.
(3) Discover what is burning, and also the seat of the fire.
(4) Muster appliances as necessary.
(5) Find all possible means of access.
(6) Ascertain that a sufficient water supply exists, using emergency pumps as required.
(7) Discover whether dangerous gases are present and equip firefighters with breathing apparatus.
(8) Ensure the safety of the firefighters.
(9) Always have a spare breathing apparatus available outside the fire zone, for rescue work.
(10) Spray all adjacent bulkheads and goods.
(11) Spray or flood any adjacent magazines containing dangerous goods.
(12) Muster extra firefighters and appliances as necessary.
(13) Watch for any complications that may arise.
(14) Continually watch for signs of the fire spreading.
(15) Remove any surrounding materials which are in danger of igniting.
(16) Make use of the ship's construction to prevent fire spread.
(17) Consider the ship's stability and pumping arrangements, if water is being used.
(18) Consider outbreaks of electrical fires.

In port, the local Fire Brigade should be called if the fire is beyond the control of the ship's staff, particularly in drydock. Liaison between the Chief Fire Officer and the ship's Officer in charge is most important, and the former must be acquainted with the following facts:

(*a*) When the fire was discovered and its location.
(*b*) Action taken so far and whether anyone is missing.

(*c*) What cargo is burning and what materials are near by.
(*d*) Whether any fireproof bulkheads exist.
(*e*) Whether ventilators are closed and where they are located.
(*f*) The pumping capacity both on the fire-main and on the bilge discharges.
(*g*) The weight of water which is able to be pumped into the ship, bearing in mind her stability.
(*h*) Details of the ship's construction which may affect firefighting.
(*j*) Any lighting arrangements.
(*k*) When the compartment was last opened.
(*l*) Whether adjacent plating is becoming heated.

THE NECESSITY FOR, AND THE USE OF, BREATHING APPARATUS

It is most important to appreciate that a gas mask is designed to filter oxygen from a fouled atmosphere. If no oxygen is present the use of a gas mask will in no way prevent a person's asphyxiation. A breathing apparatus should therefore be used, and will usually be either one in which the wearer carries his own air supply or else one in which air is supplied through a long flexible hose, either by direct suction on the part of the wearer or by foot-operated bellows. In all cases the wearer uses a lifeline, and may signal to those at its other end by giving, say,

1 pull to mean 'More air required', or
2 pulls to mean 'Slack the lifeline', or
3 pulls to mean 'Get me out quickly'.

If the others give three pulls on the line this could be used to indicate to the wearer, 'Come out at once.'

The lifeline is usually 10-mm hemp line with a wire heart and a break- 1¼-in
ing stress of 1 tonne. It is at least 3 m longer than the air hose. If the ton 10 ft
hose is more than 27·5 m long it must supply air by means of bellows. 90 ft

Class 1 ships carry two breathing apparatuses plus two for every 80 m length of passenger/service spaces of which two must be of the air-hose type. Class 7 ships carry one air-hose type among a total of:

2 apparatuses if the ship is between 500 and 2499 gross tons,
3 apparatuses if between 2500 and 3999 gross tons, and
4 apparatuses if of 4000 gross tons or more.

The self-contained apparatus has the disadvantage of supplying a limited quantity of air and when the wearer is climbing out of a compartment his exertions will demand a larger amount of oxygen than the appliance may be able to provide.

It is most important for the wearer to avoid a circular path when groping in a smoky or dark atmosphere, for he may wind his lifeline around pillars, etc. If he crawls on all fours his visibility will be improved, since the smoke is continually rising. Further, he will avoid the risk of stumbling and injuring himself. He must always move very carefully and make sure that the surface ahead is quite firm.

If breathing apparatus is used by a person sporting anything larger than a small beard, water or grease should be applied to the beard to make sure that the face mask fits tightly.

A firefighter should bear in mind that when directing his water jet through crevices it may suddenly strike at the seat of the fire and there is likely to be a violent blow-back of hot gases and steam.

Carbon fuels, when burning in a plentiful supply of oxygen, evolve carbon dioxide gas, which, while not toxic, is unable to sustain life and when concentrated 9% in air is likely to prove fatal. If the same fuels burn in an atmosphere starved of oxygen, so that combustion is incomplete, odourless, tasteless, and highly toxic carbon monoxide gas is evolved; ½% of this gas in air is fatal. Nearly all combustible materials contain carbon. If the fire is burning well with little smoke an abundant supply of oxygen is present, while the reverse is true when the fire burns badly, emitting much smoke. In this latter case fatal proportions of both carbon gases are probably present.

Petroleum fumes can be fatal when in a 0·1% concentration with air.

Oxygen will be in short supply both after an explosion and when entering a compartment which has been closed for some time, particularly if fresh paint exists, since this rapidly absorbs oxygen. The use of proper breathing apparatus is imperative, both when fire exists and *when entering a newly opened tank as part of normal ship routine.* In both cases unnecessary casualties are avoided which, in the instance of fire, will seriously hamper the efforts of the fighters.

A firefighter will find a spray nozzle useful for driving smoke ahead of him.

THE CONTROLLED FIRE

When this is believed to be true, the following points should be considered:

(1) Whether it is safe to open the compartment in order to ventilate and inspect.
(2) The breaking up and drenching with water of all smouldering debris.
(3) Steps to be taken to prevent re-ignition within the fire zone.
(4) Damage to cargo, the ship's structure, and electrical circuits.
(5) The removal of water from the compartment.

(6) The immediate servicing and recharging of all fire appliances in case there is a fresh outbreak.
(7) The treatment of all burns by first aid. Pain should be relieved by administering morphia. The burn should be protected from the air (which promotes pain) by means of clean dry dressings, making no attempt to clean or touch the burn, or to remove any clothing adhering to it. Victims of shock should be laid flat, kept warm, and given hot, sweet drinks.

FIRE TYPES

(1) Coal

A fire within bunker or cargo coal may be very slow-burning, and it may take several days to control by using carbon dioxide gas, steam being unsuitable. Often, it is of such major proportions that the fire cannot be extinguished, and it is therefore kept under control until the vessel reaches port, when the services of the local Fire Brigade are employed. Here, the danger of flashing exists when the compartment is opened. The adjacent plating must be kept cool and a constant watch kept on boundary temperatures.

The D.o.T. advise that the compartment should be totally closed against the entry of air, if fire is discovered at sea, and that carbon dioxide, inert gas, or high-expansion foam should be injected into the hold. Water or steam should never be applied directly to burning coal but may be used for boundary cooling. The space should remain sealed until the ship reaches port, when specialist advice may be obtained.

(2) Liquid Fuels

Before these can be ignited, vapours must be emitted in sufficient proportions to form an explosive and combustible mixture with air. This occurs at the flash point, and in the case of petrol will be at subzero temperatures.

Petrol vapour is heavier than air, and at the surface of the fluid the mixture is too rich to burn. Just above the surface a combustible mixture of 2–7% of petrol vapour in air may be found, while above this level the mixture is too weak to burn. It is for this reason that it is usually perfectly safe to fire a rocket from the bridge of a tanker, even one in which a leak exists.

Once the combustible layer is ignited, the fire will continue due to convection and turbulence.

When loading or discharging petrols smoking is not permitted, galley fires are extinguished, and cooking may be continued by means of steam coils. The radio and radar installations must not be used, portholes should be closed adjacent to the hoses, and danger-signal flags must be flown. If working several fuels through one hose they are pumped in or out in *descending* order of flash point, so that the most highly flammable fuels move through the line last of all. In this way the less dangerous fuels are not contaminated.

A fire within a fuel tank may be stifled by closing the tank lids, in which case it will soon become extinguished due to the limited oxygen available. Other methods include the injection of carbon dioxide gas, detergent or chemical foam, inert gas, or steam. Fire brigades may use liquid nitrogen. Steam and carbon dioxide are obsolescent on tankers.

Within an oil-fuel fire, heating may spread downwards at the rate
15 in of 37 cm per hour, and if a base-layer of water exists it may boil over, causing the blazing oil to overflow. Again, if a water spray is used to extinguish burning oil it will be instantly turned to steam just below the surface of the oil as it sinks. This produces an oil froth at the surface having a high flash risk, and which is very combustible.

Petrol, adjacent to a fire, presents a problem in that although it will not necessarily ignite within its tank due to the very rich mixture above its surface, it will absorb heat from the hot surrounding bulkheads, expand, and probably slop over or seep into the fire zone. Such a tank should preferably be pumped dry. The greatest danger exists within a tank which is closed and partly filled, for here the hot, compressed gases are likely to explode. These should again be pressed full or pumped dry. Forced air is then used to clear the tank of vapours. The pressing-up of burning liquids in tankers may spread the fire to other tanks, through the gas lines.

(3) Magazines

These should either be flooded, if in imminent danger, or else continually sprayed to keep their contents cool. Explosives generate their own oxygen, and hence their burning can be prevented only by saturation or removal.

(4) Electrical Fires

These may be fought using carbon dioxide extinguishers. The gas is a non-conductor and leaves no residue, nor will it damage delicate electrical machinery. Halon 1211 (BCF) is also ideal and again causes no damage. The use of dry chemicals is safe in that they are non-conductors, but they leave considerable residues. Foam and water should not be used on electrical fires, as they are conductors.

(5) Film

This has a highly flammable nitro-cellulose base, which on burning emits combustible toxic fumes. Ventilation should be provided to clear these fumes—it will assist the fire very little, since the burning film generates oxygen. The fire is best left to burn out, which it will do very quickly, but precautions must be taken to prevent spread.

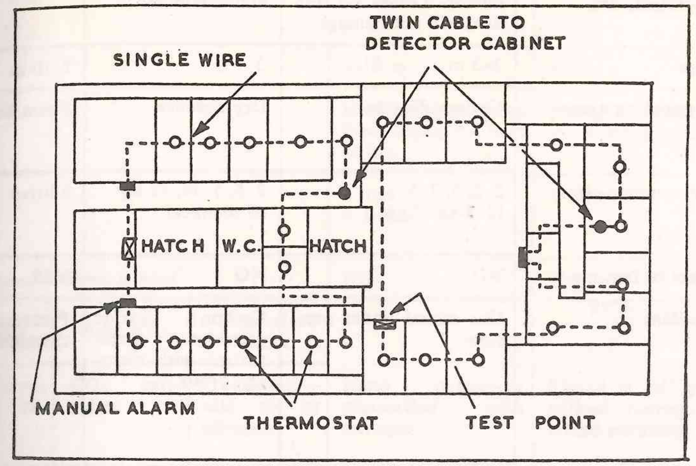
MARINE FIREFIGHTING EQUIPMENT

The tables on pages 248–9 relating to fire extinguishers is reproduced by kind permission of the Walter Kidde Company Ltd.

FIRE DETECTING APPARATUS

(1) The Kidde Zone Type System

This gives warning of fire in passenger cabins, public spaces, crew quarters, storerooms and lockers, etc., by sounding an alarm in the wheelhouse or fire station and also in the engine-room and crew's quarters, which makes possible instant location of the zone in which the fire has started. The areas are divided into zones, each having a number of



KIDDE ZONE DETECTING SYSTEM [TWO ZONES SHOWN]

FIGURE 11.1

bimetallic thermostats wired in series, and which are normally closed. A current of about 4 milliamps. is passed for continuous supervision of the circuit. Usually a key-operated test switch and a break-glass manual station are included in each zone.

When current ceases to pass through any circuit owing to a fire which operates a thermostat, or to breaking of glass at a manual station, the alarm bells are rung. The officer of the watch can then instantly locate the zone and take steps for extinguishing the fire. The manual alarm boxes are placed in full view of passengers, crew, and the fire patrol officer. Any person observing the first signs of fire is able to sound

FIRE

		Carbon dioxide	Dry chemical	Foam	Soda acid, water/CO_2, pressurised water	Halogenated hydrocarbons: Vaporising liquid *Chlorobromomethane*	Halogenated hydrocarbons: Self-pressurised *Trifluoromonobromo-methane*	
	Class 'A'. Paper, wood, cloth, general rubbish	Small surface fires only	Small surface fires only	YES — excellent. Has smothering and wetting action	YES—excellent. Water saturates materials and prevents re-ignition	Small surface fires only	Small surface fires only	
	Class 'B'. Flammable liquids: Petrol, Oil, etc.	YES—excellent. Carbon dioxide replaces oxygen, leaves no residue, does no damage	YES — excellent. Chemical smothers fire	YES — excellent. Foam floats on top of liquid and smothers fire	NO. Water will spread fire	YES. Heavy smothering gas is formed	YES. Heavy smothering gas is formed	
	Class 'C'. Live electrical hazards: motors, switches, etc.	YES—excellent. Carbon dioxide is a non-conductor. Leaves no residue, will not damage	YES — excellent. Dry chemical is a non-conductor	NO. Foam is a conductor	NO. Water is a conductor	YES. Liquid is a non-conductor	YES. Gas is a non-conductor	
5–10 ft 10–25 ft 25–35 ft	Range	2–3 m	3–7 m	7–10 m	10–15 m	6–10 m	6 m	30–50 ft 20–30 ft 20 ft
	Extinguishing agent	Carbon dioxide	Dry chemical	Foam bubbles	Water	Heavy vapour formed from liquid by heat of fire	Heavy smothering gas is discharged	
5 lb 10 lb 15 lb 25 lb lb 10 lb 20 lb 30 lb 2 gal	Most common sizes	2·5, 5, 7·5, 12·5 kg of gas	2·5, 5, 10, 15 kg of chemical	9 litres	9 litre	1 litre 4·5 litre	1 litre	2 gal 1 quart 1 gal 1 quart
	Subject to freezing	NO	NO	YES	YES—unless additive is used	NO	NO	
	Propellant	Gas stored under pressure	Carbon dioxide cartridges. Pressurised with nitrogen or air	Pressure from chemical reaction	Soda acid: Pressure from chemical reaction Water/CO_2: CO_2 cartridge Pressurised water: Pressurised—with air or nitrogen	Hand pump—or pressurised with nitrogen	Liquid is self pressurised. Nitrogen is added normally	
	Recommended maintenance	Weigh twice a year	Weigh twice a year. Check CO_2 cartridge or pressure gauge	Discharge and recharge annually	Soda acid: Discharge and recharge annually Water/CO_2: Weigh CO_2 cartridge twice a year Pressurised water: Check pressure gauge twice a year	Check pump by partially discharging twice a year, or check pressure gauge twice a year	Check pressure gauge and weigh twice a year	

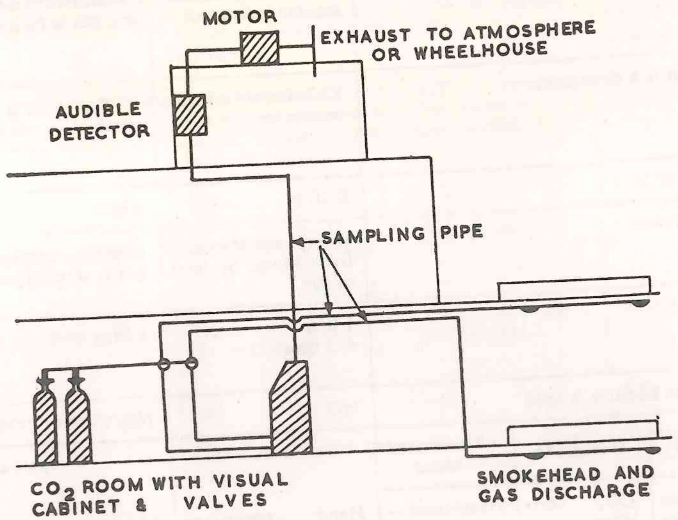
the alarm by the simple act of breaking the glass by means of a small chain-attached hammer.

Fig. 11.1 shows a typical layout of two zones in the Kidde system. A break in the circuit of either zone gives audible warning at the detecting cabinet, and operation of the control switches then indicates the zone in question. There is no limit to the number of circuits fitted in the ship and up to fifty spaces can be protected on each zone. Two electrical sources are used—normal ship's mains and a heavy-duty, nickel–iron storage battery under trickle charge. Should the mains supply fail, the battery will automatically pick up the load and carry the system for more than a week. Visible and audible warning is immediately given of: (1) power failure; (2) earthing of the circuit; (3) any attempt to close the cabinet door when the system is not in normal operation; and (4) failure of the fire-alarm bells.

The system remains in operation as a fire detector even when either of the first two faults exist.

(2) The Kidde Marine Smoke-detector

This has proved to be one of the most satisfactory means for giving warning of fires in holds, and has been in service for some thirty years. Fig. 11.2 shows, diagrammatically, the piping layout for one hold when carbon dioxide extinguishing is used in conjunction with the smoke detector. Samples of the hold atmosphere are drawn continuously from each protected hold in the ship and passed through a dark chamber which is traversed by light from hidden sources. This light is not visible,



KIDDE SMOKE DETECTOR LAYOUT

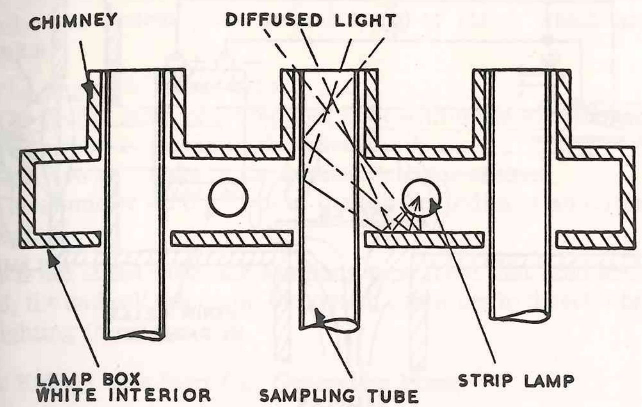
FIGURE 11.2

but serves to strongly illuminate any smoke arising from the holds. Since each pipe-end is labelled, the smoking hold is quickly and surely identified. There is no possibility of false alarm; the observer knows with certainty that smoke is issuing from a particular hold and has a rough measure of the smoke density. Once it is detected, the fire is most effectively dealt with by the carbon dioxide flooding system. This consists of a battery of steel cylinders containing the gas, whose contents can be discharged as required along the sampling pipes to any hold, or holds. The gas is prevented from reaching the detecting cabinet by means of a three-way valve which is operated immediately the burning hold has been identified and before the gas is released.

The Visual Viewing-chamber. This has recently been improved so that

it greatly increases the visibility of small traces of smoke. The black interior of the chamber is normally quite dark, but has lamps so arranged that smoke issuing from any of the sampling pipes is made clearly visible. The hot-galvanised, solid-drawn, steel pipes from the holds enter the cabinet at the bottom, where they are connected to P.V.C. pipes leading up to the viewing chamber. These pipes terminate in 12-mm diameter glass tubes which pass through a brightly lit lamp box. ½-in
Their ends protrude into the viewing chamber, where they are shielded by metal chimneys. This is shown in Fig. 11.3.

Light travels by multiple reflection and refraction along these tubes, irradiating the region near their ends with a diffuse light. This is in-



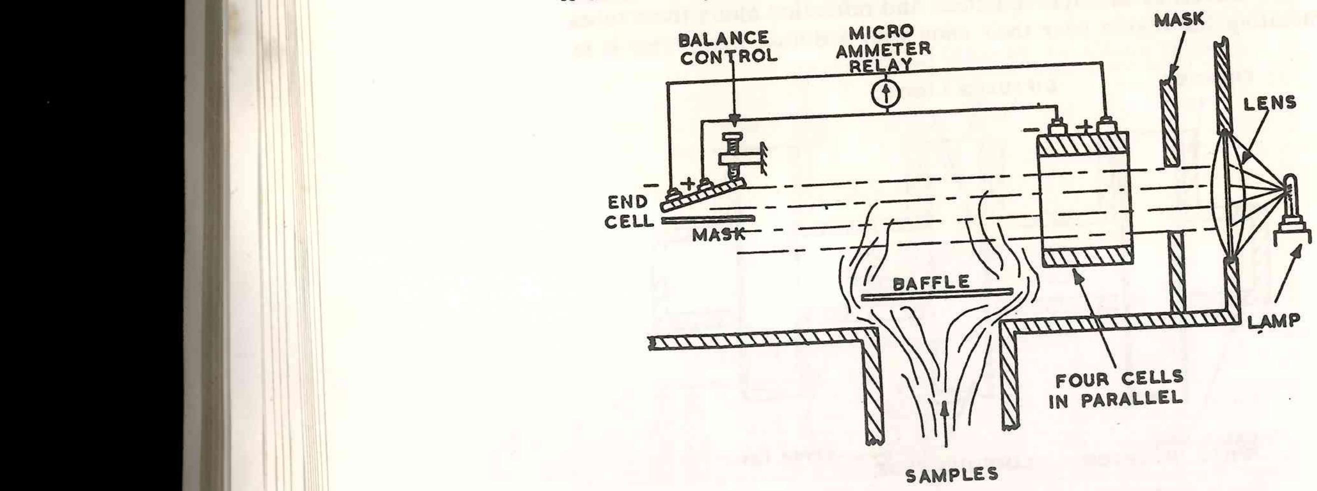
KIDDE VISUAL SMOKE DETECTOR

FIGURE 11.3

visible, but illuminates smoke issuing from any tube. The viewing-chamber window is angled from the vertical to prevent unwanted reflections from interfering with the view of the chimneys. By lifting a flap on the front of the viewing-chamber, the glass tubes can be examined a few inches below the lamp box. In this part of each tube is a small, moulded nylon, propeller-type draught-indicator whose rotation indicates that the line is not blocked.

The Audible Detector. This is fitted in the wheelhouse for additional protection. In some vessels the detecting cabinet with viewing-chamber may be installed in the wheelhouse, without employing the audible detector. The latter achieves high sensitivity by using both obscuration and reflection of light by smoke, to upset the balance of a photo-electric cell circuit. No thermionic valves are used, and a special arrangement within the circuit avoids false alarms resulting from component failure. The layout of the instrument is shown in Fig. 11.4.

A concentrated filament lamp and lens form a parallel beam. After the beam has been reduced to square cross-section by a mask it passes through a slightly larger square of inward-facing, barrier-layer-type photo-cells. These are very stable, requiring no high-tension supply, and are normally illuminated by only a small amount of stray light, so that the output of the four in parallel is about 15 micro-amps. This current is balanced by the output of the end cell, which lies at a small angle to



KIDDE AUDIBLE SMOKE DETECTOR

FIGURE 11.4

the direction of the beam and therefore receives light obliquely. The orientation of this cell is adjustable in order to balance the circuit initially. The presence of smoke in the detector cuts off light from the end cell and reflects some on to the cells of the square. The difference in output currents thus caused passes through a relay which, on operation, causes the audible and visual alarms to function. Two foreseeable causes of false alarm in such a system are gradual deterioration of a photo-cell and slow distortion of the projector-lamp filament. The circuit is therefore arranged so that either of these events causes a fault indication instead of a false alarm.

Mounted above the wheelhouse are two independent electric motors driving the main sampling fan. Their use should be alternate, and a change-over switch is provided so that each motor functions only on

alternate days. The exhaust valve may be set to discharge the sampled air to the atmosphere, or, as an additional detector, it can be set to exhaust into the wheelhouse. In this way the presence of smoke is also smelled. The visual-detector cabinet is connected to the audible-detector by a common pipe, and in this way the presence of fire within the ship is detected, while exact location is afforded by inspection of the visual-chamber. The layout in Fig. 11.2 avoids passing the sampling pipes all the way to the wheelhouse; this is a major advantage, particularly when the system is to be installed in a ship already constructed.

The alarm bells may be installed in the wheelhouse and engine-room, with additional bells fitted in the Officers' accommodation for use when in port. The same applies to the fault alarms, which emit a klaxon note.

Finally, the system gives several types of alarm which are here summarised:

(1) The ringing of alarm bells.
(2) The illumination of a coloured light within the wheelhouse.
(3) The odour of smoke in the wheelhouse.
(4) The view of smoke in the audible-detector cabinet.
(5) The ammeter on the front of the cabinet indicates an output current.

Once a fire is detected, the sampling pipe from that hold should be plugged, the end cell reset, and the system continues to detect other fires while fighting the initial one.

(3) The Kidde Lucas Inert Gas Generating Plant

Basic Principles. This equipment produces an unlimited supply of inert gas by burning Diesel oil in air, the oxygen being converted to carbon dioxide and water. After the produced gases have been cooled and washed they are directed to the fire zone. The generator can deliver 700–1 400 m³ of gas per hour at an outlet pressure of 500 gr per cm². 25 000–50 000 ft³
This meets the firefighting requirements of a ship, the largest hold of 7–8 lb per in²
which has a grain capacity of 5 700 m³. 200 000 ft³

The analysis of the gas is as follows:

Nitrogen	85%
Carbon dioxide	14%
Oxygen	1%
Sulphur dioxide and carbon monoxide . .	Negligible

By adopting a technique of water cooling by direct contact with the gas, the cooling process is combined with a cleansing and scrubbing action, which removes the bulk of the soluble acidic gases which can result from the presence of sulphur or similar impurities within the fuel.

The Plant comprises (1) a blower driven by (2) an electric motor or

Diesel engine. The latter also drives an alternator to provide electrical power for (6) and (7). (3) A compact, combined, combustion and scrubbing unit. (4) Fuel pump, controls, instrumentation, safety interlocks, etc. (5) Piping system, control valves, suitable discharge fittings, etc. (6) A water pump driven by (7), an electric motor.

27 gal The burner consumes roughly 120 litres of Diesel oil per hour. The burner is ignited by means of main and stand-by spark plugs powered from the ship's mains, via transformers or coils, or from the Diesel-driven alternator.

The inert gas is prevented from being contaminated with water droplets, after washing, by means of a baffle system within the delivery pipe. It is delivered to the fire zone at both deck and deckhead levels.

(4) The Use of Flue Gas for Inerting

tons All tankers over 20,000 tonnes (and if less than that figure, only if
tons equipped with crude oil washing systems) are required to be fitted with inert-gas systems. The most favoured and practical type is that which employs the flue gas from the funnel. The analysis of this gas is in the order of: oxygen 4·2%, carbon dioxide 13·5%, nitrogen 77%, sulphur dioxide 0·3% and water vapour 5%.

The flue gas is passed to a scrubbing tower where the gas is cleaned and cooled. A typical tower employs trays of sea-water, one above the other, with the water falling from top to bottom. The overflow from the bottom tray is piped overside through an effluent line and will contain sulphuric and sulphurous acid formed by a combination of sulphur dioxide and water. In cases of bad combustion, oily vapour may find its way into the tower and be condensed. As this passes overside the vessel may be committing a pollution offence. The gas bubbles up from the lower tray to the top, passes through a demister to remove moisture and is then piped to the tanks through a deck seal, which acts as a one-way valve and is designed to prevent cargo gas from passing back to the engine room. By this time the gas is about 2°C above the sea temperature.

The oxygen content of the gas must be kept below 5%—which also inhibits corrosion in the tanks. An alarm is usually fitted to give warning if the oxygen rises to 8%. The lowest oxygen concentration is found when boilers are working at full load.

Tank ullages are filled with inert gas for the loaded passage and will vent off in hot climates as the cargo expands. As the ambient temperature lowers, more gas will have to be injected.

When the cargo is discharged, the inert gas is driven in and this pressure aids pumping of the cargo overside. The empty tank can then either be left full of inert gas, or gas freed, or cleaned. Cleaning can be

carried out with inert gas in the compartment. On the other hand, as soon as the tank is empty, it may be ballasted, in which case the inert gas will be vented off.

It should be noted that immediately after discharge of the cargo, the inert gas will be mixed with some hydrocarbon gas and the compartment will need to be purged with more inert gas before cleaning commences. This purging may take up to 28 hours and should eventually give an explosimeter reading of 1% or less.

(5) Halon Gas (1301) CF_3 Br

This is the trade name for a compound chemically known as bromotrifluoromethane, also known as BTM. Halon is colourless, odourless, non-conductive and five times heavier than air. It inhibits the chemical reaction of fuels with oxygen. Its great advantage is that it has low toxicity to humans and is safe for up to 4–5 minutes. It boils at −57°C −71°F
and freezes at −168°C. It is up to thirty times more expensive than −271°F
carbon dioxide but is an ideal substance for rapid injection into working spaces such as engine rooms. Only 5% of the space needs to be filled with halon in order to extinguish a fire.

(6) BCF or Halon 1211 CF_2 Cl Br

The chemical name for this is bromochlorodifluoromethane. It is normally found in extinguishers and is a very effective smothering gas, which for short periods of exposure may be regarded as non-toxic. It tends to vaporise more slowly than Halon 1301 and is therefore better suited to extinguisher use, as a partial liquid jet. Halon 1301 however is slightly safer for breathing and can be used in inhabited spaces, assuming normal evacuation.

CHAPTER XII

DRYDOCKING AND LOADLINES

THE STABILITY ASPECT (EQUALLY APPLICABLE TO VESSELS AGROUND)

It is desirable that a vessel entering a drydock shall be upright and have a small amount of trim by the stern, for then she will initially rest on the blocks at the aftermost point of her keel. She will then pivot about this point in a vertical plane as the water level falls and may also be pivoted laterally by means of her fore breast-lines so that her keel may be aligned with the blocks.

Until the water level falls below the keel the vessel's weight is supported partly by the blocks and partly by the water. The upward reaction of the keel blocks may be considered as a negative weight in a moment calculation, producing a decrease in the ship's stability, and it is most important that the vessel remains stable until she takes the blocks along the full length of her keel, i.e. when she is *sewed*, for until this moment the side shores cannot be successfully rigged. Once the vessel is laterally supported by shores, her stability condition is of no practical consequence.

A few moments' thought will make it apparent to the reader that the upward thrust of the keel blocks aft is that required to destroy the vessel's trim until she is sewed, and must therefore be in direct proportion to the trim value. The reader may prefer to consider the line of blocks moving upwards towards the keel; they make contact aft and exert a certain force which is a loss in displacement (if the blocks are supporting part of the ship's weight, then the water cannot also be doing this) and eventually make contact throughout the ship's length as she tilts about an athwartships axis.

Consider a vessel trimmed 25 cm by the stern and having a moment to change trim 1 cm (M.C.T.1 cm) of 25000 tonnes-cm. The after keel knuckle is 50 m from the tipping centre or centre of flotation.

The moment causing the initial trim is 25 × 25000 tonnes-cm.

The moment destroying this trim is a force P × 5000 tonnes-cm.

They are equal and therefore,

$$25 \times 25000 = P \times 5000$$

From which $P = 125$ tonnes at the instant of sewing.

If her initial displacement was 10000 tonnes and her tonnes per cm immersion (T.P.C.) at that displacement was 25, then her displacement while being sewed becomes 9875 tonnes and she loses 5 cm of mean draught. At the same time the 125 tonnes upward thrust reduces her stability, and it is for this reason that the initial trim by the stern should be kept as low as possible.

Once the ship is flat on the blocks she loses roughly 25 tonnes of displacement for every cm loss of mean draught, i.e. an amount equal to her T.P.C. for the existing draught. This increasing thrust at the keel blocks steadily reduces the ship's stability by an amount equal to

$$\frac{P \times KG}{W-P} \text{ cm, i.e. a rise in the position of the centre of gravity.}$$

where P is the loss of displacement in tonnes, W is the initial displacement in tonnes and KG the distance of the centre of gravity above the keel measured in cm.

GENERAL PROCEDURE

Before entering a drydock, the following items should be given attention:

Repairs

A full and detailed list of repairs to be carried out while in dock should be prepared, duplicating at least six copies so that all interested parties, such as the Owners, the ship's Officers, the ship-repair Managers, the foremen, and the Dockmaster, can each be provided with a list. In dock, each item may be crossed off the list as soon as the repair is accomplished to the satisfaction of the Officer or Surveyor in charge.

Draught and Trim

In many cases these are stipulated by the Dock Authorities, who take into account the depth of water at the dock sill when the vessel is scheduled to enter, and also the *declivity*, i.e. the slope, of the blocks at the dock entrance. The Dockmaster should be informed of the draught and trim as soon as possible so that he may be able to give ample notice if he requires them to be altered.

Structural Features

The Dockmaster should be notified of the position of bilge keels, if any, the rake of the stem, the type and number of propellers, and the position of echo-sounder transmitter and receiver units. Any protruding logs (distance recorders) should be withdrawn into the hull.

Cargo

The Authorities should be informed of the existence and disposition of any cargo within the vessel. This subject will be dealt with in more detail at a later stage.

Movable Weights

These should be secured, since it is desirable that the vessel should be in the same condition of trim, preferably large stability, and zero list, both when entering and finally leaving the dock. Tanks should be either full or empty so that no free surfaces exist, which are detrimental to stability. The fore and after peak tanks should preferably be empty, since these are difficult areas to support with shores, and the vessel may become hogged. As soon as the vessel is sewed, the tanks and bilges should be sounded throughout the ship, and these readings are duplicated before refloating the vessel. A list of soundings may be given to the Dockmaster. If tanks are full there is the advantage of being able to rapidly observe leaks.

Derricks, Gangways, and Anchors

These should preferably be in the stowed positions both when entering and leaving the dock.

Inspecting the Dock

In ports of doubtful efficiency the Master should, if possible, view the dock when dry and ascertain that:

(*a*) suitable and efficient shoring arrangements are provided;
(*b*) the keel blocks have level top surfaces, are evenly dispersed, are substantially constructed, and are undamaged. They should naturally extend sufficiently to accommodate the vessel's keel: and
(*c*) whether bilge blocks or beds are provided.

The shoring of a vessel in a drydock is very necessary, since the upward pressure of the keel blocks tends to push the vessel out of shape, the bilges are inclined to sag, and the side plating tends to incline outwards. Wooden side (breast) shores are placed between the hull-side plating and the dock sides, which are stepped into *altars* to take the shore heels, making certain that the head of the shore rests on a frame, thus avoiding plate indentations. These shores are inclined slightly above the horizontal. A second layer of shores (bilge shores) are often rigged in a similar manner but just above the round of the bilge. In some docks these shores are hydraulically operated and are housed, when not in use, in the dock sides.

A line of bilge blocks, i.e. heavy baulks of timber built up into sup-

ports similarly to keel blocks, are often a permanent feature of the dock, and though more widely spaced than keel blocks, they are valuable in supporting the bilges, but they must be placed under a longitudinal side girder in order to avoid straining the plating. Once the dock is dry, these blocks are built up to the plating by means of extra wooden packing pieces and wedges. They are of particular importance when the vessel is partly or fully laden. Bilge blocks sometimes remove the need for shores.

Once the vessel has entered the dock, the caisson gate will be floated into place and locked. The vessel will be aligned over the keel blocks by the Dockmaster, using his docking-bobs forward and aft, and then the dock will be pumped dry. The following points should now be given attention:

Cleaning

As the water level falls, the ship's side will be scrubbed clean by men working from floating pontoons. If the water level falls too quickly the cleaning will be hasty and incomplete. Close liaison with the Dockmaster may result in a slowing of the pumping rate during this relatively important period. Care should be taken to see that no pontoons ground on the propellers or altars.

Shores

These cannot be secured in place until the vessel is sewed, but as soon as she has done this they will be swung into place by shore cranes and must be headed against frames to avoid hull distortion. If the vessel is in a tender condition (low stability properties), the shores may be roughly rigged as soon as the vessel contacts the blocks aft, and the pumping may be completely stopped while they are being finally secured.

Once the dock is dry, the following items must be considered, the list not being in any chronological order:

Fore and Aft Shores should be rigged in place, particularly beneath the fore peak tank where the keel blocks do not give any support.

Tanks should have been sounded as soon as the vessel was flat on the blocks, or else done now without delay.

Discharges are opened overside for inspection. Baffle plates may be removed for cleaning and coating on their inner surfaces, after which they are welded back into place.

Water Closets should be locked and arrangements made for personnel to use toilets within the dock area. In ships fitted with septic tanks, arrangements may be made to drain this tank into the shore sewers. Alternatively it may be permissible to drain the tank directly into the dock outlet drain channels.

Fire

Arrangements should be made to provide the vessel with an adequate supply of firefighting water, and in addition, all fire appliances should be ready for instant use. Frequently the Dock Authorities provide a fire-patrol service whereby one or more watchmen visit every part of the ship each hour, their movements being recorded by suitably placed time clocks.

Telephone

This should be placed aboard the ship if possible, primarily for rapid summoning of fire or ambulance services.

Electricity

Electricity supplies, suitable for the vessel's equipment, should be provided if the Diesel generators are to be overhauled. Boilers will be allowed to burn down.

An earth return may be rigged by welding a suitable cable to a bared area of hull plating. The only other earthing routes available in a ship resting on wooden blocks are along the wire hawsers, which may not provide good contacts at their extremities.

Hot Water

This must be supplied for cooking and washing facilities, and if the vessel's domestic heating equipment is to be overhauled the Dock Authorities may provide electric water boilers.

Watchmen

Watchmen should be employed to prevent unauthorised persons from boarding, and to generally attend the gangway.

Draught Marks and Loadlines

These may be repainted, the former being checked by the shipwrights. Along the side plating there are often small spots of weld at a certain known waterline. These are joined by a chalk line and the draught marks are examined for accuracy, using this as a datum line. It is sometimes convenient to arrange for the loadline survey to coincide with a drydocking, these marks being examined at the same time.

Damage

The vessel will be carefully surveyed by the Officers, a Lloyd's Hull Surveyor, the Company's Engineer Superintendent, and also the Dock-

yard Manager. The Marine Superintendent is also present. Dented plates will be straightened (faired), bearing in mind that those removed for this purpose will have to be hose-tested on replacement. Weeping rivets and seams will be caulked, the tail end shaft(s) may be withdrawn for examination of liner wear-down, and the rudder examined for suspension wear. The propeller blades will be examined for tip damage and then polished on their surfaces. When listing areas of damage, or plates which require scaling, the shell plating plan will be used, bearing in mind that plates are numbered from aft and lettered from the garboard strake ('A') upwards towards the sheer strake.

Tanks

Any tanks which need draining will have their plugs removed from the shell plating, into which they are usually recessed if they have a protruding hexagonal head to prevent it shearing. These plugs must be placed in safe custody and replaced before the dock is flooded.

Cathodic Protection

Arrangements for this should be examined by the installing firm and anodes renewed where required. The zinc plates in way of the stern frame may need renewing if badly corroded. These represent the earliest method of cathodic protection, and it is of interest to note that when Sir Humphry Davy designed them, their purpose was understood so little that they were often fitted to wooden ships.

Anchors and Cables

These may be ranged in the dock bottom for greasing, testing for wear-down, changing the cable lengths, re-marking, renewal of lead pellets, and at the same time the chain locker can be cleaned and scaled/coated if necessary. (The reader is here referred to Chapter I.)

Painting

This will generally be commenced as soon as the vessel is dry and her bottom has been cleaned of all growths. These are particularly evident at plate lap-joints, and are likely to be ignored close to the keel, where headroom is limited for working. The lower sides of bilge keels are frequently thickly coated with marine growths. The deposits may need slicing off if very hard, and in some cases they are burned off, a process called *breaming*.

Where the hull paintwork is in good condition a fresh coat of antifouling is all that is necessary, applied over a quick-drying coat of antifouling *undercoat*, which seals and binds the surface of the old paint and makes it compatible with the antifouling composition. When the paint-work is grazed or pitted, as often occurs in way of the collision bulkhead due to anchor-cable chafe, the surface should be cleaned, smoothed, and coated with a metallic primer which is anticorrosive. This is finally covered with antifouling paint.

If the vessel has rested on the keel blocks in a different position from last time, patches of her keel will be bare or short of antifouling, and particular attention should be given to this area.

For new or bare plating (and often a few plates are scaled at each drydocking in order to keep the surface smooth), three to four coats of metallic primer should be applied, followed by one coat of antifouling. To make sure that the priming coats are properly applied, it is often convenient to use separate colours for each coat, say pink, brown, and yellow. In this way, any patches short of paint will be avoided, in addition to which the Officers and paint foremen can instantly assess the progress of the painters.

As long as possible should be allowed between these coats, which dry
500 ft^2 per gal in about four hours. The covering capacity is about 10 m^2 per litre. This primer has a very high resistance to water, and a surface which is compatible with antifouling, which is now applied direct.

Antifouling composition is applied in order that the slow and constant solution of the toxic substances which it contains will keep the ship's surface in an antiseptic condition, so that no marine growth can obtain a foothold; the paint is thus a store for poisonous materials, but the antiseptic condition is obtained only at the expense of a depletion of this store, in other words it is a wasting process. The composition of the paint must be such that it has a highly controlled rate of toxic depletion. These materials are derived from copper and mercury. Arsenic is occasionally used, but is far more effectively poisonous on higher biological orders.

Because of their constituents, antifouling paints are expensive but should never be thinned, as this is a false economy. It is designed to be applied at a certain consistency, and any thinning will reduce its protective properties. The price is usually directly proportional to the strength and duration of this protection. If, in warm climates, the paint is found to be thin, two coats should be applied. The strongest and
320 ft^2 per gal most expensive antifouling covers at the rate of about 6·5 m^2 per litre.
500 ft^2 per gal Antifouling undercoats cover at the rate of about 10 m^2 per litre and dry in about two hours. Antifouling paint should always be applied over the undercoat or final primer not later than twenty-four hours after the former has dried. It must never then be allowed to dry hard unless of polyurethane base. The dock must therefore be flooded between six and twenty-four hours after application of the composition.

The boot-topping should be coated either with enamel paint or else

with antifouling composition, the latter being preferable, since weed growth is most evident at, and near, the water surface. Enamel paint, however, is far more easily cleaned of oil stains. A different coloured antifouling may be used if desired.

Flame Cleaning

Certain dockyards are using this method of paint removal in preference to the traditional scaling. The instrument is virtually a gas-supplied (oxy-acetylene) blowlamp, but the flame is emitted from a wide-angle fishtail aperture and quickly removes paint, however thick or old. The plating should then be wire-brushed by a man following the flame-operator. The method has the advantage that the metal is now dry and warm and thus ideal for painting. In damp conditions it is advisable to use teams of four men; one man burns off the paint, a second man follows close behind wire-brushing the plating clean, and the remaining two follow along with the first priming coat.

There is one point to be watched, however, which is most important. During surveys it may occur that there will be a Surveyor and Officers examining oil tanks under which flame cleaning is in progress. The oily residue on the inside bottom plating quickly vaporises into suffocating fumes. Shot blasting, sand blasting and ultra-sonic cleaning are safer methods in this respect.

Cleanliness

Every endeavour should be made to keep the ship as clean as possible, and while deck-washing may not be convenient, there is no reason why a regular daily sweeping should not be carried out. Arrangements should be made to have the ship's refuse removed at frequent intervals, particularly in hot weather.

Smoke-detecting Gear

If the ship is light, an admirable opportunity is afforded to carry out testing and cleaning of this system by means of compressed air.

When the vessel is ready to leave the drydock the following items will need attention:

Discharges

These should have all non-return valves replaced, and baffles fitted (where supplied).

Plugs

All tanks should have their underwater drain plugs in place, and in most drydocks the dock is not flooded until the Dockmaster is presented with a signed certificate stating that an Officer has inspected the hull and is satisfied on this count.

Times

The ship's log should be checked to see that it contains:

(1) The time at which the vessel entered the dock.
(2) The time at which the gate was closed.
(3) The time when pumping commenced.
(4) The times when the vessel was sewed and also when the dock was dry.

When leaving, the log should contain:

(1) The time when flooding commenced.
(2) The time when the vessel floated.
(3) The times when the gate was opened and when the vessel left the dock.

A report should be furnished to the owners, retaining a copy aboard, giving all the above times, details of the work done in dock, the quantities and types of paint used, the Marine Superintendent's opinion of the initial condition of the underwater paintwork, and all other relevant facts.

DOCKING METHODS

In past days there were two methods of exposing a ship's underwater surface, and they are worthy of mention purely from the points of view of interest and increasing the reader's sea vocabulary.

Careening

In this case the vessel was run close inshore over a suitable beach, at high water, so that she grounded at low water and heeled over. The time available for repair and maintenance work was necessarily very limited. The method is still widely used for small craft. It is, of course, essential that the sea-bed dries out completely at low water in the locality of the vessel.

Heaving Down

Here, a vessel was heeled over by means of tackles set up between her masts and another ship, hulk, or shore attachments. Her masts were

rigged with extra preventer shrouds to distribute the stresses involved. The method was not so successful as careening, but since the hull was waterborne, there was little hull stress, unless, of course, it touched the sea-bed.

Nowadays, there are three basic methods for preparing a ship for underwater hull work:

(1) A Graving Dock

This is one which is excavated from the land and closed to the sea or river by means of a floating caisson gate. This is virtually a large, robustly-built, steel tank. The edge of the dock bottom beneath the gate is referred to as the sill. The sides of the dock are terraced into concrete steps or altars into which the shores are heeled. Along the centre line of the dock, huge baulks of timber are built up into keel blocks. In some cases another parallel line of bilge blocks or beds is built on each side of the centre line. The blocks are tied together to prevent them from toppling or being tripped as the vessel is sewed or refloated. The line of the blocks' upper surfaces is usually on a slight gradient relative to the horizontal, known as the declivity. The dock is filled from the river or sea, and the gate is opened when the levels of the water on both sides are coincident. The ship is then floated in and positioned over the keel blocks, the gate is closed, and the dock is pumped dry.

The top edge of the gate, along which persons may walk, is often 15 m above the dock bottom and the gate has to withstand, in this case, a maximum pressure of 12 tonnes/m^2 if the water outside the dock is of density 1 tonne/m^3 and 3 m below the gate-edge.

50 ft
2 500 lb/ft^2
64 lb/ft^3 10 ft

(2) A Floating Dock

This is virtually a huge, flat, subdivided steel tank rather like a ship's double bottom, on the upper centre-line of which is a line of keel blocks, with or without associated bilge beds. This forms the bottom of the dock, which has no ends but high narrow sides which are also tanks. These are constructed along the longer sides of the rectangular dock.

The tanks, both in the double bottom and the sides, are flooded so that the dock bottom is at a deeper draught than the ship's keel. The ship is then floated over the dock's centre-line and the latter is pumped dry until the ship is clear of the water. The docking Manager will require detailed data regarding the ship's stability, trim, and loading condition, and may require any of these to be changed. Each section of the dock must be capable of lifting that portion of the ship's length, and weight, which lies within it, and the ship must therefore be evenly loaded. If this is not arranged, the dock is subjected to severe bending stresses.

To keep the dock properly trimmed, the ship's centre of gravity must be vertically above the dock's centre of buoyancy, and these points are marked, by means of paint, on the sides of both the ship and dock. The two eventually form one floating craft or system, the stability of which, like any craft, is directly proportional to the beam of the waterplane, i.e. the area of the craft's cross-section at, and parallel to, the water level. This, and therefore the stability of the system, is least when the water level is between the ship's keel and the dock bottom, for then the water-plane area is only that of the narrow side tanks. This may be referred to

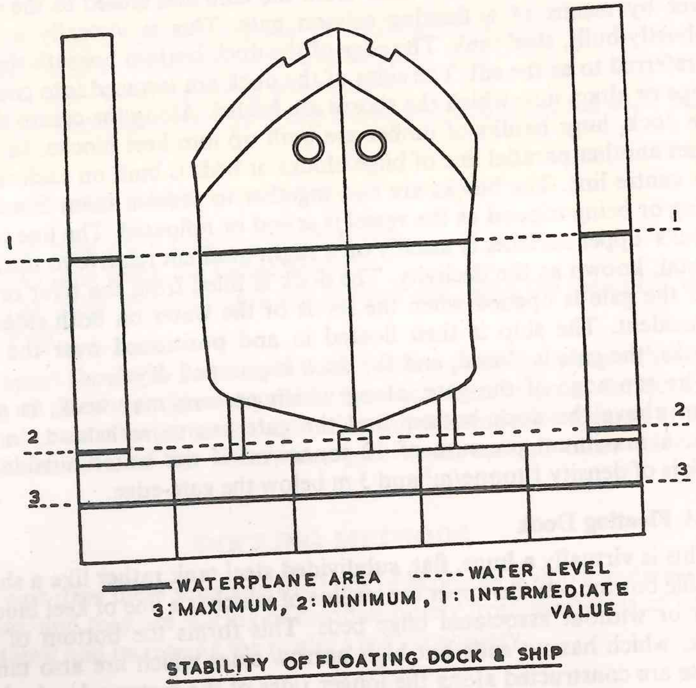


FIGURE 12.1

as the *critical moment* of docking. (In the case of a graving dock, this occurs just before the vessel is sewed, for then the upthrust at the keel is at a maximum for the unshored condition.) In the floating dock the stability is greatest when the dock bottom is clear of the water surface. There is an intermediate value, varying with the draught of the ship, when the ship is still submerged, for then the waterplane area is that of the ship together with the side tanks' area. These conditions are illustrated in Fig. 12.1. Free surfaces in the dock's and ship's tanks will reduce the stability of the system.

(3) The Floating Cradle

This is used for small vessels, and consists of a reinforced slipway on which is built a railway carrying a heavy cradle. The latter is run down the slipway into the water under the ship's keel, and when the ship rests on the cradle the two are hove up the slipway.

DOCKING WITH CARGO ABOARD

In such cases the ship is likely to be subjected to severe stresses and be strained. Certain precautions must therefore be taken. The pressing-up of tanks beneath holds will add weight to the ship but should help to distribute the weight of cargo evenly over the inner bottom, and avoid local loading. As soon as the vessel is sewed, divers may be employed to build up the bilge blocks before further pumping is allowed. This makes sure that the vessel is well supported before too much of her weight is transferred to the keel blocks. In such a case, bilge blocks should be underneath a longitudinal side girder to avoid plate-buckling. Extra shores will have to be employed throughout the ship's length and at her ends. If the damage or repair work is in a suitable position it may be possible to pump out only some of the dock water, i.e. sufficient to expose the area in question, and leave the vessel partly waterborne. This reduces not only the reaction of the blocks but also any tendencies for the ends to droop (*hogging*), and also tendencies for the bottom plating to sag between the lines of blocks. The Dockmaster must initially be furnished with a detailed loading plan.

LOADLINES

The International Load Line Rules (1968) apply to all vessels whose Governments are parties to the Loadline Convention of 1966. All British ships, with the exception of:

(1) warships,
(2) vessels engaged solely in fishing, and
(3) pleasure yachts,

are required to use statutory loadlines to ensure that they do not become submerged more than is prudent, having regard to the latitudes and seasons in which they are sailing. They must not put to sea unless the ship has been surveyed, marked with loadlines, complies with assignment conditions and carries proper stability information.

These loadlines are awarded by Assigning Authorities, such as the Department of Transport but more often on behalf of the Government, Lloyd's Register of Shipping and the British Committee of the

French Bureau Veritas. The vessels must be constructed and equipped as laid down in the Loadline Rules (obtainable from H.M. Stationery Office) to certain conditions of assignment, after which a summer loadline (in salt water) is computed, other freeboards are assigned, and the marks are cut in or painted on the ship's sides. A loadline certificate is presented to the Owners, and must be posted in a conspicuous position within the ship, while in force. The certificate is valid for five years, but an annual survey is held to ensure that the conditions of assignment are fulfilled and the loadline marks are unaltered. Before a Master can sign on a crew he must enter details of this certificate and his loadlines into the agreement. Every voyage, similar particulars must be recorded in the Official Logbook.

International loadline ships are those of 24 m and over. They will have an International Loadline Certificate (1966). Other vessels will have a United Kingdom Loadline Certificate. If a vessel is loaded so that in a condition of zero list, her loadline is submerged, her owner or Master shall be liable to a fine of £2000 and in addition another £2000 for every centimetre that her appropriate load line is submerged. A further fine of £2000 is likely if she is sent to sea in an overloaded condition. These are maximum fines in a court of summary jurisdiction. It is a defence to prove that the overloading was caused by deviation or delay beyond the Master's control. A vessel may be detained until she ceases to be overloaded.

Amidships **means at the centre of the length of the summer load water-line.**

Loadline Marks

These shall be painted in white or yellow on a dark ground or in black on a light ground, and shall be carefully cut in or centre-punched on the sides of iron or steel ships. On wooden ships they shall be cut in for at least 3 mm. (⅛ in)

The Deck Line is a horizontal line measuring 300 mm × 25 mm (12 in × 1 in) marked amidships, with its upper edge passing through the point where the continuation of the upper surface of the freeboard deck (or its sheathing) intersects the outer surface of the shell plating. The *freeboard deck* is the uppermost complete deck having permanent means of closing all openings in weather sections, e.g. hatchways.

The Loadline Disc is 300 mm in external diameter and 25 mm thick. (12 in 1 in) Its centre is amidships and below the deckline. The disc is intersected by a horizontal line measuring 450 mm × 25 mm (18 in × 1 in) whose upper edge passes through the centre of the disc. This line, at its upper edge, marks the summer salt waterline and is often referred to as the *Plimsoll line* after Samuel Plimsoll, a pioneer in the prevention of ship-overloading.

The Loadlines. At a distance of 540 mm (21 in) forward of the centre of the disc, there is a vertical line 25 mm (1 in) wide, from which horizontal lines measuring 230 mm × 25 mm (9 in × 1 in) extend forward and aft, the upper surfaces of which indicate the maximum depths to which the ship may be submerged in differing circumstances and seasons.

Types of Loadlines

(1) Steamers, Including Tankers (Fig. 12.2). The loadlines are shown for the *starboard* side of a ship. The following are marked:

Summer (*S*). This is level with the Plimsoll line and is the basic computed freeboard line. A separate table is used for computing the tanker summer loadline. Other loadlines are based on the summer mark.

Winter (*W*) is one forty-eighth of the summer draught below the summer line.

Tropical (*T*) is one forty-eighth of the summer draught above the summer line.

Winter North Atlantic (*WNA*) is marked on all vessels of 100 m or under in length. It applies to voyages within the North Atlantic north of the 36th parallel of latitude, during the winter months, as laid down in the Loadline Rules. It is marked at a distance of 50 mm below the winter loadline.

When the vessel is floating in fresh water, the freeboard may be reduced by an amount known as the Fresh Water Allowance (FWA) and this is calculated from the formula

$$\frac{W}{4\,T}\text{mm}$$

where W is the displacement in tonnes, in salt water at the summer loadline, and the symbol T represents the TPC (tonnes per cm immersion) in salt water at the same level. In the event of the displacement (W) being indeterminable, the Fresh Water Allowance is taken as one forty-eighth of the summer draught.

Fresh Water (*F*) is the summer fresh-water loadline. The distance between (S) and (F) is therefore equal to the FWA.

Tropical Fresh Water (*TF*) is, by a similar argument, situated above (T) by an amount equal to the FWA.

All the above distances are measured between the upper edges of the respective loadlines.

(2) Timber-carrying Vessels (Fig. 12.3). These loadlines are awarded to vessels engaged in the timber deck-cargo trade, excluding wood pulp, and are only to be used when the cargo is carried in accordance with the 1968 Deck Cargo Regulations. Such a vessel must have a

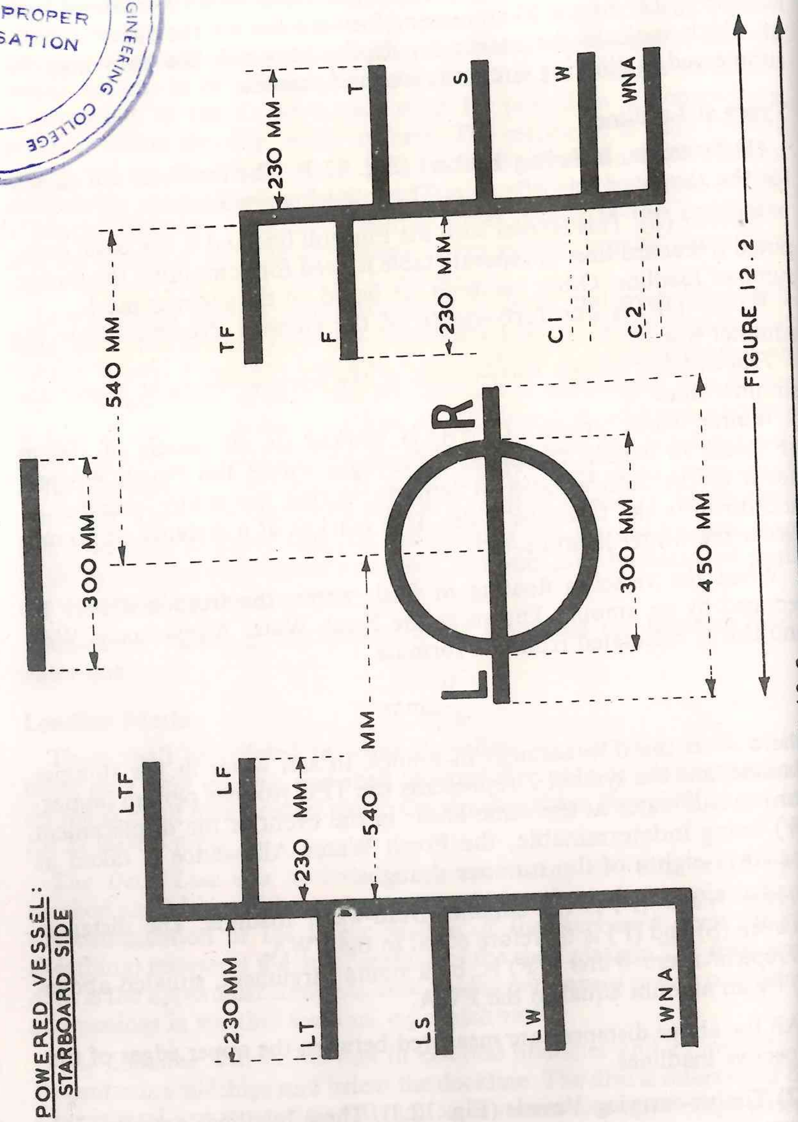


FIGURE 12.2

FIGURE 12.3

forecastle extending at least 7% of the ship's length, and a poop or raised quarter-deck. Her double-bottom tanks within the midships half-length must be subdivided, and the ship must be fitted with efficient rails or bulwarks at least 1 m in height. Eyeplates for securing lashings 39 in
must be affixed to the sheer strake not more than 3 m apart. Her 10 ft
steering-gears must be adequately protected from cargo damage.

The vessel must fill her wells solidly with timber up to the standard height of her superstructures. In this way, she obtains greater reserve buoyancy and her summer freeboard may be reduced. This naturally reduces certain other loadline freeboards.

She will have a second set of loadlines suitated 540 mm abaft the 21 in
centre of the loadline disc, similarly marked for other loadlines, but with each letter prefixed by 'L' (Lumber).

Lumber Summer (*LS*) is at some computed level above the Plimsoll line, and its upper edge marks the summer salt-water timber loadline.

Lumber Winter (*LW*) is $\frac{1}{36}$ of the lumber summer draught below $\frac{1}{3}$ in /ft
(LS).

Lumber Tropical (*LT*) is $\frac{1}{48}$ of the lumber summer draught above $\frac{1}{4}$ in/ft
(LS).

Lumber Winter North Atlantic (*LWNA*) is on the same level as the (WNA) loadline, where marked. It therefore applies only to vessels of 100 m or under in length. 328 ft

The Loadline Certificate gives a separate Fresh Water Allowance for both ordinary and lumber freeboards.

Lumber Fresh Water (*LF*) is therefore situated above (LS) by an amount equal to the FWA.

Lumber Tropical Fresh Water (*LTF*) is above (LT) by an amount equal to the FWA.

(3) Sailing Ships (Fig. 12.4). These ships have a deckline, a disc with an intersecting line, and two 230-mm loadlines situated 540-mm forward 9-in 21 in
of the disc centre. The intersecting line marks the waterline for winter, summer, and tropical conditions. It is therefore an (S), (T), and (W) line.

The Fresh-water Loadline (*F*) is above the intersecting line by an amount equal to the FWA, computed as for steamers.

The Winter North Atlantic Line is below the intersecting line by an amount directed by the Assigning Authority.

Subdivision Loadlines

These may be assigned to a passenger vessel aboard which spaces exist which are used for the carriage of either passengers or cargo. She may have the usual loadline markings as shown in Fig. 12.2, and in addition a subdivision loadline (or loadlines, up to usually three in number), marked (C) to indicate Convention (Safety). Where there is more than one of these loadlines they are marked C1, C2, and C3, numbering them downwards towards the keel, so that C3 indicates the maximum freeboard. They are all situated below the Tropical (deepest salt water) loadline and often on the forward side of the vertical line. Two of these loadlines are shown pecked in Fig. 12.2.

Details of these loadlines are found in the Passenger and Safety Certificate, posted in a conspicuous position aboard the ship, and also in the Declaration of Survey (Survey 1 A), which is in the custody of the Master. The various spaces relating to each loadline are recorded in

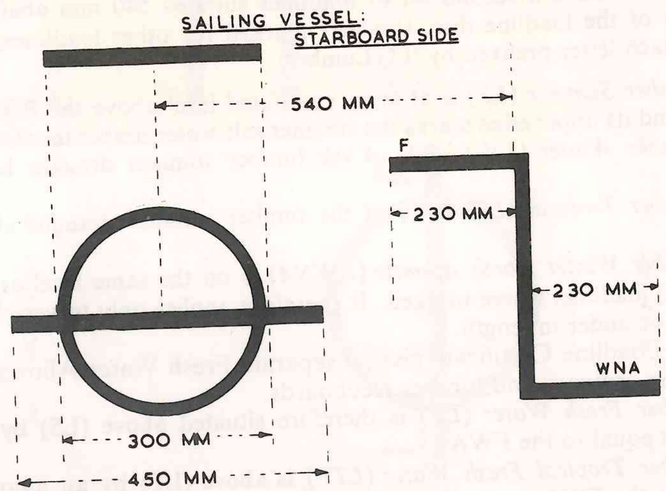


FIGURE 12.4

these forms. Whenever all the spaces are used for cargo carriage only the vessel loads to her usual loadlines. If, however, a space is used for the carriage of passengers, then the vessel must not submerge beyond the appropriate subdivision loadline.

These loadlines are not connected with the International Loadline Rules, but are provided under the terms of the Safety Convention and computed for British ships by the Department of Transport (D.o.T.) in the United Kingdom.

In the Far East, such as India, Ceylon, Hong Kong, and Singapore, vessels may be seen with additional subdivision loadlines marked D1, D2, etc., situated below the (C) lines. These provide an even greater freeboard, and are used in similar circumstances to the (C) lines but in bad weather seasons, such as the south-west monsoon in the Indian Ocean.

The Calculation for the Dock Allowance

Considering, for the sake of convenience, the summer season, a vessel can load until she is submerged to the upper edge of the summer loadline provided she is in water of specific gravity 1·025. In water of specific gravity 1·000 she can submerge to the upper edge of the freshwater loadline (F).

If the difference between these two levels is 125 mm (her fresh-water 5 in
allowance), then it means that she can submerge her (S) line by 125 mm 5 in
if she is loading in fresh water in summer.

If the water in the dock is of some intermediate S.G., then she may submerge her summer loadline by an amount (the dock allowance) calculated as a direct proportion.

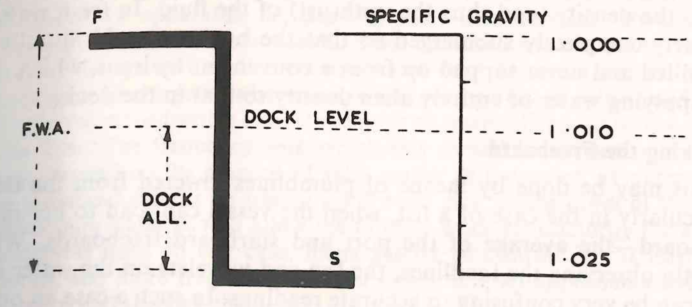


FIGURE 12.5

Suppose the vessel in the above case is loading in dock water of specific gravity 1·010. Fig. 12.5 shows the fresh and salt summer loadlines and the corresponding S.Gs. The dock allowance is shown by the distance D.A., extending upwards from the summer loadline, and level with 1·010 on the scale of S.Gs.

By simple direct proportion,

$$\text{D.A.} : \text{F.W.A.} :: 15 : 25$$

meaning that the dock allowance is the same fraction of the fresh-water allowance as 15 is of 25.

So, $$\frac{\text{D.A.}}{\text{F.W.A.}} = \frac{15}{25}$$

And, $$\text{D.A.} = \frac{15}{25} \times 125 \text{ mm}$$ 5 in

$$= 75 \text{ mm}$$ 3 in

So the summer loadline, or any other salt-water loadline when in season, can be submerged by 75 mm when the vessel is loading in dock 3 in
water of this S.G.

The S.G. is measured by means of a hydrometer. A bucket of the dock water is obtained from overside, clear of all discharges, and not from the wash-deck line hydrants. The hydrometer is inserted into the water and spun between the fingers to break down surface tension, which may affect the reading. The S.G. is read from the scale adjacent to the water level. Some hydrometers show density, taken as roughly one thousand times the S.G., i.e. water of specific gravity 1·025 has a density of 1025 grams per litre.

The hydrometer may be made of brass; it has a long, thin stem on which are graduated the densities or specific gravities spaced in harmonic progression. The lower end of the stem joins a buoyancy chamber, below which there is a weighted sphere. The instrument is of constant volume and weight, and therefore varies its depth of immersion according to the density (and thus the upthrust) of the fluid. In fresh water it is nearly completely submerged so that the bucket should initially be well-filled and never topped up from a convenient hydrant, which may be supplying water of entirely alien density to that in the dock.

Checking the Freeboard

This may be done by means of plumblines lowered from the deck, particularly in the case of a list, when the vessel can load to her mean freeboard—the average of the port and starboard freeboards. When directly observing the loadlines, the lop and wavelets on the water surface can be very confusing to accurate readings. In such a case an open-ended glass tube may be held vertically against the loadlines with one end submerged. The water level will then remain fairly static within the tube. Such a method is equally useful when reading draughts.

CLEANSING OF FRESH-WATER TANKS

Although this may naturally be done at any time, it is quite likely to be carried out while in drydock, and for that reason is included in this chapter. In addition to cleansing, the tank may need to be cement-washed with a solution of cement in fresh water at a thin, creamy consistency. Attention should also be paid to the thick cement coating in the bottom of the water tanks, which just covers the rivet heads. Where cracked, this should be suitably keyed and refilled.

The following advice is from a Department of Transport Merchant Shipping Notice:

The attention of Shipowners and Masters is drawn to the need to ensure that the health of crews is not jeopardised by the use of fresh water from tanks which are not adequately and regularly cleansed, by the use of filters which are not periodically serviced and maintained, or by the use of sea water in the preparation of food.

The Board's investigations suggest that insufficient attention is being paid to these matters, and Masters are, therefore, requested to ensure that the following precautions are taken:

1. Fresh Water Tanks

Drinking water tanks should be opened up, cleaned out, cement washed (or, if coated with a bituminous, plastic, or other proprietory composition, recoated where necessary) and aired at intervals not exceeding 12 months. In addition, it is recommended that tanks should be thoroughly pumped out and, where necessary, hosed prior to re-filling at approximately six-monthly intervals. During the cleaning process scrupulous attention should be paid to the hygiene and personal cleanliness of those engaged on the work.

2. Filters

When filters are fitted arrangements should be made for the maintenance and care of the apparatus, i.e. cleaning and where necessary changing the media to ensure that the apparatus does not become contaminated by bacteria and other foreign matter. It is recommended that the media, i.e. the carbon candles, should at intervals be removed and washed out in chlorinated water and lightly scrubbed with a brush to remove all traces of deposit on the surface of the filter. The frequency with which this should be carried out will, of course, depend on the amount of solid matter in the water, as water which gives a marked deposit on standing will soon clog up the pores of the filter, whereas pure water should allow the filter to work satisfactorily for a quite considerable time. In any case, filters should be cleaned out at least once a month, and more frequently if water containing an appreciable sediment is being passed through them.

It cannot be too strongly stressed that filters will not guarantee the bacteriological purity of the filtered water. Therefore, whenever there is any doubt as to the quality of the water, chlorination should be carried out in accordance with the instructions laid down in the Ship Captain's Medical Guide.

3. Use of Sea Water

The use of sea water in the preparation of food, washing up of dishes, cleaning of galley equipment or in installations such as potato peelers, should where possible be avoided. Where its use is unavoidable there should always be a final rinse through with fresh water. Under no circumstances should sea water be used for these purposes when the vessel is in, or in the vicinity of, port or coastal areas.

It is recommended that a warning on the above lines should be issued to Catering Department staffs.

PEST CONTROL IN SHIPS

There are two types of rat: the brown one, which is a shore dweller and tends to burrow, and the black one, which climbs, and frequents ships. The latter species is a plague carrier, transmitting the disease by means of its fleas.

Rats commence breeding at the age of two to three months, and up to ten may be born in a litter. The period of gestation is only three weeks, and it is therefore possible for a male and a female to cause the evolution of nearly 20000 rats in twelve months.

It is required that rats should be prevented from leaving a ship when in port. It is equally desirable of course, that rats from ashore should not join the ship. This prevention is carried out by means of circular alloy rat-guards which clip over the mooring lines, or by means of canvas parcelled around the moorings both at the shore and the ship (i.e. two parcellings on each line), well tarred, and each extending
2 ft 0·6 m in length.

The gangway should be hoisted clear of the quay when not in use, e.g. at night, or else well illuminated and/or whitewashed. Rats will avoid well-lighted places. Stores should be moved regularly to discover whether rats are harbouring, and refuse should not be allowed to accumulate on the ship.

Any rats caught alive should be drowned and then burned. They should not be taken ashore.

The International Sanitary Convention (Paris) 1926 requires that a Port Sanitary Authority shall be responsible for the issuing of Certificates of Deratisation and Certificates of Exemption from Deratisation. A ship calling at a port where the Convention applies, and having neither of these certificates, will most probably have to be fumigated.

Both Certificates are valid for six months, and whichever certificate is held should be presented on arrival at each port, to the Local Port Health Officer.

The Certificate of Deratisation is issued to the Master after fumigation has taken place. The Certificate of Deratisation Exemption is issued to a Master, if the Inspector is satisfied that there is no evidence of rats on the ship.

To this end, it is both politic and economic to ensure that the vessel is continuously kept rat-free.

United Kingdom vessels have an excellent reputation for being hygienic. In 1899 gas fumigation was first seriously attempted in the form of sulphur dioxide. In 1921 hydrocyanic acid gas (hydrogen cyanide or prussic acid gas) was used successfully, and continued in popularity until about 1952.

The use of hydrocyanic gas (HCN) involves great inconvenience and cost, for all work has to cease on board the ship, and it has to be completely evacuated except for the fumigating staff. Several deaths are recorded where personnel have been left aboard, sleeping in their cabins. However, in some ports, the use of HCN may still be necessary in order to obtain a Deratisation Certificate.

The most popular method employed in the United Kingdom at the present time is fumigation by means of sodium fluoracetate (1080), and this will deserve the issuing of a new Certificate.

The use of 'Biotrol' baits maintains a ship rat-free, for Biotrol is an anti-coagulant bait which is combined with a palatable fungicide in whole cereal grains. As a result, the bait stays fresh and attractive to rats for up to twelve months.

Only one-fortieth of a gram of bait per thousand grams of body weight, taken regularly, will kill a rat within a week. The rat feeds without suspicion, and is in no way bait-shy. The bait is practically harmless to domestic animals and humans.

The following is an M Notice, No. 115, cancelled but still relevant:

NOTICE TO SHIPMASTERS

FUMIGATION OF SHIPS WITH HYDROGEN CYANIDE

Fumigation with Hydrogen cyanide is a dangerous process which should be undertaken only by responsible persons with full knowledge of the nature of the gas and of the necessary precautions.

The Nature of the Gas

Hydrogen cyanide—which is also known as hydrocyanic acid gas or prussic acid gas—is an invisible and highly poisonous gas. It has a faint almond-like odour. Many people however cannot smell it, and in some cases the sense of smell becomes deadened. It is therefore highly dangerous to rely on the sense of smell for detecting the presence of the gas.

It is a fallacy to imagine that because the gas is a little lighter than air it can be induced to escape upwards merely by opening port holes or hatches of ships. When once mixed with air it cannot thus easily be got rid of. The whole atmosphere of a compartment or ship must be changed, and this can be done only by applying the well-known principles of ventilation. The circulation of air may be assisted by mechanical means, and special attention must be paid to places where ventilation is obviously difficult or slow, e.g., forepeaks, deep holds with small hatches, etc.

Warning Notices

Warning notices should be displayed on every gangway and other means of access to the ship before the fumigation is started, and they should be kept in position until the operation is over and ventilation is complete.

Preliminary Search for Unauthorised Persons

Before any part of a ship is put under gas steps should be taken to see that no unauthorised person is on board.

Clearance after Fumigation

The ship must be properly ventilated and the fumigant operators must ascertain by test that in no part of the risk area is the fumigant concentrated by more than one part by volume in one hundred-thousand parts of air.

Bedding, blankets, pillows, cushions, thick carpets, etc., must be thoroughly beaten in the open air.

Special attention should be paid to cabins and sleeping compartments. It is often advisable, after they are apparently free from gas, to close them for one hour and again test the air.

In cold weather ventilation is slow and repeated tests may be necessary. As the temperature rises gas may be liberated from materials which have retained it. In such circumstances it may be necessary to heat compartments and then re-test them before they are declared free of gas.

Special attention should be paid to cold storage chambers.

The crew's quarters or cabins must not be occupied during the night following a fumigation. If, however, this is unavoidable, all doors, port holes and other openings of spaces must be kept open and special attention must be paid to the previous beating—*in the open air*—of bedding, blankets, pillows, etc.

If the vessel has been fumigated with the cargo on board, special care is necessary, and the atmosphere should be kept under observation when unloading is in progress.

Symptoms of Poisoning

Hydrogen cyanide is extremely poisonous and poisoning may result from breathing the gas or absorbing it through the skin. The warning signs are irritation of the throat, dizziness, nausea, general weakness and headache, palpitation, a feeling of suffocation, pallor, deep breathing, sudden unconsciousness followed by a cessation of breathing, in that order.

A person showing these symptoms must be immediately removed to a pure atmosphere, laid down with his head into the wind and first aid must be given without delay, Speed is essential. A doctor must be summoned at once. The first aid procedure, if the patient is conscious, is as follows:

(1) Break a capsule of amyl nitrite on to a piece of cloth and allow the patient to inhale the vapour.
(2) Remove or cut away splashed clothing.

If the patient is unconscious, then in addition to (1) above, artificial respiration should be started simultaneously with (2) above. The patient should be kept warm and not walked about.

The reader's attention is drawn to the Hydrogen Cyanide (Fumigation of Ships) Regulations, 1951, in which precautions are laid down regarding the treatment of ships by this gas. Notice of the forthcoming fumigation must be given to the Medical Officer of Health; operators are required to be adequately trained and equipped with respirators. The Rules explain how unauthorised persons are permitted to enter the risk area in the event of emergency such as fire.

In the Port of London in 1959, 112 vessels were deratted by the use of sodium fluoracetate (1080) compared with only thirteen by the use of HCN. The use of 1080 has proved popular with shipowners as it presents no fire risk or danger to humans. It does not give off poisonous fumes and it cannot be absorbed through the unbroken skin. It is odourless and tasteless in use and presents no repellent effect. Rats drink a lot of water and will approach the solution confidently.

While deratting with 1080, the crew may remain on board and work can proceed in those parts of the ship not under treatment.

Article 52 of the International Sanitary Regulations requires that a vessel shall be kept in a condition such that the number of rodents on board is negligible. Such a ship can exist on Deratting Exemption.

This is achieved using the anti-coagulants baits, distributed through the ship in polythene sachets which are broken by the rats. These sachets help to keep the bait fresh. Ships with past records of rodent infestation have been kept completely clear by the use of these baits.

In the Port of London, 100 ships are deratted nearly every year. Over 2000 rats are destroyed on vessels in the port each year.

Methyl Bromide

This substance is a very effective fumigant, readily penetrating such commodities as soil and timber. It is highly toxic to man and should be used only by trained and competent operators. Symptoms of poisoning, which resemble drunkenness, may be delayed for several hours. A victim of poisoning may take years to recover. The gas is first smelled when in a concentration of 10000 ppm but by then it is far too late—poisoning having occurred at 35 ppm. A lachrymatory agent (producing tears) is usually added to the gas, to act as a warning.

Fumigated areas should be made gas-tight and operators should use halide detector lamps outside the area to detect leakage—they are basically blowlamps with a copper insert. When methyl bromide is present, the flame turns to a pale-green or bright-blue colour.

A ship should not be fumigated with methyl bromide until she has been searched and evacuated. Accommodation should be sealed and keys handed to the operator. On large vessels, total evacuation is not necessary, only of the areas adjacent to the fumigation. Ventilating systems should be watched for gas seepage.

CHAPTER XIII

THE OFFICER OF THE WATCH

TIME KEEPING

THE day at sea is divided into six 4-hour periods called watches. These extend, and are named as follows:

From 8 p.m. to midnight	the first watch
From midnight to 4 a.m.	the middle watch
From 4 a.m. to 8 a.m.	the morning watch
From 8 a.m. to noon	the forenoon watch
From noon to 4 p.m.	the afternoon watch
From 4 p.m. to 8 p.m.	the evening watch

In past days the evening watch was broken at 6 p.m. into two 2-hour periods called the first and second *dog watches*. This enabled two sets of watchkeepers (the watch-and-watch system) to alternate their routine day by day. Nowadays there are invariably three sets of watchkeepers, and the practice may only be used on small vessels manned by two watchkeeping officers.

The time is sounded by means of the ship's bell—usually the one fitted to the bridge-front bulkhead, the clapper of which is moved by means of a lanyard extending to the helmsman's position. The beginning of the watch is denoted by making 8 bells, the end of the first half-hour by 1 bell, the end of the first two half-hours by 2 bells, and so on, so that 3.30 a.m. and p.m., for example, is sounded by 7 bells. The number of bells made therefore never exceeds 8, except at midnight on the 31 December, when 16 bells are made, i.e. 8 for each year, often rung by the youngest member of the ship's company. The bells are made in pairs, followed by a single one if any, leaving a distinct pause between each pair and between a pair and an odd stroke. E.g. 3.30 is made as

1, 2, . . . 3, 4, . . . 5, 6, . . . 7

At a quarter of an hour before the end of each watch, i.e. 3.45, 7.45, and 11.45, one bell is made to call the next watchkeepers.

The bell system in the dog watches (if kept) is unusual, unless it is

treated as a full 4-hour watch. Even today in three-watch systems the dog-watch bells may be made, as follows:

1630 hrs. 1 bell	1700 hrs. 2 bells	1730 hrs. 3 bells
1800 hrs. 4 bells	1830 hrs. 1 bell	1900 hrs. 2 bells
1930 hrs. 3 bells	1945 hrs. 1 bell	2000 hrs. 8 bells

The bells are similar to those for other watches up to and including 1800 hrs. and also the watch-calling bell at 1945 hrs.

Many Masters today dismiss the use of the bells on the grounds that clocks are fitted throughout the ships. Others prefer to use them during the hours of daylight only, particularly when passengers are carried. It is perhaps a pity that such a well-known custom of the sea is tending to die out.

THE DUTIES OF THE OFFICER OF THE WATCH (O.O.W.)

A. At Sea

These are summarised as follows:

(1) Maintaining an efficient lookout, both ahead and astern, supplemented at night, and possibly by day as well, by one or more crew lookoutmen, posted where the O.O.W. thinks fit.

(2) Checking the vessel's position whenever possible and necessary. This does not imply a continuous sequence of sextant work. When coasting, many Masters require the ship's observed position to be plotted on the chart every 15–20 minutes. These fixes may be supplemented by the use of radar, according to the Master's Standing Orders. Whenever possible, radar ranges and bearings should be checked at least once a watch by means of visual bearings to ensure that this navigational aid is functioning properly. Radio direction-bearings and Consol counts may also be used by the O.O.W. in addition to Decca, satellites or Loran.

(3) Ensuring that the helmsman is maintaining a proper course, and steering to the best of his ability under the prevailing weather and sea conditions. A glance at the wake, by day, will provide a quick check on his accuracy. Course recorders and auto-pilots must also be checked.

(4) To keep a sharp lookout when men are working near the ship's side or when moving about the decks in heavy weather.

(5) To use the echo-sounding machine when instructed to do so.

(6) In fog, to ring the engine-room telegraphs to 'Stand-By', to commence sounding the Regulation fog-signal, to commence and organise a radar watch, to call the Master, to post extra lookouts forward and/or aloft, and to reduce to a moderate speed.

(7) To record all details of passing aircraft, in the Deck Logbook.

(8) To reply by visual signalling to any vessel or aircraft, particularly