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B.R. 2092

HANDLING SHIPS

1954

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B.R. 2092

HANDLING SHIPS

Navigation and Direction Department
ADMIRALTY S.W.1

AMENDMENTS

Amendment No.	Authority	Date of insertion in this copy	Initials

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B.R. 2092 *Handling Ships*, 1954, having been approved by My Lords Commissioners of the Admiralty is hereby promulgated for information and guidance.

OU 5274 is superseded and copies are to be destroyed in accordance with the instructions contained in B.R. 1.

By Command of Their Lordships,

To Commanders-in-Chief, Flag Officers
and Commanding Officers of Her Majesty's
Ships and Vessels concerned.

CONTENTS

(SO 6541)

ILLUSTRATIONS

(*Other than those in the text*)

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CHAPTER I

PROPULSION

When studying the handling qualities of any particular class of ship, the first factors to be considered are the number and size of the propellers and the horse-power and type of the propelling machinery. The technique of handling a single-screw ship fitted with reciprocating engines is very different from that required in the case of a twin or quadruple-screw ship with turbine engines. Similarly there is quite a specialised technique in certain aspects of the handling of a triple-screw ship.

Number of propellers

In general, battleships, cruisers and modern fleet aircraft carriers are fitted with quadruple screws. *Indomitable* and *Illustrious* class fleet aircraft carriers have triple screws. Most other types of major warships and submarines have twin screws. Trawlers, certain A/S frigates, and the majority of fleet oilers, maintenance ships and servicing craft are single-screw ships.

Fast coastal craft are in a separate category, and are fitted with two, three or four propellers.

Type of machinery

Steam turbine machinery with single reduction gearing is fitted in the great majority of H.M. Ships, but double reduction gearing is being fitted in most new construction. Certain twin-screw frigates and minesweepers, all landing ships, and all single-screw ships have reciprocating engines, though there are a few turbine driven single-screw Fleet Auxiliaries. In addition some new construction frigates are to be fitted with internal combustion engines.

Apart from submarines, which are not discussed in this book, and coastal and smaller craft, internal combustion engines are not fitted as main propulsive machinery in H.M. Ships, other than certain AA and AD Frigates, Fleet Repair Ships, Landing Ships, and vessels of the Fleet Train.

Type of propellers

In the modern single-screw warship the propeller is invariably right-handed, that is to say when going ahead it turns in a clockwise direction viewed from astern.

Twin and quadruple-screw ships are fitted with outward-turning propellers, i.e. the starboard screws are right-handed and the port screws left-handed. In modern triple-screw ships the outer propellers are out-turning, and the centre propeller is left-handed.

Fast coastal craft are again an exception, the propellers being normally all right-handed or all left-handed in order to simplify engine installation.

Both the diameter and the pitch of the propellers are important factors when considering their reactions on the ship. In general, ships fitted with steam reciprocating engines have large and comparatively slow turning propellers, whereas in most turbine-engined ships, unless fitted with double reduction gearing, relatively small fast-turning propellers are necessary. Broadly speaking, the larger the propeller the smaller the loss of power resulting from slip and the sternward velocity of the race, and the greater the efficiency.

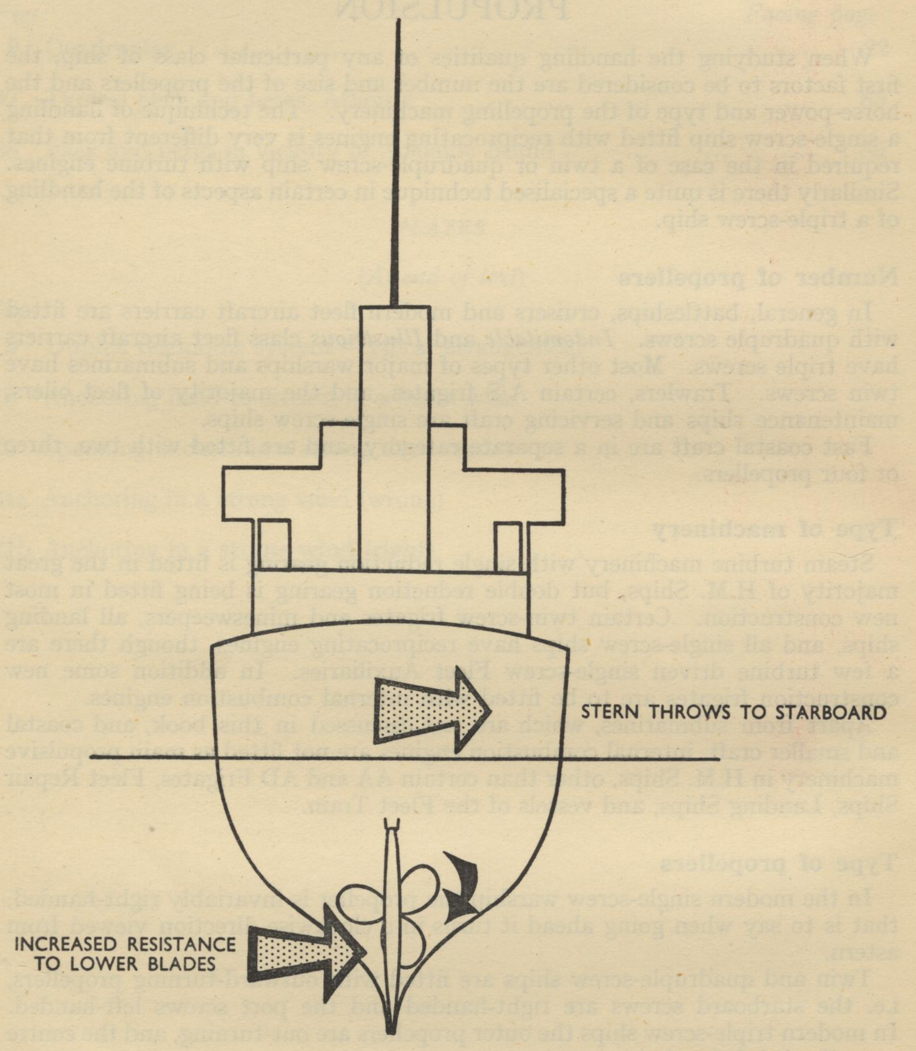


FIG. 1.—Screw effect. Right-handed Single-screw ship moving ahead from rest.

Number of blades

Three bladed propellers are most common in H.M. Ships, though four- and five-bladed propellers are occasionally fitted for particular purposes.

REACTIONS FROM PROPELLER MOVEMENT

The rotation of a screw propeller produces various reactions on the ship's hull other than simple thrust in the fore-and-aft line. The most pronounced of these reactions is the Screw or 'Paddlewheel' effect, caused principally by the increased resistance of the water to the more deeply immersed lower blades.

The single-screw ship

Proceeding ahead from rest, screw effect is most evident in the case of a single-screw ship, and for a right-handed propeller results in a throw of the stern to starboard when going ahead from rest, and to port when going astern from rest. (*Fig. 1.*)

Once headway has been gained, this effect is modified to some extent by the 'Wake', which is the disturbance caused by the passage of the hull through the water. An important component of this disturbance, Frictional Wake, is a belt of water dragged along with the hull by skin friction, causing a disturbance which is greatest against the upper blades and there may be a tendency for the ship's stern to be thrust to port.

In addition, the impingement of the rotating screw race on the rudder comes into play at speed. The turning effect will depend on relative size and position of rudder and propeller.

The two other components of the 'Wake', Streamline Wake and Wave Wake, are caused respectively by the closing in of the water at the stern, and the orbital motion of the water in the ship's wave pattern.

REVERSING THE PROPELLER WHILST MOVING AHEAD. The effect of reversing the propeller whilst moving ahead will be to throw the stern to port, after an interval during which headway is being lost and sternway gained.

PUTTING THE ENGINE AHEAD WHILST MOVING ASTERN. Should the engine be put ahead whilst the ship has sternway, the throw of the stern to starboard will be delayed until the momentum of the swing to port has been overcome.

The twin- or quadruple-screw ship

When a twin- or quadruple-screw ship proceeds from rest, or is moving with all screws turning either ahead or astern at the same revolutions, the screw effect of one set of propellers is neutralised by the other, and there is no tendency for the stern to be thrown in either direction. (*Fig. 2.*)

If, however, one set of screws is reversed, a pronounced turning effect is produced by all propellers revolving in the same direction. In addition, certain other unbalanced reactions will assist the turn.

TURNING AT REST. Consider a twin-screw ship at rest, starting to turn to port; the starboard engine being put ahead, and the port engine astern. (*Fig. 3.*)

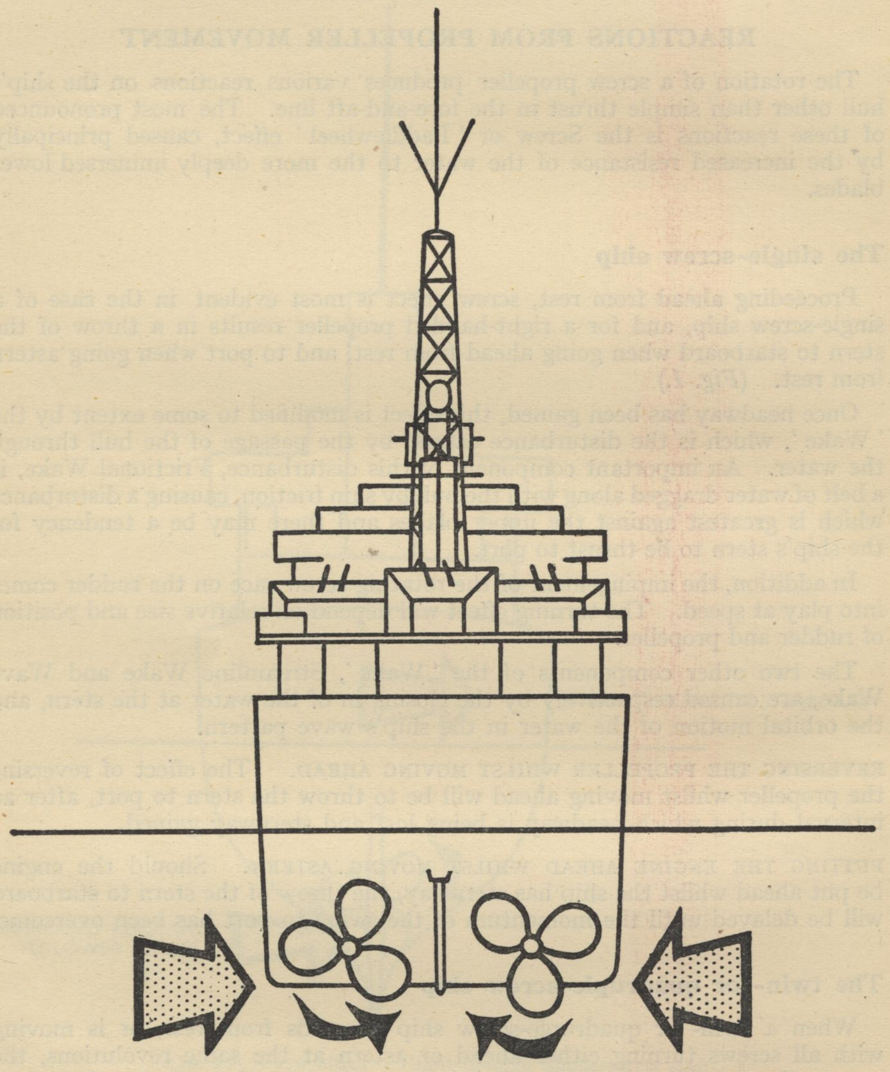


Fig. 2.—Twin-screw Ship proceeding ahead. Screw effect of starboard propeller neutralises that of port.

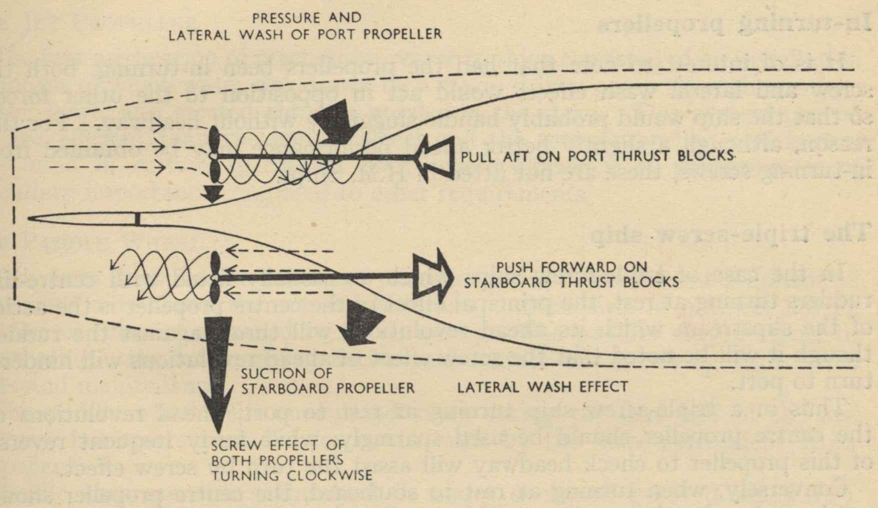


Fig. 3.—Twin-screw Ship turning at rest to port. Starboard engine ahead, port engine astern.

Both propellers are revolving clockwise, viewed from astern, and are producing four principal reactions on the hull:—

(*a*) *Screw effect*. As previously explained, this will throw the stern to starboard, and will thus assist the turn to port.

(*b*) *Pressure and suction*. The ship being at rest, the starboard propeller is drawing water from under the quarter and ejecting it astern, thus creating a partial vacuum between the propeller and the hull. Conversely the port propeller is drawing water from astern and building it up under the port quarter. The resultant pressure and suction effect will also assist the turn to port.

(*c*) *Lateral wash*. When propeller slip is abnormally high, as in the case of a ship turning at rest, the slipstream becomes confused and a certain amount of water is thrown to each side. This is known as Lateral Wash. The wash from the lower blades normally passes clear under the ship's bottom, but that from the upper blades is thrown either against the hull or away from it, according to the direction of rotation of the propellers. In the figure, water is being thrown against the hull by the upper blades of the port propeller, and away from it by the upper blades of the starboard. This produces a further ' pressure and suction ' effect, which again assists the turn to port.

> *Note*.—The magnitude of the pressure and suction effects described in (*b*) and (*c*) depends on the form of the ship in the vicinity of the propellers, so that in the case of a destroyer hull (*Fig. 2*) the effects are less.

(*d*) *Thrust*. The astern revolutions of the port propeller exert a pull aft on the port thrust blocks, whilst the starboard propeller pushes forward. The effect is not great compared with the forces already described, owing to the small couple available in comparison with the length of the ship.

If a turn to starboard is considered, the port engine being put ahead and the starboard astern, it will be seen that these four reactions will again act in conjunction to assist the turn.

In-turning propellers

It is of interest to note that had the propellers been in-turning, both the screw and lateral wash effects would act in opposition to the other forces, so that the ship would probably handle sluggishly without headway. For this reason, although a slightly better ahead performance may be obtained from in-turning screws, these are not fitted in H.M. Ships.

The triple-screw ship

In the case of triple-screw ships which are usually fitted with centre-line rudders turning at rest, the principal effect of the centre propeller is the action of the slipstream which its ahead revolutions will throw against the rudder, though it will be noted that the screw effect of ahead revolutions will hinder a turn to port.

Thus in a triple-screw ship turning at rest to port, ahead revolutions on the centre propeller should be used sparingly, while fairly frequent reversal of this propeller to check headway will assist the turn by screw effect.

Conversely, when turning at rest to starboard, the centre propeller should not be reversed owing to the resultant opposition of the screw effect. Headway should as far as possible be checked by increased astern revolutions on the starboard engine.

Value of propeller reactions

As previously mentioned, the value of the various propeller reactions when turning at rest is dependent on the size of the propeller, and the power of the engine turning it. Screw effect and lateral wash are most marked in the case of large, slow-turning propellers, and are almost entirely absent in small, high-speed propellers. Pressure and suction effect and thrust are dependent on the volume and speed of the water in the slipstream, and hence on engine power.

Response to engine orders

The rapidity with which a ship responds to engine orders is also dependent on the type of machinery fitted. A propeller driven by a reciprocating engine, whether steam or internal combustion, is quickly stopped and reversed at moderate ship speeds and develops full torque in either direction in a matter of seconds; whereas a turbine engine installation compares most unfavourably in both these respects. Moreover, with the turbine engine, astern power comparable to the available ahead power is never obtainable, owing to the limited amount of astern blading which can be fitted without overall loss of efficiency.

Effect of shallow water. Wall effect

Modification of the normal propeller reactions owing to the restriction in flow caused by shallow water or the close proximity of a solid wall is discussed in *Chapters IV* and *V*.

Some unorthodox propeller designs

This brief discussion of screw propeller action would be incomplete without reference to some of the more unusual propeller forms.

The Jet Propeller

The first application of mechanical power to ships consisted of an installation by means of which water was drawn by a steam-driven pump through openings in the bows, and ejected through nozzles in the stern. This system proved far less efficient than the paddle wheel and the screw propeller, and is now only used in certain specialised craft where efficiency of propulsion is of secondary importance compared to other requirements.

The Paddle Wheel

This term is applied to a form of propeller which rotates about a horizontal transverse axis above the vessel's waterline, and consists of a wheel having paddles or ' floats ' attached to its periphery. The paddles may be fixed or ' feathering ', the latter giving better performance but involving high initial costs and maintenance.

The paddle wheel held undisputed sway during the first half of the last century, but was superseded for ocean work by the more convenient screw propeller.

Paddle tugs are still maintained in many dockyard ports (*Chapter IV*). These are invariably ' side wheelers ', and are fitted with feathering floats.

Vertical Axis Propellers

These are virtually feathering paddle wheels set in the bottom of a vessel on a vertical axis. The degree of feathering can be controlled so that the resultant of the blade forces acts in any desired direction, with the result that the vessel can be both propelled and steered. Though the efficiency is less than that of comparable paddle or screw installations, this arrangement gives remarkable steering control at slow speed, and is thus eminently suitable for craft operating in crowded and restricted waterways. The design in most common use is the Voith-Schneider or Kirsten Boeing.

Controllable Pitch Propellers

These are propellers in which the pitch can be altered so that the full power of the machinery can be developed at optimum efficiency and under all conditions of service, e.g. in bad weather with a foul bottom, or when towing. The pitch can also be reversed to enable the ship to go astern without reversing the direction of rotation of the main engines. Such a feature gives unequalled rapidity of manoeuvre and is of advantage in providing a convenient means of reversing internal combustion, including gas-turbine machinery. It is also of advantage in making possible very low controlled speeds, which are not otherwise conveniently obtainable with powerful internal combustion machinery. Due to the shape to which the blades must conform near the boss and to the larger size of the boss itself, there is a small loss of efficiency compared with fixed pitch propellers when working at high speeds.

The fitting of such propellers is at present restricted to tugs, minesweepers and certain specialised types of ship.

GAINING AND LOSING SPEED

A knowledge of the rate at which a ship may be expected to gain and lose speed is obviously of great importance when manoeuvring. While a rough estimate can be made from her tonnage and engine power, and while the feel of a ship can quickly be sensed with a little experience in handling her, it is important in fleet work that more precise data should be available.

Factors affecting gain and loss of speed

The following factors are relevant when considering the acceleration powers of a ship:—

(*a*) *Inertia* (including the mass of water dragged along by the ship). A heavy ship will evidently be slower both to gain and lose speed than a ship of smaller displacement and comparable engine power.

(*b*) *Shape of Hull.* Of two ships of similar displacement, the one with finer lines will accelerate more rapidly and carry her way further than the one of fuller form.

(*c*) *Power and Type of Engines.* A ship fitted with reciprocating engines will respond more rapidly to engine orders than a turbine-engined ship. This is perhaps particularly noticeable in the time taken to run down the turbines from a high ahead speed, even with maximum astern steam applied.

Certain diesel-engined ships, fitted with reverse reduction gearing and non-reversing engines, have no positive means of stopping the engines turning. In consequence, when the order stop is given the shaft will continue to trail although the gearbox is in 'neutral', and the braking effect of the propeller will be largely lost.

(*d*) *Design of Propellers.* The effect of propeller size and design on acceleration must be considered in conjunction with the type of machinery. A given shaft horsepower can be attained most rapidly with a reciprocating engine driving a large slow-turning propeller of coarse pitch. Similarly when losing speed the large propeller acts as a considerable drag when slowed or stopped, and the effect of astern revolutions is immediately felt.

(*e*) *State of Ship's Bottom.* The drag of a foul bottom will evidently have more effect during a reduction of speed than when accelerating from rest.

Starting and stopping trials

These are normally carried out in conjunction with Turning Trials.

The information required for Fleet Work purposes includes:—

GAINING SPEED

The time taken and distance required to reach a certain speed when

(*a*) Proceeding ahead from rest.

(*b*) Increasing speed when under way.

(*c*) Regaining the original speed after a turn.

LOSING SPEED

Similar data for

(*d*) Reduction of revolutions when steaming ahead.

(*e*) Stopping engines when steaming ahead.

(*f*) Reversing the engines when steaming ahead.

The following extracts from results of trials are of interest:—

(*a*) Assuming that full power is available, it will take approximately 8 minutes to accelerate a battleship from rest to 12 knots, 5 minutes for a heavy cruiser, 2 minutes for a destroyer, and 3½ minutes for a twin-screw frigate fitted with reciprocating engines.

(*b*) It will take about 30 seconds to bring to rest one or more turbines in a battleship or cruiser steaming ahead at 12 knots, and about 20 seconds in a destroyer; whereas in the twin-screw reciprocating frigate the time required to bring the engines to rest is only 15 seconds.

(*c*) The total time required to bring these ships to rest from 12 knots, using full astern revolutions, will be about 4½, 3, 1 and 1½ minutes respectively.

Factors affecting speed

FOUL BOTTOM

The growth of weed and shell on the ship's bottom, rudder, and propellers, has a most marked effect on her speed and fuel consumption. The power required to overcome skin frictional resistance does not however increase so rapidly with speed as is the case with wave-making resistance, so that the loss of speed due to fouling may with fair accuracy be represented as a percentage of the clean bottom speed at a given number of revolutions.

The effect is approximately the same for all classes of ship, e.g. with a considerable growth corresponding to 6 months out of dock in average tropical waters, a reduction in the region of 10% may be expected. Under these conditions a 30 knot battleship might thus have her maximum speed reduced to about 27 knots, while normal revolutions for 15 knots would give only 13½ knots through the water. The new bottom compositions in current use may considerably improve these figures.

High speed steaming and visits to fresh water rivers will reduce the weed, while with a very foul bottom considerable improvement can be effected by listing the ship and scraping both weed and shell, the greater part of the growth being near the waterline.

Frequent observations and knowledge of local conditions are the only means of determining with any accuracy the allowance to be made for foul bottom. In most tropical and subtropical harbours, growth is very much more rapid than in temperate waters, but conditions also vary considerably between ports in the same area.

PARAVANES, ASDICS, ETC., have an appreciable effect on the ship's speed which must be determined by trial.

SHALLOW WATER

The passage of a ship through shallow water usually results in a reduction of speed for the same revolutions, and the higher the speed, up to a point, the more noticeable is the effect.

The principal reason for this reduction of speed is the change in the streamline flow around the ship owing to the restriction in the water gap between the ship's bottom and the sea bed. This restriction results in an increase in the volume of entrained water and an intensification of the transverse wave formation, both of which phenomena cause increased resistance to the ship's progress.

A further reason for the reduction of speed in shallow water is the loss of propulsive efficiency through increased propeller slip and the change in the flow of water past the stern.

The presence of shallow water may be detected from the increased size of the stern wave. As the transverse wave trough which normally occurs near the quarters becomes deeper, causing increased trim by the stern, the associated crest astern of the ship becomes higher, and in extreme cases this may result in the flooding of the quarter deck of a low freeboard ship at high speed.

In certain high speed moderate draught ships such as destroyers there may however be an appreciable reduction in resistance beyond a certain critical speed in shallow water. The phenomenon is extremely complex, and the behaviour of different designs of ship at varying depths and speeds can at present only be determined by experiment.

Increase in draught at high speed

In addition to increased trim by the stern in shallow water, the bodily sinkage normal to a ship in motion is aggravated, particularly at high speed.

Typical figures for this sinkage derived from the results of model experiments, are as follows:—

SPEED	TYPE	DEEP WATER		12 FATHOMS	
		INCREASE IN DRAUGHT		INCREASE IN DRAUGHT	
		Forward Inches	Aft Inches	Forward Inches	Aft Inches
15 knots	Aircraft Carrier	7	4	8½	8½
	Cruiser	3	2	9	4
	Destroyer	4	1	7	½
25 knots	Aircraft Carrier	20	11	— 31½	161
	Cruiser	13	8	10½	62
	Destroyer	1	22½	— 16	60

Thus, while an aircraft carrier drawing say 33 feet aft, may have 39 feet under her keel when at rest in 12 fathoms, when crossing the same depth at 25 knots this clearance would be reduced to about 25 feet 6 inches. In shallower water the effect will be more pronounced and correspondingly more dangerous.

COMMUNICATION BETWEEN BRIDGE AND ENGINE ROOM

It is important that bridge and engine-room personnel should be fully conversant with the methods of communication between bridge and engine room in their ship, and with the standardised wording of verbal orders.

Engine and revolution telegraphs

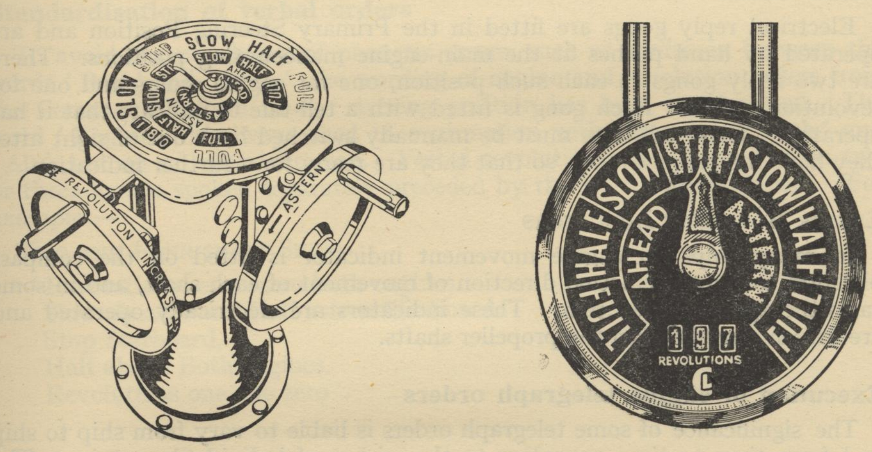
The main-engine orders in H.M. Ships are passed as follows:—

(*a*) From the Compass Platform, or other conning position, to the Primary Steering Position by voice, either by voice-pipe or by electric voice transmission system (' conning intercom ').

(*b*) From the Primary Steering Position to the engine room(s) by mechanical telegraph.

The mechanical telegraph is usually of the shafting type, but chain transmission is fitted in some frigates and in Fleet Auxiliaries, and in tugs. Special lightweight transmission is fitted in light craft. Although mechanical telegraphs have some disadvantages, experience has shown them to be more reliable than electric telegraphs.

The pedestals containing the telegraph operating handles are known as telegraph transmitters. The order instruments in the engine rooms are known as telegraph receivers. In some designs the operating handles and transmission gears for both engine and revolution orders are housed in one pedestal. (*Fig. 4.*) Similarly some receivers indicate both engine orders and revolution orders.



(*a*) Transmitter. (*b*) Receiver.

FIG. 4.—Combined engine order and revolution order telegraph.

The telegraphs are arranged as follows:—

(*a*) *Single-shaft Ships.* One engine order system and one revolution order system are fitted.

(*b*) *Two-shaft Ships.* Two engine order systems, one for each shaft, and one revolution order system, are normally fitted. The latter serves both shafts and operates two receivers, one in each engine room in ships so arranged.

(*c*) *Three-shaft Ships.* Separate engine order systems and revolution order systems are fitted for each shaft.

(*d*) *Four-shaft Ships.* Two sets, each comprising one engine order system and one revolution order system, are fitted. One of these sets serves the port shafts and the other the starboard shafts. Each system has one transmitter and two receivers, the latter being fitted one at each main-engine manoeuvring position on the side concerned.

In some ships a separate and additional set of telegraphs is fitted to transmit engine orders from the Emergency Conning Position.

Operation of Telegraphs

Nearly all telegraph transmitters require one turn of the operating handle for each order. The handle should be turned smartly and not slowly, and should be brought to the top centre position each time. If this is not done the order may not be correctly transmitted. Care must be taken not to turn the telegraphs abruptly on to their limit stops.

Telegraph Repeats

Repeat indicators of the engine and revolution orders are fitted in various positions such as the Compass Platform, Damage Control Headquarters, and Boiler Rooms, depending on the size and class of ship. The transmission for these repeats may be mechanical or electrical.

Reply Gongs

Electrical reply gongs are fitted in the Primary Steering Position and are operated by hand pushes at the main-engine manoeuvring positions. There are two reply gongs to each such position, one for engine orders and one for revolution orders. Each gong is fitted with a tell-tale to indicate that it has operated. These tell-tales must be manually switched back out of sight after they have indicated a reply, so that they are ready for a further indication.

Engine Movement Indicators

In many ships an engine movement indicator is fitted on the compass platform to show the actual direction of movement of each shaft, and in some cases the approximate r.p.m. These indicators are electrically operated and are driven directly from the propeller shafts.

Execution of engine telegraph orders

The significance of some telegraph orders is liable to vary from ship to ship and from time to time according to the wishes of individual captains. The most usual system is as follows:—

SLOW AHEAD A predetermined number of revolutions just sufficient to give steerage way ahead.

SLOW ASTERN A predetermined number of revolutions just sufficient to give adequate control when manoeuvring.

HALF AHEAD The revolutions ordered by the revolution telegraph as required for all speeds above Slow and up to Full Power.

HALF ASTERN (*a*) *Two-shaft Ships fitted with one revolution order system.* A predetermined number of revolutions, thus leaving the single revolution telegraph available for half ahead revolutions on one shaft. The number of revolutions chosen for half astern in this case should be that quickly attainable without undue forcing of boilers and engines.

(*b*) *Other Ships.* The revolutions ordered by the revolution telegraph for the shaft or shafts concerned.

FULL AHEAD AND FULL ASTERN, Emergency Orders, used only as such, and calling for the maximum revolutions it is possible to develop in the shortest possible time, risk of damage to machinery being accepted to ensure the safety of the ship.

The frequently adopted use of ‘ double ringing ’ to indicate emergency full ahead and astern is not recommended. This procedure takes some seconds with Naval telegraphs, it can cause confusion, and it is very liable to delay the required operation of the engines.

An exception to the use of ‘ Full ’ as a specific emergency order occurs in special vessels such as tugs where it is regularly used to provide maximum kick against the rudder when turning short.

Revolution Orders

Alterations of revolution orders are only complied with when the appropriate engine telegraph is at ‘ Half ’. There is however no objection to using a revolution order telegraph to warn the engine room what revolutions it is intended to use when the appropriate engine order telegraph is next put to ‘ Half ’. This practice can be helpful and is recommended.

Standardisation of verbal orders

To avoid the possibility of phonetic errors, such as confusion between the words ‘ Port ’ and ‘ Both ’, the wording of engine and revolution orders from the Compass Platform to the steering position has been standardised. The word ‘ Engines ’ is always used in conjunction with the words ‘ Both ’ and ‘ All ’, but on no other occasion. Verbal revolution orders are given as two or three figures spoken separately preceded by the word ‘ Revolutions ’. For example:—

Two and Four-shaft Ships

‘ Revolutions seven zero both engines.
Slow ahead Port, Half astern Starboard.
Stop Starboard.
Half ahead Both engines.
Revolutions one one zero ’.

Three-shaft Ships

‘ Revolutions seven zero All engines.
Slow ahead Port and Centre, Half astern Starboard.
Stop Starboard.
Half ahead All engines.
Revolutions one one zero ’.

Operation of Reply Gongs

Each change of engine orders is acknowledged by the engine room by means of the engine order reply gong(s), using the following code:—

Slow	...	One ring.
Half	...	Two rings.
Full	...	Three rings.
Stop	...	Two double rings.

Similarly each change of revolution orders is acknowledged by a single ring on the appropriate revolution reply gong(s). These rings indicate that the order has been received and will be complied with. Movements of a revolution order telegraph are complied with only when the appropriate engine order telegraph is at *Half*, and no reply will therefore be given by the engine room if a revolution order telegraph is altered at any other time. The revolutions so ordered will however be complied with when the appropriate engine order telegraph is next put to *Half*.

If an engine or revolution order cannot be obeyed, or if a defect requires an engine to be slowed down or stopped, this will be indicated by the engine room by a series of rapid rings on the appropriate reply gong. Such a signal must be reported by the steering position to the Compass Platform without delay. Such an occurrence will also be separately reported by telephone from the engine room to the Compass Platform, but this report might be delayed by a communication difficulty. The report by gong from engine room to Primary Steering Position and thence by voice to the Compass Platform is therefore of great importance.

Delays in response to engine orders

There is an unavoidable interval between an engine order being given on the Compass Platform and the engines attaining the required speed and direction of rotation. This occurs even when manoeuvring at comparatively slow speeds. The interval is made up as follows:—

(*a*) The time taken to transmit the order, approximately two or three seconds.

(*b*) The time taken to operate the main-engine throttle valves. This will vary from one second, for a simple increase or decrease of speed, to three seconds, to shut one throttle and to open the other to change the direction of rotation.

(*c*) The time taken to decelerate and/or to accelerate the main engines. This may vary from about five seconds for a simple comparatively small speed change, to thirty or more seconds for a change from half ahead to half astern.

Thus it will be seen that when an engine order is given on the Compass Platform, the full effect does not take place until ten seconds to half a minute or more later. It follows that engine orders given in rapid succession at intervals of half a minute or less will have little effect on the ship. Such a proceeding can however cause confusion and errors in the steering position, due to constant ringing of reply gongs, and in the engine rooms. The start of useful performance of an order is shown by the engine direction indicator or by the wash from the screw, and a close watch on these indications may save many unnecessary and useless orders.

Testing of Telegraphs

The engine telegraphs and associated equipment must be adequately and carefully tested in harbour and at sea. The specified occasions for test are:—

(*a*) Before proceeding to sea.
(*b*) Daily, when at sea, by arrangement with the O.O.W.
(*c*) Once a week in harbour.

The Engineer Officer or his representative tests the actual engine and revolution telegraphs, while the electrical repeats and reply gongs are the responsibility of the Electrical Officer.

'Obey Telegraphs'

The order 'Obey telegraphs' must be given in time for it to be passed from the Control Engine Room to other engine rooms before engine movements are required. Telegraph orders are not obeyed until this order is received. It is recommended that it should be passed personally by the Officer-of-the-Watch by telephone to the Engineer Officer.

Co-operation between bridge and engine room

It is important that the engine room should be given timely warning of future requirements such as large increases of speed. If this is not done it may not be possible to meet the requirement at once without risk of damage to machinery.

The Engineer Officer should be personally informed immediately any order affecting the speed for which steam is to be maintained is received. Similarly the engine room should be informed as soon as it is possible to shut down any extra boilers which may have been required for leaving harbour, manoeuvring, etc. This has an important effect on fuel economy.

The order 'Finished with main engines. Revert to ...... hours notice for steam' should be given as soon as the ship is satisfactorily secured or is riding to her anchor in her correct berth. It is recommended that this order should also be passed personally by the Officer-of-the-Watch.

Training of Personnel

All ratings employed as telegraphmen should be thoroughly trained in their duties. An ignorant or careless hand at the telegraphs endangers not only his own ship, but others in company. Quartermasters and telegraphmen should be fully conversant with the following points:—

(*a*) The standard wording of engine and revolution orders.

(*b*) The correct manipulation of telegraphs.

(*c*) The reply gong routine and the method of re-setting tell-tales.

(*d*) The action to be taken to report the emergency ringing of reply gongs.

(*e*) Their responsibility for checking that the reply gongs have indicated correct receipt of each order, and for querying by telephone any doubtful reply.

(*f*) Their responsibility for reporting immediately to the Compass Platform any apparent defect or unusual stiffness in a telegraph.

Bridge Control

Certain coastal craft, including minesweepers and fast patrol boats, are fitted with Bridge control of engine speed and direction as an alternative to Engine Room control. Such controls should only be operated by trained personnel. Violent or unduly rapid movement, particularly of reversing controls, may cause excessive wear, and possibly extensive damage if frequently operated. It is important that all concerned should be conversant with the procedure whereby the control of the engines is changed from Bridge to Engine Room and vice versa.

The Control Engine Room

In all ships with more than one engine room, one is specifically used as the Control Engine Room unless a separate Machinery Control Room is fitted. The Engineer Officer or the Engineer O.O.W. is stationed in this Control Engine

Room, to which all messages from the Compass Platform should be passed. On some occasions four-shaft ships steam on two shafts in order to conserve fuel. Under such circumstances the usual Control Engine Room may not be in use, and it is important that all concerned on the Compass Platform and in the steering position are aware which engine room has taken over control.

TELEPHONES

In nearly all H.M. Ships, telephonic communication is fitted directly from the Compass Platform, the Primary Steering Position, and the alternative conning positions, to all engine rooms. In addition there is usually a separate direct line from the Compass Platform to the usual engine control position. All these lines of communication are fitted with sound-powered telephones and manual call-ups, so that they are independent of outside power supply. In addition, communication with the engine rooms can be made through the Main Exchange and the DCHQ Exchange.

CHAPTER II

STEERING ARRANGEMENTS

Rudders

The simplest and cheapest form of rudder is the conventional 'unbalanced' design, hung from a vertical sternpost and pivoted about its leading edge (*Fig. 5a*). This form of rudder is generally fitted in low-powered merchant ships, though unbalanced rudders will also be found in some of the fastest ocean liners.

To obtain the necessary powers of manoeuvre in a warship, the requirement is for a proportionately larger rudder, which must be capable of rapid operation without a corresponding increase in the power required to turn it. All modern warships are therefore fitted with a form of 'balanced' rudder. This may have its weight taken entirely inboard at the rudder head (*Fig. 5b*), or some of its weight taken outboard by an extension to the keel carrying a steadying pintle (*Fig. 5c*). The latter design is losing favour owing to the heavy strains imposed on the lower bearing at high speed, and owing to the interruption caused by it to the smooth flow of water on to the rudder.

The balanced rudder normally has between 25 per cent. and 30 per cent. of its area before the line of its axis. This 'balancing' materially reduces the power required to move the rudder when the ship is proceeding ahead.

Although more power is required to move the unbalanced rudder at a given speed of ship, it is generally the more efficient of the two types in the early stages of a turn. Being pivoted about its leading edge, the action of putting the rudder over builds up water pressure against the deadwood before the rudder, and considerably increases the initial ship turning-moment.

Once the ship is swinging, however, the action of deadwood is to retard the sideways motion of the stern through the water, with a resultant increase in the turning path.

Conversely, although the cutting away of the stern profile before a balanced rudder has the effect of reducing the tactical diameter, it may result in unsteady steering. An appropriate balance must therefore be maintained particularly for certain special types, such as minesweepers, in which good course-keeping must be combined with reasonably quick turning.

The importance of having both rudder and steering gear well below the waterline for protection is another consideration affecting the design of rudders for warships.

Positioning of rudder with relation to propellers

H.M. Ships are, in general, fitted with single or twin partially-balanced rudders, though high speed craft and certain shallow-draught vessels may carry triple or quadruple rudders.

The positioning of the rudders with relation to the propeller slipstreams is of primary importance when considering the handling qualities of a ship. A rudder directly in the way of the propeller is affected not only by the flow of water caused by the ship's forward speed, but also by the slipstream, which is travelling appreciably faster relative to the rudder than the water in the wake. This slipstream, or propeller-race effect, is particularly advantageous when manoeuvring with little headway.

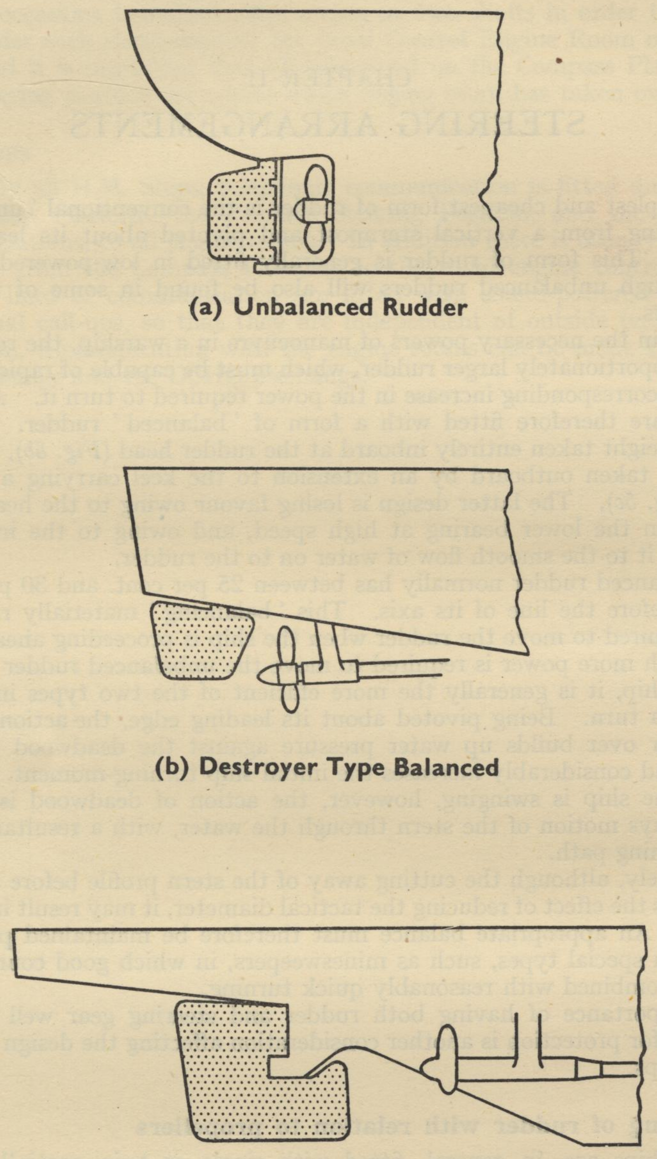


FIG. 5.—Types of rudder.

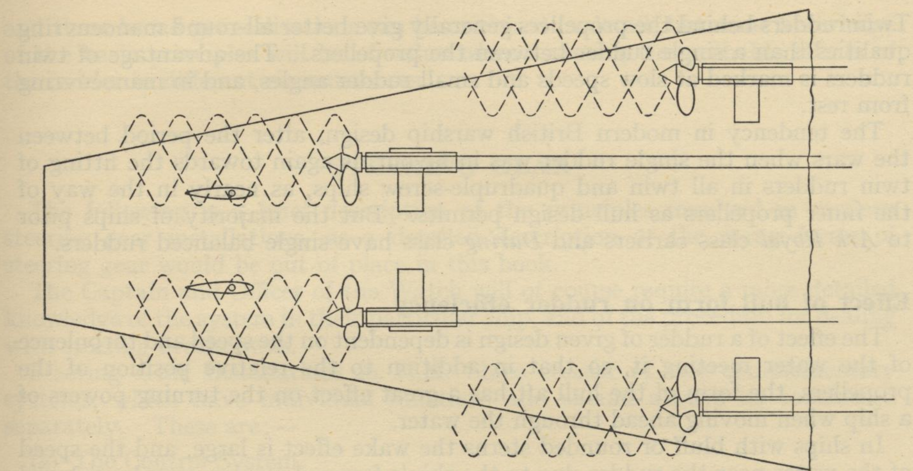


FIG. 6.—Quadruple screw ship with twin rudders in slipstream of inner propellers.

Figs. 6 and 7 show diagrammatically that the slipstream from a propeller turning with normal slip travels away from it in a well defined column of water of approximately the same diameter as the propeller. In the case of a twin or quadruple-screw ship, therefore, the single rudder, unless of a very broad and shallow design, will not enter the slipstream proper until at an appreciable angle. This is a disadvantage in the initial stages of a turn, especially when the ship has little or no headway through the water, though in this case an increase of propeller revolutions above those normal to the speed of the ship will alter the behaviour of the slipstream so that a part of it may directly affect the rudder (*Chapter I*).

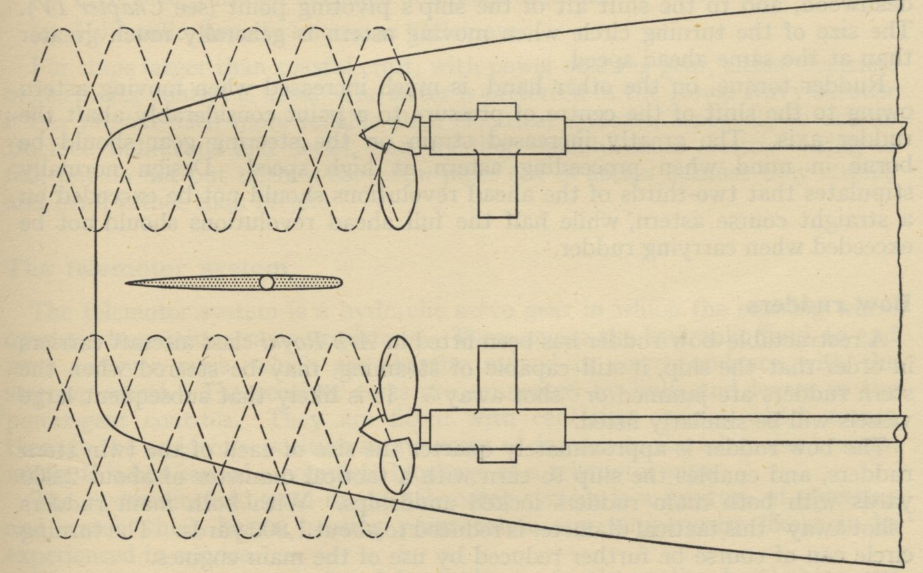


Fig. 7.—Single-ruddered twin-screw ship rudder does not enter slipstream until at appreciable angle.

Twin rudders behind the propellers generally give better all-round manoeuvring qualities than a single rudder between the propellers. The advantage of twin rudders is marked at slow speeds and small rudder angles, and in manoeuvring from rest.

The tendency in modern British warship design, after the period between the wars when the single rudder was in favour, is again towards the fitting of twin rudders in all twin and quadruple-screw ships, as nearly in the way of the inner propellers as hull design permits. But the majority of ships prior to *Ark Royal* class carriers and *Daring* class have single balanced rudders.

Effect of hull form on rudder efficiency

The effect of a rudder of given design is dependent on the speed and turbulence of the water meeting it, so that in addition to the relative position of the propellers, the form of the hull aft has a great effect on the turning powers of a ship when moving ahead through the water.

In ships with bluff or rounded sterns the wake effect is large, and the speed of the water near the rudder due to the ship's forward motion may be reduced by as much as 35 per cent. The resultant eddying may cause a part of the rudder to be in dead water, or even in disturbed water following the ship. This effect will be accentuated if the engine is stopped and the propeller dragged through the water immediately ahead of the rudder.

Conversely, in a ship with a fine run, the reduced wake effect will result in greater rudder efficiency.

Effect of rudder on a ship with sternway

Although the pressure on the rudder when the ship is moving astern may be nearly as great as when moving ahead at a similar speed (the loss of propeller-race effect being partially offset by absence of wake), the ship turning-moment is much reduced owing to absence of hull reaction due to deadwood, and to the shift aft of the ship's pivoting point (see *Chapter IV*). The size of the turning circle when moving astern is generally much greater than at the same ahead speed.

Rudder torque, on the other hand, is much increased when moving astern owing to the shift of the centre of pressure to a point considerably abaft the rudder axis. The greatly increased strain on the steering gear should be borne in mind when proceeding astern at high speed. Design normally stipulates that two-thirds of the ahead revolutions should not be exceeded on a straight course astern, while half the full ahead revolutions should not be exceeded when carrying rudder.

Bow rudders

A rectractable bow rudder has been fitted in *Ark Royal* class aircraft carriers in order that the ship, if still capable of steaming, may be steered when the stern rudders are jammed or 'shot away'. It is likely that subsequent large vessels will be similarly fitted.

The bow rudder is approximately quarter the size of each of the twin stern rudders, and enables the ship to turn with a tactical diameter of about 2,800 yards with both main rudders locked amidships. With both main rudders 'shot away' this tactical diameter is reduced to about 1,800 yards. The turning circle can of course be further reduced by use of the main engines.

The foregoing paragraphs show very briefly some of the factors which will affect the turning powers of various designs of ship. The subject is complex,

and these broad generalisations can be criticised in detail, but some knowledge of the basic principles will be of value when assessing the probable effects of the rudder in different circumstances.

STEERING GEAR

The following is a brief description of the principles involved in modern steering gear installations, as a detailed description of the many forms of steering gear would be out of place in this book.

The Captain and Officer of the Watch will of course require a more detailed knowledge of the system in their particular ship, and of the procedure for dealing with steering breakdowns.

Steering Gear Installations in H.M. Ships consist of two complementary systems, which have individual functions and should always be considered separately. These are:—

(*a*) The Control System.

(*b*) The Power System.

The power system is situated as close to the rudder as is practicable. The control system connects it to the Primary Steering Position, which is usually situated in a central, well protected, and quiet position as near to the bridge as is practicable.

POWER STEERING GEAR

The control system

The control system can be one of the following:—

(*a*) Mechanical, through chains or shafts and gears.

(*b*) Electrical, through magslips or similar systems.

(*c*) Hydraulic, usually known as 'telemotor'.

For ships larger than coastal craft, with power steering gear, either electrical or telemotor control is used. The latter is preferred in the Royal Navy because it has proved itself more reliable than electrical systems, especially in action. Buckled bulkheads and decks, and flooding, usually cause electric wiring to fail, but do not put telemotor system pipes out of action because they stretch and bend rather than break.

The telemotor system

The telemotor system is a hydraulic servo gear in which the steering wheel operates transmitter rams or pistons. These pump the hydraulic fluid to and from receiver rams, which are thereby moved in correspondence with the steering wheel. The receiver rams are connected by links and levers to the power-gear controls. They are fitted with centering springs which return them to the amidships position in the event of damage to the telemotor system, unless this has caused a complete blockage of a telemotor pipe.

The hydraulic fluid used in the telemotor system is a mixture of glycerine and water which has a freezing point below any temperature likely to be experienced in service.

The telemotor system is fitted in duplicate in the earlier battleships and carriers and in smaller ships, and in quadruplicate in *Vanguard, Ark Royal,* and *Hermes* class. The several transmitters are assembled into one unit operated by a single steering wheel (*Fig. 8*) except that where a bow rudder is fitted this has a separate transmitter unit and wheel. The pipe leads of the several transmitters are as widely separated as possible horizontally and vertically. The arrangement of the several receivers depends on the arrangement of the power gear.

All telemotor control systems are arranged so that the receivers can be disconnected from the control-gear links, so that the latter can then be operated by a hand-operated local control wheel.

A typical arrangement of a duplex telemotor system is shown diagrammatically in *Fig. 9* (*at end of text*).

The power system

The power system can be any one of the following:—

(*a*) Steam engine and gearing.
(*b*) Electric motor and gearing.
(*c*) Steam engine and hydraulic system.
(*d*) Electric motor and hydraulic system.
(*e*) Internal combustion engine and hydraulic system.

Of these power systems the internal combustion engine and hydraulic system is the one least likely to be affected by action damage which may cut steam and electric supplies, but the amount of maintenance required to keep this type of engine running continuously makes use of this system as the main one impracticable. It is used as the reserve system in large warships.

The steam engine and gearing and the electric motor and gearing systems tend to be heavy and subject to rapid wear and tear, either mechanical or electrical or both. In these power systems the engine or motor is started and stopped and reversed by the control system as necessary to give the required movement of the rudder.

The electric motor and hydraulic system is used generally in H.M. Ships up to and including cruiser size, although in some vessels with small electric generator capacity the steam engine and hydraulic system is used. A combination of steam turbines and electric motors with the hydraulic system is used in larger ships such as carriers and battleships. Reserve diesel engines may also be fitted.

When used in conjunction with the hydraulic system the steam engines, electric motors, and diesel engines are solely prime movers. When in use they run continuously at a steady speed in one direction, and drive oil pumps whose delivery can be varied and reversed as required by movement of their swash-plates or similar mechanisms.

The oil pumps move the oil to and from rams which operate the tiller and hence the rudder. The movement of the latter depends solely on the movement of the pump controls, and therefore on the working of the steering wheel which operates the pump controls via the control system.

A modified type of hydraulic power system has recently been introduced in which the oil pumps are solely sources of oil delivered at the required pressure in one direction and returned by pump suction in the other. In this system the movement of the oil to and from the rams, and hence the movement of the rudder, is controlled by a distributing valve which is operated by the control system. This involves provision of heavy and complicated means to unload the oil pumps when no oil flow is required for rudder movement, for if this were not done heavy wear of the pumps would result.

(*to face p.* 22)

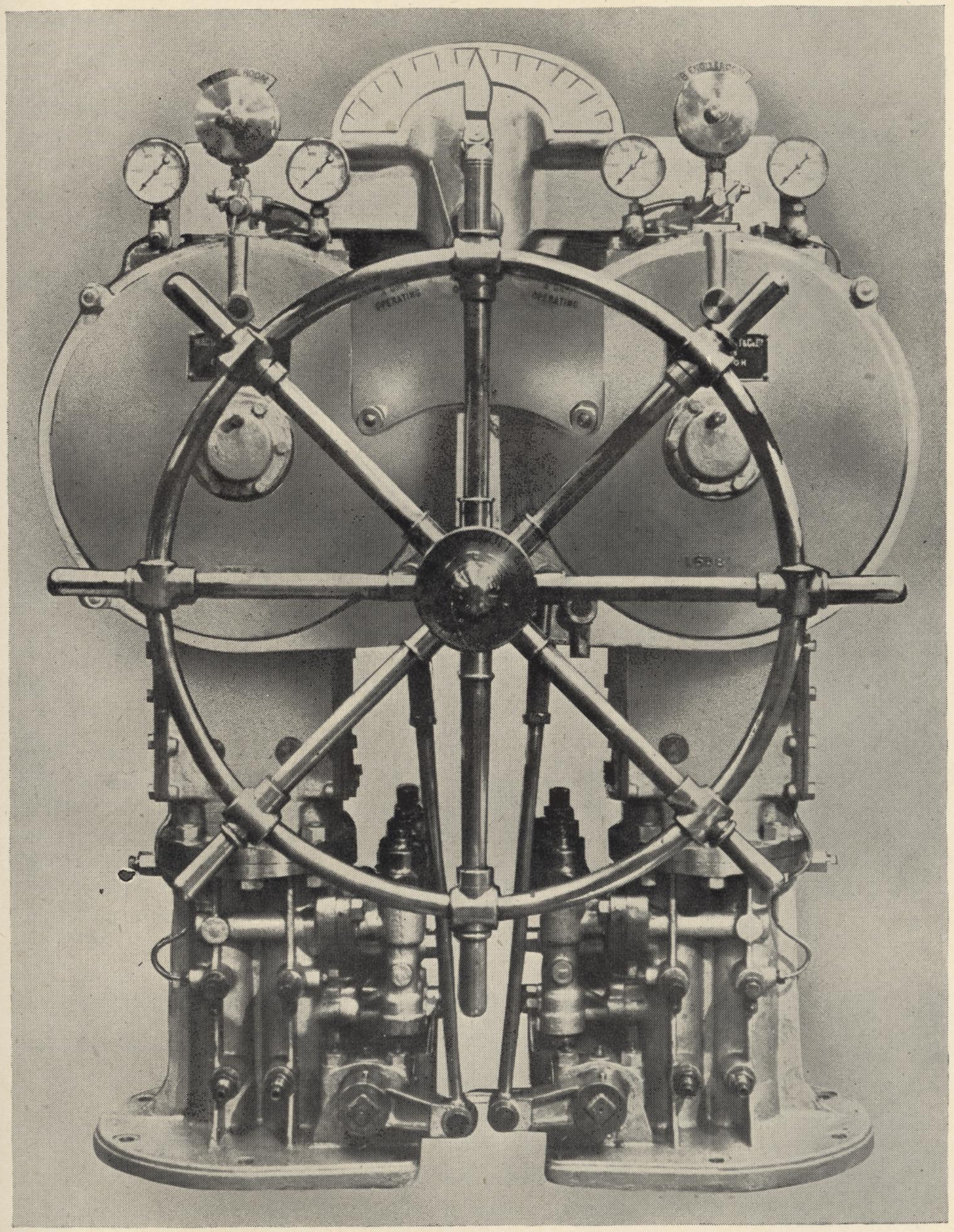


FIG. 8. Quadruplex steering wheel in *Eagle*

Local control of tiller gear

The majority of hydraulic power system oil pumps are arranged so that their swashplates can be disconnected from the control system and then operated independently by a hand wheel or lever. This permits direct hand-controlled operation of the tiller gear in the event of damage to the control system or link gear.

Hand operation of rudder

In the majority of H.M. Ships with hydraulic tiller gear a hand-operated hydraulic pump is fitted for centring or otherwise adjusting the rudder if all power pumps fail. This method of rudder movement is too slow for normal steering.

Alignment of wheel and rudder

There are two general systems of steering:—

(*a*) In which the wheel or hand lever is used merely to move the rudder, and is returned to a central or neutral position when the rudder has reached the required position. This system requires an accurate indicator at the steering position to show the position of the rudder.

(*b*) In which the wheel is used to position the rudder as well as to move it. In this system the wheel is turned to a position to correspond with the required rudder angle, and is held there as long as this rudder angle is required, the steering gear being designed to align the rudder in the same position as the wheel. Any rudder indicator fitted with this system merely shows that the gear is functioning correctly, and is not essential for its operation.

The second of these systems is preferred in H.M. Ships, in order to avoid dependence on a rudder indicator, the transmission system of which could be interfered with by action damage or power failure.

Hunting gear

In the steering gear fitted in H.M. Ships it is therefore essential that the rudder be moved by the control system and power system to a position exactly corresponding to that at which the steering wheel is placed. To ensure that the rudder moves to, and stops at, this position, a form of power cut-off operated by the movement of the rudder is employed. This is known as the "hunting gear".

THE STEERING GEAR OF VARIOUS CLASSES OF H.M. SHIPS

Ark Royal

(*a*) Twin stern rudders and a rectractable bow rudder.

(*b*) Quadruplex telemotor control system for stern rudders and separate simplex telemotor control system for bow rudder.

(*c*) Steam turbine and hydraulic *primary* power system for each stern rudder.

(*d*) Electric motor and hydraulic *secondary* power system for each stern rudder.

(*e*) Diesel engine and hydraulic *reserve* power system for each stern rudder.

(*f*) Electric motor and hydraulic system for bow rudder.

(*g*) The secondary power system comes into action automatically if the primary power system fails, and in addition can be brought into action from the Primary Steering Position as required.

(*h*) The reserve power system is brought into action separately when required.

(*j*) Hydraulic power to the stern tiller gears is controlled by distributing valves operated by the control system and the hunting gear.

(*k*) The usual hand-operated local controls are fitted.

Eagle

As *Ark Royal* except that the hydraulic power to the tiller gears is controlled by the operation of the hydraulic pump swashplates by the control gear and hunting gear.

Vanguard

(*a*) Single rudder.

(*b*) Quadruplex telemotor control of all power systems.

(*c*) Steam turbine and hydraulic *primary* power system.

(*d*) Electric motor and hydraulic *secondary* power system.

(*e*) The secondary power system comes into action automatically if the primary power system fails, and in addition can be brought into action from the Primary Steering Position as required.

(*f*) Hydraulic power to tiller gear is controlled by operation of the hydraulic pump swashplates.

King George V class battleships and earlier fleet carriers

(*a*) Single rudder.

(*b*) Duplex telemotor control of primary power system, and separate simplex telemotor control of secondary power system.

(*c*) Electric motor and hydraulic *primary* power system.

(*d*) Steam turbine and hydraulic *secondary* power system.

(*e*) A hand-operated hydraulic pump is fitted to move the tiller gear as required if all power fails. This method is too slow for normal steering.

(*f*) As *Vanguard*.

Hermes class light fleet carriers

(*a*) Twin rudders.

(*b*), (*c*), (*d*), (*e*) and (*f*) as *Vanguard*, with separate power systems for each rudder.

(*g*) Diesel engine and hydraulic reserve power system for each rudder, brought into action as required.

Colossus and *Majestic* class light fleet carriers

(*a*) Single rudder.

(*b*) Duplex telemotor control system.

(*c*) Electric motor and hydraulic power system in duplicate.

(*d*) Diesel engine and hydraulic reserve power system.

(*f*) As *Vanguard*, except *Bulwark* and *Centaur* in which the control is similar to *Ark Royal*.

Cruisers

(*a*), (*b*) and (*c*) as *Colossus*.

(*e*) and (*f*) as *King George V*.

Daring class

(*a*) Twin rudders.

(*b*) Duplex telemotor control system from Primary Steering Position and separate simplex telemotor control system from Emergency Conning and Steering Position.

(*c*) Otherwise as cruisers, except that all gear aft is situated in a single tiller flat.

Destroyers are similar, but with a single rudder.

New first rate frigates are similar to *Daring* Class, but without the Emergency Conning and Steering Position.

Other frigates are similar with a single rudder, though in early frigates the power is provided by a steam engine instead of by an electric motor.

Smaller vessels and submarines are not discussed in this book.

Conning and steering positions—nomenclature

Fig. 10 shows typical arrangements of conning and steering positions in H.M. Ships. The nomenclature has been standardised as follows:—

Bridge

The expression 'Bridge' (of which the Admiral's Bridge and Compass Platform are particular cases) refers to those positions in the upper portion of the bridge structure from which fleets, squadrons, groups of ships, or single ships are controlled and fought by the Admiral and/or Captain.

Bridges may be open or closed, according to current Admiralty policy for the type of ship concerned.

Admiral's Bridge

The compartment designed for the use of the Admiral in controlling the fleet at sea.

Compass Platform (C.P.)

The compartment in the fore part of the bridge structure designed as the ship's primary conning position.

Pilotage Positions

The open position on the top deck of the bridge structure (in ships fitted with a closed compass platform) provided to facilitate handling in confined waters, berthing, etc.

Conning Tower

An armoured conning position separate from the compass platform.

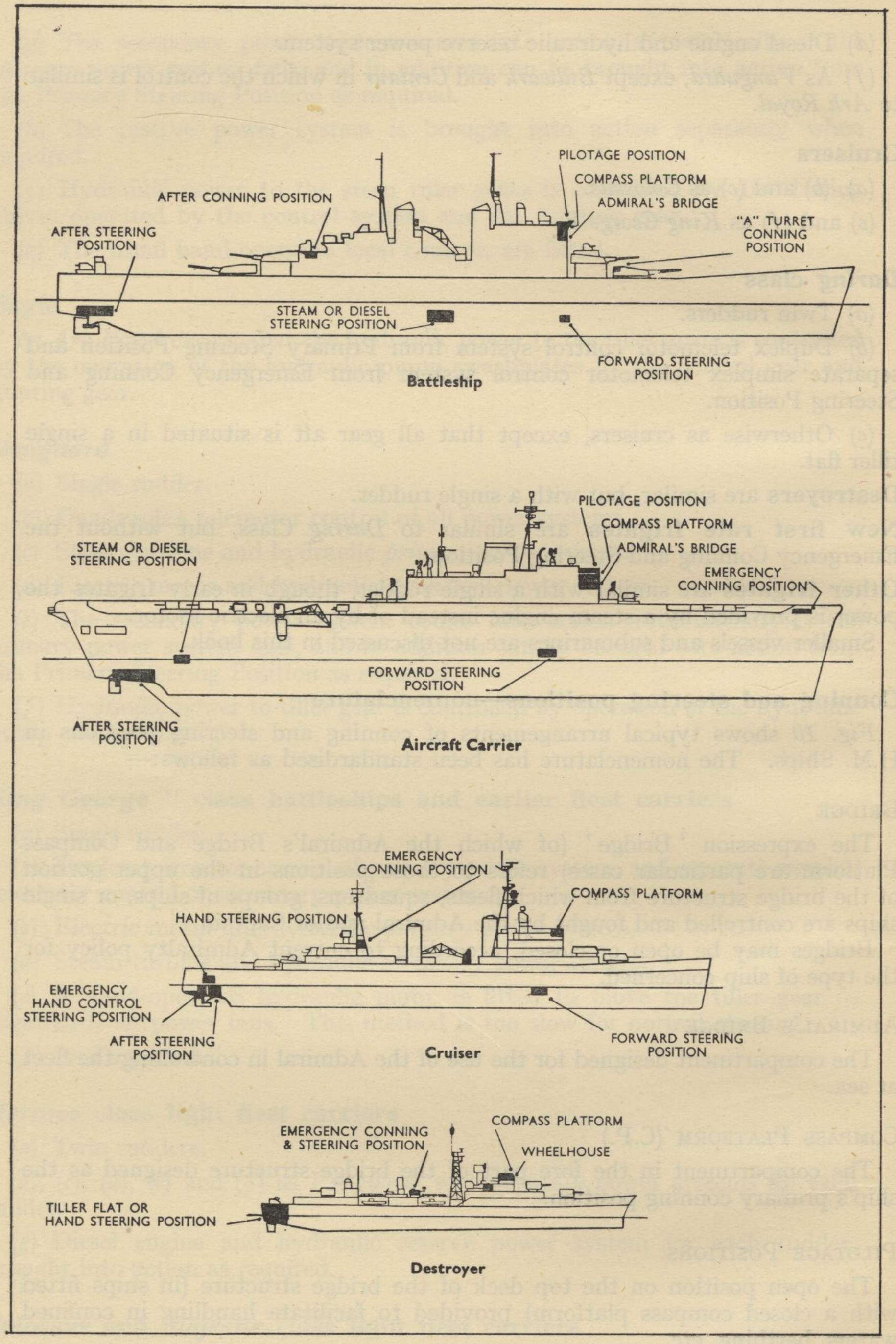


FIG. 10. Conning and steering positions—nomenclature

Alternative Conning Positions

In capital ships, several alternative conning positions may be provided. These are distinguished by their positions in the ship, e.g. 'A' turret conning position, after funnel conning position, etc. One of these will be the emergency conning position.

Emergency Conning Position (E.C.P.)

One such position is provided physically well separated from the compass platform. In larger ships it may be fitted with additional communications to enable the second-in-command to carry out his functions in action.

In battleships it is either the funnel conning position or a position in the after superstructure.

In carriers it is sided, port and starboard.

In cruisers it is in the after superstructure.

In destroyers it is either amidships or aft, and, if fitted with a steering wheel, is also called the Emergency Steering Position.

Forward Steering Position (F.S.P.)

The compartment designed as the primary steering position in cruisers and above.

Bow Rudder Steering Position

In certain large ships the position from which the bow rudder is controlled. This position may be sited in the forward steering position.

Wheelhouse

The primary steering position in destroyers and small craft.

Steam (or Diesel) Steering Position

Adjacent to the steam (or diesel) steering engine. If more than one such position is fitted, they are known by their relative positions, e.g. port or starboard.

After Steering Position

The mechanical wheel for local control of power steering is fitted in a steering compartment aft. If more than one such wheel is fitted, they are known by their relative positions, e.g. port or starboard.

Hand Steering Position

The position which contains the hand pump for operating the rudder gears by hand. It is usually referred to as the " tiller flat " in destroyers.

Emergency Hand Control Steering Position

The position at any of the power steering gear pumps where the latter are fitted with direct manual control for emergency use. Where more than one such position is fitted, they are distinguished by the ship's numbers or letters of the pumps concerned or of the machinery spaces in which the pumps are fitted.

Tiller Flat

This compartment in destroyers and below houses both the After Steering Position and the Hand Steering Position. The term is used in a collective location sense.

STEERING COMMUNICATIONS

Verbal steering orders

Communication between Compass Platform and Primary Steering Position is normally by Conning Intercom, and also by voicepipe. In addition, sound-powered telephones are fitted between all conning and steering positions, and between these positions and the Control Engine Room (or Machinery Control Room).

To facilitate the change-over of steering positions in large modern ships, a broadcast and talk back is also fitted between the Control Engine Room (or Machinery Control Room) and each secondary steering position.

Standardisation of verbal steering orders

It is most important that steering orders should be given and acknowledged in the standard form, as described in the Manual of Seamanship, Volume I. When ordering the course to be steered, the word ' zero ' replaces ' nought ', as with revolution orders.

Steering order instruments

These usually consist of electrically operated step by step indicators, and link the Compass Platform and Emergency Conning Position with all steering positions. The instruments are usually graduated in five-degree steps, a gong in the receiver sounding at each step.

Rudder indicators

These are usually electrically operated direct from the rudder head, the indicators being fitted at all conning and steering positions, the Machinery Control Room, and Damage Control Headquarters.

GENERAL NOTES ON OPERATION OF POWER STEERING GEAR

The wheel should be turned with a steady even motion. It should not be moved at too great a rate as this serves no useful purpose, puts unnecessary strain on the gear, and makes the wheel stiff to operate.

The pressure gauges fitted to the telemotor transmitter give a most useful indication of the correct working of the gear. Helmsmen should note the pressures shown by these gauges during normal operation, and should keep a regular watch on them so that defects are quickly recognised.

The rudder indicator should always correspond to the wheel indicator. If it does not, the watchkeeper in the After Steering Position should be asked by telephone for a check on the actual position of the rudder.

The effect of carrying rudder for long periods may cause wheel and rudder to get out of step. Correct alignment can be regained by putting the wheel amidships for a few seconds, in which position it operates the telemotor automatic by-pass, thus allowing the telemotor receivers to move to their central position and control the steering pumps so as to bring the rudder amidships.

STEERING GEAR DEFECTS

It is not intended to attempt a detailed analysis of the many possible varieties of steering gear defect and breakdown. The most likely sources of failure are as follows:—

Wheel jam

(*a*) This can happen with hand gears, and with chain or shafting control gears, due to some obstruction in the line of gears. In such a case it may take

some time to locate and clear the obstruction, and it will be necessary to change to a different steering position.

(*b*) It is most unusual for a wheel jam to occur with telemotor gear, but it can be caused by complete blockage of a telemotor pipe. This will be indicated by a high pressure on one transmitter gauge on the side of the damage. The hand by-pass valve on that pipe lead should be opened, after which it should be possible to continue steering with the remainder of the transmitter and the other pipe lead or leads.

(*c*) It is possible, though unlikely, for a telemotor transmitter to jam in its gears. This can be recognised by a solid mechanical jam, with no excess pressure showing on any transmitter gauge. It is unlikely that anything can be done quickly to correct such a defect, and it will be necessary to change to another steering position. Before leaving a jammed telemotor transmitter, all its hand by-pass valves should be opened to free the locked hydraulic fluid, otherwise delay may be caused in the change over.

Complete failure of telemotor system

This is very unlikely, but could be caused in action by damage which cuts or completely flattens all pairs of telemotor leads. It will be necessary to change over to another steering position.

Complete failure of steering pump power

This is indicated by failure of the rudder to follow the wheel when the telemotor transmitter is free, and its gauges show that the telemotor system is working correctly. It should also be indicated by the ringing of the steering pump alarm bells, unless power to them has also failed. It will be necessary to use emergency diesel or hand pump steering until power supplies are restored, or to steer by main engines.

Partial failure of steering power

In large modern ships with several sources of steering power, e.g. two turbine pumps and two motor pumps, special pressure gauges in the Primary Steering Position will indicate if the primary (turbine) pump in use fails for any reason. There should be no failure of steering, because the secondary (motor) pump on that system should take over supply of steering power automatically. Under such circumstances the correct action is to change over to the other system so that a primary (turbine) pump is once again in use, with a secondary (motor) pump in immediate reserve. This change over is effected by operation of a hand lever on the telemotor transmitter.

General

If the steering gear fails to operate correctly in any way, the quartermaster should at once inform the Compass Platform or other conning position in use. The Control Engine Room or Machinery Control Room should then be informed by telephone.

If the failure involves a change over of steering positions it will be necessary to steer the ship by main engines in the interval, using drastic reductions of speed on one side or the other to counteract any swing.

The Captain's Orders should contain detailed instructions for the procedure for changing over steering positions.

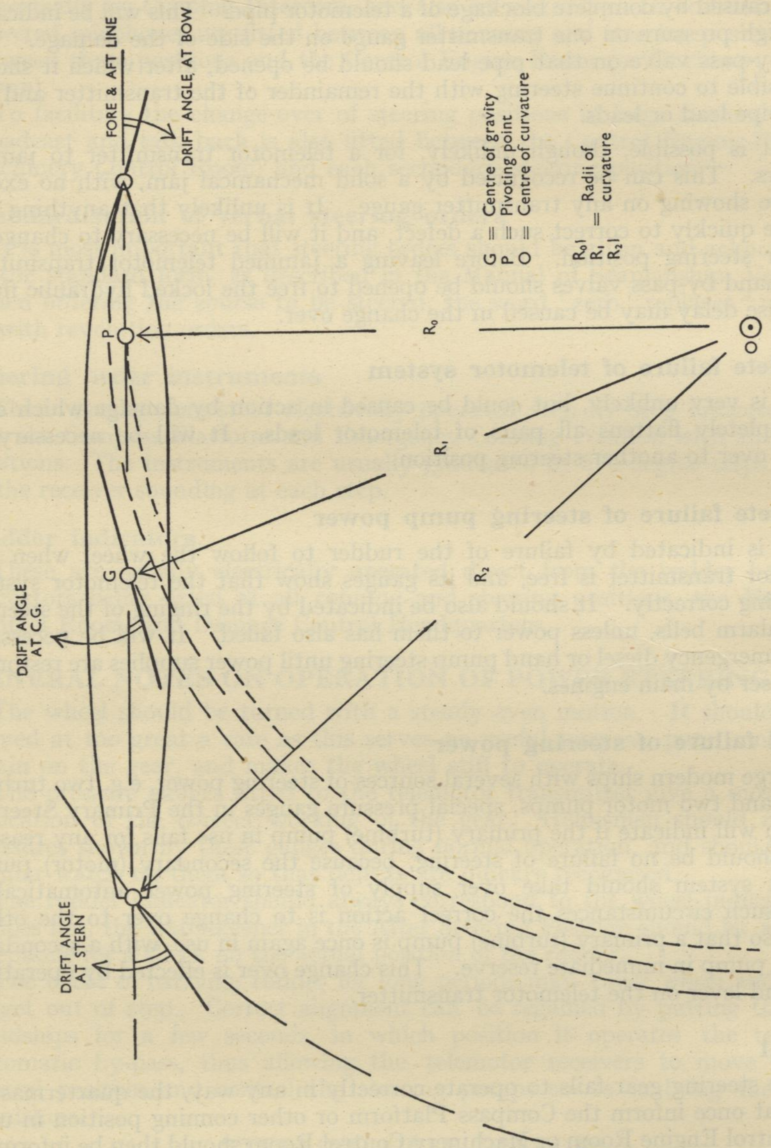


FIG. 11.—The path of a ship when turning.

CHAPTER III

THE BEHAVIOUR OF SHIPS WHEN TURNING

The path of a ship when turning

When the rudder of a ship is put over she will, after a certain time-lag, begin to leave her straight course and travel along a path which is at first one of increasing curvature. After turning through 90° the path will become approximately circular.

Definitions

DRIFT ANGLE

Fig. 11 is an exaggerated illustration of the paths described by various parts of a ship turning under rudder when steaming ahead.

It will be seen that each point in the ship follows a path approximately concentric with that described by the centre of gravity. The angle which the tangent to each curve makes with the fore-and-aft line is known as the Drift Angle at that point in the ship.

The drift angle has its highest value at the stern and it will be seen that this angle gradually diminishes to zero at a point where the fore-and-aft line becomes tangential to the path, finally becoming negative in value at the bow. The drift angle considered by ship designers is the drift angle at the centre of gravity.

The value of this drift angle is dependent on a number of factors such as the ship's underwater form and design of rudder, her displacement and speed, and the direction and force of the wind; but in any particular ship is principally dependent on the angle of rudder in use. The drift angle is not constant throughout a turn, increasing rapidly as angular momentum is developed, and only settling down to an approximately steady value of about 12° at the centre of gravity, when the ship has turned through about 90°.

PIVOTING POINT

For purposes of practical ship handling it is of more interest to know the position about which the ship is pivoting, in other words the point where the drift angle is zero. To an observer at this position the bow will appear to be swinging towards the centre of curvature, and the stern away from it.

The position of the Pivoting Point is dependent on the same factors as the value of the drift angle, but varies in any particular ship more with the speed than with the angle of rudder. The expression is therefore somewhat illusory. Even in a battleship it may oscillate between the bows and the centre of gravity as the variables on which its position depends alter during the course of a turn. For practical purposes an average position must be considered.

In ships of orthodox performance, such as battleships, aircraft carriers, and cruisers, the average position of the pivoting point is about one-third of the ship's length from the bows. In faster designs, such as destroyers, it will be farther forward, while in the extreme case of fast light craft, such as M.T.B., it may be ahead of the boat when turning at speed.

For recording purposes in seagoing trials the position of the compass platform is invariably plotted.

From *Fig. 12* it will be seen that the radius of curvature is smallest at the pivoting point and greatest at the stern, to an extent depending on the drift angle. This factor must be taken into account when plotting the path of a ship in restricted waters, e.g. when turning into harbour between two breakwaters.

Turning Circle

Fig. 12 illustrates the path of the compass platform of a typical ship turning through 360° when steaming ahead. This path is known as the Turning Circle of the ship at a certain speed and rudder angle.

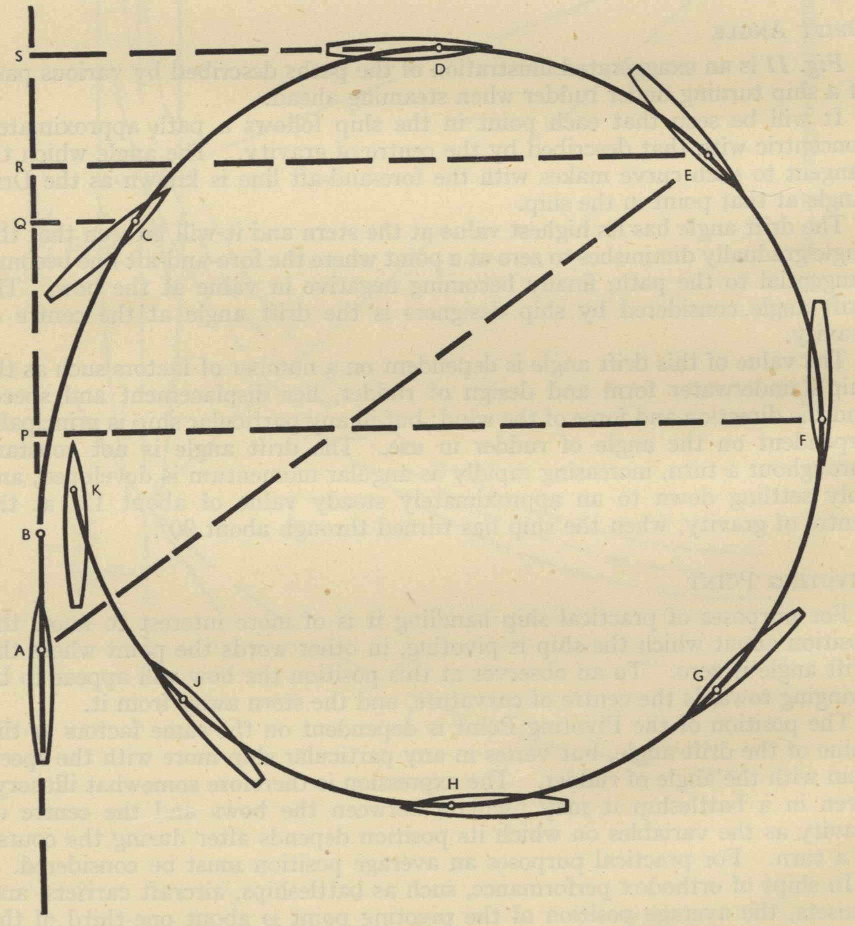


Fig. 12.—Turning Circle.

'A' is the position of the compass platform at the moment of starting to put the rudder over. 'B' the position at which the ship begins to turn. 'C', 'D', 'E', etc., the positions when the ship has turned through 45°, 90°, 135°, etc. The distance 'AB' is dependent on the speed of the ship and the rate at which the rudder is applied, and various other factors as explained in *Chapter II*. At 'K', on completion of a 360° turn, most ships will be slightly inside their original track.

The Advance of a ship for a given turn is the distance that her compass platform moves in the direction of her original line of advance, measured from the point where the rudder is put over. 'AQ' is the Advance for a turn of 45°; 'AR' the advance for 135°.

The Transfer of a ship for a given turn is the distance that her compass platform moves at right angles to her original line of advance. 'SD' is the Transfer for a turn of 90°.

The Tactical Diameter is the amount that the compass platform has moved at right angles to the ship's original line of advance when she has turned through 180°. 'PF' is the Tactical Diameter, or Transfer for 180°.

The Final Diameter is the diameter of the turning circle when the ship's path has finally become circular.

The Distance to New Course is the distance, measured along the original line of advance, from the position of the compass platform when the rudder is put over to the point of intersection between the old and new courses. 'AS' is the Distance to New Course for a turn of 90°. For turns of over 135° the Distance to New Course becomes excessive for plotting purposes.

The Intermediate Course and Distance is the length of the line joining the position of the compass platform when the rudder is put over and the position when the ship has turned through any particular angle. 'AE' is the Intermediate Distance for a turn of 135°. The Intermediate Course for this turn is the angle 'SAE'.

The Length of the Arc is the distance along the path described by the compass platform during a turn, measured from the point where the rudder is put over. 'ABCDEFG' is the length of the arc for a turn of 225°. It should be noted that the figures given on Form D 500 are related to the centre of gravity of the ship and require a small adjustment when related to the position of the compass platform.

TURNING TRIALS

Necessity for Accurate Data

Fleetwork and navigation in pilotage waters require that a ship's path under rudder can be accurately plotted. For this reason, comprehensive Turning Trials are carried out in new construction ships, both before acceptance, by the Director of Naval Construction, and after commissioning, by the ship's officers. Both the scope, and the method of conducting these two sets of trials, differ considerably, and the data obtained from them are presented in a different form. The following remarks refer to the turning trials carried out by ship's officers.

Conditions for Trials

Good weather conditions are necessary for the trials. The effect of wind and sea on turning performance is so marked that results obtained other than in calm conditions may show confusing variations from the normal.

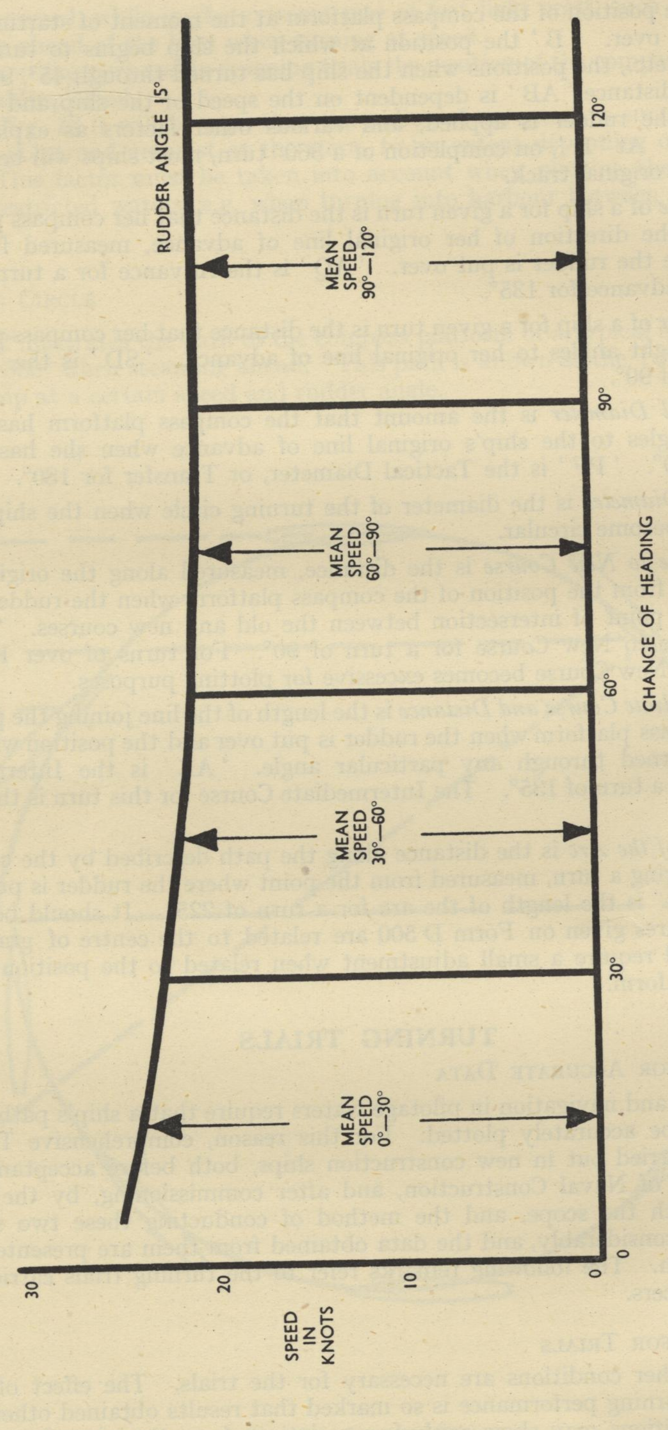


Fig. 13.—Speed at any Point in a Turn.

Absence of tidal stream will similarly contribute towards satisfactory results when the method of plotting the position of the compass platform involves the use of a fixed datum point, either moored or on shore.

The trials, being intended primarily for fleet work, are carried out in at least 20 fathoms, and prefrably in a depth of at least ten times the ship's draught, to avoid shallow water effects. Additional trials are sometimes carried out by ship's officers to determine the extent to which the turning data are modified when manoeuvring in shallow water.

Summary of Trials

Detailed instructions for carrying out Turning, Starting and Stopping, and Manoeuvring Trials are contained in Form S.347. It will be seen that the 14 Turning Trials are catered for at ' Economical ', ' Half ' speed and ' High ' speed, using various angles of rudder, Port and Starboard.

The Starting and Stopping Trials are referred to in *Chapter I*.

In addition, two ' Manoeuvring ' trials are carried out by Capital ships and Cruisers. These involve full speed and maximum rudder, the rudder being reversed during each turn.

Paths of Typical Ships

Tables I to IV (*Appendix I*) show the results of turning trials carried out by D.N.C. for various classes of ships. The method of measurement of the turning path is more accurate than that normally available to ship's officers. These curves represent the mean results of several turns. It should be remembered that the results of similar trials under apparently similar conditions may vary, and that the behaviour of all ships of a class may not be exactly the same.

Loss of Speed when Turning

The effect of the drag of the rudder and the sideways drift of the ship will result in a progressive loss of speed along the arc during the first 180° of a turn. In the early stages the reduction of speed is not great, but between 20° and 90° the speed drops rapidly, and continues to fall, though at a reduced rate, until the ship has turned through about 180°.

Determination of the Speed at any Point in a Turn

From the time taken to turn through every 30° and the observed length of arc (*Appendix I*) the mean speed for every 30° can be calculated and plotted graphically as shown in *Fig. 13*. The speed along the arc after turning through any number of degrees can thus be determined.

From graphs plotted for various speeds and rudder angles, the probable speed at any point in a turn can be found.

Allowance for Loss of Speed when Turning

When a ship is steadied on her new course after a turn, an appreciable time will elapse before she regains her normal speed. To allow for this when plotting the ship's track for navigational purposes, and allowance known as the ' Time Correction ' must be applied. (See *Admiralty Navigation Manual Volume I*.) For Fleetwork purposes a ' Distance Correction ' is more applicable.

Speed of Engines when Turning

When a twin or multiple-screw ship is turning under rudder, both sets of screws (after a slight initial increase by the outer) will tend to decrease speed; the inner set losing speed more rapidly than the outer. After turning through about 120° each shaft will reach steady revolutions. The final mean revolutions of the shafts will be lower than the original revolutions by an amount depending principally on the rudder angle.

It is the practice, both at sea and for trial purposes, to adjust the power of each set of engines throughout a turn so as to maintain the speed of each shaft at the revolutions ordered. This has the effect of increasing the tactical diameter. This adjustment is not of course possible at full power, and in some ships it is not permissible at certain speeds owing to vibration.

Conditions influencing Turning Performance

At moderate speeds the turning effect of a rudder may reach its maximum value at about 40°. Beyond this angle there may be a breakdown in the flow of water past the rudder, resulting in a loss of suction on the side away from the direction of the turn. At high speeds certain designs of rudder may have an optimum angle as low as 25°, beyond which an increase in tactical diameter may be expected owing to the breakdown in flow conditions. Most warships are limited to a full rudder angle of about 37°. It should be appreciated that when the drift angle has fully developed the angle of incidence of the rudder is correspondingly reduced, and a rudder which has ' broken down ' in the early part of a turn may ' recover ' in the later stages.

In addition to the positioning and design of the rudder, or rudders, and the rudder angle used, the following are the principal factors influencing the turning performance of a ship:—

(*a*) *Hull form.* A ship of fine underwater form will turn in a larger circle than a ship of similar length and draught but of fuller form, though the ship of fine form will be steadier on a course. The modern fast warship, of great length in proportion to her beam and draught, will thus have a considerably larger tactical diameter than her slower and stouter predecessor, though recent research in rudder design has resulted in considerable improvements in the turning performance of the fast streamlined hull.

As mentioned in *Chapter II*, the cutting away of the stern profile will decrease the tactical diameter, but will make the ship less steady on a course.

(*b*) *Draught and trim.* A moderate reduction in the draught of a ship, such as that resulting from prolonged steaming, will usually tend towards a slight increase in her tactical diameter, whereas an increase in draught will have the opposite effect. A considerable reduction in draught, as in the case of a cargo ship flying very light, may result in a marked decrease in tactical diameter. This extreme condition is not generally applicable to large warships.

The Advance is little affected by change in draught.

Trim by the stern is usually accompanied by an increase in the tactical diameter, and vice versa, but a ship trimmed by the stern will generally steer better on a course than when trimmed by the bow.

(*c*) *List.* The effect of list is to hinder a turn in the direction of the list, and assist a turn away from it. A list to port will decrease the tactical diameter of a ship turning to starboard.

The heel to leeward caused by a strong wind is thus a contributory reason for the tendency to carry lee rudder.

(*d*) *Speed.* The tactical diameter of most heavy ships when turning under the influence of a given rudder angle is affected by their speed, and at high speeds the advance increases considerably.

Lighter ships, such as destroyers, increase their tactical diameter considerably at speeds above 20 knots. This is partly due to the exaggerated trim by the stern adopted by these vessels at high speed, and partly to the reduction in rudder efficiency at high speed and large angles of rudder.

(*e*) *Wind and sea.* A ship will tend to turn under the influence of wind when there is a difference in the exposed area forward and aft. In most ships the pivoting point is well forward when moving ahead, so that the pressure on the greater exposed area abaft this point will tend to turn her into the wind. The effect on the ship's turning circle will generally be to expand the curve in the two quadrants in which her bows are turning away from the wind, and to contract it elsewhere.

Owing to a ship's sluggishness in answering her rudder when turning away from the wind, a greater advance than normal must be allowed, and it should be remembered that when carrying a large amount of weather rudder the normal tactical rudder may be insufficient to start the turn.

The effect of waves on the turning performance of a ship is more complicated, and is dealt with in greater detail in *Chapter VII*. Generally, waves tend to make a ship sluggish except when turning across the trough of a quartering sea. The effect of a sea on the bow or beam is usually to impede that part of the ship which is swinging against the direction of wave motion, while not materially assisting that part which is swinging in the direction that the waves are travelling.

(*f*) *Unsteady course and revolutions before starting a turn.* Variations in both the Advance and the Tactical Diameter, particularly the former, are caused by unsteadiness of course immediately before the wheel is put over at the start of a turn.

It cannot be expected that port and starboard turning circles can ever agree exactly for this reason, and also because the revolutions of the shafts may differ slightly.

In high speed ships some difference in turning may result if the rudder ' breaks down '.

(*g*) *Depth of water.* The effect of shallow water is generally to reduce the rate at which a ship will turn, and increase both the Advance and the Tactical Diameter.

Heel when Turning

The centre of pressure of the rudder being normally well below the centre of gravity of the ship, the initial reaction to the application of rudder will be a heel inwards. As the ship gains angular velocity, the couple formed by centrifugal force and the lateral resistance of the hull will overcome this tendency to heel inwards. The resultant outward heel is very noticeable in modern ships turning at high speed. If the rudder is eased quickly, the removal of opposition to the centrifugal couple will result in further outward heel, which will persist until the rate of turning decreases.

In power boats carrying heavy deck loads, the outward heel during a turn may be dangerously aggravated by easing or reversing the rudder. This effect was particularly noticeable in the old steam picket boats. Should an alarming outward heel develop it is preferable to reduce speed.

In fast shallow-draught craft, whose resistance to lateral movement is relatively small, most of the centrifugal force during a turn is expended in side

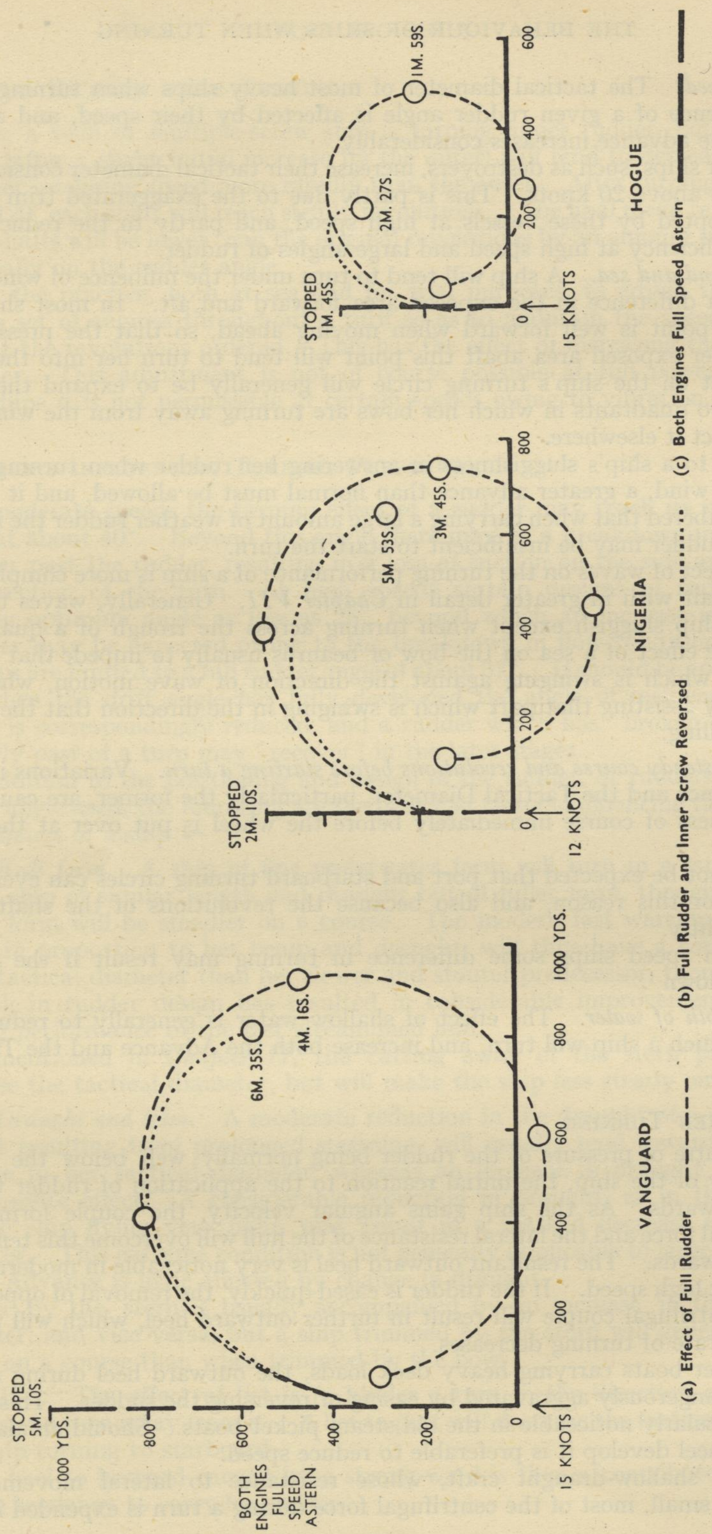


FIG. 14.—Effect of reversing inner screw.

slip, and not in outward heel. This results, when turning at speed, in pronounced inward heel due to the pressure on the rudder. In some of the latest Fast Patrol Boats the initial inward heel caused by four rudders at high speed may be violent.

Effect of Reversing the Propellers on the Inside of a Turn

When the screws on the inside of the turn are reversed at the moment of putting the rudder over, the effect will generally be to reduce the tactical diameter. The advance may or may not be affected. The speed of the ship along the arc will be drastically reduced as astern revolutions are worked up, and the time taken to turn through 180° will be correspondingly increased.

Fig. 14 shows typical paths with full rudder and inner screws reversed, in comparison with the normal turning circles under full rudder.

The circles are not markedly affected during the first quadrant for a variety of reasons, but principally because the inner engines in turbine driven ships take some time to run off their ahead revolutions and develop effective astern power (*Chapter I*).

Heavy ships will lose headway after turning through about 180°, and thereafter the tendency is often towards gathering sternway.

Destroyers may lose headway after turning through 60° or so, and will consequently have a greatly reduced transfer.

The distance covered before all way is taken off the ship, if both engines are put full speed astern instead of putting the rudder over, is also shown.

The circumstances in which reversal of the inner screws will be advantageous is one of the points on which officers should form an opinion on assuming a new command. Evidently, where reduction in the turning circle is the primary requirement, and considerable loss of speed is acceptable or desirable, for example when negotiating a sharp turn after passing through breakwaters, the inner screws can often be used astern with good effect.

When avoiding a danger ahead, however, the reduction in advance with inner screws reversed is usually so small when the ship is proceeding at any speed that no particular advantage would be gained, other than loss of headway. If a turn under full rudder appears unlikely to clear the danger by a good margin it may be preferable not to risk a broadside encounter, but instead to take as much way off the ship as possible by going full speed astern on both engines.

In Fleet work, reversal of the inner screws is seldom advantageous.

Steaming with One Engine Stopped

The amount of rudder required to maintain the course will naturally vary with individual ships and in different weather conditions. A heavy ship may require 10° of opposing rudder, and a destroyer considerably less. A smaller rudder angle will be required if the shaft can be trailed, but if machinery repairs are being carried out this will not normally be possible.

Steering by Main Engines

The procedure will vary according to circumstances, and with the opinions of individual commanding officers. Some prefer a standard procedure whereby the same set of engines is always maintained at constant revolutions, and the other set varied so as to maintain the course. When it is required to make good the best possible speed it will however be preferable to keep the weather engines at constant revolutions and to decrease the revolutions on the lee engines as necessary to maintain the course.

Investigations at Admiralty Experiment Works, Haslar

The turning and manoeuvring qualities of H.M. Ships on completion are determined by a trial party from Admiralty Experiment Works, Haslar. Complete turns are made to Port and to Starboard covering a wide operational range of rudder angle and approach speed. Some trials are carried out with propellers on one side working astern and on the other ahead. The turning path of the ship is determined by triangulation from the bearing of a freely floating buoy measured by recorders on the ship well forward and aft. Accuracy is ensured by photographic methods. Generally one ship only of each class is selected for trial but trials are also carried out on other ships if any relevant modifications are embodied or if any special manoeuvres are required.

Investigations are also made at Admiralty Experiment Works, Haslar, to the requirements of the Director of Naval Construction during the design of the ship to determine the best arrangement of hull, propellers and rudders for quick steering and good course keeping, consistent with the general requirements of the design. Experiments are made on free propelled models and the turning path and angle of heel of the hull accurately recorded photographically. Measurements are also made of the forces on the rudder and hull, including the torque on the rudder, for information on the turning qualities and on the design of rudders and steering gear. Modifications are tested as necessary to ensure the most efficient design of the ship as regards steering qualities generally.

CHAPTER IV

HANDLING SHIPS IN NARROW WATERS

In the foregoing chapters, something of the theory of a ship's behaviour under the influence of propeller and rudder has been discussed. But though a clear idea of fundamentals will form a valuable background, ship handling is essentially an art rather than a science, and the subsequent chapters will deal only with the more practical aspects of the subject.

The qualities of the ship

In order to form an assessment of the ship's qualities, any officer, on assuming a new command, will be well advised to study in the Ship's Book and Navigational Data Book all the relevant information such as the details of her propelling machinery and steering arrangements; her liveliness under engines and rudder; and any peculiarities of construction such as abnormal projection of screws, or overhanging superstructure.

Although there will not be time for detailed consideration of any of these points during the course of a manoeuvre, a clear mental picture of the ship's characteristics must contribute towards good judgment.

The earliest opportunity should be taken of forming a practical assessment of the ship's qualities by carrying out in open waters such manoeuvres as dropping and picking up a lifebuoy, turning into and off the wind, steering at slow speed and with sternway, and turning at rest.

Modification of the ship's qualities by external conditions

(*a*) The Effect of Wind

Of all the external conditions which modify the theoretical behaviour of a ship, wind is the most important and complex. Not only may it have a drastic effect on steering, particularly at slow speed, but in extreme cases it may overcome the combined efforts of screws and rudder to turn the ship in the required direction.

In addition, the rate of drift due to wind during the course of a manoeuvre must be one of the first considerations when drawing up a plan of action, though its effect on a warship is not subject to the great variation due to change of loading which is such a complicating factor in the handling of cargo ships.

It should not however be assumed that wind will necessarily add to the difficulties of a manoeuvre. Particularly in single-screw ships, a wind may often be turned to good advantage, and can be used to expedite a manoeuvre which would have been tedious, or even impracticable, in a flat calm.

(*i*) *The effect of wind on steering.* Most ships tend to turn into the wind when they have headway, and are correspondingly slow in turning off the wind (*Chapter III*). This effect is accentuated as the ship loses her way, though at very slow speed the bow will fall off, and after losing all way the usual tendency is to lie approximately beam on.

With sternway, the tendency of the *stern* to seek the wind is even more pronounced, particularly in ships with high forecastles, such as destroyers and frigates. This is because the pivoting point moves well aft as the ship gathers sternway, especially when her engines are turning astern.

It follows that the average warship will steer most easily into wind, whether she has headway or sternway, though there are of course exceptions. Some twin-screw frigates in particular, owing to their high forecastle and superstructure forward, and light draught, become unmanageable at slow speed into wind, but steer well with the wind right astern, though should they sheer to bring the wind on the quarter considerable rudder may be required to bring the stern up again.

(*ii*) *The effect of wind on turning at rest.* When turning at rest in calm weather a ship will pivot about a point somewhere between her centre of gravity and the centre of area of her underwater profile. This point will normally be somewhat forward of amidships, but will move forward or aft with trim by the bow or stern respectively, and will also vary according to the way her engines are being worked.

Under the influence of wind, the attitude of a ship with no head or stern way will depend on the relation between the area of hull and superstructure exposed to the wind before and abaft her 'at rest' pivoting point, the usual attitude for a warship being with the wind a point or two before or abaft the beam. Any attempt to turn her away from this attitude will require a greater turning moment than the normal.

This sluggishness when turning at rest in a beam wind is accentuated by the piling up of water on her weather side before she starts to drift, and on her lee side subsequently; but if there is sufficient room to acquire slight head or stern way, the bow or stern respectively will usually turn more readily into the wind owing to the shift of pivoting point.

(*iii*) *Drift due to wind.* Any ship will drift to leeward under the influence of wind, the amount increasing progressively with loss of way, and with an increase in the angle of the wind to the fore-and-aft line. In a ship with headway the rate of drift is accentuated when carrying lee rudder.

As the ship loses her way, she will tend to turn broadside to the wind. When, finally, her only motion is to leeward, she will begin to transmit this motion to the water immediately surrounding her, until eventually both ship and surrounding water are moving bodily to leeward.

Immediately the ship acquires head or stern way, she will move into water with relatively little drift, and her own drift to leeward will be correspondingly reduced.

(*b*) THE EFFECT OF CURRENT

A constant current has no effect on a ship's manoeuvring qualities, nor do questions of difference of trim, or of attitude to the direction of the stream, alter its effect. The allowance to be made for a constant current is in fact purely that of the distance the ship will be carried by the movement of the water during the period of the manoeuvre. The ship's performance relative to the water is not affected.

It will sometimes happen, however, that the current is not constant over the area in which the manoeuvre is to be carried out, and the two ends of the ship may consequently not be in water moving at the same rate over the ground.

This question is discussed more fully in *Chapter V*.

(*c*) THE EFFECT OF SHALLOW WATER

It has been shown briefly in *Chapter I* how speed is affected in shallow water. Similarly complex conditions exist with regard to steering. The flow of water round the ship is no longer truly three-dimensional, and the pressure and velocities of the water are disturbed from the normal. Underneath the ship the water gap between the hull and the sea bottom is restricted, and the difficulty of maintaining a normal streamline flow in this gap is increased by the frictional drag of the hull, thus tending to make the ship directionally unstable. Further, the efficiency of the rudder is reduced by the increase in frictional wake, and this condition is aggravated in ships designed so that the rudder does not readily receive benefit from the wash of the propellers. As a result, a ship will take longer to obey her rudder when altering course in shallow water, and correspondingly longer to check a yaw or sheer.

Experiment has shown that unsteady steering begins to show itself when the draught is more than three-fifths the depth of water, and that any attempt to proceed at high speed in shallow water will greatly accentuate this effect.

Steering vagaries become even more pronounced when the water is restricted as well as shallow, e.g. in a canal or river. The increased difficulties experienced, and the measures recommended to overcome them are described on a later page.

The rate of turning at rest will similarly be reduced in shallow water, largely owing to the restriction in the flow of water from one side of the ship to the other under the keel.

Fig. 15 illustrates the profile and midships section of a heavy ship manoeuvring in 6½ fathoms, e.g. in Gibraltar harbour. The ship is drawing 32 feet.

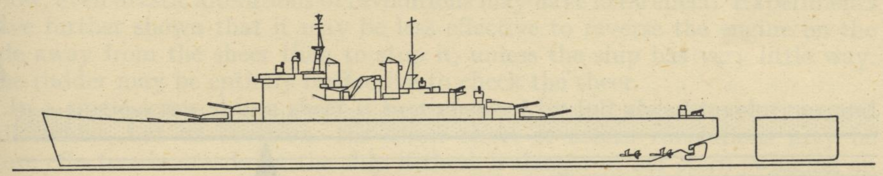


FIG. 15.—Clearance between keel and sea bottom—*Vanguard* in Gibraltar harbour.

This extremely small clearance between keel and bottom in most enclosed harbours is often not appreciated, but it can readily be understood from the above illustration how great an effect shallow water may have in restricting angular momentum. In addition, the restriction in the flow of water to and from the propellers and around the rudder will result in eddies, which in extreme cases may entirely negative their turning effect, so that it will sometimes be necessary to stop or reduce the speed of the engines, and allow the eddies to subside, before the turn can be continued.

Passage through canals and narrow channels

Ships moving through canals and restricted waterways tend to bank up the water ahead of them to an extent depending on their displacement and speed. For this reason local orders impose a speed limit in harbours and dock approaches, so as to avoid flooding adjacent shores and damaging craft in the vicinity. In canals, where depth and width are little more than the

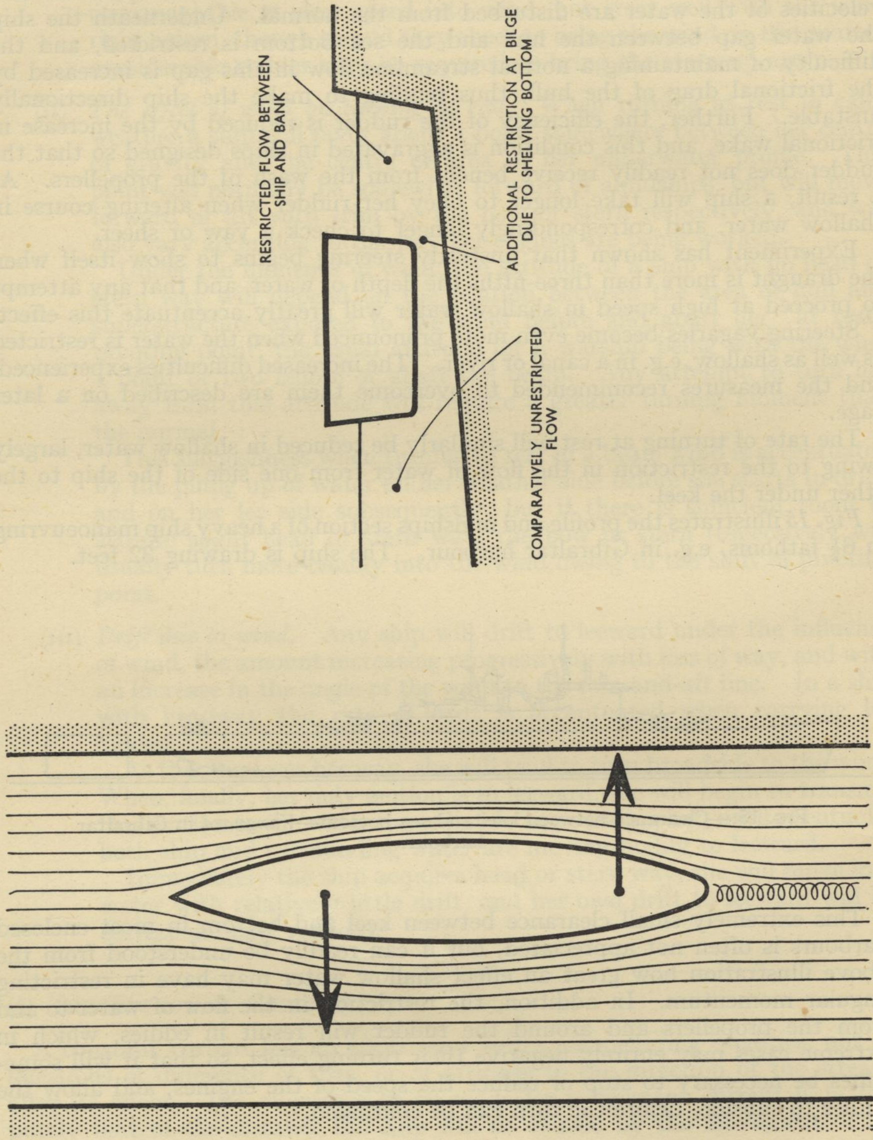


Fig. 16.—Canal effect.

draught and beam of the largest ships which pass through, this effect is pronounced. It is on record that a ship proceeding at undue speed in the Manchester Ship Canal parted the hawsers of a ship three miles ahead.

Effect on Speed

The banking up of the water ahead of a moving ship results in a current in the opposite direction, so as to maintain the level of water in the canal. This current is strongest close to the ship and near the surface, and least at the bottom of the canal and near its sides. Combined with the effect of shallow water described in *Chapter I*, this opposing stream retards the ship's progress. For example, a heavy ship passing through the narrow sections of the Suez Canal will make good approximately 5 knots at revolution for 7 knots, whilst passage through the Gaillard Pass of the Panama Canal may reduce the ship's speed by as much as 40 per cent.

Effect on Steering

So long as the ship remains in the centre of the canal, the pressure distribution is equal on either side of the ship, but should she move towards one bank the resulting restriction in flow on that side will cause a corresponding reduction in pressure, particularly on the stern. Consequently the ship will tend to sheer back towards the centre, sometimes violently. (*Fig. 16.*)

It has been shown, both by experiment and by practical experience, that the best method of breaking a bad sheer is to increase the speed of the engine on the side towards which the ship is sheering, and to reduce speed, or even stop the engine, on the other side; but unless the initial speed of the ship is low, even drastic alterations of revolutions may have little effect. Experiments have further shown that it may be less effective to reverse the engine on the side away from the sheer than to stop it, unless the ship has very little way. The rudder may be entirely ineffective to check the sheer.

In a single-screw ship a sheer is best checked by full ahead revolutions and full rudder, but on occasions the screw effect of astern revolutions may be more effective in steadying the ship if there is danger of her stern swinging on to the starboard bank.

In a heavy ship, if prompt action with the engines has produced no effect by the time the bow has sheered to the centre of the channel, little can be done to avoid striking the opposite bank beyond letting go both anchors and reversing the engines at full power. The mid-channel anchor should be let go first.

This tendency of a ship to sheer into deeper water when running nearly parallel to shoal water is the well known phenomenon known as ' smelling the ground ', and is by no means confined to passage through canals. It is equally noticeable when there is ample sea room on the side away from the shoal, and can sometimes be put to good account. The effect is most marked when there is a shelving bottom; the discrepancy in pressure and suction on inner and outer bow and quarter being accentuated in such a case. (*Fig. 16.*)

Rounding a Bend

In Appendix III the results of the experimental investigation into the grounding of H.M.S. *Nelson* in the Portsmouth Harbour channel are reproduced in some detail. This is a classic example of a heavy ship taking an uncontrollable sheer through running too close to the inner bank when negotiating a bend in a narrow channel.

In canals and narrow channels where there is little current ships should approach a bend keeping to the centre of the channel, but inclining to the outside of the bend. The bow will then be forced away from the outer bank, so that the bend can sometimes be negotiated without rudder, or even with reverse rudder.

Two Ships Meeting

When two ships are meeting in a restricted channel, rather than inclining towards their respective sides, they should steer to pass close to each other. With due care there is little possibility of accident, because, as they close, the water pressure between them will force their bows apart; on passing they will tend to parallel each other; and when separating their sterns will be drawn together. These influences will thus counteract the effect of the nearer bank, and the two ships should have no difficulty in regaining the centre of the channel.

Limiting Speed

Every ship has a critical speed above which, in certain depths, her steering becomes increasingly erratic. Ships habitually using the great sea canals

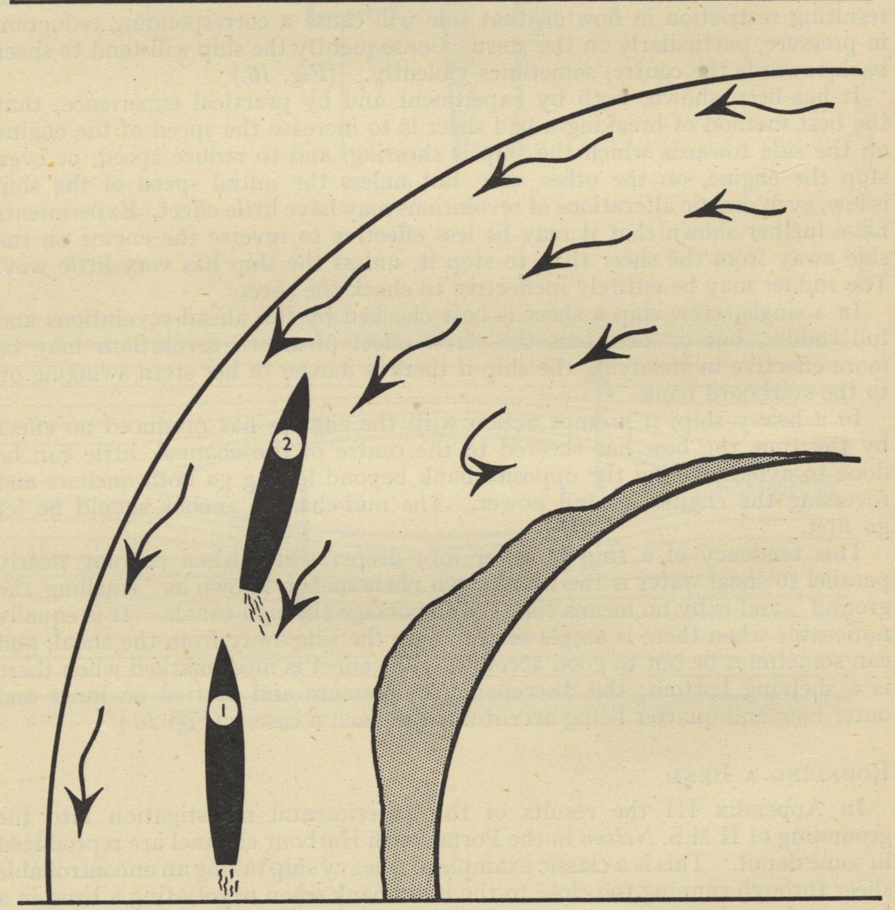


Fig. 17.—Rounding a bend in a river.

have a speed known as their " canal speed ", which cannot be exceeded with safety. Speed must also be limited to avoid damage from wash and risk of touching ground owing to increase of draught.

It is also noteworthy that ships have a limiting speed in a canal which it is *impossible* to exceed, no matter how much the speed of the engines is increased.

Idiosyncrasies of Certain Classes of Ship

The previous behaviour of other ships of a class in any particular canal should always be studied, and a record of available information kept in the Navigational Data Book. A certain hull may tend to be unsteady in a certain canal. For instance during the Second World War ships of the *King George V* class repeatedly grounded in the Suez Canal, though not always in the same section, while *Nelson*, *Richelieu*, and the fleet carriers experienced no difficulty.

The Effect of Current

When there is much stream, it is usually advisable to maintain the ' Canal Speed ' through the water, rather than to adjust the speed over the ground. This applies particularly if stemming the stream, when the necessary increase of speed would accentuate canal effects.

In rivers, the water is usually deepest and the stream strongest in the middle of straight reaches, and near the outer bank at bends. A ship passing from a straight reach to a bend, stemming the current, will therefore be running across the strength of the stream, so that her bows will at once be carried towards the outer bank unless rudder is applied in good time in the direction of the turn. (*Fig. 17.*)

For this reason, the technique of inclining towards the outside of the bend should be used with caution when stemming any considerable stream. Nevertheless the importance of avoiding the inner bank in such circumstances is intensified, for not only will the water usually be shallower near the inner bank, but any sheer which this shallow water causes towards the opposite bank will at once be accentuated as the bows reach the faster water in mid-stream.

When rounding a bend with the stream, the faster water near the outer bank will accentuate the swing of the stern, and opposite rudder must be applied in good time to steady the ship into the next straight reach. The avoidance of the inner bank is generally not of such importance when rounding a bend with a following stream.

The use of tugs

In all large ports a design of tug has been developed which best meets the requirements of that port. In dockyard ports, where tugs are required for moving ships without steam, in addition to ordinary towing purposes, both paddle and screw tugs are usually maintained.

Screw tugs are more suitable for towing ahead, and by reason of the relatively deep immersion of the propeller can exert more power in rough weather. Single-screw tugs steer well at slow speed when towing from the hook. They can also maintain their position easily and without loss of power when pushing. Twin-screw tugs, unless fitted with twin rudders, are unhandy in these circumstances, but are otherwise more manoeuvrable and are more suitable for the ocean rescue commitments of a naval port by virtue of their greater power.

Paddle tugs are neither intended nor suitable for long tows in the open sea. On the other hand they are better adapted for towing alongside; the turning moment exerted by their paddles is greater, and they are capable of developing more power astern. Their shape precludes their use alongside submarines and other bulged ships, but conversely, when alongside ships with considerable overhang, such as aircraft carriers, their protruding paddle boxes are an advantage. They are well suited for pushing against a ship, although they suffer from the same steering difficulties at low speed as do twin-screw tugs. When pulling they suffer from the further disadvantage that the towing hook is fitted well abaft the pivoting point owing to the obstruction of the paddle boxes and engine room amidships.

Girding

Ships should avoid gathering head or stern way when a tug's hawser is growing at a broad angle to the ship's fore-and-aft line, e.g. when hauling off a wharf. Lack of judgment in such circumstances may manoeuvre a tug into a helpless position, possibly capsizing her.

Modern tugs have great engine power in relation to their size, and the strength of their towing hawsers is in proportion to their engine power. Consequently if a tug is 'girded', that is to say pulled laterally through the water with the towing hawser growing out on her beam, it cannot be guaranteed that the hawser will part before she is capsized; moreover in these circumstances there is a possibility of the slipping arrangements in the tug failing to function. Although regulations require that slipping arrangements are also to be provided in the ship being towed, it should be remembered that when a hawser under strain is slipped from a high freeboard ship it is liable to endanger the crew of the tug.

Use of Tugs Alongside

Multiple-screw ships with steam at command should not employ tugs alongside if it can be avoided, since this involves risk of fouling the propellers, and damage to the ship or tug if there is any swell. The ship's own engines can usually provide all the astern power required, as well as considerable turning moment, and a tug alongside will not necessarily expedite the manoeuvre. Moreover in such a position a tug can be of little assistance in preventing the ship from drifting broadside, and will probably render more valuable service by standing by to pass a hawser if required, or by pushing.

A twin-screw ship with one engine disabled may however usefully employ a tug secured to the disabled side.

When using a tug alongside a single-screw ship it is usually preferable to secure it on the port side, so that the drag of the tug when the ship's engines are put astern will act in opposition to the screw effect. Similar considerations apply to the use of a single-screw tug alongside a twin-screw ship.

When using a screw tug alongside, it should normally be secured as far aft as possible, whereas a paddle tug should be secured amidships, nearer the pivoting point of the ship. The paddle tug turns at rest owing to the couple exerted by its paddles, whereas the screw tug depends on the lateral forces of screw effect and rudder.

Use of Tugs to Push

With the thin plating used in the structure of many modern ships, the employment of tugs to push should be exercised with reserve, though there may be no alternative in certain circumstances, for instance in the case of a restricted berth and a strong offshore wind. A tug cannot push if the stream is of any strength, nor if the ship has way on her, and in this connection the

importance of avoiding head or stern way when tugs are pushing or pulling to assist a turn 'at rest' is also stressed. Twin-screw tugs in particular may find it impossible to keep pointed, while the difficulties of a pushing tug of any type will always be aggravated by the propeller wash caused by excessive use of the ship's main engines.

Use of Tugs Ahead

When a ship cannot be controlled by her rudder alone, and when passing through narrow harbour channels with sharp bends, it is advisable to employ a tug ahead to assist the rudder. Ships with large turning circles will also require to use their main engines to check the advance and assist the turns. If an additional tug is available she should stand by at the bends ready to act in an emergency. A tug may also be used astern as a 'power rudder', paddle tugs being particularly suited for this function.

A bow tug should be slipped if the speed of the ship rises to within three knots or so of the maximum available speed of the tug, bearing in mind that the tug will have to ease her engines to slip the tow, and that the drag of the towing hawser will further reduce her speed after slipping. In practice, a capital ship can usually proceed at seven knots with a dockyard screw tug towing ahead. The automatic reduction of speed to four or five knots by the end of an alteration of course allows time for the tug to recover position after the turn. It is important that the tug should work over to the inner bow of the ship before the turn is started. If she does not do so, not only will she hinder the turn, but she will run the risk of being girded.

Use of parked aircraft

Aircraft can be used to assist carriers in turning at rest in narrow waters when tugs are not available.

Groups of aircraft are ranged at the appropriate corners of the flight deck, so that when their engines are running at high power the turning effect on the ship becomes appreciable. Aircraft can also be used to assist the ship in leaving or berthing at a jetty without tugs.

Aircraft fitted with liquid-cooled engines are liable to overheat and cannot be used for prolonged runs.

Pilots

The relations between Captain and Pilot, and the ultimate responsibility of the Captain for the safety of his ship, are laid down in *Queen's Regulations and Admiralty Instructions*, Article 3475.

The pilot should be regarded as the expert on local conditions and in certain circumstances the Captain may have to rely entirely on his knowledge, but this does not necessarily mean that the actual handling of the ship should be undertaken by the pilot.

While it is normally desirable for the Captain to handle the ship, with the pilot offering the necessary information, there may be occasions where the channel is intricate, tugs are employed, or expert local knowledge is necessary, when it will be preferable for the pilot to order the precise movements of the engines and rudder, in order to avoid the controversial procedure of dual control. Nevertheless, whatever procedure is adopted, the Captain's responsibility remains.

The procedure in British Naval Ports is laid down in *Queen's Regulations and Admiralty Instructions*, Article 3442.

CHAPTER V

ENTERING HARBOUR

General considerations

Whether berthing alongside, securing stern to, or to buoys, or anchoring, the ship-handling problem can conveniently be sub-divided under one or more of the following headings:—

(*a*) Reduction of headway and control of the ship at slow speed.

(*b*) Turning in a confined space.

(*c*) Steering with sternway.

Reduction of Headway and Control at Slow Speed

Astern power in many ships is a weak point. Although the design of engines and propellers is the governing factor (*Chapter I*), another important consideration in the case of a steam ship is the number of boilers connected. Before manoeuvring in harbour it is advisable to ensure that a good reserve of power is available.

Table V indicates the practice in certain classes of ship regarding the distance at which speed is reduced and engines stopped when approaching an anchorage. A more accurate assessment for any individual ship can be made from the Starting and Stopping Trials on Form S.347.

These figures will also serve as a guide to reduction of speed when entering a confined harbour, but it should be remembered that the ship will retain her steering qualities better so long as her propellers are turning ahead. For this reason, especially when berthing heavy ships, it is advisable to take most of the way off while there is still ample sea room, so as to be able to make use of ahead revolutions during the final stages of the approach.

Should the berth be approached with too much way, thus leaving no alternative but to put the engines astern, the ship may take a sheer and be out of control at a critical period of the manoeuvre. This risk must sometimes be accepted when there are cross currents in the approach, as sufficient way must be maintained to counteract their effect. Similarly, when a strong wind is blowing, considerably more headway may be necessary to maintain steering control and to reduce leeway.

The improvement in steering qualities when the propellers are turning ahead is particularly marked in ships with rudders in the propeller slipstream, e.g. in single and triple-screw ships, and in multiple-screw ships fitted with two or more rudders. In the case of the triple-screw ship, good steering control at very slow speed can usually be maintained by stopping, or even reversing, the outer engines, while the centre engine is kept turning slow ahead.

Similarly in quadruple-screw ships, particularly when fitted with twin rudders, a great improvement in steering qualities at slow speed can be achieved if the inner shafts can be kept turning slow ahead independently of the outer shafts; in other words if the ship is manoeuvred as if she had triple screws. This is difficult to arrange unless each engine can be controlled by a separate telegraph but in heavy ships of the future it is probable that separate electrically-operated engine and revolution telegraphs will be installed on the compass platform for this purpose.

It should be noted that this system must be used with discretion, since prolonged running of astern turbines may cause overheating and consequent damage to machinery. *Chapter XIII* 'The Capabilities and Limitations of Machinery', deals more fully with this subject.

The extent to which a ship will carry her way may be much affected by a head or stern wind, the heavy ship being obviously less affected than the light, assuming proportional windage areas. In strong winds the distances shown in *Table V* may require considerable modification.

The effect of a contrary or following current is more positive, but is not dependent on the type of ship except in so far as the heavier ship, being slower to lose her way through the water, will be affected for a longer period.

When reducing the way of a ship, shallow water may modify her response to astern revolutions to a marked extent. As in the case of turning at rest in shallow water, this effect is due to the restriction in the flow of water between the hull and the sea bottom, resulting eventually in the piling up of the propeller race under the ship's quarter. The resultant loss of astern power is particularly noticeable when the water is restricted as well as shallow, e.g. when entering solid walled pens. In such cases, if there is little room to spare ahead, care should be taken that wires are ashore and headway reduced to a minimum before the propellers reach the line of the entrance.

Assessment of headway. The bottom log is of little value for assessment of headway at low speeds, and in any case will probably have been raised before entering harbour. The movement of shore objects close to the ship, and near the beam, in relation to more distant objects, will usually provide the best indication of speed over the ground. In an open anchorage, particularly at night, small squares of wood thrown into the water near the bridge can be used to show when the ship has lost her way through the water.

Turning in a Confined Space

Space is seldom so restricted that the ship must be turned on her heel, and the manoeuvre will be unnecessarily prolonged if advantage is not taken of the effect of slight head or stern way whenever space permits, and provided tugs are not being used to push, or to pull at an angle.

(*a*) *The single-screw ship*

In calm weather, headway and an initial swing to starboard will greatly assist a single-screw ship to turn, the effect of reversing the engine being then to accentuate the swing as well as to reduce headway. The turn is completed by backing and filling, ahead and astern. The rudder will have most effect if moved hard-a-starboard immediately before each ahead movement, amidships as the engine is reversed, and hard-a-port as soon as the ship has gathered sternway.

In calm weather it is not possible to turn the average single-screw ship short round to port, owing to the contrary swing which is developed as the engine is put astern. The magnitude of this reaction is, however, dependent on the size and pitch of the propeller, and it may be found in certain motor or turbine-driven single-screw ships that the small high-speed propeller is remarkably free from screw effect. In such ships a turn short round to port may be practicable when there is no wind.

In a strong wind, on the other hand, it may frequently be easier to turn a single-screw ship short round to port than to starboard. It will be seen from *Fig. 18a* that when endeavouring to turn to starboard with a strong wind initially on the starboard beam, if space is so restricted that all headway must

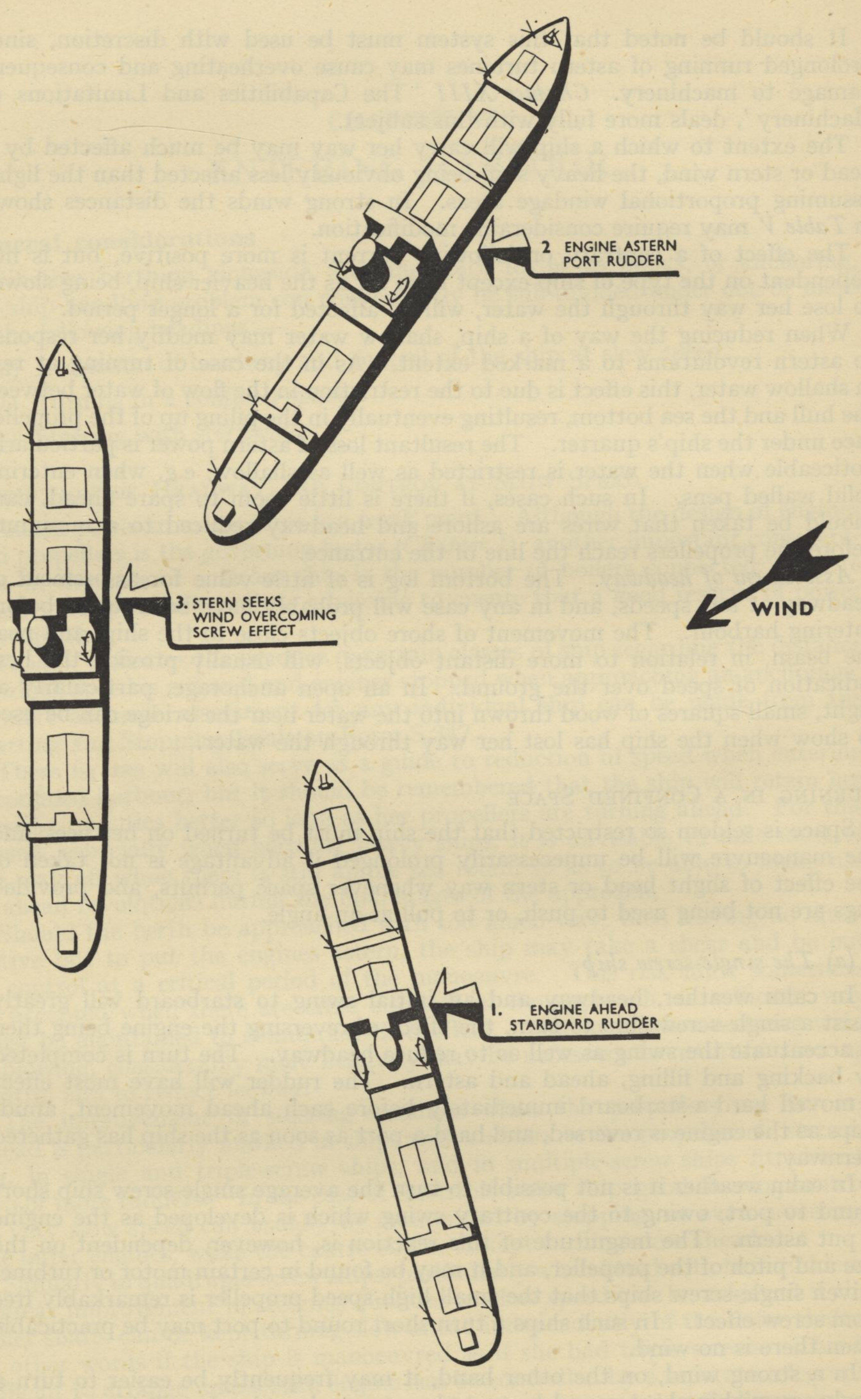


FIG. 18A. Turning short round in a single-screw ship—into wind

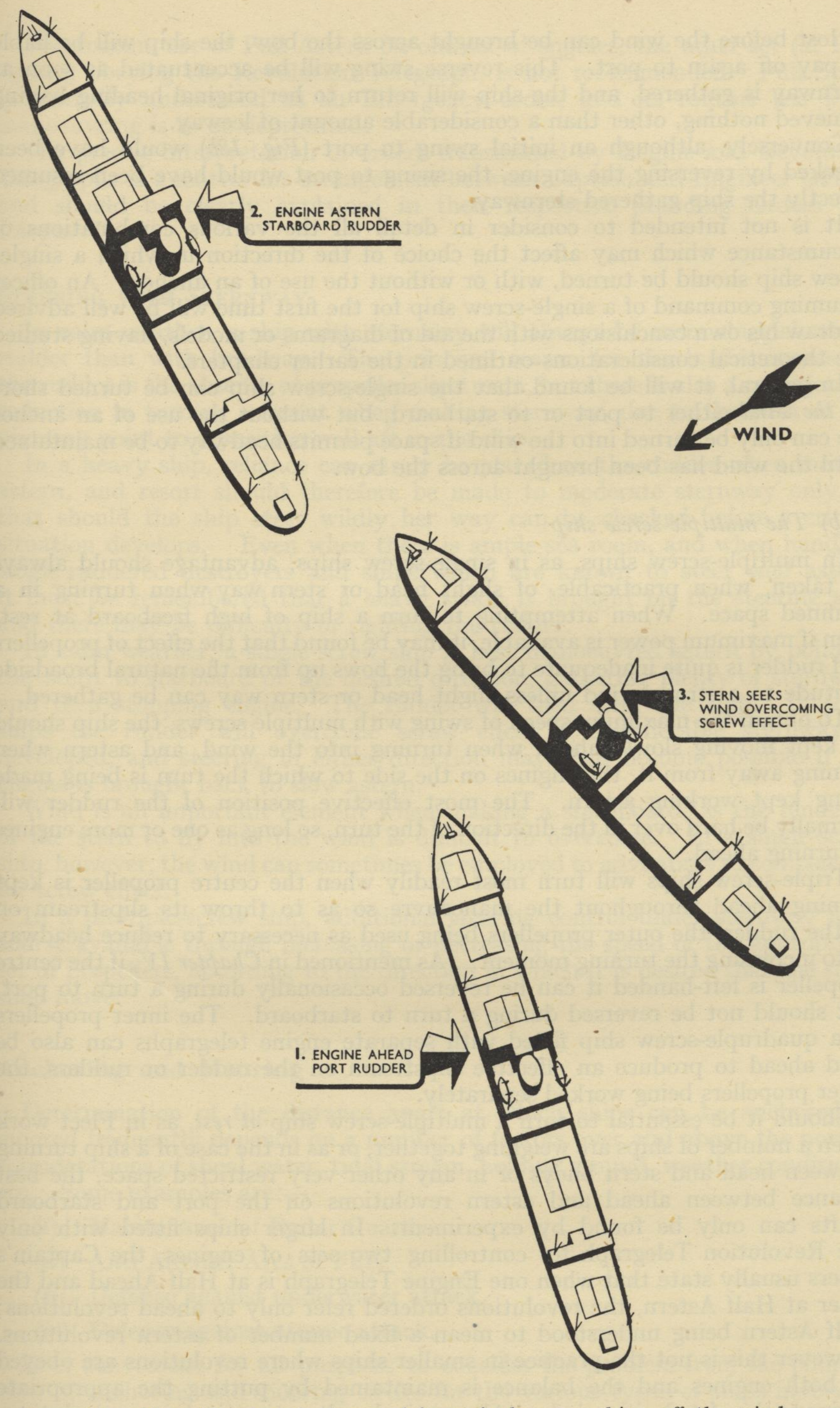


FIG. 18B. Turning short round in a single-screw ship—off the wind be lost before the wind can be brought across the bow, the ship will be liable to pay off again to port. This reverse swing will be accentuated as soon as sternway is gathered, and the ship will return to her original heading having achieved nothing, other than a considerable amount of leeway.

Conversely, although an initial swing to port (*Fig. 18b*) would have been checked by reversing the engine, the swing to port would have been resumed directly the ship gathered sternway.

It is not intended to consider in detail all the various combinations of circumstance which may affect the choice of the direction in which a single-screw ship should be turned, with or without the use of an anchor. An officer assuming command of a single-screw ship for the first time will be well advised to draw his own conclusions with the aid of diagrams or models, having studied the theoretical considerations outlined in the earlier chapters.

In general, it will be found that the single-screw ship can be turned short *off the wind* either to port or to starboard, but without the use of an anchor she can only be turned into the wind if space permits headway to be maintained until the wind has been brought across the bow.

(*b*) *The multiple-screw ship*

In multiple-screw ships, as in single-screw ships, advantage should always be taken, when practicable, of slight head or stern way when turning in a confined space. When attempting to turn a ship of high freeboard at rest, even if maximum power is available, it may be found that the effect of propellers and rudder is quite inadequate to bring the bows up from the natural broadside attitude to a strong wind unless slight head or stern way can be gathered.

To obtain the maximum speed of swing with multiple screws, the ship should be kept moving slowly ahead when turning into the wind, and astern when turning away from it, the engines on the side to which the turn is being made being kept working astern. The most effective position of the rudder will normally be hard over in the direction of the turn, so long as one or more engines is turning ahead.

Triple-screw ships will turn most readily when the centre propeller is kept turning ahead throughout the manoeuvre so as to throw its slipstream on to the rudder, the outer propellers being used as necessary to reduce headway or to increasing the turning moment. As mentioned in *Chapter IV*, if the centre propeller is left-handed it can be reversed occasionally during a turn to port, but should not be reversed during a turn to starboard. The inner propellers of a quadruple-screw ship fitted with separate engine telegraphs can also be used ahead to produce an effective slipstream on the rudder or rudders, the outer propellers being worked separately.

Should it be essential to turn a multiple-screw ship *at rest*, as in Fleet work when a number of ships are weighing together, or as in the case of a ship turning between head and stern buoys or in any other very restricted space, the best balance between ahead and astern revolutions on the port and starboard shafts can only be found by experiment. In larger ships fitted with only one Revolution Telegraph for controlling two sets of engines, the Captain's orders usually state that when one Engine Telegraph is at Half Ahead and the other at Half Astern, the revolutions ordered refer only to ahead revolutions; Half Astern being understood to mean a fixed number of astern revolutions. However this is not the practice in smaller ships where revolutions are obeyed on both engines and the balance is maintained by putting the appropriate engine to slow for short periods. Alternatively, alterations in Astern revolutions may be transmitted by telephone.

The routine use of Full Astern on one set of engines, the other set (at Half Ahead) obeying the Revolution Telegraph, is not recommended. Full Speed is normally understood as an Emergency order, and its routine use when manoeuvring is to be deprecated.

The precise interpretation of orders transmitted by Engine and Revolution Telegraphs is a matter for arrangement between Captain and Engineer Officer, and should be clearly explained in their respective Standing Orders (see *Chapter I*).

Steering with Sternway

In calm weather, a ship with sternway will always be more sluggish under rudder than with headway. The principal reason for the ineffectiveness of the rudder is the absence of propeller slipstream, but there is also a considerable reduction in turning moment when making sternway, due to the shift of the pivoting point to a position well aft in the ship.

In a heavy ship, reliance can rarely be placed on the rudder when moving astern, and resort should therefore be made to moderate sternway only, so that should the ship steer wildly her way can be checked before a critical situation develops. Even when there is ample sea room, and when handling single-ruddered destroyers and ships which are known to steer well astern, it must be remembered that a heavy strain is brought on the steering gear and there may be difficulty in righting the rudder.

In calm weather, a single-screw ship is best manoeuvred astern by pointing the stern to starboard of the desired direction, gathering plenty of sternway, and then stopping engine. The rudder will then steer the ship. In some ships the rudder will overcome screw effect if considerable sternway is developed, and steering in either direction may then become possible if the engine is brought back to slow astern.

Wind is an important element when making a sternboard, as the tendency of the stern to fly into the wind is difficult to overcome. In a single-screw ship, however, the wind can sometimes be employed to advantage to compensate for screw effect.

In a multiple-screw ship, additional steering control under sternway is of course available through increasing or decreasing the speed of the appropriate set of propellers, according to the direction in which it is desired that the stern shall move.

Anchoring and Mooring

Determination of the distance apart at which ships can be anchored or moored frequently depends on a number of factors over and above the normal considerations of shoal water, tidal stream, holding ground, weather conditions, etc. Some examples are:—

(*i*) Maintenance of Radar Guard.

(*ii*) Anti Aircraft Arcs of Fire.

(*iii*) Defence against underwater attack.

(*iv*) Defence against atomic attack.

It is convenient for all purposes to consider the problem from the point of view of anchoring and mooring circles for the various types of ships involved, since the diagrammatic presentation will make it comparatively easy to assess the advantages and disadvantages.

SINGLE ANCHOR

Normal circle. If there are no considerations other than those of safe distances between ships, the radius for the normal circle required for any ship can be taken as the length of cable it is intended to use plus the length of the ship, plus an allowance as a safety margin which in normal conditions should be fifty yards. Such a circle would make allowance for ships of dissimilar types, e.g. an aircraft carrier and a cruiser not only swinging in opposite directions where wind and tide are contrary but also drawing their cables out to their full extent in the direction of the swing.

Reduced circle. Where space is restricted and such conditions as those described above are unlikely, the circle may be proportionately reduced, but the circle for any particular type of ship should not normally be reduced below the length of the ship plus a fifty-yard safety margin.

MOORING

When ships are moored in order to conserve space, an allowance of fifty yards in addition to the length of the ship should normally be made, but this may be reduced to not less than twenty yards where conditions are favourable. The advantage gained is not very great if it is intended to construct a mooring plan which allows ships to weigh independently in all conditions of wind and tide. This aspect is discussed in *Chapter XII*.

PROXIMITY OF BERTHS TO SHOAL WATER, ETC.

In the case of anchor berths the distance between a normal circle and shoal water should not usually be less than one cable.

With mooring berths it is necessary to consider the line of the anchors, and the possibility of the direction of wind or stream being directly towards the danger. When the worst possible combination of factors has been considered, not less than one cable safety distance should usually be added.

It should be appreciated that the foregoing remarks are intended as a guide since conditions are so variable that each particular problem must be assessed on its own merits.

Table VII (*Appendix I*) gives the minimum circles for use when arranging berths for various types of ships when at single anchor, and when moored.

APPROACH TO AN ANCHOR BERTH

An accurate approach to an anchor berth is greatly facilitated if steerage way is maintained until the anchor is let go, and when anchoring in company this procedure is essential for station-keeping purposes. In H.M. Ships it is therefore the usual practice to anchor with headway, and to lay the cable out under the ship; rather than to gather sternway as soon as the anchor is let go, and bring the ship up with the cable growing out ahead.

When anchoring in company ships should lay out their cable in a straight line from their anchor, way being taken off with the engines and not with the cable-holder brakes. A heavy strain on the cable will not only tend to weaken or part it by nipping it severely in the hawse pipe, but may also drag the anchor away from the correct berth.

An indication of the distances at which speed should be reduced, and engines stopped, when approaching an anchorage, may be obtained from *Table V*. Modifying factors, such as the effect of wind and current, have already been discussed earlier in this chapter. When anchoring in very deep water it is customary to veer cable during the approach. Speed should therefore be reduced earlier, so as to allow time for the necessary cable to be veered and

prepared for letting go. Conversely, engines will normally be stopped somewhat later to allow for the drag of the anchor and cable through the water.

While it may be the normal practice to anchor H.M. Ships with headway, it should not be assumed that this is the best method under all circumstances. For instance, when stemming a strong current it will often be preferable to lay the cable out with sternway, so that there will be no doubt when the ship has got her cable, and no risk of the cable getting under the bottom if the direction of the current has been wrongly estimated. If the cable is laid out against the current, steam must be kept on the engines and the ship watched carefully until it is certain that she is riding correctly.

When it is inconvenient to stem a slight current, it may be sufficient to lay the cable out across it. The bight of cable will act as a brake and prevent undue strain whilst the ship is swinging and getting her cable.

Whilst consideration must be given to the effect of wind, a high contrary wind is normally necessary to overcome the effect of a moderate stream, and the ship should be anchored head-to-stream rather than head to wind. Anchoring head-to-stream with a beam wind, it is often advisable to let go the lee anchor and lay out the cable as the ship comes astern. Drift of the bow to windward will be checked by the cable, and the ship will assume an attitude athwart wind and stream. The cable will then grow clear on the lee bow. (*Fig. 19.*)*

Violent yawing in a strong river current can be checked by letting go both anchors spanned across the stream (*Fig. 20*)* but this procedure is evidently unsuitable for tidal waters, when each change of stream would put half a turn in the cables.

When it is necessary to anchor with the stream, a heavy strain is brought on the cable when the ship has swung half-way round. It may be possible to avoid this by starting to turn immediately the anchor is let go; the engines then being worked so as to continue the turn, and the cable veered in small amounts before the strain becomes excessive. In a strong stream, however, unless a heavy ship is manoeuvred with delicate judgment, there is risk of the cable running out to a clench and parting before the ship is finally swung. If circumstances permit, it is more seamanlike to turn the ship round before anchoring.

While a strong wind will not affect the choice of anchoring course so much as a strong current, similar considerations apply, especially in ships with high freeboard. But whereas it is a comparatively simple manoeuvre to stem a strong current and lay the cable out with sternway, this is not the case in a strong wind, owing to the tendency of the ship to fall broadside on as she loses her way. The engines are unlikely to be effective in bringing her bows back into the wind, while severe snubbing of the cable will probably drag the anchor.

The alternative procedure of anchoring into wind with headway may result in the ship drifting back broadside-on over her anchor and dragging a narrow bight of cable with her which may foul the anchor and break its hold (*Fig. 21a*).*

It may sometimes be preferable, therefore, to approach the berth a point or two off the wind, and with the minimum of headway. The weather anchor is let go, and as the way is taken off the ship the increased leeway will result in the cable being laid out approximately at right angles to the wind. (*Fig. 21b.*)* Although the ship may fall back broadside-on, the cable will be dragged in a wide bight, the straightening of which should slowly bring her bows to the

* *These figs. will be found at the end of text.*

wind without disturbing the anchor. The second (lee) anchor can be let go in position (*c*) without risk of fouling the other cable.

Ships which steer particularly badly into wind at slow speed may sometimes find it necessary to anchor steaming dead slow down wind.

Approach to a Mooring Berth

The following remarks refer to 'Mooring' as understood in H.M. Service, i.e. with two anchors down and cables middled at a mooring swivel. This method of anchoring the ship, although giving reduced holding power when the ship is riding in any direction other than in the line of the anchors, is sometimes necessitated by restricted swinging room, or by Fleet requirements.

It is important that the cable should be laid out from the first anchor in a straight line to the planned position of the second anchor, and that the ship's stem should be held as near as possible to this line when middling (*Fig. 22* (*a*) and (*b*).

The first (normally the weather) anchor should therefore be let go with good steerage way on the ship, and the course steered should be such as to make good along the intended line of the anchors, up to the time of letting go the second anchor. *Table V* gives an indication of the distances at which speed is reduced and engines stopped in various classes of ship when mooring. It will be seen that these distances are slightly less than those indicated for coming to single anchor.

The work of middling should not be left entirely to the cable holders. If there is a cross wind or current, endeavour should be made to work the engines so that the bows are kept on the line of the anchors. In calm weather, with no cross current, the engines should be used to gather slight sternway to assist the middling process.

Normally the line of anchors will be selected with a view to stemming the current or prevailing wind. A heavy ship is recommended to avoid attempting to moor with a stream of more than half a knot under her, and should circumstances arise when the crowded state of the anchorage, combined with the strength of the stream, precludes attempting to turn under way, it will be safer to turn the ship on one anchor first.

When mooring against a strong current it is sometimes preferable to execute a dropping moor (*Fig. 23*). After letting go the second anchor, the ship can be steamed back towards the upstream anchor, thus reducing the strain on it when middling.

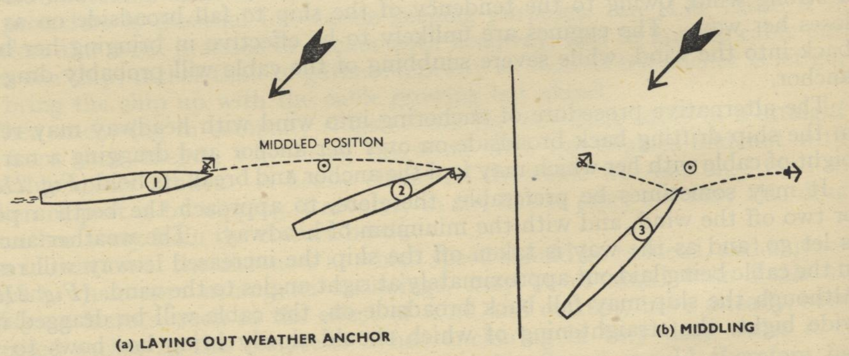


Fig. 22.—The running moor.

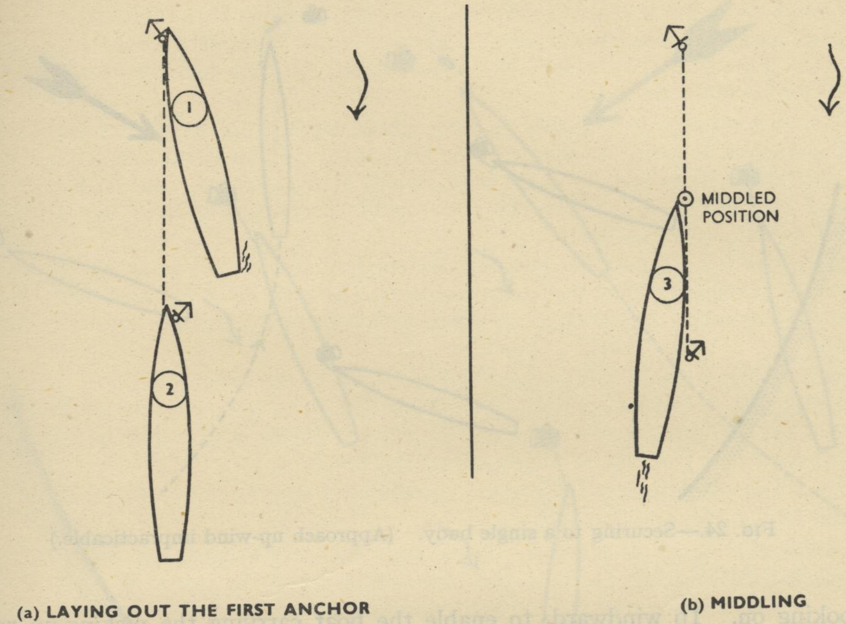


Fig. 23.—The dropping moor.

Care of Cables when Anchoring and Mooring

Great strain is brought on cables by anchoring heavy ships with much way on. The parting of chain cables is often due to gradual weakening as a result of the excessive strain to which they are subjected when mooring. Care in the handling of the ship, as well as in the manipulation of the cables, will increase their life and reduce the possibility of accidents through parting.

The efficiency of ships' cables is of such importance that speed in anchoring and mooring should give place to a method in which the strain on the cables is reduced to a minimum.

Securing to a Single Buoy

This manoeuvre requires little explanation unless complicated by wind or stream, or a combination of the two.

When deciding the best line of approach to a head mooring, stream is generally the over-riding consideration. In calm weather the bows cannot be held close to the buoy by the use of engines and rudder alone unless the ship is heading directly up or down stream, while in the case of a wind across the stream the ship will normally only require to be headed slightly to windward in order that the pressure of the stream shall balance leeway.

In both single and multiple-screw ships the approach should preferably be made with the least possible headway in order to minimise the sheer when the engines are put astern.

When there is no stream, if a head-to-wind approach is impracticable it is important that the ship should be brought to rest short, and well to windward of the buoy. Short, so that the bows can be kept from falling off to leeward by turning slowly into the wind with slight headway during the process of

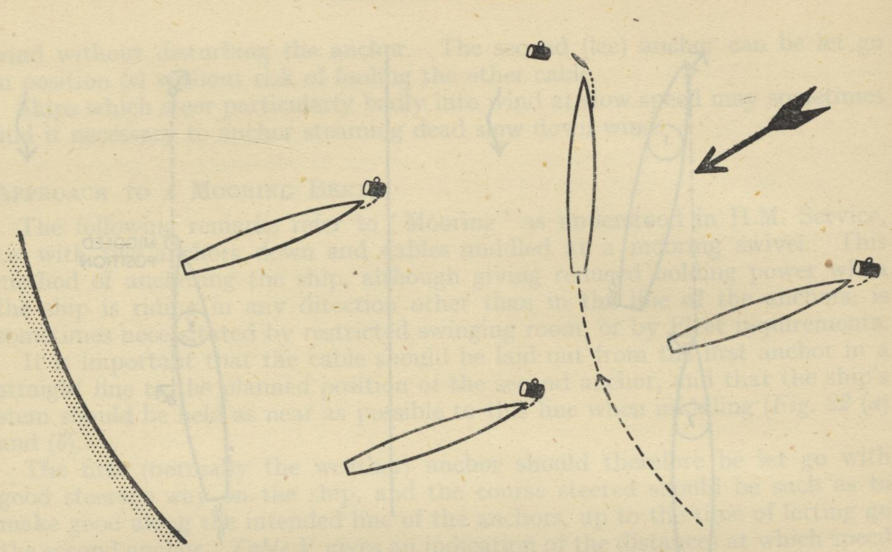


FIG. 24.—Securing to a single buoy. (Approach up-wind impracticable.)

hooking on. To windward, to enable the boat carrying the picking-up rope to make the buoy, and to ensure that the ship will not lose the buoy through drifting too far to leeward before the picking-up rope is hooked on.

Fig. 24 shows a typical case when a direct up-wind approach may be impracticable.

If space had permitted, it would have been preferable to turn the ship to leeward of the berth, with or without an anchor. With regard to the use of an anchor to assist a turn it should perhaps be stressed that the manoeuvre may be indefinitely prolonged by anchoring foul of a telegraph cable, or inside the span of buoy moorings. A further disadvantage in the use of an anchor, especially in ships of high freeboard, is the difficulty of keeping the bows into wind when weighing.

Fig. 25 shows a situation when wind and stream are from different directions.

The direction of other ships lying at head moorings in the vicinity will enable an approximate estimate to be made of the most suitable approach course, but it should be remembered that ships of different classes may take up very different attitudes in conditions of opposing wind and stream. Moreover the bridles by which they are riding may be growing at a considerable angle to their fore-and-aft lines, or if the wind is strong they may be yawing heavily. It is the direction of the bridles, rather than the heading of the ship, which will indicate the best approach course.

In ships with high forecastles and poor manoeuvring power, e.g. Ocean Minesweepers and Frigates, an approach down wind will often be preferable. The ship can approach very slowly and be held stern to wind without difficulty, while the whaler can be slipped well to windward and should have no trouble in getting to the buoy. It will not be easy to hold the stern into wind when the ship is stopped, and the disadvantage of this method of approach will be apparent when endeavouring to shackle on while the ship is swinging to the wind and straining at the picking-up rope. The approach head-to-wind may however present more difficulties, as it is impossible to hold these ships into

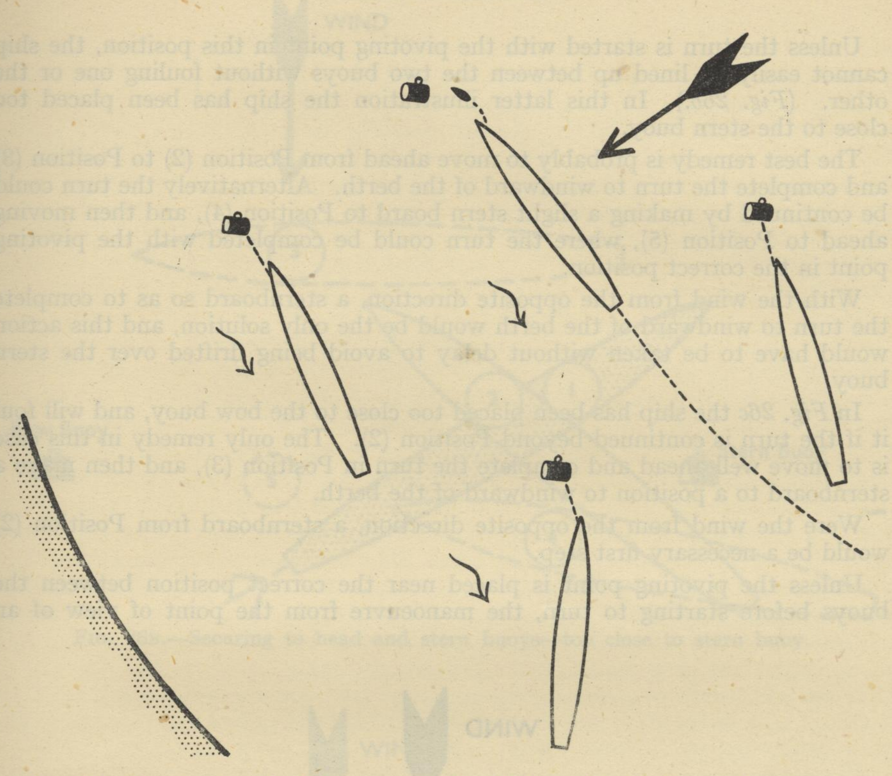


FIG. 25.—Securing to a single buoy. (Wind and stream from different directions.)

wind at very slow speed and the boat may take some time to grapple the buoy, especially if there is much lop on the water.

When securing to a single buoy it should not be assumed that the manoeuvre ends when the picking-up rope is hooked on. Especially in heavy ships, engines should be used as necessary to keep the appropriate hawse pipe over the buoy during the process of shackling on the first bridle.

SECURING BETWEEN TWO BUOYS

This manoeuvre is almost invariably complicated by the necessity for turning in the vicinity of the buoys so that the ship shall be secured heading out of harbour. In most harbours where head and stern buoys are employed, space is so restricted that the ship must be turned on her heel between the buoys.

In such cases, the prime requirement is to start the turn with the pivoting point in the position it will occupy when the ship is finally secured, with due allowance for wind and stream during the turn. (*Fig. 26a.*)*

* For convenience in these illustrations the pivoting point is shown in the approximate position of the bridge. Reference to *Chapter IV* will show that when turning *at rest* the pivot is likely to be nearer the mid-point. It is, however, so much the lesser evil to be too close to the bow buoy that the use of the bridge as the pivot will be an error in the right direction.

Unless the turn is started with the pivoting point in this position, the ship cannot easily be lined up between the two buoys without fouling one or the other. (*Fig. 26b.*) In this latter illustration the ship has been placed too close to the stern buoy.

The best remedy is probably to move ahead from Position (2) to Position (3) and complete the turn to windward of the berth. Alternatively the turn could be continued by making a slight stern board to Position (4), and then moving ahead to Position (5), where the turn could be completed with the pivoting point in the correct position.

With the wind from the opposite direction, a sternboard so as to complete the turn to windward of the berth would be the only solution, and this action would have to be taken without delay to avoid being drifted over the stern buoy.

In *Fig. 26c* the ship has been placed too close to the bow buoy, and will foul it if the turn is continued beyond Position (2). The only remedy in this case is to move well ahead and complete the turn in Position (3), and then make a sternboard to a position to windward of the berth.

Were the wind from the opposite direction, a sternboard from Position (2) would be a necessary first step.

Unless the pivoting point is placed near the correct position between the buoys before starting to turn, the manoeuvre from the point of view of an

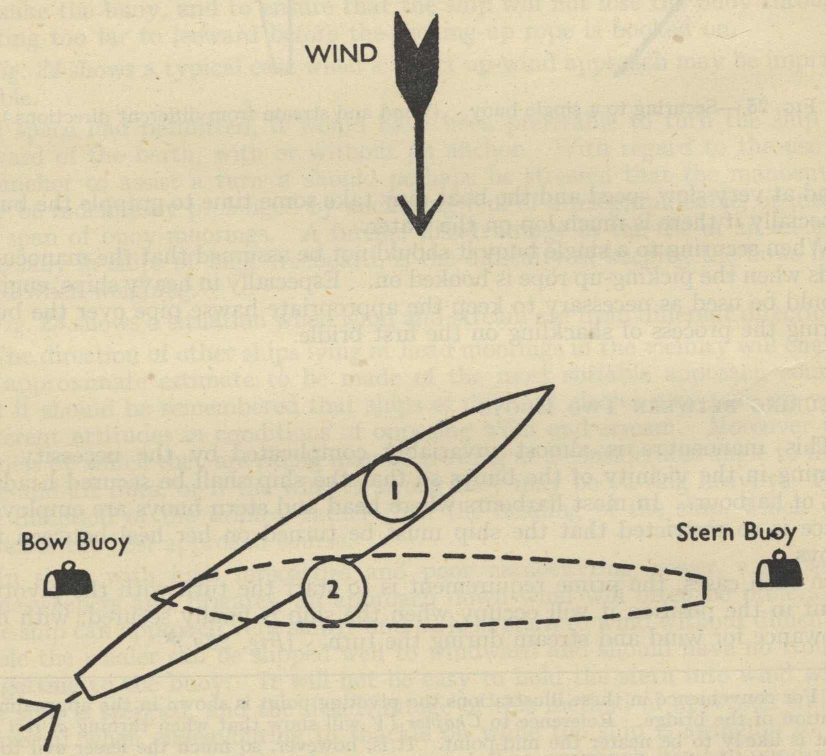


Fig. 26A.—Securing to head and stern buoys.

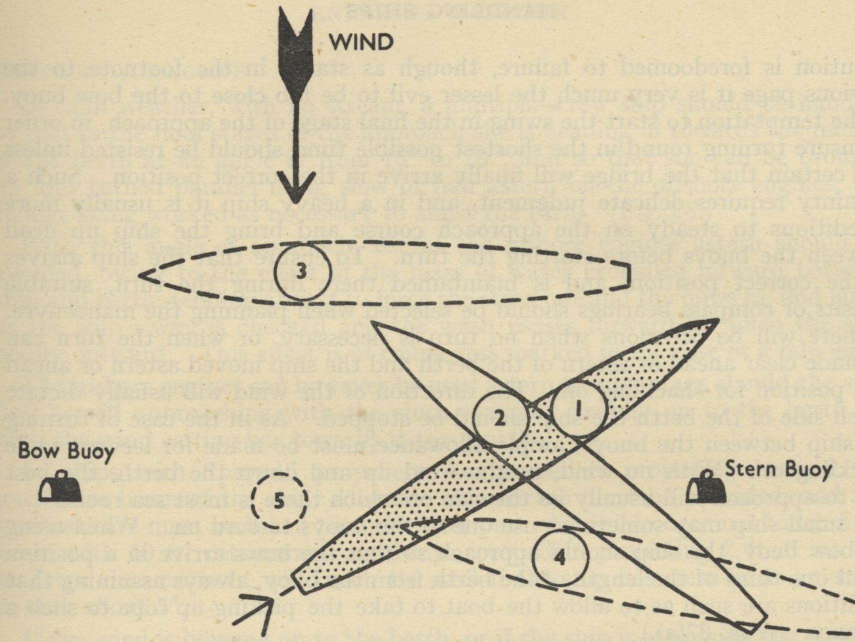


Fig. 26B.—Securing to head and stern buoys—too close to stern buoy.

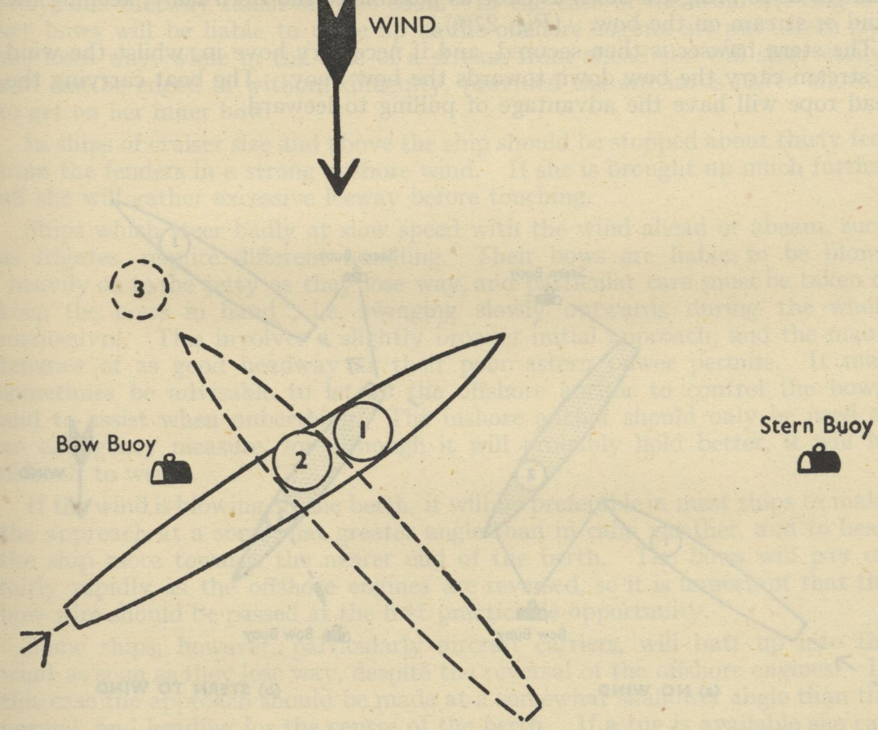


Fig. 26C.—Securing to head and stern buoys—too close to bow buoy.

evolution is foredoomed to failure, though as stated in the footnote to the previous page it is very much the lesser evil to be too close to the bow buoy.

The temptation to start the swing in the final stage of the approach, in order to ensure turning round in the shortest possible time, should be resisted unless it is certain that the bridge will finally arrive in the correct position. Such a certainty requires delicate judgment, and in a heavy ship it is usually more expeditious to steady on the approach course and bring the ship up dead between the buoys before starting the turn. To ensure that the ship arrives in the correct position, and is maintained there during the turn, suitable transits or compass bearings should be selected when planning the manoeuvre.

There will be occasions when no turn is necessary, or when the turn can be made clear ahead or astern of the berth and the ship moved astern or ahead into position for shackling on. The direction of the wind will usually dictate which side of the berth the ship should be stopped. As in the case of turning the ship between the buoys, ample allowance must be made for leeway while shackling on. With no wind, or the wind up and down the berth, the best side to approach will usually be the side on which there is most sea room.

A small ship may sometimes use one of the buoys to turn on. When using the bow buoy, the ship should approach so that the bows arrive in a position about one-third of the length of the berth from the buoy, always assuming that conditions are such as to allow the boat to take the picking-up rope to such a distance. (*Fig. 27(a).*)

The ship is turned by moving the engines slow ahead with full rudder, and at the same time heaving in on the picking-up rope.

When the wind or stream is setting out of harbour, the approach should be made so as to bring the stern as close as possible to the stern buoy, keeping the wind or stream on the bow. (*Fig. 27(b).*)

The stern hawser is then secured, and if necessary hove in, whilst the wind or stream carry the bow down towards the bow buoy. The boat carrying the head rope will have the advantage of pulling to leeward.

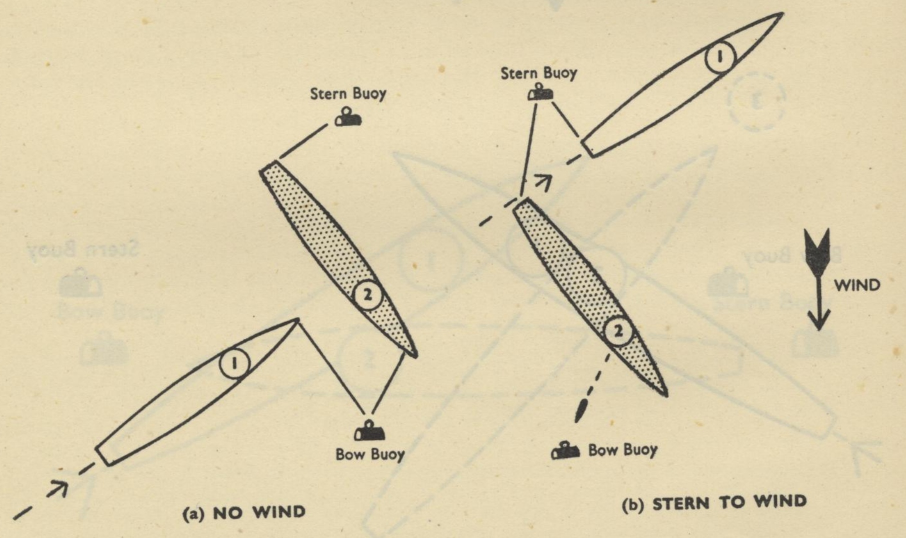


FIG. 27. Securing to head and stern buoys (small ship).

BERTHING ALONGSIDE

In calm weather, with no stream, a multiple-screw ship should be handled so that in the final stages of the approach she is heading in towards the middle of the berth at an angle of from 15° to 20°; and so that she can be brought up and turned parallel using slow or half astern on the offshore engines, the rudder being worked as necessary to assist the turn. (*Fig. 28.*)

With this angle of approach, use of the inshore engines astern should be avoided, owing to the effect of the mass of water propelled forward between ship and berth, tending at first to force the stern out and the bows in, and later, as the ship's way is checked and the wash passes forward, to force the ship bodily outward. This effect is of course less marked in the case of a pile jetty.

The inshore engines can however be used astern to advantage should the ship find herself approaching with the stern swinging heavily on to the berth, or with the wind setting her towards it too rapidly.

In ships with 'proud' propellers, i.e. propellers projecting beyond the maximum beam of the ship, adequate catamarans must be provided, and the greatest care must be taken that the after part of the ship does not touch first. Even with 10 ft. catamarans amidships, propellers projecting 2 ft. 6 ins., as in *Town* class cruisers, will touch the wall if the ship lies stern-in at an angle of only about 5°.

If the wind is blowing on to the berth, or if the ship is stemming the stream, the approach should be made at the same angle as in calm weather, but heading for the far end of the berth or even further off, according to the strength of wind or stream. (*Fig. 29.*) The ship should not be slewed parallel to the jetty, nor the way taken off, too soon. In the case of the wind blowing on, her bows will be liable to come up as the offshore engines are put astern and she loses way, while in the case of a stream from ahead she will steer easily, and can be edged in without difficulty, provided the stream is never allowed to get on her inner bow.

In ships of cruiser size and above the ship should be stopped about thirty feet from the fenders in a strong onshore wind. If she is brought up much further off she will gather excessive leeway before touching.

Ships which steer badly at slow speed with the wind ahead or abeam, such as frigates, require different handling. Their bows are liable to be blown 'heavily on to the jetty as they lose way, and particular care must be taken to keep the bows in hand', i.e. swinging slowly outwards during the whole manoeuvre. This involves a slightly broader initial approach, and the maintenance of as good headway as their poor astern power permits. It may sometimes be advisable to let go the offshore anchor to control the bows, and to assist when unberthing. The inshore anchor should only be used as an emergency measure, for although it will probably hold better, it will be difficult to weigh.

If the wind is blowing off the berth, it will be preferable in most ships to make the approach at a somewhat greater angle than in calm weather, and to head the ship more towards the nearer end of the berth. The bows will pay off fairly rapidly as the offshore engines are reversed, so it is important that the bow wire should be passed at the first practicable opportunity.

Some ships, however, particularly aircraft carriers, will butt up into the wind as soon as they lose way, despite the reversal of the offshore engines. In this case the approach should be made at a somewhat shallower angle than the normal, and heading for the centre of the berth. If a tug is available she can usefully be employed towing ahead, so that she can help to keep the bows off.

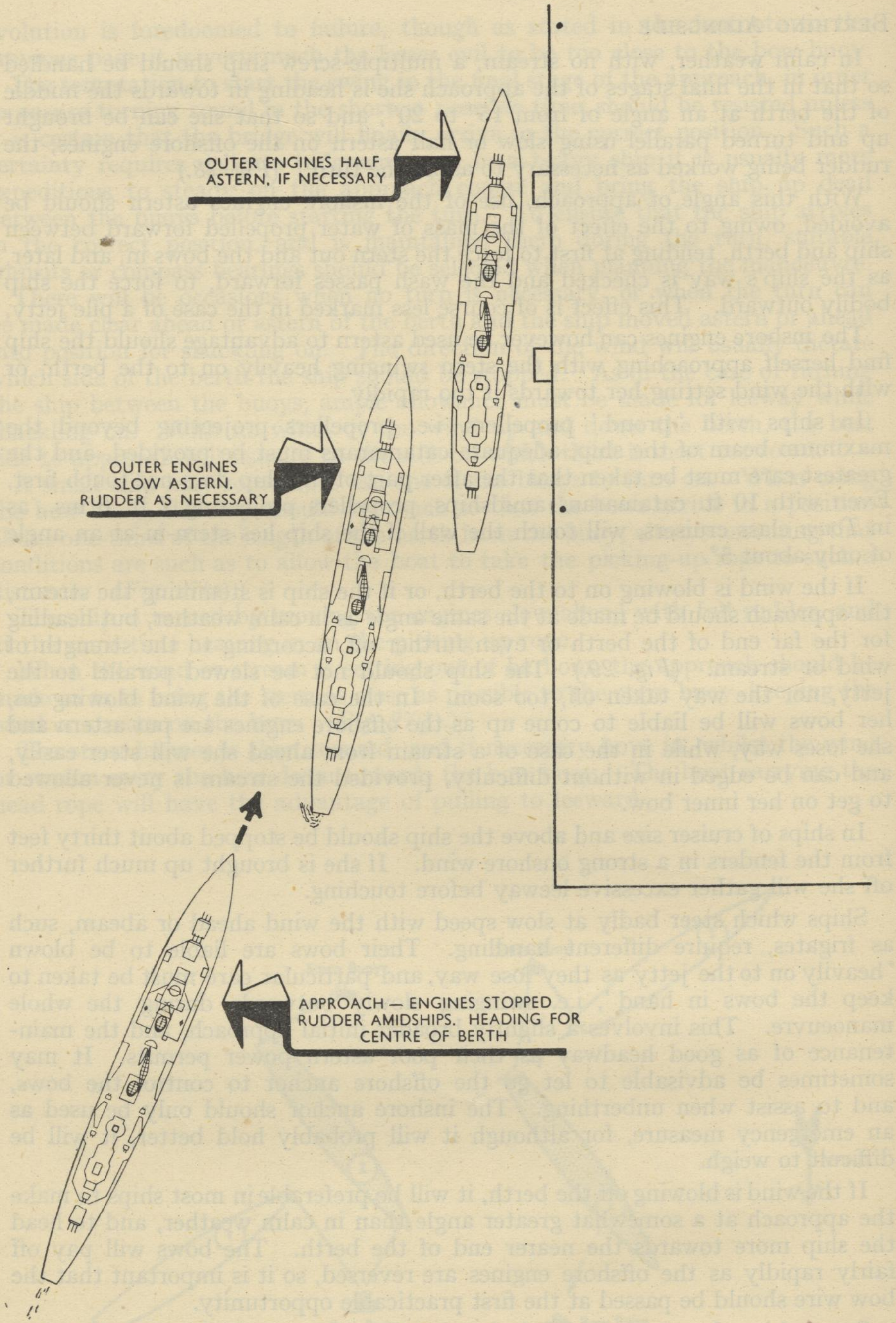


FIG. 28.—Berthing along-side (calm weather).

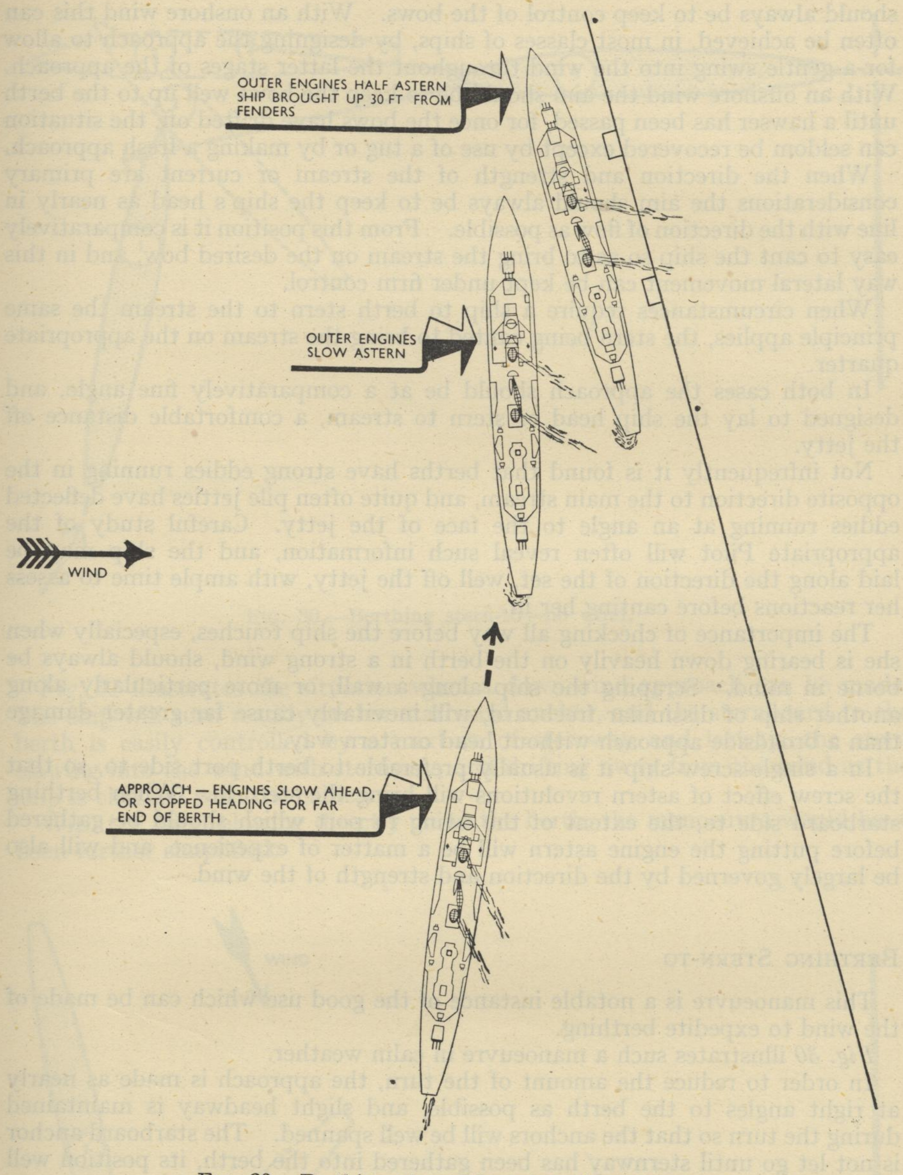


FIG. 29.—Berthing along-side (wind blowing on).

If the wind is blowing along the berth from astern, the approach should always be made at as shallow an angle as possible so that the effect of the wind on the inshore quarter of the ship will not be too marked. Care should be taken not to approach with too much headway.

Every opportunity should be taken to observe the effects of wind and tide on the behaviour of a ship. Frequently, with correct assessment, one factor may be used with advantage to counteract the other. The guiding principle should always be to keep control of the bows. With an onshore wind this can often be achieved, in most classes of ships, by designing the approach to allow for a gentle swing into the wind throughout the latter stages of the approach. With an offshore wind the aim should be to keep the bows well up to the berth until a hawser has been passed, for once the bows have drifted off, the situation can seldom be recovered except by use of a tug or by making a fresh approach.

When the direction and strength of the stream or current are primary considerations the aim should always be to keep the ship's head as nearly in line with the direction of flow as possible. From this position it is comparatively easy to cant the ship so as to bring the stream on the desired bow, and in this way lateral movement can be kept under firm control.

When circumstances require a ship to berth stern to the stream the same principle applies, the stern being canted to bring the stream on the appropriate quarter.

In both cases the approach should be at a comparatively fine angle, and designed to lay the ship head or stern to stream, a comfortable distance off the jetty.

Not infrequently it is found that berths have strong eddies running in the opposite direction to the main stream, and quite often pile jetties have deflected eddies running at an angle to the face of the jetty. Careful study of the appropriate Pilot will often reveal such information, and the ship may be laid along the direction of the set, well off the jetty, with ample time to assess her reactions before canting her in.

The importance of checking all way before the ship touches, especially when she is bearing down heavily on the berth in a strong wind, should always be borne in mind. Scraping the ship along a wall, or more particularly along another ship of dissimilar freeboard, will inevitably cause far greater damage than a broadside approach without head or stern way.

In a single-screw ship it is usually preferable to berth port side to, so that the screw effect of astern revolutions will bring the stern in. When berthing starboard side to, the extent of the swing to port which should be gathered before putting the engine astern will be a matter of experience, and will also be largely governed by the direction and strength of the wind.

Berthing Stern-to

This manoeuvre is a notable instance of the good use which can be made of the wind to expedite berthing.

Fig. 30 illustrates such a manoeuvre in calm weather.

In order to reduce the amount of the turn, the approach is made as nearly at right angles to the berth as possible, and slight headway is maintained during the turn so that the anchors will be well spanned. The starboard anchor is not let go until sternway has been gathered into the berth, its position well inshore of the first making control of the bows easier when weighing.

It is recommended that anchors should be let go on bearings of the bollard to which the stern hawser is to be secured, due allowance being made for the distance between the stern and the pelorus, adjusted for the heading on letting go.

Should it become apparent during the turn that the first anchor has been let go too close to the shore, the situation can be rectified by letting go the second anchor further out.

The turn on the first anchor would have been expedited, particularly in a single screw ship, by a moderate wind from any direction other than offshore.

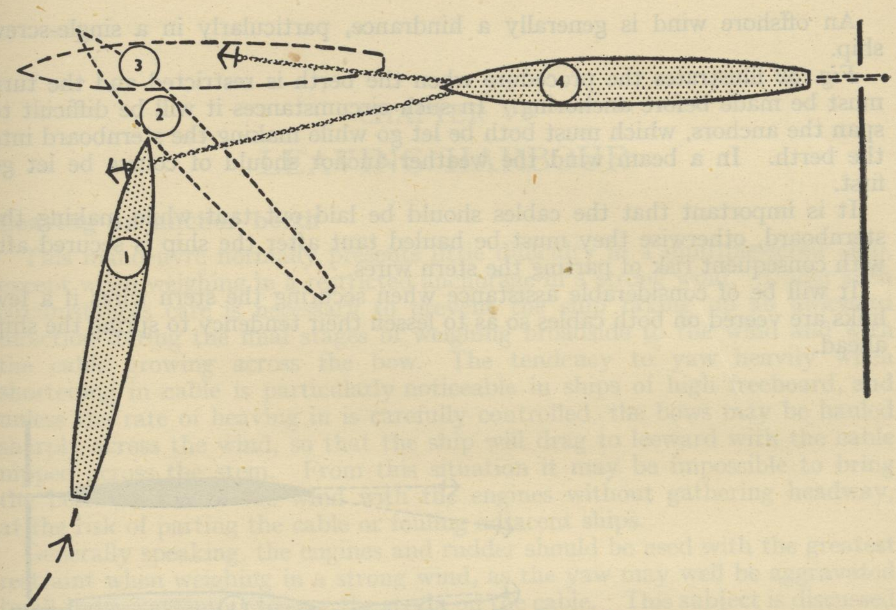


Fig. 30.—Berthing stern-to—no wind.

Fig. 31 illustrates the situation when a down-wind approach can be made. The ship will turn readily on her starboard anchor, and the sternboard to the berth is easily controlled by a mixture of sternway and leeway, the stern clawing into the wind with sternway, and drifting away from the wind as the ship is checked with the cables.

With the wind blowing directly on to the berth, the manoeuvre would have been further simplified.

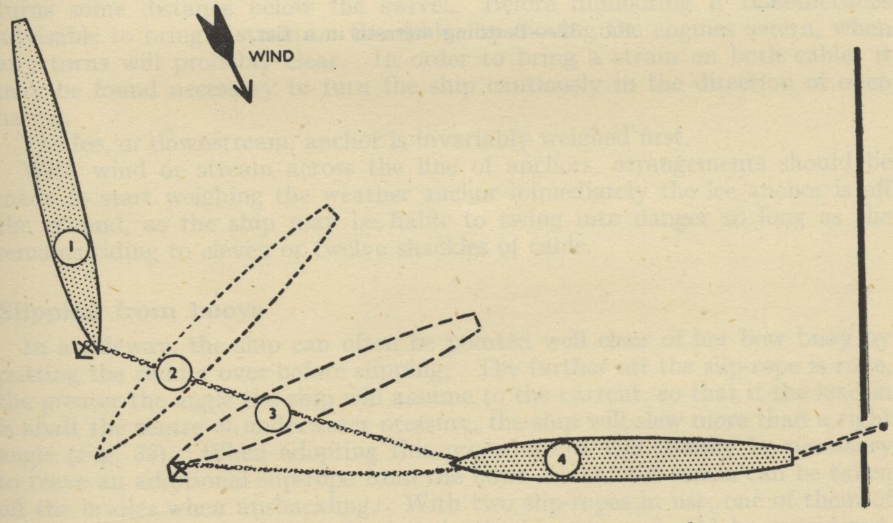


Fig. 31.—Berthing stern-to—down-wind approach.

An offshore wind is generally a hindrance, particularly in a single-screw ship.

Fig. 32 illustrates the procedure when the berth is restricted and the turn must be made before anchoring. In such circumstances it will be difficult to span the anchors, which must both be let go while making the sternboard into the berth. In a beam wind the weather anchor should of course be let go first.

It is important that the cables should be laid out taut while making the sternboard, otherwise they must be hauled taut after the ship is secured aft, with consequent risk of parting the stern wires.

It will be of considerable assistance when securing the stern wires if a few links are veered on both cables so as to lessen their tendency to spring the ship ahead.

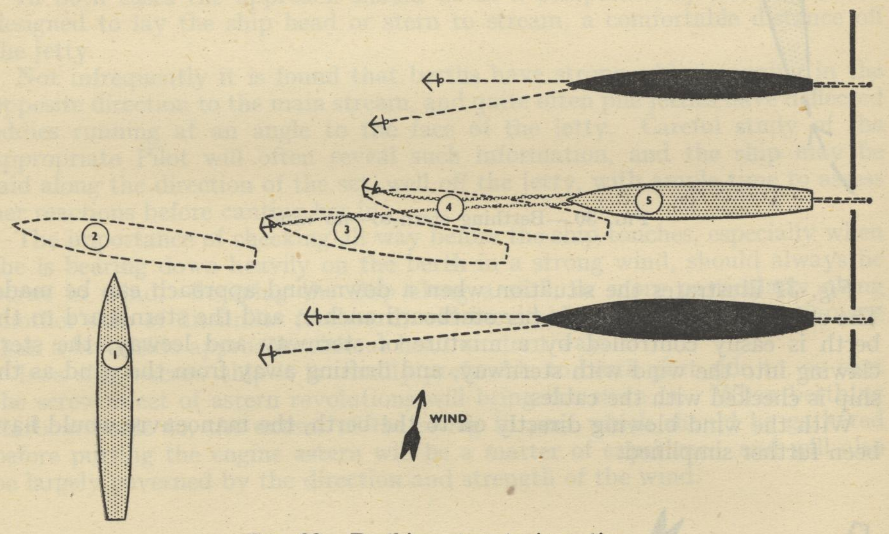


FIG. 32.—Berthing stern-to in a tier.

CHAPTER VI

LEAVING HARBOUR

Leaving an anchor berth

This manoeuvre normally presents little difficulty in a multiple-screw ship, except when weighing in a restricted anchorage in a strong wind. Under such circumstances care is necessary to prevent the ship taking up an awkward direction during the final stages of weighing broadside to the wind and with the cable growing across the bow. The tendency to yaw heavily when shortening in cable is particularly noticeable in ships of high freeboard, and unless the rate of heaving in is carefully controlled, the bows may be hauled sharply across the wind, so that the ship will drag to leeward with the cable nipped across the stem. From this situation it may be impossible to bring the bows back into the wind with the engines without gathering headway, at the risk of parting the cable or fouling adjacent ships.

Generally speaking, the engines and rudder should be used with the greatest restraint when weighing in a strong wind, as the yaw may well be aggravated by ill-judged attempts to ease the strain on the cable. This subject is discussed in greater detail in *Chapter VII*.

In calm weather it may be necessary, in a restricted anchorage, to turn a single-screw ship on her anchor before weighing, the turn being made with engine slow ahead and rudder hard over in the direction of the anchor in use; but if there is any wind, the final process of weighing will usually result in the ship returning to her original heading, so that this method cannot be used.

Unmooring

Although the cables may give the impression of being clear, there may be turns some distance below the swivel. Before unmooring it is sometimes advisable to bring a strain on the cables by moving the engines astern, when any turns will probably clear. In order to bring a strain on both cables it may be found necessary to turn the ship cautiously in the direction of open hawse.

The lee, or downstream, anchor is invariably weighed first.

With wind or stream across the line of anchors, arrangements should be made to start weighing the weather anchor immediately the lee anchor is off the ground, as the ship may be liable to swing into danger so long as she remains riding to eleven or twelve shackles of cable.

Slipping from buoys

In a tideway, the ship can often be pointed well clear of her bow buoy by putting the rudder over before slipping. The further aft the slip-rope is rove, the greater the angle the ship will assume to the current, so that if the lead-in is abaft the centre of underwater pressure, the ship will slew more than a right angle (*Fig. 33*). When adopting this procedure, it will usually be necessary to reeve an additional slip-rope from the bows so that the strain can be taken off the bridles when unshackling. With two slip-ropes in use, one of them of great length, the possibility of a jam in the buoy ring should be considered.

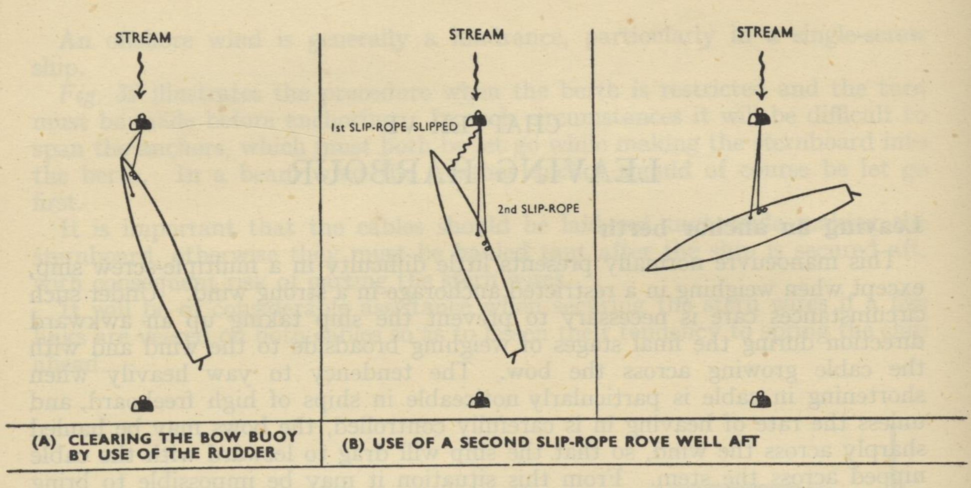


FIG. 33.—Slipping from buoys.

The strain on the second slip-rope will be very severe if the stream is of any strength.

If a slip-rope is rove from right aft, the ship will swing right round with her bows down stream. This procedure is evidently only suitable for very small ships.

When secured between head and stern buoys, similar use can be made of the stern buoy for pointing the ship, if the stream is from astern, but it will be inadvisable to attempt to swing the ship right round as she will probably foul the other buoy.

If the wind is near the beam, time can frequently be saved by easing away both the head and stern slip-ropes, so that the ship rides well to leeward of the two buoys. When ready to slip, both slip-ropes can be let go together, and the engines put ahead at once, though it is more advisable to wait for the report ' All clear aft ' before slipping forward.

Leaving an alongside berth

When leaving an alongside berth unaided by tugs it is usually preferable to leave stern first, after swinging the stern clear by going ahead against a spring. In order that the best use may be made of the spring for this purpose, it is important that the mechanics of the manoeuvre should be understood.

Fig. 34 illustrates the simple reactions on the ship when engines are moved ahead against a spring, and the importance of correct positioning of spring and fender if the stern is to be swung well clear.

It will be seen that the line of the spring must be forward of the point where the ship is bearing on the wall or fender if it is to exert the correct turning moment. But however far forward the spring is rove, it will lose most of its turning effect directly the stem takes on the wall, so that the turn must then be continued, if necessary, with engines and rudder alone.

It is advantageous if the fender can be moved forward as the stem comes in to the wall, but as it may often jam it is preferable to place it initially as far forward as possible consistent with being well abaft the line of the spring, or to have another fender available further forward.

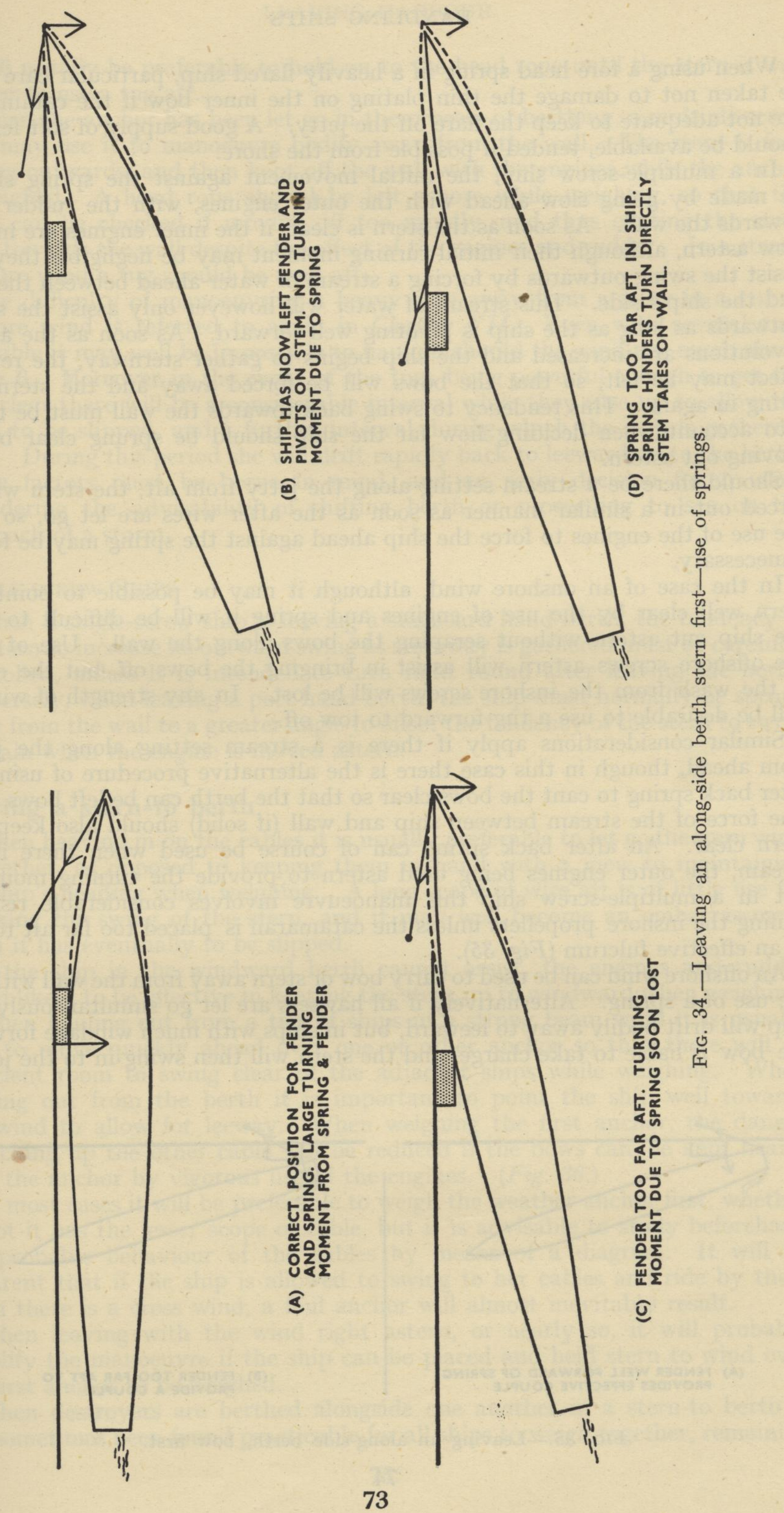


FIG. 34.—Leaving an along-side berth stern first—use of springs.

When using a fore head spring in a heavily flared ship, particular care must be taken not to damage the thin plating on the inner bow if the catamarans are not adequate to keep the flare off the jetty. A good supply of soft fenders should be available, tended if possible from the shore.

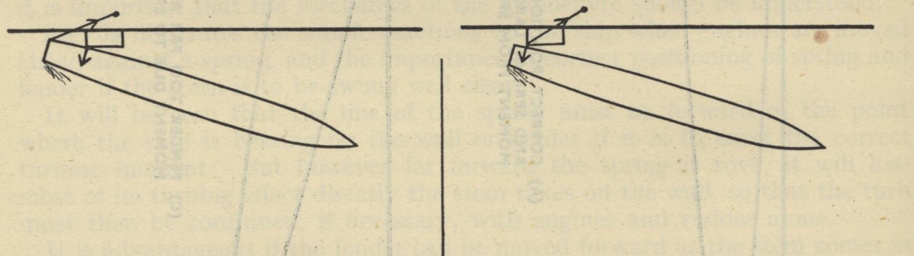
In a multiple-screw ship, the initial movement against the spring should be made by going slow ahead with the outer engines, with the rudder over towards the wall. As soon as the stern is clear, if the inner engines are moved slow astern, although their initial turning moment may be negligible they will assist the swing outwards by forcing a stream of water ahead between the wall and the ship's side. This stream of water will however only assist the swing outwards as long as the ship is pivoting well forward. As soon as the astern revolutions are increased and the ship begins to gather sternway, the reverse effect may be felt, so that the bows will be forced away and the stern will swing in again. This tendency to swing back towards the wall must be taken into account when deciding how far the ship should be sprung clear before moving out astern.

Should there be a stream setting along the jetty from aft, the stern will be forced out in a similar manner as soon as the after wires are let go, so that the use of the engines to force the ship ahead against the spring may be found unnecessary.

In the case of an onshore wind, although it may be possible to point the stern well clear by the use of engines and spring it will be difficult to take the ship out astern without scraping the bows along the wall. Use of only the offshore screws astern will assist in bringing the bows off, but the effect of the wash from the inshore screws will be lost. In any strength of wind it will be desirable to use a tug forward to tow off.

Similar considerations apply if there is a stream setting along the jetty from ahead, though in this case there is the alternative procedure of using an after back spring to cant the bows clear so that the berth can be left bows first. The force of the stream between ship and wall (if solid) should also keep the stern clear. An after back spring can of course be used when there is no stream, the outer engines being used astern to provide the turning moment, but in a multiple-screw ship this manoeuvre involves considerable risk of fouling the inshore propellers unless the catamaran is placed too far aft to act as an effective fulcrum (*Fig. 35*).

An offshore wind can be used to carry bow or stern away from the wall without the use of a spring. Alternatively if all hawsers are let go simultaneously the ship will drift bodily away to leeward, but in ships with much windage forward the bow is liable to take charge, and the stern will then swing in to the jetty.



(A) FENDER WELL FORWARD OF SPRING PROVIDES EFFECTIVE COUPLE

(B) FENDER TOO FAR AFT TO PROVIDE A COUPLE

Fig 35.—Leaving an along-side berth, bow first.

It will usually be preferable to hold on to the head rope until the stern is well out, or to use a tug aft.

When the anchor has been let go in the process of berthing, a multiple-screw ship may use it to manoeuvre bodily away from the wall. The stern is first sprung outwards, and then kept off the wall with the engines while the anchor is weighed. A head rope should be left ashore while weighing, so that the bows can be checked if moving off too rapidly, and thus canting the stern back towards the wall despite the effect of the engines and rudder. In a strong onshore wind a tug should be used aft.

The difficulty of manoeuvring a heavy ship away from a jetty in a strong onshore wind is referred to again in *Chapter VII*. Even with several tugs available it may well be impossible to haul off should the wind rise much above Force 6. Moreover in the event of the tugs being powerful enough to get the ship clear there will be a considerable interval while they ease up to allow the wires to be slipped, and a further interval during which the ship is gathering way. During this period she will drift rapidly back to leeward on to the berth. These factors must be borne in mind, and an early decision taken when considering the advisability of shifting berth or proceeding to sea on the approach of a storm.

Single-screw Ships

When a single-screw ship is leaving a starboard hand berth, the tendency of the stern to increase its outward swing as sternway is gathered must be carefully controlled, unless it is intended to turn right round after leaving the berth. Conversely, when leaving a port hand berth, the ship must normally be sprung away from the wall to a greater angle to offset the tendency of the stern to swing in again when the engine is moved astern.

Leaving a stern-to berth

When heaving in on the cables it is usually preferable to let go the stern wires altogether, as opposed to keeping them in hand with a view to maintaining the ship's heading when weighing. A long scope of wire aft is of little use for checking the swing of the stern, and it may well become an embarrassment when it has eventually to be slipped.

If the ship in the windward berth cannot assist, the engines and rudder are unlikely to be effective in keeping the stern up to windward when weighing, so when hauling out from a tier of ships in a strong beam wind it is usually best to move quickly ahead over one or other anchor so that there will be sufficient room to swing clear of the adjacent ships while weighing. When moving out from the berth it is important to point the ship well towards the wind to allow for leeway. When weighing the first anchor, the danger of picking up the other cable will be reduced if the bows can be kept nearly over the anchor by vigorous use of the engines. (*Fig. 36.*)

In most cases it will be preferable to weigh the weather anchor first, whether or not it has the lesser scope of cable, but it is advisable to study beforehand the probable behaviour of the cables by means of a diagram. It will be apparent that if the ship is allowed to swing to her cables and ride by them when there is a cross wind, a foul anchor will almost inevitably result.

When leaving with the wind right astern, or nearly so, it will probably simplify the manoeuvre if the ship can be placed and held stern to wind over the first anchor to be weighed.

When destroyers are berthed alongside one another in a stern-to berth it has sometimes been found practicable for all ships to weigh together, remaining secured to each other until anchors are aweigh; the outer propellers of the wing ships being used to maintain the heading of the group, or to turn the group into the fairway after weighing.

This procedure is not suitable if the anchors of the wing ships are laid ont at a broad angle, nor if there is a strong cross wind.

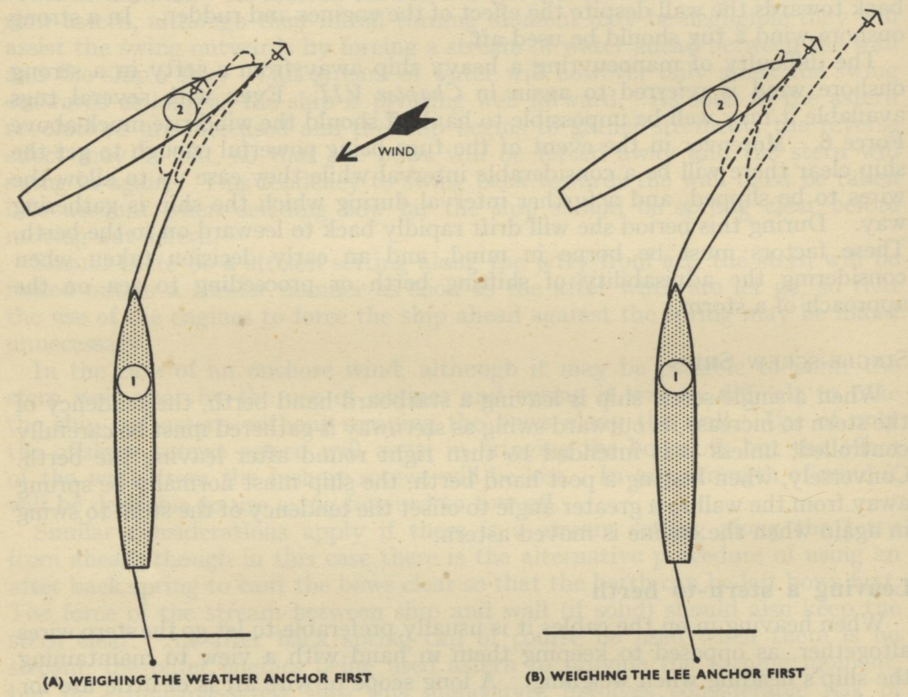


FIG. 36.—Leaving a stern-to berth in a cross wind.

CHAPTER VII

HANDLING SHIPS IN HEAVY WEATHER

This subject is of fundamental importance to the seaman, but has tended to become obscured by the great increase in size, strength, and power of ships during the past half-century. There is to-day perhaps an undue reliance on the ability of the modern steel hull and superstructure to take any punishment which the sea can inflict, and a tendency to regard weather damage as an unavoidable misfortune or an honourable wound. In many instances it is neither, and in such circumstances is as culpable as any other damage resulting from careless shiphandling.

The behaviour of a ship in heavy weather should be a study of equal importance to an officer assuming a new command as are her handling qualities in narrow waters, and as recommended in *Chapter IV* all the relevant information in the Ship's Book and Navigational Data Book should be studied, and the earliest opportunity taken to observe the ship's behaviour in a seaway. The experienced seaman will quickly form an assessment of the extent to which his ship can be ' driven ' without damage, and of the best course of action to ensure her safety in extreme weather conditions.

The superficial damage to which a warship is liable in heavy weather includes damage to or loss of boats, damage to guard rail and awning stanchions, and flooding of spaces through inefficient or damaged hatches and ventilating trunks. The risk of this type of damage must of course frequently be accepted for operational reasons, but as frequently can be avoided by quite minor adjustments of course and speed involving little or no alteration to the ship's timetable.

Under extreme weather conditions there will in addition be risk of damage to hull, superstructure, and machinery, seldom justifiable even for operational reasons.

The decision as to the degree of risk of weather damage which must be accepted is often complicated, and will not be discussed in this chapter, which is primarily concerned with the handling of the ship to the best advantage once this decision has been taken. It may not be out of place however to stress the responsibility of a force commander for the safety of the ships under his command, and the responsibility of individual ships for informing their senior officer if weather conditions seem likely to result in damage if course and speed are maintained. While the heaviness of the going for the smaller ships may not be appreciated in time by the force commander, it will also sometimes be the case that the smaller ships do not appreciate that their larger consorts may be unaware of the degree to which conditions have deteriorated, particularly at night.

Characteristics of sea and swell waves

The formation and action of waves at sea is discussed in some detail in the *Admiralty Manual of Navigation, Volume III*. Some of the more important facts which emerge are as follows:—

(*i*) The particles of water in an unbroken wave do not move along with the wave, but oscillate within quite narrow limits, moving upwards as the crest approaches, forwards as the crest passes, downwards as it recedes, and backwards almost to their original positions as the trough passes.

(*ii*) Both length and steepness increase with wind speed, but when the wind rises above ten knots the rate of increase of height becomes much greater than that of length. No individual wave can however attain a steepness of more than that which corresponds to a height/length ratio of about 1 in 10 without breaking at the crest.

(*iii*) A group of waves moves at only half the speed of the individual waves forming the group.

Consequently the same wave does not remain the highest of a group, but waves passing through a group attain their maximum height at the centre.

'White horses' do not therefore remain on the same waves, and in a simple wave formation a wave only foams at the crest when passing near the centre of a group. In a cross sea, which is the rule rather than the exception, waves will however break more frequently.

In deep water, the water forming the broken crest of a wave may be considered as moving forward and downward at about half the speed of the wave.

(*iv*) In the most general terms, the fact that a wave attains its maximum height when passing near the centre of a group accounts for the familiar periodic appearance of an extra large wave. The combination of two or more wave patterns similarly results in a fairly regular recurrence of groups of large and small waves, with occasional periods of comparative calm. The number of waves in each group, and the interval between successive appearances of extra high groups varies with the type of sea.

Effects of wave motion on a ship

All ships have a natural period of roll and pitch according to their dimensions and condition of loading.

The period of roll is the time a ship takes to roll from one side to the other and back again.

The period of pitch is the time the bows of a ship take to rise from the horizontal, fall, and return to the horizontal.

The period of encounter is the time interval between the passage of two successive wave crests past any given point in the ship.

The movement of a ship in roll or pitch depends on the size of the waves and the relation between the period of encounter and the ship's period of roll or pitch, the greatest movement developing when there is synchronisation. The period of encounter depends on the wave length, and on the wave speed relative to the ship. Thus the period of encounter can be varied by alteration of the ship's course and speed.

When the period of the ship is small in comparison with the period of encounter she will tend to ride the waves, keeping her deck parallel to their slope. In a beam sea this will result in rapid, heavy rolling. In a head sea a small period of pitch should result in an easy motion, without shipping much water.

When the period of the ship is large in comparison with the period of encounter she will roll or pitch independently of the waves. In a beam sea this should mean a comparatively easy motion, though waves slapping against the weather side may make her wet. In a head sea a comparatively long period of pitch may result in occasional burying of the bows and exposure of propellers and rudder.

When the period of encouter approaches synchronisation with the period of roll or pitch, the ship's motion will be violent. In a beam sea this may result in dangerously heavy rolling, while in a head sea the severe and rapid pitching movement may cause frequent racing of propellers and unfair hogging and sagging strains.

Heaving

Another important effect of wave motion on a ship is the loss of stability she will suffer as she rides over the crest of a wave. In a ship with a low reserve of stability this may result in a dangerous increase of roll or list, particularly in a high beam wind.

The Effect of Breaking Waves

Although in a high wind the sea may appear to be a continuous succession of breaking crests, most of the broken water is often wind-blown, and it is only near the centre of each group and combination of groups that waves will attain the necessary height/length ratio to break with full force. Waves will also break as a result of meeting an obstruction, or when the water shoals to less than about twice their height, or when they encounter a contrary stream.

As previously remarked, the forward motion of the water in a wave crest is greatly increased directly the wave breaks. Moreover the front of broken water is considerably steeper than the front of an unbroken wave. The impact of a breaking wave on a ship is thus very much more severe, and it is likely to cause more structural damage as well as being a greater threat to stability.

Shiphandling in heavy weather

No rules can be laid down for the best action to be taken by different classes of ship to avoid weather damage in varying circumstances, and the following remarks are therefore couched in the most general terms.

Head Sea. Excessive Pitching

The most effective action will usually be to increase the period of encounter by a reduction of speed. There may however be occasions, when the wave length is appreciably less than the length of the ship, when a considerable *increase* of speed will be more effective, through reducing the period of encounter so that the ship will not have time to develop a heavy pitch, and will cut steadily through the waves.

An increase of speed, if ineffective, may well result in heavier damage, and should normally only be attempted when a reduction has been found unsatisfactory.

Ships with wide and heavily-flared bows such as aircraft carriers are particularly liable to damage through pounding into a heavy head sea, and will often be found to be taking more punishment at quite moderate speed than much lighter ships with straighter bows, such as destroyers. Destroyers on the other hand, on account of their comparatively light construction, will not stand being pitched violently into a head sea at high speed. They tend to bump heavily and to bury their bows, with resultant heavy bending strains forward, and in recovering to scoop a great weight of water over the forecastle, which may damage guns and superstructure.

Similar remarks apply to cruisers, particularly those with very fine lines and little flare, such as the *Colony* class.

Pitching can also be reduced by an alteration of course to bring the sea on the bow, while maintaining the speed. Although the period of encounter is thus increased, the resultant motion will often be more uncomfortable, and the ship wetter, and steering may become difficult. On the other hand an alteration of course will in certain conditions be the only method of reducing propeller racing.

Beam Sea. Excessive Rolling

An alteration of speed will have little effect on the motion of the ship in a beam sea, but an alteration of course, by reducing or increasing the period of encounter, will have considerable effect.

In most cases a ship which is rolling excessively will be more comfortable if the sea is brought on the quarter, rather than on the bow, though the resultant yawing may be heavy. In destroyers, for instance, steering may become impossible in a heavy quartering or following sea, and it then may be necessary to heave to head to sea.

Heavy ships will rarely roll so violently in a beam sea that course must be altered to avoid damage to boats or loss of stability. Their period of roll is usually large compared with the period of the steep seas which in shallow water or intense local storms may cause excessive rolling in smaller ships of shorter period.

Following Sea. Yawing, Pooping, and Broaching to

The greatest danger under this heading is loss of control through remaining too long on the forward slope of a wave, particularly when it is breaking. This will result in planing or surfing with rudder almost useless, and if a heavy yaw develops, the probability of broaching to when the bows eventually bury themselves in the trough. In a sea of such dimensions as to be capable of this effect, e.g. of equal length to the ship or greater, it is therefore important that the ship's speed should be kept well *below* the wave speed.

In a heavy ship this will not present much difficulty, as waves of 600 ft. or more in length will usually have a speed of at least 30 knots. Waves of 300 ft. and less may however be travelling at under 15 knots, and it is in these circumstances that destroyers and small escort vessels must watch their speed carefully in a heavy following sea.

A further drawback to high speed in a following sea, particularly noticeable in small ships, is the build up in height of the waves as they combine with the ship's stern wave.

Loss of control may also occur when the ship is borne for any length of time on a wave crest. Both bow and stern will ride high in the water, the rudder will lose efficiency, and the propellers may race. Should the ship finally pitch down the forward slope she may take a violent sheer and broach to, while if she falls back into the following trough she will do so with a wallowing action and may be pooped if the next wave is breaking heavily.

Although a reduction of speed in a heavy following sea will increase the danger of pooping, the results of broaching to are likely to be more disastrous. The ship may yaw at right angles to her course and be thrown violently on her beam ends, in which position she is at the mercy of the next wave which, if it breaks onboard, will make a clean sweep of her upper deck, if it does not capsize her.

Both the height and steepness of waves are increased on reaching shallow water, so that when crossing a river bar from seaward there is increased danger of broaching to, with the attendant risk of running out of the buoyed channel

after being turned across the sea. The temptation to 'make a dash for it' must be firmly resisted, and the speed kept well below the wave speed.

Heaving to

When weather conditions become so extreme that the immediate requirement to ride out the storm in safety outweighs all other considerations, the ship may be forced to heave to.

A warship will normally have sufficient engine power and manoeuvrability to enable her to be brought either head or stern to sea. The decision as to which course to adopt will depend on the class of ship and the sea room available to leeward. The condition of drifting in the trough of the sea with engines stopped will usually result in excessive rolling, and is not to be recommended, though a low-powered merchant ship may find this the safest method in certain states of trim, particularly if the ship will lie with wind and sea abaft the beam and if an effective oil slick can be laid.

Generally speaking, medium-sized cruisers and below will handle better when steaming slowly with the sea slightly on one bow. In a heavy following sea these lighter ships are prone to excessive yawing, and may broach to or be pooped. Single-screw ships, such as some older frigates, heaving to head to sea, will usually find that the ship's head can be kept up more easily when the wind is fine on the port bow. In multiple-screw ships the use of the lee engines only may help in maintaining a course slightly off the wind.

Larger ships will often be more comfortable steaming dead slow with the sea a point or two on the quarter, or right astern, the choice being a matter for trial and error. Aircraft carriers in particular are liable to damage their bows when pounding heavily in a head sea, even at the slowest speed which will give steerage way, while battleships, with their lower freeboard and more sluggish movement, may ship a tremendous weight of water.

The use of oil may be extremely effective in preventing the waves breaking, particularly in the case of a ship drifting with engines stopped, or when spread from windward by another ship. The various methods of releasing the oil to the best advantage are fully described in the *Manual of Seamanship*. Oil should be used in moderation, particularly in rescue or salvage work when boatwork may have to be attempted, or lines hauled through the oily water.

In small ships a sea anchor may be helpful in keeping wind and sea abaft the beam when drifting, but a sea anchor of sufficient size to keep the ship head or stern to sea is unlikely to be practicable.

Turning in a Heavy Sea

There may be considerable risk in attempting to turn a ship about in a heavy sea, and good judgment is required in selecting the most suitable moment to start the turn.

If head to sea, and turning to run, the risk of damage is generally greatest half-way through the turn, when the sea comes on the beam, and it is at this point that the greatest difficulty will be found in forcing the ship round. Before starting the turn, therefore, the arrival of the relatively calm periods must be carefully timed, and an estimate formed of the probable rate of turn, so that the time that the ship will be beam on may coincide with a calm period.

The turn should be made as rapidly as possible, but without developing too much headway. This can best be achieved by short bursts of speed against full rudder in the early part of the turn, perhaps helped by reversal of the inner engine. Once the ship is half-way round, the turn should be completed at full power on both engines, the speed of the engines being reduced again immediately it is seen that the ship is answering.

In a following sea, speed should be reduced as far as is practicable before starting the turn. The ship will probably swing round to the beam-on position fairly rapidly, and on this account it would seem preferable to reserve a relatively calm period for the last and more difficult half of the turn, but the risk of broaching to if the turn is started at an inopportune moment must also be borne in mind. In order to complete the turn as quickly as possible without gathering undue headway into the sea, it may be helpful to reverse the inner engine, but much will depend on the normal handling powers of the ship. Maximum ahead revolutions on both engines against full rudder may well be needed to bring her bows up into the wind.

Factors Contributing to Heavy Rolling

Light Draught. Though a warship is not subject to the great variations in draught of a cargo ship, the effect of expenditure of fuel and ammunition on rolling qualities may be appreciable. Although the inconvenience of cleaning salt water out of flooded fuel tanks is considerable, flooding may occasionally be necessary to avoid weather damage due to excessive rolling.

Free water. The free movement of water from one side of the ship to the other, whether in flooded compartments below the centre of gravity, or on deck, will increase the period and degree of roll. This effect will be most marked when the free water is high in the ship, e.g. in bulwarked ships with inadequate or inefficient freeing ports. In ships with continuous bulwarks or well decks, such as small escort vessels and tugs, the correct functioning of freeing ports is essential to stability in rough weather.

Snow and ice. Any considerable coating of snow and ice on rigging, superstructure, or on deck, will obviously affect the stability of a ship adversely, but to an extent which may not be generally appreciated. For instance, a deposit of six inches of loosely-packed snow on the flight deck of a large aircraft carrier can add a topweight of as much as 100 tons, while a coating of two inches of frozen spray over the exposed area of a cruiser's upperworks may amount to 30 tons or more. When de-icing is impracticable, due allowance must be made for the modified sea-keeping qualities of ships in such conditions.

Action damage. Measures to restore stability lost through action damage are fully discussed in the Handbook of Damage Control.

Anti-Rolling Devices

Bilge Keels are the simplest and most common form of anti-rolling device, and are fitted in the great majority of H.M. Ships. They are built approximately perpendicular to the hull, at or near the turn of the bilge, and are usually continuous over about half the length of the ship. In general, bilge keels materially decrease the amplitude of roll, and slightly increase the period. Their effectiveness increases with the forward speed of the ship, and largely for this reason a ship will usually roll most heavily when stopped and drifting in a beam sea.

Gyroscopic stabilisers have been fitted in some merchant ships and yachts. They are an effective form of stabiliser, but have the disadvantage of great weight, and, so far as warships are concerned, the vulnerability of the heavy rotating element.

Fin stabilisers are fitted in a number of H.M. Ships. In this system, in its most simplified form, retractable rudder-type finds project almost horizontally through the side of the ship at points near the turn of the bilge on each side.

The angle of incidence of the fins to the flow of water past the ship is varied automatically as the ship rolls, the leading edges of the fins on the side which is moving down being turned up, and vice versa. The disadvantage of this system of stabilisation, apart from its complexity and weight, is that the effectiveness of the fins depends on the ship's forward speed through the water, and that their operation involves a small, though appreciable loss of speed.

Anti-rolling tanks, which reduce the amplitude of roll by varying the amount of water in tanks on opposite sides of the ship, have been fitted in the past to some merchant ships. Considerations of weight, space and vulnerability make this system quite unsuitable for warships.

HEAVY WEATHER IN HARBOUR

At anchor

Most warships, because of the disposition of their superstructure, will yaw violently when lying at single anchor in a gale. It is when falling back on her cable after 'fore-reaching' at the extremity of a heavy yaw that a ship is most likely to dislodge her anchor. A second anchor let go underfoot can thus be effective not only in reducing the extent of the yaw but also in checking the tendency to surge ahead towards the riding anchor. When used with this intention, the precise moment at which the second anchor is let go is probably of little importance, observing that it will drag over the bottom as the ship continues to yaw—albeit to a reduced extent. Most seamen will prefer to let it go near the middle of the yaw.

When very severe weather is expected, the second anchor is probably best used to back up the riding anchor, provided that sufficient cable remains in the locker for the riding cable to be veered a further three or four shackles. In this case the second anchor should be let go at the extremity of the yaw away from the riding anchor, and the cables veered together so that the ship lies back on both. The principal objection to this procedure is the possibility that a shift of wind may lead to difficulty when it is required to weigh the second anchor.

The most effective use of the second anchor has long been a subject of controversy amongst seamen.

Steaming to the cable to ease the strain is not a recommended practice. It will be difficult or impossible to judge the direction of the anchor, and the danger of steaming up abreast of it while yawing needs no elaboration.

At a head buoy

If secured to a head buoy, on the other hand, the strain on the bridles and buoy mooring may be effectively eased by judicious use of the engines. In the blinding rain which often accompanies a storm, an officer in the eyes of the ship and in telephonic communication with the bridge should be able to ensure that a fair strain is kept on the bridles and that the ship does not over-ride the buoy.

Anchoring in a gale

As remarked in *Chapter V*, the usual procedure, whereby the cable is laid out in a straight line as the ship loses headway, may lead to an awkward situation in a strong wind because of the tendency of the ship to fall back broadside on. Similarly if the anchor is not let go until headway has been lost, the ship will fall heavily off the wind, and when checked will probably dislodge her anchor. In both cases the second anchor, if let go with the intention of backing up the first anchor, will almost certainly become foul, particularly if the ship has fallen off so that the cable of the first anchor is across the stem or under the ship.

It would appear preferable to approach the berth a point or two off the wind, and with bare steerage way. The weather anchor is let go, and as the ship loses her way she will start to fall off further at a rate which may be controllable to some extent by the engines and rudder. The cable will thus be laid out approximately at right angles to the wind, and will then be dragged to leeward in a wide bight. The second (lee) anchor can be let go as the ship starts to get her cable, and both cables are then veered as requisite. A foul anchor is unlikely to result from this procedure as the side of the first anchor is kept boldly presented to the wind, and the cable is not dragged back over itself in a narrow bight. Moreover, the anchor is less likely to be dislodged if turned flat on the bottom than if ' somersaulted ' by a pull from the opposite direction to that in which the cable was originally laid.

Ships such as escort carriers, which are particularly unhandy at slow speed in strong head winds, may find it preferable to approach the berth down wind. If this procedure is adopted the engines must be put astern in good time, say half cable before letting go and the ship kept stern to wind with the engines while laying out the cable. When she is finally brought up by her cable she should swing rapidly round without dislodging the anchor, but it is important that the turn should be made towards the hawse pipe in use. The second anchor can be let go underfoot when the ship has swung. It should not be let go earlier, or the cables will be crossed.

Weighing in a gale

If the decision to shift berth or proceed to sea is delayed until the ship starts to drag, considerably difficulty may be experienced in weighing, particularly when the ship has been riding to both anchors and has dragged them in alignment with the wind.

If the capstan arrangements allow both cables to be hove in simultaneously, the anchor with the lesser scope of cable can probably be weighed first, provided the other cable is kept taut. Much will depend on the behaviour of the ship but it will usually be best to try and keep the anchor which is being weighed at open hawse by use of the engines, though this will often be impossible if the ship is yawing violently.

If only one cable can be hove in at a time, the cable with the longest scope must be weighed first. If this anchor can be prevented from coming home it will not pick up the other cable but as soon as it has been weighed, the ship will fall heavily back on the other and much will depend on the speed with which this second cable can be brought to the capstan and hove in. In case the ship should get into a difficult situation when attempting to weigh the second anchor, preparations should be made to buoy and slip the cable.

If the nearer anchor is weighed first, leaving the other cable slack on the bottom, there will almost certainly be trouble as the ship yaws and pulls the slack cable over the anchor which is being worked.

If the second anchor was used underfoot, it can be weighed without difficulty. When weighing the riding anchor, engines and rudder should only be used when absolutely necessary to assist the capstan, otherwise yawing may be aggravated. Similarly the rate of heaving in should be regulated so that the bows are not hauled violently across the wind.

Leaving a head buoy in a gale

If buoy work is impossible, the cables must be broken on deck and the bridles slipped. When one anchor is catted the work of uncatting should be progressed as far as possible before slipping so that anchor and cable may be secured before reaching the open sea.

The strain on the buoy mooring is likely to be such that the buoy will spring back well clear of the ship on slipping, so that there will be no difficulty in avoiding it if the engines are put ahead at once.

Leaving head and stern buoys in a gale

When it is practicable to slip the stern wires and swing to the bow buoy, the problem is uncomplicated, but in harbours where head and stern moorings are provided it is unlikely that there will be much swinging room. There may also be occasions when it is possible to slip the bow buoy and swing to the stern buoy before proceeding, but more often, when the wind is broad on the beam or abaft the beam, it will be preferable to slip both buoys simultaneously. Every precaution must be taken to ensure that there is no delay at either end, and that the propellers are not fouled by the stern wires or slip rope.

Leaving an alongside berth in a gale

The most difficult situation will be when the wind is blowing on to the jetty. Although tugs may succeed in hauling the ship clear, she will not be able to move ahead or astern so long as they are pulling, for fear of girding them. The essence of the problem therefore is that the ship should be hauled sufficiently clear to ensure that she does not drift back on to the jetty during the period when she is slipping the tugs and gathering way.

If a fore spring proves ineffective, a small ship may be able to cast her stern well out by running a wire from right forward to a point well inside the jetty. When the engines are moved astern, the bows will be hauled into the jetty and the ship will pivot on them as she tries to align herself with the pull of the wire. She will gather sternway more rapidly on slipping than she would if a fore spring had been used and she is therefore less liable to scrape her bows heavily on the jetty before getting clear.

When an anchor has been let go in the process of berthing, the manoeuvre is considerably simplified. If a tug is not available, the first consideration will be to get the stern clear by going ahead on a fore spring. The cable is then hove taut and the spring slipped as the bows come clear of the jetty. While weighing the anchor the stern is kept out with the engines and rudder.

CHAPTER VIII

HANDLING SHIPS IN ICE

This subject is discussed in some detail in recent editions of the Arctic and Antarctic Pilots, and in certain special publications, amongst which the *Manual of Ice Seamanship* (U.S. Navy Hydrographic Office Publication No. 551) is of particular interest.

The following chapter deals solely with the ship-handling problem as applied to warships, and omits the more general aspects of ice navigation such as the formation and movement of sea ice and the variation in ice conditions with season and locality. The descriptive terms conform to those used in the Admiralty Sailing Directions, but for convenience a repetition or expansion of some of the more common definitions is given below.

Pack-ice

Any area of sea ice other than fast-ice (which is ice that has developed from shorewards, i.e. is ' fast ' to the coast).

Sludge or Slush

The initial stage in the freezing of sea water, when it assumes a greasy appearance and a scum of ice crystals is formed on the surface. Sludge is little hindrance to navigation, though it will reduce the ship's speed for a given number of revolutions, and may choke circulating water intakes if these are near the surface. Bottom logs, asdics, etc., need not be housed in sludge, though a towed log becomes useless. Sludge should not be confused with Brash or Mush, which are terms applied to small fragments of other forms of ice, e.g. the wreckage of drift-ice.

Pancake-ice

The next stage in development after sludge. Pancakes from 1 to 6 feet across, and approximately circular in shape, form after 2 or 3 days of freezing temperature. Before consolidating into floes, these pancakes may be a foot or more in thickness. They generally have raised rims due to the pieces striking against each other. In an area of pancake-ice the pieces are usually crowded together, but with unfrozen water in the many spaces between their points of contact. The majority of H.M. Ships will not be able to maintain their normal cruising speed in pancake-ice without risk of damage to plating. If forced under the ship this type of ice may damage a bottom log or asdic dome, and can bend or break a propeller blade. It is impracticable to run paravanes or to use any form of towed sweep in pancake-ice.

Drift-ice

Loose, very open pack, in which the majority of floes are of greater size and age than pancake ice but are more widely separated, so that the area of clear water is greater than that of ice. There is no clear distinction between drift-ice and open pack, but the former term is applied to smaller and lighter floes which are often soft and in a state of decomposition, though in this case they may have relatively hard underwater spurs due to the melting back of the exposed ice. Drift-ice should be treated with respect, and when the larger floes cannot be avoided they should be approached with caution. Drift-ice

will restrict the use of paravanes, sweeps, etc., in proportion to the frequency of the floes and the possibility that the ship may have to steam dead slow or stop. As a general rule their use should not be attempted.

Open pack. This term is applied to an area of heavier floes, for the most part not in contact but with many leads and pools through which a ship can be navigated with caution.

Close pack. The floes are mostly in contact and will block the passage of any but specially strengthened vessels.

Deliberate and routine passages through pack-ice should only be attempted by specially equipped vessels, but more or less impromptu operations in drift-ice and open pack may be required of any class of ship. The majority of H.M. Ships are quite unsuited for forcing a passage through close pack, and it must be clearly understood that when such conditions are discussed in subsequent paragraphs, the circumstances in which a ship is compelled to adopt these ice-breaking tactics are assumed to be dictated by emergency.

Damage which may be caused by ice

As in the previous chapter, the ship-handling problem is best approached by an examination of the type of damage to which a warship is subject when working in these exceptional conditions.

The chief source of weakness is the bow plating, which generally speaking will be unsuitable for impact, except at very slow speed, with large masses of hard ice of a greater thickness than 1 foot, the average thickness of pancake-ice. Although thicker floes may be pushed aside, a large and unyielding floe is liable to bend the stem, or may tear open the plating as the ship slews round after impact. The majority of floes are at least 3 feet thick, and unless composed of very soft ice cannot be penetrated with safety.

Propeller blades are very liable to bending or fracture from impact with ice, though in some warships they are so deeply immersed that only an upended floe will be dangerous. On the other hand the majority of warships are fitted with multiple screws, which are considerably more liable to damage than a centreline screw. Similarly twin rudders are a great disadvantage when working through ice. Trim by the stern is usually advisable to obtain deeper immersion of propellers and rudder, but an extreme ' bows light ' condition will have an adverse effect on manoeuvrability, and should be avoided. Bilge keels are a major source of trouble through their liability to be wrenched away from the hull on impact with ice forced under by the ship's advance. Other hull projections such as scupper guards, eye-bolts, and even rivets, may also be the cause of serious leaks.

In the extreme case of the ship being beset in the ice, the square cross-section of the average warship's hull will render her particularly liable to be crushed.

Operations in drift-ice

The only effective way of avoiding damage is evidently to avoid contact with the ice. This may be possible at slow speed in drift-ice, that is to say very open pack with large areas of clear water between the floes. When the floes cannot be avoided they can often be fended off with long staves. This may not be practicable from the forecastle, because of its height, but should be quite feasible from the quarter deck, where it is of particular importance owing to the tendency for ice to be drawn in under the counter, especially when the ship is swinging. An extempore propeller guard rigged at the waterline on each quarter may give some protection, but it will be difficult to fit effective securing arrangements. Wooden catamarans, with their outer corners faired off, have been tried, but these are liable to up-end and foul the propellers in much the same manner as a floe.

Drift-ice may sometimes be soft and rotten, so that floes will break up readily with little risk of damage to the ship's hull. Nevertheless if other considerations permit, evasive action should be the rule. The behaviour of an up-ended floe is unpredictable, and although the ice may not be sufficiently hard to cause direct damage to propellers or rudder, large masses jammed in the vicinity of the 'A' brackets, or between rudder and hull, or on the rudder itself, can be the cause of a breakdown. A careful propeller watch is essential so that the propeller can be stopped when a floe or block cannot be fended clear. At the same time a propeller dragged through the water for any considerable period is more liable to accumulate debris, and the opinion is sometimes expressed that the blades are more liable to fracture when stopped than when turning slowly. Certainly in much broken ice it will be better to keep the propeller rotating, as it will act as a guard for the rudder, so that only pieces of ice which have been cut up by it will be allowed to pass. In such conditions it is advisable to use only a few degrees of rudder.

Ship handling in drift-ice is largely a matter of careful conning at moderate speed. At high speed, greater concentration and skill are required to avoid the floes, and a small error of judgment may result in serious damage. In this connection it should be noted that ' full speed ' in the majority of publications on ice navigation refers to the maximum speed of the average small merchant vessel, some 10 to 12 knots.

This emphasis on manoeuvrability when working in drift-ice leads to the conclusion that large warships, e.g. cruisers and above, are eminently unsuitable even for these comparatively easy conditions. Destroyers also, by reason of their light construction and projecting propellers, come in the category of vessels which are best kept clear of any area of ice unless operational requirements justify the virtual certainty of damage.

Operations in open pack

Should it be necessary to work through open pack, as defined, the need for manoeuvrability is of even greater importance, as the requirement is then not only handiness in negotiating tortuous lanes and leads rather than individual floes, but also the ability to select the best points of cleavage, and the capacity to back and fill readily.

Close pack

Pack-ice is continually in motion under the influence of wind, tidal stream, or current. As a result of the varying movement of adjacent masses, there will be a tendency for cracks, lanes, and leads to open and close from hour to hour and day to day. Swell will also tend to break up the ice, and in narrow or shallow waters the vertical movement of the tide will have the same effect. Conversely, this complex movement of the ice will result in areas of pressure, with rafting and tenting and the formation of pressure ridges.

Entry into an area of ice which is verging on the distinction of being classified as close pack is therefore a step which, in an unprepared ship, should never be taken without due deliberation and careful preliminary reconnaissance. The choice of the point of area will be governed primarily by the position of the nearest suitable lead, or area of open water as it is improbable that entry would be attempted at all unless with the prospect of attaining clearer water in the direction of the objective.

The leads and lines of weakness in the pack can best be seen from aloft,

(*to face p.* 88)

Fig. 37. Typical pack and bergs, Atlantic.

(*to face p.* 89)

Fig. 38. Pack and bergs in vicinity of Adelaide Island.

and it is therefore essential that the crow's nest should be efficiently manned. If possible the ship should be conned from there. If air reconnaissance is available, observers should be carefully briefed, in particular so that pools of water lying on unnavigable ice may be recognised as such and not erroneously reported as leads or open pack. Regions of pressure, as evidenced by tenting or rafting, must be avoided at all costs.

Entering the ice-edge

Should it be necessary to break through an area of close pack, the ice should, when possible, be entered up-wind, as the leeward side will be less compact and the sea calmer. Where bights exist, use should be made of them. Although the dangers of entry into the windward side of the pack may not appear too formidable at the time, it should be assumed that ice conditions in that area are deteriorating, and that pressure is building up. When there is no lee, consideration should be given to lying off and waiting a change of wind. Entry should be made at the lowest speed which will give steerage way, but once the bow is in the ice and cutting it or pushing it to one side, revolutions should be increased again to avoid losing headway. The ice should always be entered on a course perpendicular to the line of its edge, and the same rule applies when breaking out of the pack into open water.

Once in the pack, the manoeuvrability of the ship will be much reduced, and she will often move in the direction of least resistance irrespective of the position of the rudder. Bursts of power against full rudder may frequently be necessary to keep her head in the required direction and to prevent the stern swinging against the ice. In twin-screw ships a propeller watch is essential to warn the bridge when ice in contact with the hull is approaching the propellers on each side, in order that the propeller may be stopped until the danger is past. Care must however be taken not to gather sternway into ice which has closed in astern. If it should be necessary to back out from unyielding pack, any pieces of ice which have closed in astern should first be washed away by ahead revolutions, but if collision with ice appears inevitable when the ship has sternway, propellers should be stopped and the rudder put amidships.

The ship's bow should never be forced into a narrow lead between large floes if there is any movement tending to bring the floes together. Either one floe should be pushed away to widen the lead, or a part of one floe should be broken off to achieve the same object.

In an unprotected ship it is most inadvisable to attempt to force on through ice which is becoming so compact that the ship seems unlikely to be able to leave a clear lane astern of her. To continue in such conditions may result in the ship being brought to a standstill and yet unable to manœuvre herself astern, or she may be nipped between two floes. It will be better to stop and await more favourable conditions. By so doing, possible damage will be avoided, fuel will be saved, and in all probability no time will be lost. The decision whether or not to keep going will be influenced by operational requirements, and by whether the ship is entering or breaking out of the ice. If the ship has just entered the ice and it is early in the season, it will be well to stop and wait, whereas if it is near the end of the season, or if there is only a little way to go to reach open water, it will be advisable to keep going. In low visibility and at night the ship should always be stopped, since the best direction in which to work can no longer be seen.

Stopping in the ice

When stopping, a patch of clear water should be chosen, if possible, and the ship laid alongside the ice so that the wind keeps her against it. No ice anchors are required if this is done, and any closing in of the ice due to the wind will be seen in good time. If no clear water is available, the ship should be stopped between small floes rather than large ones, so that if the ice subsequently closes up under pressure, some of the pressure will be absorbed by the small floes rafting or being forced under the ship. Once the ice has met under the ship the danger of the ship being damaged by the pressure is greatly diminished.

The ship must never, if it can be avoided, be stopped between two large floes, particularly if their edges are irregular in shape. If such floes should move together under pressure and a point of ice should bear against the ship's side it will almost certainly damage it, and quite possibly stove it in. If the edges of the floe are straight, the pressure will be borne ever more of the side, but even so there will be danger of being crushed.

The best place for a ship to winter is in a shallow enclosed bay; enclosed so that there can be no pressure in the ice, and shallow so that no icebergs can drift in and menace the ship. She should be secured on what is normally the windward side of the bay.

ENGINE MOVEMENTS

When manoeuvring in ice, the engine room must expect frequent engine orders, and it is important that there should be no delay in carrying them out.

Towing in ice

Should it be necessary to tow a disabled ship through pack-ice, the tow should be kept as short as swell conditions permit, so as to give greater control of the towed ship and to minimise the chance of floes drifting between the two ships and parting the towing wire or damaging the other ship. When there is no swell, it should be possible to keep the tow clear of the water. When towing in this manner, at very short stay, the stern of the towing ship will require to be well fendered, and prompt and skilful action will often be necessary to avoid collision as the tow rides ahead. The wash of full power from the towing ship can sometimes be used effectively to keep the other ship clear.

The behaviour of the ship in tow must be carefully watched, so that alterations of course in leads, or when avoiding floes, may be made without putting her into the ice. When towing at very short stay, two towing wires may be used with advantage, as widely spanned as possible. If led through the hawsepipes, it may be necessary to get the anchors inboard rather than cat them, to avoid fouling the ice.

The strain on the towing wires will be very severe if the towed ship comes in contact with heavy ice, and special precautions must be taken against nipping and chafing at the lead-in. Bollards should not be used as securing points if this can be avoided; they are liable to be torn out by the sudden jerks caused if ice is encountered when towing at short stay.

Icebreakers are usually constructed with notched sterns to take the bow of the towed ship, thus avoiding the difficulties and dangers of working through close pack with a free tow at short stay. The towed ship is hauled close up into the stern indentation, and icebreaker and tow work as one unit. It may be necessary on occasions for a ship not designed for the purpose to attempt to tow in this manner, if towing at short stay proves impracticable. Evidently in such circumstances the chief concern of both ships will be adequate fendering.

Convoying in ice

This aspect of ice navigation is discussed in some detail in Notes on Convoying in Ice (H.D.394), and in H.O.551 previously referred to. As far as H.M. Ships

are concerned, such an operation is unlikely at short notice. In the exceptional circumstances which would require one of H.M. Ships to be convoyed through ice it is probable that a full discussion of the tactics to be employed could be arranged beforehand.

Releasing the ship when fast in the ice

This problem is discussed in the Sailing Directions. The majority of H.M. Ships will not be prone to run up on the ice, and the remarks on this particular situation will only be applicable to such small ships as have a rounded forefoot. Any of the expedients described may however be of assistance in freeing any class of ship, in whatever circumstances she is fast or beset. Explosives will sometimes be the only effective method of shifting the ice, particularly when the ship has attempted to widen a crack, and has become nipped. In such cases, 8 oz. charges about ten feet clear of the ship's side where the pressure seems greatest will often cause a temporary movement of the floes which will enable the ship to come astern, provided her engines are turning full speed astern when the charges are detonated.

Dangers when beset

The danger to a ship beset depends chiefly on the underwater shape of her hull, the time of year, and the locality in which she lies. A ship with deep straight sides is more likely to be damaged than one with a rounded section which will rise as the pressure increases and will allow the ice to meet under her. A ship temporarily beset in the spring or summer is unlikely to be damaged if she is caught in an area of little pressure.

A well-built ship beset and forced to winter in the open pack will not necessarily come to any great harm provided she does not subsequently drift into an area of pressure, for instance an area where the ice is being pressed against a coastline, and provided she has adequate reserves of fuel and stores.

Icebergs are another source of danger to a ship beset, particularly in the Antarctic. Owing to their great size and draught these may move independently of the pack, ploughing through the floes and building up a 'bow wave' of pressure ice which can crush a ship if unable to manoeuvre clear. The smaller Arctic bergs are generally not such a menace in this respect.

Conclusion

Ship handling technique in pack ice is dependent basically on the strength, power, and manoeuvrability of the individual ship. A lightly built warship such as a destroyer or frigate will not stand up to impact with heavy floes, her propellers are extremely vulnerable, and her hull will quickly be crushed in pressure ice. Heavier warships are no better suited to ice operations, for although their armoured sides can better withstand pressure, their thin bow plating and projecting propellers are generally as vulnerable as those of the smaller ship. Unless specially built for ice operations, a warship must therefore be handled with the object of avoiding impact with thick ice, unless taken at very slow speed directly on the stem. Only the smaller ships have the necessary manoeuvrability to achieve this object.

The ability to differentiate between hard ice and soft ice, and between passable and impassable pack; to recognise weathered floes with their dangerous underwater spurs; to detect lines of weakness and to select the most suitable leads, etc., can only be gained by experience, and no amount of text-book knowledge will stand in its stead. Sea ice is a navigational hazard of the first order, and should be accorded all due respect. On the other hand it is a hazard which can be greatly minimised by skilful ship handling and a sensitive appreciation of the capacity of the ship to withstand damage.

CHAPTER IX

HANDLING SHIPS DURING TOWING OPERATIONS

H.M. Ships may be called upon to take in tow at short notice any type of ship or craft which has become disabled or partially disabled in the open sea. Such ocean rescue work requires the highest degree of seamanship, even when undertaken by salvage tugs specially designed and equipped for the purpose. By comparison most warships are singularly unsuited for the task, and the difficulties confronting them on these occasions are correspondingly aggravated. But although, where towing operations are concerned, the average warship compares unfavourably with the rescue tug, these handicaps can be minimised by skilful shiphandling and are only emphasised here in order that the nature of the problem may be fully appreciated.

Ocean-going tugs have certain features in common. Firstly they are as small as possible consistent with good seakeeping qualities and adequate power and endurance. A short, squat ship is handy at slow speed in a seaway; moreover the towing deck is under the direct control of the bridge, and the distance between forecastle and towing deck is so short that a head-on approach when passing the tow can be adopted if circumstances require it. Secondly the rescue tug is often single-screwed, with an overhanging and well padded counter, while if twin-screwed, she is fitted with efficient rope guards. Thirdly, the tug has a low towing deck, probably with a self-rendering winch or a shock-absorbing towing hook fitted near the centre of gravity, and with overhead towing horses to provide a clear run for the gear.

Warships in general are the antithesis of the salvage tug in all these respects, and the problem is complicated by their widely different handling characteristics, so that it is not practicable to discuss in any detail the recommended procedure for passing a tow in all the possible combinations of circumstances. The following general principles should however be of value to Commanding Officers who have had no first-hand experience of this type of work.

Methods of establishing contact

Unless the disabled ship is short-handed or abandoned, boatwork should be avoided as an unnecessary complication. The first line can usually be passed more expeditiously by gun or rocket, while in calm weather it is often possible to approach close enough for a heaving line to be used. Should these methods fail owing to weather conditions it is probable that boat-work will also be impossible, and it will then be necessary to make contact with a floating line. When gun, rocket, or heaving line are used it will always be preferable to throw from windward, but when a grass line is used this is generally best floated on the leeward side, so that the other ship will drift down on it. Alternatively it can be dragged by the towing ship across the bows of the disabled vessel, or sailed to leeward attached to a life raft or cask.

Maintaining position when passing the tow

The distance between the two ships should be kept as short as possible while the towing hawser is being passed and secured. The operation will be much more difficult if this distance is allowed to widen rapidly from the moment

first contact is made by light line. For example, it will be a slow and painful procedure to haul in a heavy wire by hand if the distance much exceeds 100 feet, while in more normal circumstances, with power available, the distance cannot be increased beyond about 300 feet without risk of parting the messenger.

Attitude and drift of the disabled ship

In order to maintain this comparatively short distance between the two ships it will be necessary, before approaching to establish contact, to make a careful assessment of the other ship's heading and her direction and rate of drift. For this reason an experienced tug-master will invariably circle a disabled vessel at close range before approaching to pass a line.

When there is no wind, most ships will, when stopped, tend to lie across the principal wave front, with a slight drift in the direction in which the swell is running, but the lightest breeze will modify this attitude according to the disposition of hull and superstructure. Different types of ship will lie at slightly different angles to the wind, and trim will introduce further variations.

Abnormal trim and underwater damage or trailing wreckage will modify a ship's attitude. For instance a destroyer with her bows blown away might be expected to lie nearly head to wind.

Attitude and drift of own ship when stopped

Before deciding on the direction of approach, an estimate must be made of the probable behaviour of own ship when way is taken off her. If she is expected to lie in approximately the same attitude as the disabled ship, as would be the case with two ships of the same class, it will usually be preferable to close on a similar heading. In most other cases an approach down wind is likely to give the best results, as will be explained later. If in doubt as to the attitude which own ship will adopt under the prevailing conditions, she should be stopped, if circumstances permit, and her behaviour noted, before a close approach is attempted.

An approach down wind may also be preferable if it appears that heavy rolling on a similar heading will make work difficult on deck.

Direction of approach. Drifting attitudes similar

If the drifting angles and rates of the two ships are expected to be similar, the approach is best made on a slightly converging heading and aiming to pass very close across the weather bow of the disabled ship. There is little danger in a close approach under these circumstances, observing that own ship will make considerably less leeway as long as she is making headway. (*Fig. 39 overleaf.*)

The first lines can be passed at any stage, but to avoid long leads of messenger and risk of fouling the propellers it will probably be easiest to pass from aft, as own ship's quarterdeck comes within range of the disabled ship's forecastle. As way is taken off own ship she should be manoeuvred so as to take up position some 100 feet ahead of the other, and on the same heading, and endeavour should be made to hold her on this heading while the towing gear is being passed.

Should effective connection not be established when passing to windward of the disabled vessel, it may be difficult to regain a good position by making a sternboard and it will usually be more practicable to go right round and make another approach.

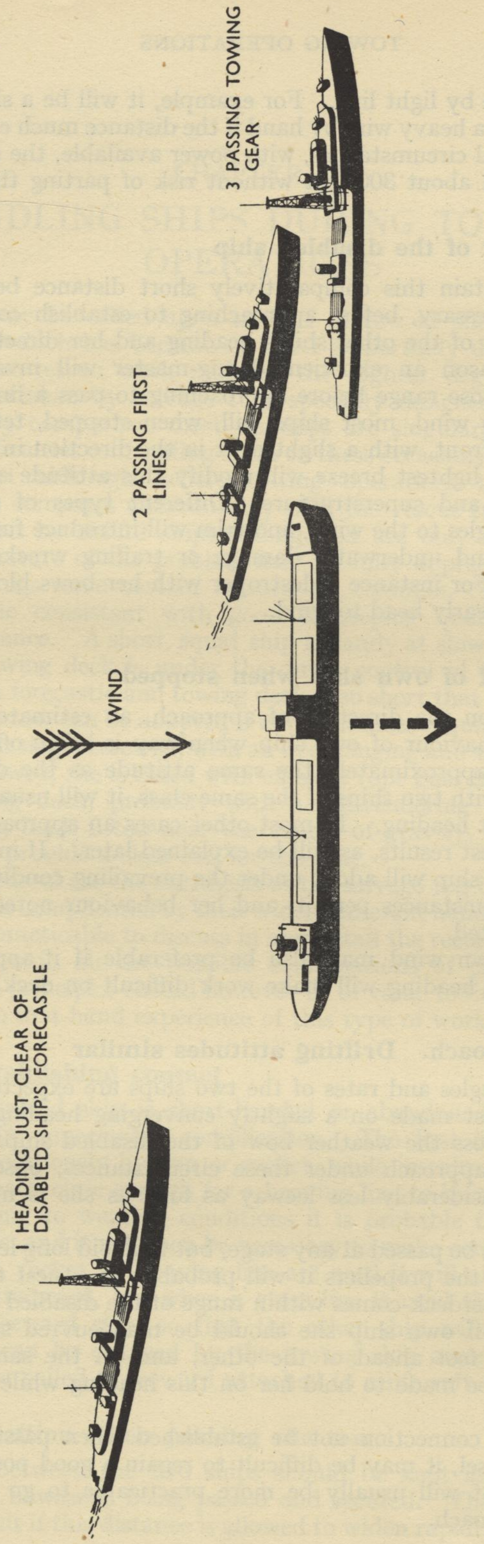


FIG. 39.—Approach to a disabled ship—drifting attitudes similar.

When the tow has been passed and secured the towing ship should proceed slowly ahead on or near her present course while the gear is being payed out, and should not attempt to turn to the final course until the disabled ship is in tow. The alteration should then be made in very easy stages.

Direction of approach. Drifting attitudes dissimilar

It may be the case that the towing ship is not expected to assume the same drifting attitude as the disabled ship, nor to drift at the same rate. In these circumstances a down-wind approach is usually preferable, observing that most warships will steer quite well at slow speed with the wind astern unless there is a heavy following sea, whereas head to wind and sea they are liable to pay off rapidly and uncontrollably as headway is lost. Furthermore this tendency to pay off when head to wind will be accentuated as sternway is gathered with the object of maintaining position on the drifting ship, but it will usually be comparatively easy to hold the stern up into the wind with slow astern revolutions while maintaining a slight drift down wind. The following examples of the down-wind approach will illustrate the point.

Disabled Ship Broadside. The towing ship should turn well to windward of the other so that her approach course with the wind dead astern will lead her 100 feet or so across the other ship's bows. (*Fig. 40.*) The greatest

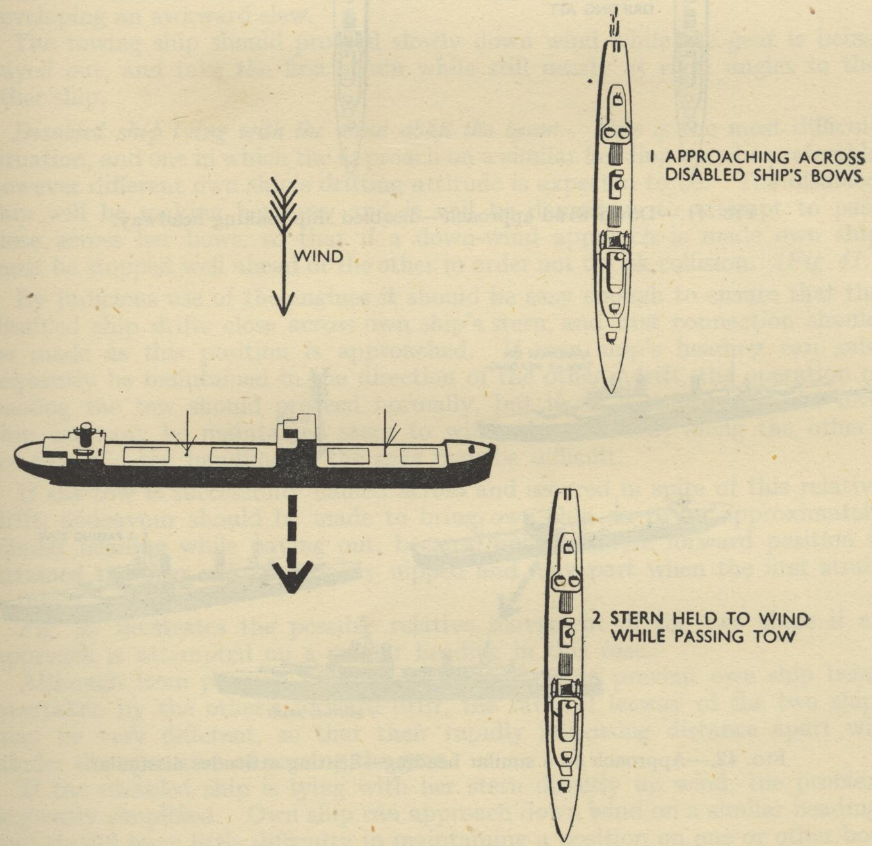


FIG. 40.—Down-wind approach to a disabled ship.

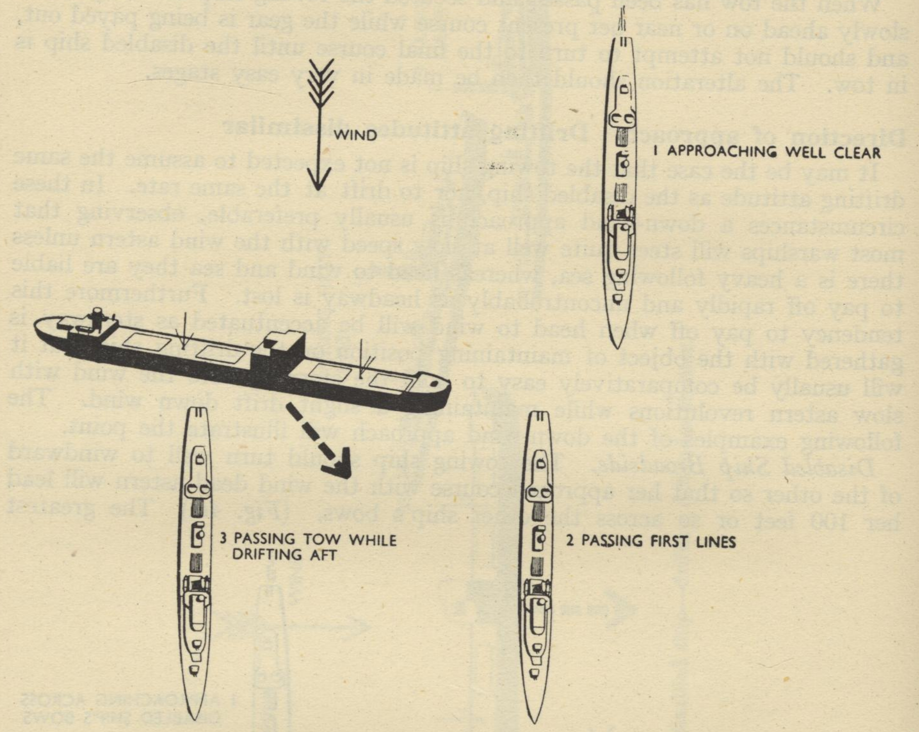


FIG. 41.—Down-wind approach—disabled ship making headway.

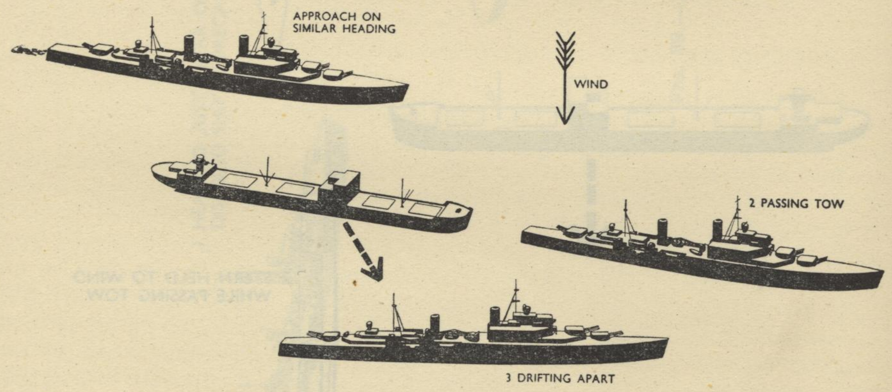


FIG. 42.—Approach on a similar heading—drifting attitudes dissimilar.

attention is required during the approach to ensure that own ship's path remains that distance ahead of her. If the other ship appears to be drifting ahead, and narrowing the estimated gap, it is not sufficient to alter a few degrees away, because a further alteration will almost certainly be required later, thus bringing the wind well on the quarter in the final stages. It will be better to elbow out so as to run down towards a position considerably further ahead.

The approach should be made at the slowest speed which will give good steering control. The precise moment, and the method of passing the first line is a matter of seamanship on which individual opinions will vary. If the forecastle is considered the best place for the gun or heaving line, as being under the direct control of the bridge, then great care will be needed to keep the messenger clear of the propellers while the ship moves ahead so as to take up a position slightly to leeward of the other's bows. No attempt to haul the towing gear across should be made until this position is reached.

There should be no great difficulty in maintaining a position just ahead and to leeward of the disabled ship's bow, providing she is drifting dead to leeward and assuming that own propellers can be used, at any rate on the disengaged side. Any tendency to over-run own ship can quickly be corrected with a few ahead revolutions, using the rudder as necessary to adjust the heading. Astern revolutions can be also used to maintain distance without fear of developing an awkward slew.

The towing ship should proceed slowly down wind while the gear is being payed out, and take the first strain while still nearly at right angles to the other ship.

Disabled ship lying with the wind abaft the beam. This is the most difficult situation, and one in which the approach on a similar heading may be preferable however different own ship's drifting attitude is expected to be. The disabled ship will be making headway and it will be dangerous to attempt to pass close across her bows, so that if a down-wind approach is made own ship must be stopped well ahead of the other in order not to risk collision. (*Fig. 41.*)

By judicious use of the engines it should be easy enough to ensure that the disabled ship drifts close across own ship's stern, and first connection should be made as this position is approached. If own ship's heading can subsequently be maintained in the direction of the other's drift, the operation of passing the tow should proceed normally, but if, as is more probable, own ship can only be maintained stern to wind, she will drift along the other's lee side and the handling of the gear may be difficult.

If the tow is successfully hauled across and secured in spite of this relative drift, endeavour should be made to bring own ship on to an approximately similar heading while paying out, because unless a more forward position is attained the gear will be unfairly nipped and may part when the first strain is taken.

Fig. 42 illustrates the possible relative movement of the two ships if an approach is attempted on a similar heading in this case.

Although from position (2) it should be simple to prevent own ship being overtaken by the other's forward drift, the rates of leeway of the two ships may be very different, so that their rapidly increasing distance apart will hinder the operation of passing the gear.

If the disabled ship is lying with her stern directly up wind, the problem is greatly simplified. Own ship can approach down wind on a similar heading, and should have little difficulty in maintaining a position on one or other bow while the tow is passed.

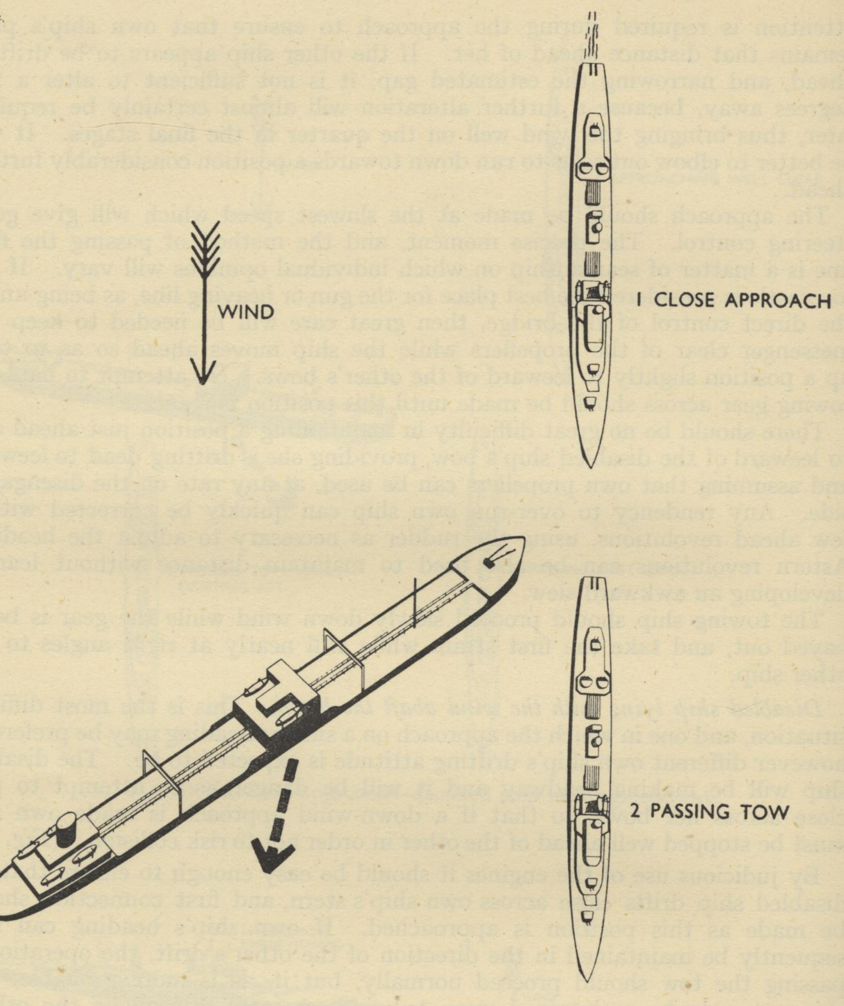


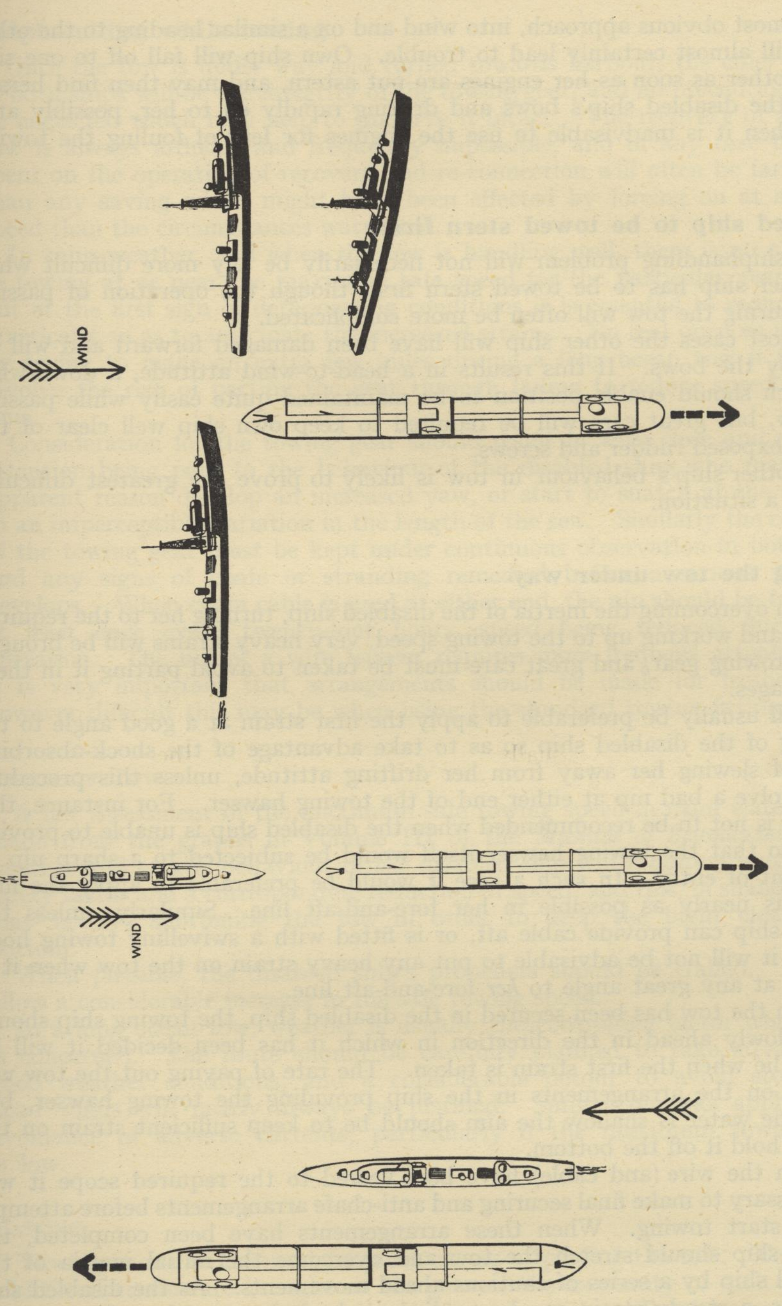
FIG. 43.—Down-wind approach—disabled ship making sternway.

Disabled ship lying with the wind before the beam. In this case the disabled ship will be making slight sternway, so that a close approach down wind can be made without danger. (*Fig. 43.*)

Should the disabled ship be lying directly into wind, however, the operation will be difficult. If a down-wind approach is attempted, so that the two ships lie abreast each other, bow to stern, as in *Fig. 44a*, it may be difficult to prevent them closing, and it will be equally difficult to disengage in order to pay out the tow.

The length of the average warship will preclude a head-on attitude (*Fig. 44b*), as might be attempted in this case by a salvage tug.

It will probably be more effective to run slowly across the disabled ship's beam, as in *Fig. 44c*, and drift close down her side while passing the tow.



Bow to stern. *a*

Head on. *b*

Crossing. *c*

FIG. 44.—Disabled ship lying head to wind.

The most obvious approach, into wind and on a similar heading to the other ship, will almost certainly lead to trouble. Own ship will fall off to one side or the other as soon as her engines are put astern, and may then find herself across the disabled ship's bows and drifting rapidly on to her, possibly at a time when it is inadvisable to use the engines for fear of fouling the towing gear.

Disabled ship to be towed stern first

The shiphandling problem will not necessarily be any more difficult when the other ship has to be towed stern first, though the operation of passing and securing the tow will often be more complicated.

In most cases the other ship will have been damaged forward and will be down by the bows. If this results in a head-to-wind attitude, a down-wind approach should enable position to be maintained quite easily while passing the tow, but great care will be required to keep own ship well clear of the other's exposed rudder and screws.

The other ship's behaviour in tow is likely to prove the greatest difficulty in such a situation.

Getting the tow under way

When overcoming the inertia of the disabled ship, turning her to the required course, and working up to the towing speed, very heavy strains will be brought on the towing gear, and great care must be taken to avoid parting it in these early stages.

It will usually be preferable to apply the first strain at a good angle to the heading of the disabled ship so as to take advantage of the shock-absorbing effect of slewing her away from her drifting attitude, unless this procedure will involve a bad nip at either end of the towing hawser. For instance, this method is not to be recommended when the disabled ship is unable to provide cable, so that the towing hawser itself would be subjected to a sharp nip at the point of entry. In such a case it would be preferable to apply the first strain as nearly as possible in her fore-and-aft line. Similarly, unless the towing ship can provide cable aft, or is fitted with a swivelling towing hook or slip, it will not be advisable to put any heavy strain on the tow when it is leading at any great angle to *her* fore-and-aft line.

When the tow has been secured in the disabled ship, the towing ship should move slowly ahead in the direction in which it has been decided it will be best to lie when the first strain is taken. The rate of paying out the tow will depend on the arrangements in the ship providing the towing hawser, but when the water is shallow the aim should be to keep sufficient strain on the wire to hold it off the bottom.

When the wire (and cable) have been veered to the required scope it will be necessary to make final securing and anti-chafe arrangements before attempting to start towing. When these arrangements have been completed, the towing ship should stretch the tow and overcome the initial inertia of the disabled ship by a series of cautious ahead movements. As the disabled ship responds, a steady strain can be applied at dead slow speed, and as soon as she starts to follow the revolutions can be worked up very gradually and course slowly altered in the required direction. The catenary of the towing hawser is the best guide to the handling of the ship during these initial stages. Under ocean towing conditions the aim should be to keep the bight well submerged at all times.

Shiphandling while towing

Once the tow is under way and turned towards harbour, the chief concern of both ships will be the integrity of the towing gear, and no precaution should be neglected which may help to preserve it intact. The recovery of a parted tow is always arduous and frequently impossible, and in any case the time spent on the operation of recovery and re-connection will often be far greater than any saving which might have been effected by forcing on at a higher speed than the circumstances warranted.

In calm weather, and when the tow is handling well, there is no objection to towing at or near the maximum safe speed for the particular gear in use, but at the first sign of deteriorating conditions it is essential to reduce speed drastically so as to anticipate the increased strains. No real purpose is served by trying to make an extra few miles during a long ocean tow if this will involve the risk of parting the gear through failing to reduce speed in good time.

Consideration for the towing gear should result in very close and constant attention being paid to the behaviour of the disabled ship, who may for no apparent reason develop an increased yaw, or start to snatch at the tow due to an imperceptible variation in the length of the sea. Similarly the condition of the towing gear must be kept under continuous observation in both ships, and any signs of chafe or stranding remedied before a serious weakness develops. When chain cable is used at either end, the nip should be freshened at least once every twenty-four hours, speed being reduced during this operation. The nip of a wire hawser requires more frequent attention, and it is very important that arrangements should be made for freshening it, however difficult this may be when using the standard towing fittings.

Speed of Tow

A fair assessment of the maximum safe towing speed in calm water can be made from the graphs in Volume III of the *Manual of Seamanship*. Bad weather and erratic behaviour of the disabled ship will require a much higher safety factor and a corresponding reduction of speed, and this, in shallow water, may involve shortening the tow in order to keep the bight clear of the bottom.

When possible, the disabled ship's propellers should be trailed. This will allow a considerable increase in the safe towing speed.

In a long ocean tow, weather is usually the controlling factor where speed is concerned. The route should be carefully planned to take advantage of good weather conditions, and a considerable detour to avoid storms and head winds will nearly always be justified. Similar remarks apply to the avoidance of adverse currents, particularly if the maximum towing speed is low.

Yawing

Yawing is one of the most frequent causes of parting the tow. Very heavy additional strains are brought on the gear at the extremity of each yaw, and the resulting bad nip weakens it at the same time. Furthermore, yawing introduces chafe. It is worth while going to a great deal of trouble to reduce yaw, whether evidenced in the first stages of the operation or introduced later due to changing conditions.

When the disabled ship can use her rudder for steering, yaw can usually be kept within moderate limits provided the towing speed is sufficient to give steerage way. When the steering gear is out of action a reduction in yaw can often be achieved if the rudder can be moved over to a sufficient angle to give a constant sheer. Large angles of rudder should however be avoided, owing to the increased drag. If the rudder cannot be moved, much the same effect can be produced by trailing one set of propellers only.

Trim by the head will invariably cause a yaw which will increase with the towing speed and will be particularly heavy in ships with fine bows. Unless this trim can be corrected, it may be necessary to tow stern first. If correction is possible the best results will usually be achieved with slight trim by the stern.

List and underwater damage will also cause yaw, and will increase the towing strain.

When list and trim cannot be corrected, an alteration in the towing speed will often reduce the amount of yaw. For instance a heavily-listed ship can sometimes be steadied by an increase in speed, while with a ship trimmed by the head the reverse is usually the case.

Another method of reducing yaw is by alteration of the point of tow to one or other bow of the disabled ship, so as to give a constant sheer. Alternatively a steadying sail forward or aft will sometimes have the same effect. The use of a towing bridle spanned to either bow is unlikely to be effective unless towing at very short stay.

Heavy weather

When ships are pitching, the strains on the towing gear will be reduced if the length of tow can be adjusted so that both ships rise and fall to the waves in unison. If the bight shows a tendency to break surface, either the length of tow should be increased or the speed reduced, or in deep water, both.

In very bad weather it is probably preferable to turn and run slowly before wind and sea, rather than to heave to, heading into it. The latter procedure is likely to result in far heavier strains on the gear, although steering may be easier. When running with the gale it may be possible to steady the disabled ship by streaming a drogue. Obviously, running should not be resorted to if this is likely to bring the ships anywhere near a lee shore.

In extreme weather conditions, which the gear cannot be expected to withstand, it may be preferable to slip the tow rather than to hold on until the gear parts. The disabled ship may ride more easily when drifting, with the towing gear trailing as a sea anchor, while the towing ship will have freedom of manoeuvre and can spread oil where it will be most effective.

Recovery of the entire tow, when the weather moderates, will probably be impracticable unless the disabled ship can use her windlass, or unless the water was shallow enough for the end to be buoyed when slipped.

Remarks on the use of oil, when towing in heavy weather, will be found in the *Manual of Seamanship*.

Procedure if disabled vessel sinks when in tow

Should the disabled vessel show signs of instability, the towing vessel must make arrangements to slip the tow at short notice. It is assumed that the crew of the other ship will already have been removed.

When in deep water it is important that the tow should be slipped before the weight of the foundered ship comes on the gear, otherwise considerable damage may be caused aft before the tow parts. If great importance is attached to the recovery of the towing hawser, it may be possible to sever it with a well-directed shot at the other ship's bows, before she settles.

In shallow water the first consideration must be to tow the sinking ship clear of the main shipping routes. A secondary consideration will be the possibility of recovering the towing gear. In good conditions, if engines are stopped as soon as the other ship starts to settle, and the towing ship then manoeuvred so that she drifts well clear to leeward of the wreck, the gear may be hove in to as short a stay as is considered prudent, and then cut. Before cutting adrift, the wreck should be accurately fixed and buoyed.

Beaching a damaged ship

When anxiety is felt concerning the buoyancy or stability of the tow, consideration should be given to the possibility of beaching her before she sinks. The optimum conditions for beaching are a sheltered bay, a soft and gently shelving bottom, and high water.

If the value of the sinking ship warrants the risk, the operation can best be performed by securing the towing ship alongside the lee quarter of the other and pushing her as far in towards the selected beaching point as is practicable before slipping and going astern to clear her. Before attempting the operation as much as possible of the towing gear must be recovered, otherwise the disabled ship may anchor herself before reaching the beach.

When the decision is taken to beach, there may be other ships standing by in the vicinity which are more suitable for the purpose by reason of their lighter draught or better manoeuvrability. The best control during a beaching operation will be achieved by securing a light draught ship on each quarter of the disabled vessel.

When the towing ship is of greater draught, or if for other reasons the risk of securing alongside the sinking ship is not justified, the best that can be done is to heave in the tow to short stay and cut adrift when heading in the general direction of the beach, while there is still room to manoeuvre clear.

Final arrangements for the security of the beached ship, such as laying out anchors and hawsers, are more a matter of salvage than shiphandling.

Shortening in the tow

Before entering shallow or restricted waters, or handing over to harbour tugs, the tow must be brought to short say. This will give better manoeuvrability and will also ensure that the bight is kept clear of the bottom. The latter consideration is of the first importance when the bottom is rocky or uneven. When the towing ship has a powerful winch aft, the operation of shortening in can be carried out while still retaining headway, though speed should be reduced as far as possible to relieve the strain. Similarly the disabled ship, if she has power, will have no difficulty in retrieving her cable. When neither ship can heave in by power, the towing ship must ease down gradually until both ships are stopped, and then endeavour to haul in the towing hawser by hand, but this procedure will only be practicable if plenty of sea room is available, and, in shallow water, if the bottom is free of snags. If shortening in by hand proves impossible it may be necessary to slip the sea tow at both ends as soon as the disabled ship has been taken over by the harbour tugs.

When towing in restricted waters, great care will be necessary in order to keep the towed ship clear of dangers and navigational marks. Ample allowance must be made for leeway and the sag of the tow to leeward. When there is sufficient water on either side, consideration should be given to passing navigational marks on their downstream or leeward side.

Taking an anchored ship in tow

If there is little sea, the simplest method of passing a tow to an anchored ship will probably be from alongside her, and on the opposite side to her cable if she has only one anchor down. When the tow has been passed, the towing ship should move ahead and stand off well clear while the anchor is being weighed, keeping the towing hawser fairly taut and off the bottom.

It is more likely that the operation will be in the nature of an emergency, with a gale of wind, considerable sea, and a lee shore. In such circumstances, and with the disabled ship yawing badly, the risk of laying alongside will probably not be justified and it will be preferable to manoeuvre just clear of her extreme range of yaw so as to make connection by gun line at the moment when she swings closest.

If manoeuvring room is very limited an approach down wind may be the only possible course, the towing hawser being passed from the forecastle and endeavour made to haul the anchored ship clear of danger by going astern. If the disabled ship has difficulty in weighing, it may be necessary, as a last resort, to order her to slip her cables, and then to try and hold her off until tugs can be called up.

CHAPTER X

HANDLING SHIPS DURING REPLENISHMENT OPERATIONS

The whole subject of replenishment at sea is covered in detail in B.R. 1742. The following remarks amplify the section on manoeuvring and shiphandling in that book, and are intended to be read in conjunction with it.

The shiphandling problem is essentially one of taking up and maintaining station at very close distance, and in calm weather this should present no particular difficulty provided the effects of interaction are appreciated and allowed for. In rough weather the effects of sea and swell assume a greater importance than interaction, and there may be considerable difficulty and risk in maintaining close station abeam when ships have much motion. In very bad conditions this method will be impracticable.

Briefly, the shiphandling requirement during replenishment is as follows. The supplying ship, which may be a fleet auxiliary or another warship, maintains a signalled course and speed. The receiving ship closes her to pass the gear, and must then keep station at a constant distance during the entire operation. Whether the abeam or the astern method is used, station is maintained entirely by shiphandling, and no use is made of tow or breast lines. In the abeam method, distance is judged from a distance line between the two ships, and in the astern method from a marker buoy streamed by the supplying ship. In the abeam method, the rig is kept clear of the water and speeds up to 20 knots may be practicable. In the astern method the hose is trailed in the water and forms a bight near the receiving ship, so that the maximum speed with this method is limited by the strength of the hose. Speeds above 15 knots are not normally attempted by this method.

Interaction

The movement of a ship through water creates comparative zones of pressure and suction due to alteration in the spacing of the " stream lines " as illustrated in *Fig. 45*.

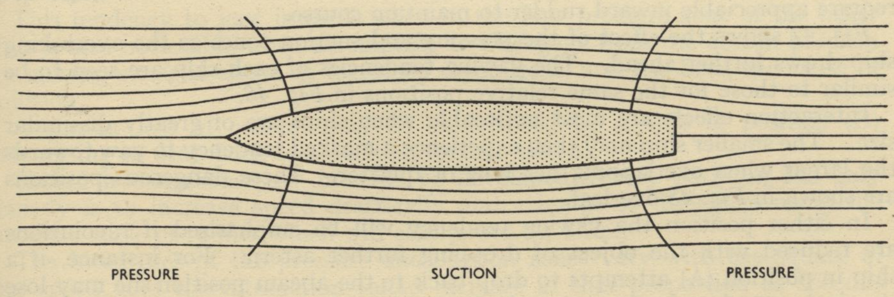


FIG. 45.—Regions of pressure and suction near a ship in motion.

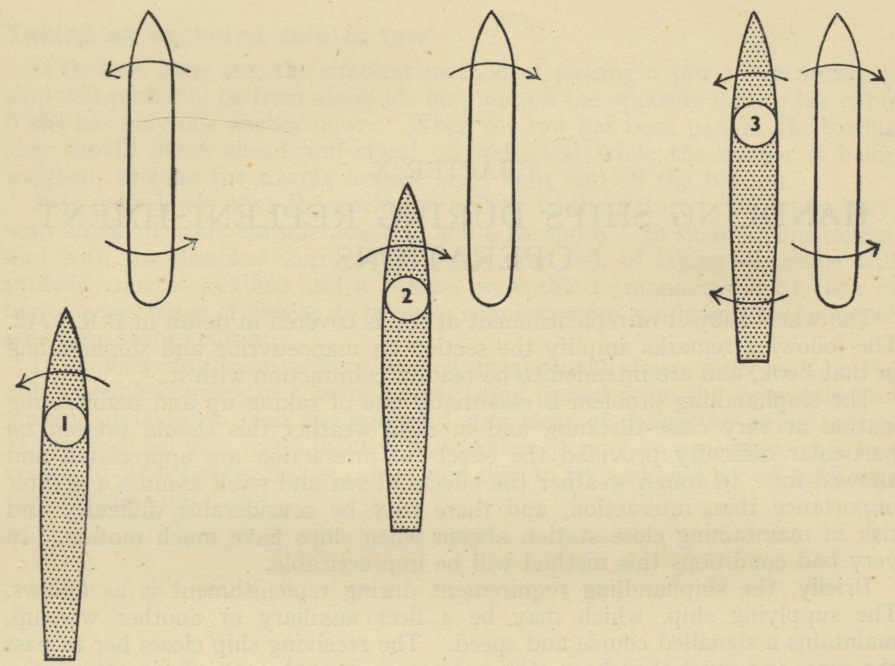


FIG. 46.—Interaction when another ship approaches closely from astern.

Ahead and astern, where the greater spacing of the stream lines results in a reduction of flow relative to the ship, the pressure is increased. Amidships, the restriction of the stream lines results in an increase of the relative flow, and the pressure is reduced.

Fig. 46 shows the effect of these pressure and suction zones when another ship approaches closely from astern to the abeam position.

As the suction zones of the two ships begin to overlap, the bow of the overtaking ship will experience an attraction inwards (*Fig. 46*). This attraction will persist until the abeam position is reached, when the bow of each ship will be repelled from the other.

In addition to this tendency to yaw, there is in positions (1) and (2) a tendency for both ships to be forced bodily apart. In position (3), when ships are abeam of each other, there is a considerable mutual attraction due to the coincidence of the zones of suction. In practice this mutual attraction is usually counteracted by the tendency of each ship to yaw outwards, so that both ships will require appreciable inward rudder to maintain course.

Fig. 47 shows the effect of the pressure and suction zones as the overtaking ship draws further ahead. The yawing tendencies of each ship are seen to be similar to those for the same relative positions in *Fig. 46*.

Interaction effects are most noticeable when ships are of greatly dissimilar size. The smaller ship may then experience a marked tendency to yaw towards the larger when overlapping her bow or quarter. These dangerous positions are shown in *Fig. 48* overleaf.

In either position the yawing tendency will be emphasised if revolutions are reduced with the object of dropping further astern. For instance, if a ship in position (A) attempts to drop back to the abeam position she may lose steering control and yaw across the bows of the larger ship. She should first

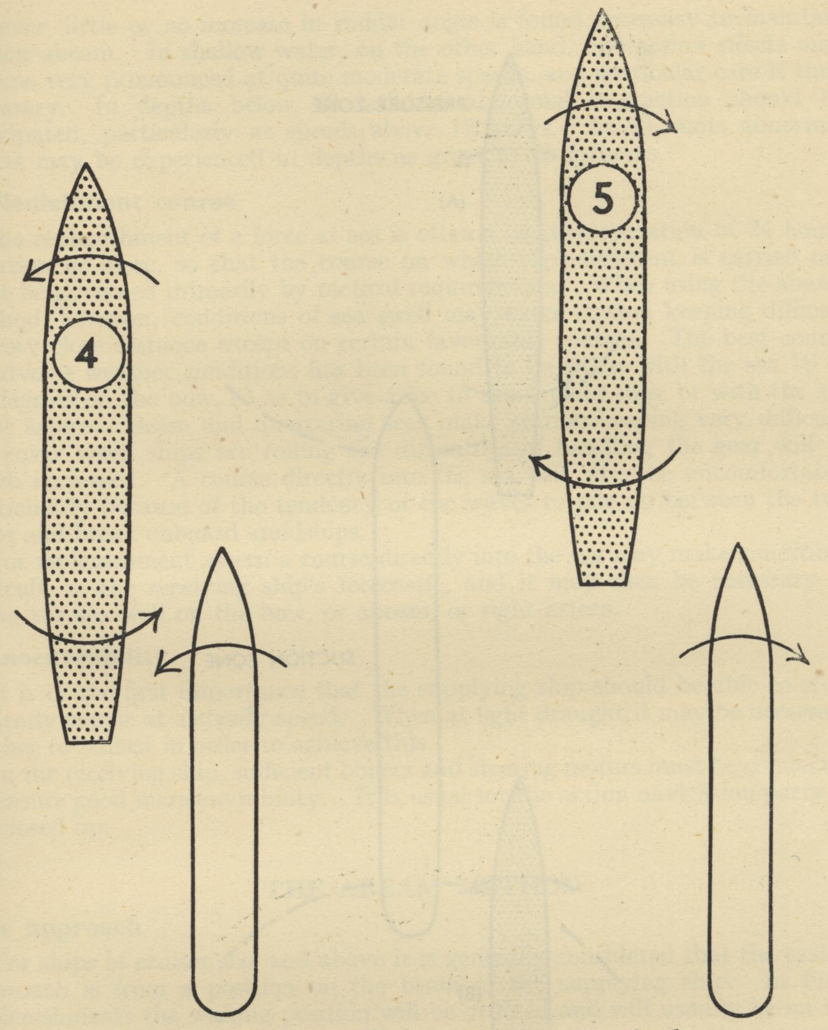


FIG. 47.—Interaction as overtaking ship draws ahead.

alter course outwards and then, when well clear, she may reduce speed and drop back.

This tendency to yaw inwards when in the bow pressure zone of the other ship is also noticeable when attempting to disengage from the abeam position by moving straight ahead at increased revolutions, and has been the cause of collision.

A similar loss of control may be experienced by a ship in position (B) attempting to drop back to a position further astern.

Should a dangerous yaw inwards be developed in any position, the only remedy is to increase speed drastically and attempt to disengage using the smallest angle of rudder which will counteract the sheer.

The intensities of the pressure and suction zones vary with the square of the speed, and the interaction forces increase in that proportion as speed is increased. Owing to the improvement in steering control at higher speed,

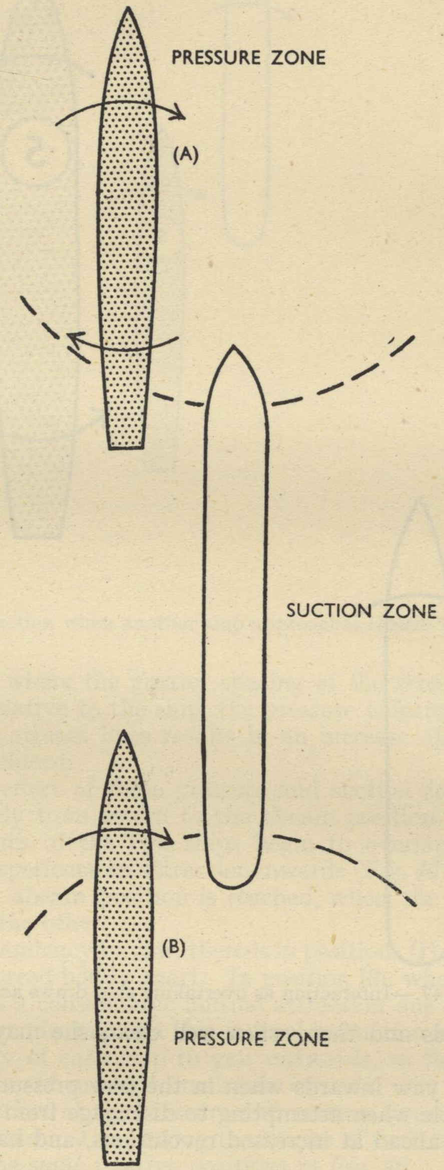


FIG. 48.—Dangerous positions when ships are of dissimilar size.

however, little or no increase in rudder angle is found necessary to maintain station abeam. In shallow water, on the other hand, interaction effects may become very pronounced at quite moderate speeds, and particular care is then necessary. In depths below 15 fathoms abnormal interaction should be anticipated, particularly at speeds above 12 knots. At 20 knots abnormal effects may be experienced in depths as great as 20 fathoms.

Replenishment course

The replenishment of a force at sea is often a lengthy operation of 24 hours duration or more, so that the course on which replenishment is carried out must be governed primarily by tactical requirements. When using the abeam method, however, conditions of sea swell may make station keeping difficult at very close distance except on certain favourable courses. The best course in adverse weather conditions has been found to be either with the sea 10 to 20 degrees on the bow, so as to give a lee to the smaller ship, or with the sea right astern. Beam and quartering seas make station keeping very difficult, moreover when ships are rolling the difficulties of handling the gear will be much increased. A course directly into the sea will often be uncomfortable, particularly because of the tendency of the waves to pile up between the two ships and break onboard amidships.

For replenishment astern a course directly into the sea may make conditions difficult on the receiving ship's forecastle, and it may then be necessary to bring the sea well on the bow, or abeam, or right astern.

Manoeuvrability

It is of the first importance that the supplying ship should be able to steer a steady course at a steady speed. When at light draught it may be necessary for her to ballast in order to achieve this.

In the receiving ship, sufficient boilers and steering motors must be connected to ensure good manoeuvrability. It is usual for the action navigation party to be closed up.

THE ABEAM METHOD

The approach

For ships of cruiser size and above it is generally considered that the easiest approach is from a position on the beam of the supplying ship. In Fleet replenishments the waiting position will be ordered and will usually be on the beam or fine on the quarter, but whichever position is occupied the approach from abeam is best made by first taking up station about 1 cable on the beam of the supplying ship, and then closing gradually from there. A 5 degree alteration inwards and a slight increase of speed will close the gap to 100 feet or so within a few minutes. A closer approach is not necessary for making contact by gunline, and interaction effects may be felt inside this distance. A more spectacular approach, with a bolder alteration inwards, will save little time and could be awkward if misjudged, moreover the result might well be unsettling to the supplying ship and to ships replenishing on her other side.

Smaller ships, with more rapid acceleration and deceleration, may approach from the quarter, but although this method will enable contact to be established slightly sooner, particularly if the waiting position is abaft the beam, there will usually be some delay in settling down to the exact speed of the supplying ship. Interaction effects should be anticipated when entering the suction zone, as previously remarked, and a closer approach than 100 feet, or so, should not be attempted, observing that some loss of steering control will certainly be felt as speed is reduced. Some small ships such as frigates, who may not have much in hand over the speed of the supplying ship, have experienced difficulty in getting through the pressure zone. When the bows finally overlap the supplying ship's quarter, and the suction zone is entered, the tendency is then to overtake so rapidly that a drastic reduction in revolutions is found necessary, with the usual ill effect on steering.

Aircraft carriers normally replenish on their starboard side, whether supplying or receiving, so that operations can be seen from the bridge.

The correct station

If ships are of similar size, interaction effects are least noticeable when directly abeam, and if of greatly dissimilar size, when the smaller ship is in the intermediate area between the bow and stern pressure zones. The precise relative position of the receiving ship relative to the supplying ship during replenishment will however be governed principally by the positions of the equipment in each ship. By day these positions are indicated by hand flags. By night the supplying ship indicates the position abreast which the receiving ship should keep her bridge.

Speed

When using abeam methods, no difficulties have been experienced in replenishing at speeds from 10 to 15 knots, and even up to 20 knots. Below 10 knots ships have insufficient manoeuvrability to steam close aboard one another in safety. Interaction effects should be closely watched at the higher speeds, particularly in shallow water.

Alterations of speed are controlled by individual supplying ships in small steps.

Maintaining station

It is usual for the receiving ship to keep station on the supplying ship, but there may be occasions when the receiving ship is the less manoeuvrable of the two and it is preferable to reverse the procedure.

Station is maintained entirely by shiphandling, and no use is made of tow of breast lines. It is therefore of the first importance, as previously remarked, that the supplying ship shall maintain a steady and accurate course and speed.

It is generally considered that keeping close station abeam is simplified if two officers are employed, one watching the distance line and adjusting the course, and the other adjusting the speed, either by watching a mark in the other ship, or the transit of two marks, or by watching the angle which the distance line makes with the side of either ship. In most ships it is the practice to have the distance line well forward so that it will indicate a sheer before the distance apart of the ships at the pivoting point has changed. The officer responsible for the course will find it necessary to watch the compass continuously, and to make a frequent check of the quartermaster's reactions by noting the movement of the rudder indicator.

In good weather conditions by day, station keeping should present no problem provided quartermaster and engine room are warned of the importance of using small angles of rudder and gradual adjustments of revolutions. The course should be steered by compass and direct rudder orders should not be given except in emergency. The usual graduation of revolution telegraphs in two or three revolution steps should permit sufficiently close adjustment of speed, but it may sometimes be found necessary to order an intermediate

setting by telephone. The Mountbatten Station Keeping System has been found of great assistance during replenishment.

In rough weather, when ships have much motion, station keeping will obviously be more difficult, and larger rudder angles and revolution adjustments will be required, particularly when ships are of greatly dissimilar size. If the replenishment course is to windward, it is important that the smaller ship should be given a slight lee, so that the tendency of the sea will not be to throw her towards the steadier ship. A course from 10 to 20 degrees off the wind has been found most satisfactory.

With a following sea, destroyers and frigates are prone to heavy yawing, particularly at speeds approximating to the speed of the waves. Speeds between about 2 knots less and 8 knots more than the sea should be avoided, the theoretical upper limit being rarely attainable when replenishing. Larger ships, however, will often find conditions much more comfortable with a following sea than with a head sea.

Night replenishment, whether in peace or war, is usually carried out with ships darkened. It is generally considered that station keeping is easier when neither ship is showing any bright sources of light which by their glare will tend to blot out outlines and make estimation of distances and angles difficult.

Opinion is generally in favour of using a small pin light forward in the receiving ship to indicate the fore-and-aft line from the bridge.

The markers on distance lines are usually indicated with small red lights at night.

Alterations of course

When replenishment is in progress, alterations of course by a force are usually ordered in steps of 20 degrees, individual supplying ships controlling this alteration, for ships replenishing from them at the time, in steps of 5 degrees. It is the usual practice, when giving the executive signal for each 5 degrees, for the supplying ship to indicate '1st', '2nd', '3rd' or 'Last' 5 degrees, in addition to passing the ship's head continuously by telephone.

Disengaging

Disengaging is best effected by a slight alteration outward and a slight increase of speed. It is usually sufficient for the disengaging ship to put her rudder amidships if she has previously been carrying inward rudder. Large alterations of speed and large rudder angles should not be used when within ½ cable or so of the supplying ship, as the effects are likely to be felt by her and by any other ships replenishing from her. The practice of disengaging by a large increase of speed on the present course is particularly objectionable. Not only will it upset the supplying ship, but it may also result in a dangerous yaw inwards by the disengaging ship (p. 107). The dangers of reducing speed without first altering outwards, when intending to drop astern, have also been remarked upon on a previous page.

THE ASTERN METHOD

The approach

In the astern method, the normal method of passing the hose from the supplying ship is by streaming a line with a float on the end, the line being grappled from the receiving ship's forecastle. In this case the approach is made from right astern. Having grappled the hose line the receiving ship steams ahead and heaves it in. By the time the hose end reaches the fairlead the marker buoy should be abreast her bridge. This marker buoy is veered by the supplying ship to such a distance that when it does come abreast the receiving ship's bridge the hose will be towing in a bight of about 100 feet (*Fig. 49*).

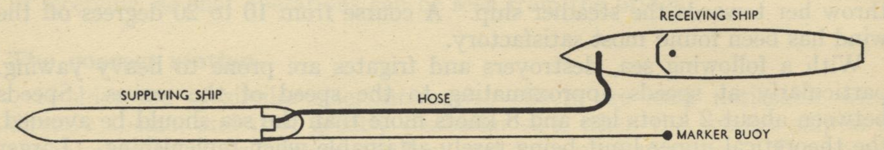


FIG. 49.—The astern method.

An alternative method of passing the hose is by gunline, the receiving ship closing the supplying ship's quarter to make contact. Care must be taken not to overlap excessively, nor to get too close, as interaction effects are particularly noticeable in this position and especially when reducing speed to drop back again to the astern position.

Obviously the gunline method is not practicable when ships are already replenishing abeam on each side.

Maintaining station

Station keeping is considerably simplified in the astern method, and slightly larger errors ahead and astern of station are permissable. It is essential, however, to maintain the bight in the hose as narrow as possible, and steering must be carefully watched. The wider the bight the greater the strain on the hose.

Speed

In the astern method, speed is restricted by the strength of the hose, but provided the bight is kept fairly narrow—not more than about 40 feet across—speeds up to 15 knots should be practicable in calm weather. Rough seas will bring greatly increased strains on the hose; moreover accurate station keeping will be more difficult. Speeds above 10 knots should not normally be attempted when pitching heavily.

Alterations of course

When a single ship is replenishing by the astern method, no special procedure is necessary for altering course. When two ships are replenishing astern simultaneously, or when the abeam method is also being used, it will be necessary to signal alterations in steps as previously described.

Disengaging

When the hose has been passed by the float method, the receiving ship disengages by dropping astern, veering the bight of hose line as she goes.

If the gunline method was used, the receiving ship must regain station on the quarter of the supplying ship in order to pass back the hose line.

CHAPTER XI

HANDLING SHIPS IN A FLEET

In spite of the revolutionary changes in tactics which have followed the technical developments of the second World War, and the change in strategic requirements resulting from the subsequent international re-alignment, there still remain a number of occasions when ships of a Fleet or Task Force may be required to manœuvre in close formation in time of war.

For this reason alone the practice of this art in time of peace would be of prime importance, but because, in addition, the handling of ships in company develops the virtues of initiative, good judgment, confidence, and comradeship, besides being of ceremonial value, the frequent execution of manoeuvres in formation is likely to continue a prominent feature of Fleet training.

With regard to comradeship, the maxim 'Remember your Next Astern' has become almost a colloquialism, but in its application to fleet work is as important to-day as at the time the first edition of this book was published, over half a century ago. Thus, although the first concern of the officer of the watch must be the safety and correct station of his own ship, he must always bear in mind his obligations to adjacent ships. He will learn from the mistakes of his next ahead how best he may help his next astern. If his ship is the guide he must pay particular attention to the steering, and if he notices the ships astern steering badly he should realise that this may well be the fault of his own ship.

A similar responsibility rests on the engine-room department, whose close attention to the maintenance of steady and correct revolutions will greatly assist accurate station keeping.

Station keeping

MEASURING DISTANCES

The distance between ships is measured between their foremasts, so that allowance must be made for the position of the measuring instrument in the observer's own ship and the position of the object being ranged on in the other ship.

When using a vertical angle of the truck or of a similar object, the waterline immediately below it should be observed. This point cannot be seen when in column, but some equivalent level can be selected by eye. Alternatively the waterline may be neglected and any two well defined marks used, such as the main truck and the deck level at the stern, the necessary adjustment to the setting of the instrument being made from previous calculation.

When steaming at night without lights, station may be kept by eye assisted by such aids as the varying size of the ship ahead seen in the field of a binocular, or the variations in height between her shaded stern light and own jackstay pin light, or a mark on the forestay. In calm weather the first sign of closing or opening on the ship ahead is always most readily detected by the movement of a mark in the observer's ship relative to an object in the other ship.

Radar and Asdics can greatly simplify the task of station keeping, both in close formation and at a distance, whenever their use is permissible.

Speed Flags

Speed flags are of assistance when entering and leaving harbour, but it is important to become accustomed to keeping station without them. The change in the wake under the quarter of a ship, or even an audible increase in the speed of her boiler room fans, will frequently indicate an alteration of speed to an observant officer of the watch.

Use of Small Alterations of Speed and Rudder

A ship should be kept in station by the smallest possible alterations of speed and rudder, though certain conditions, such as bad weather or tide rips, may make large rudder angles unavoidable. This will be in turn have some effect on the speed, but the maintenance of a steady course must take precedence.

As regards speed, small alterations applied at the first indication of the ship getting out of station will usually suffice, but unless the officer of the watch is able to give the station keeping his undivided attention this first indication may be missed, and resolute measures must be taken to regain station. A ship one cable out of station is not justified in taking a quarter of an hour creeping back.

Destroyers and lighter craft are more easily affected by wash and other external conditions, and require larger but briefer alterations of speed than are necessary in heavy ships.

Correct Station on the Guide

Ships in line are ordered to maintain bearing and distance from their guide, but this order is qualified by another which directs them to be guided by the motions of the nearest ship between them and their guide, provided that such ship is maintaining her station. In practice it is often difficult to get frequent and accurate distances of the guide; nevertheless officers who endeavour only to maintain their distance from the next ship towards the guide will not keep good station. When ships repeat the mistakes of others, the effect is cumulative down the line, and results in increased difficulty for the rear ships.

Column. In modern heavy ships the primary steering position is invariably below armour, and the ship must therefore be conned by the officer of the watch. Station is best kept in column by ordering the quartermaster to steer a course which will maintain the correct compass bearing of the foremast of the column guide.

In ships where the quartermaster has a view, correct station in column is usually most accurately kept by following the leader of the column and not by endeavouring either to keep in the wake of the next ahead, or to keep the masts of the column in line. This applies particularly at high speed, when ships ahead may be steering erratically, and thoughtless confirmity to their wanderings would result in a cumulative snaking of the line.

When in column ships must not get astern of station. Not only does it take longer to regain ground than to lose it, but any lengthening of a column may inconvenience other units forming on it or passing astern. Nevertheless, ships that habitually keep much inside distance will at times embarrass the column Commander, and may cause delay in carrying out a manoeuvre.

Line Abreast and Line of Bearing

Whereas in column the bearing of the guide does not tend to change rapidly, and the chief problem is the maintenance of distance, on a line of bearing a small discrepancy in course or speed from that of the guide may result in a fairly rapid change of bearing, as well as a change of distance. A plot of the correct and actual positions of the ship on the Battenberg or Mooring Board will assist.

In *Fig. 50* ' XX ' is the track of the guide, 'A' the position of own ship when in correct station, and ' YY ' the course of the unit.

If observations show that the ship has gained bearing and is inside distance it might be assumed, without plotting, that the correct action is to reduce speed and alter course *outward*, but if the actual position of the ship, 'B,' is plotted, it will be seen that the correct action is a reduction of speed and a slight alteration *inward*.

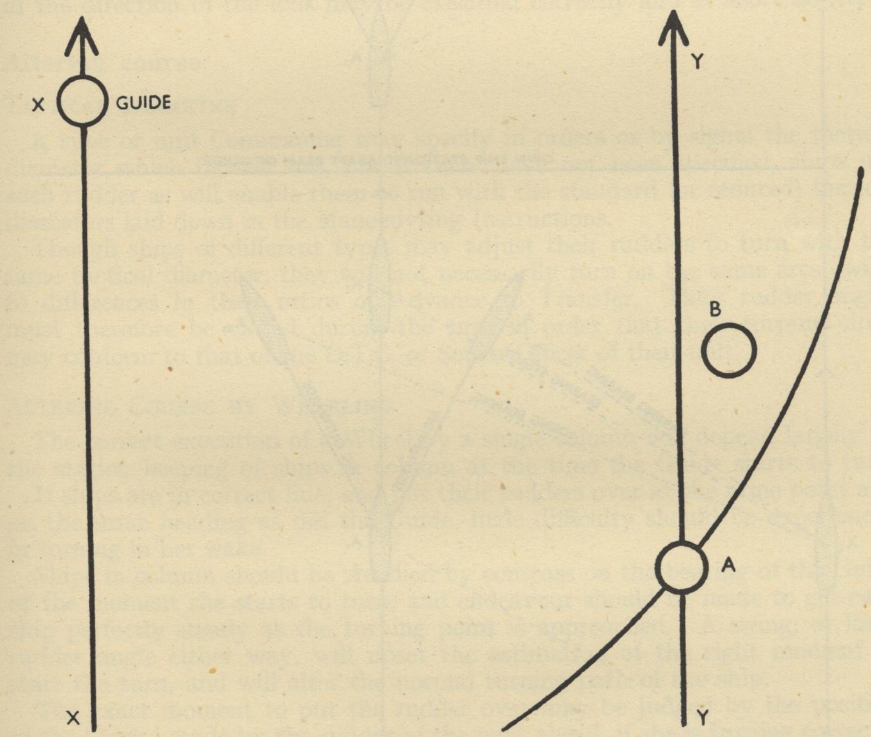


Fig. 50.—Keeping station on a line of bearing.

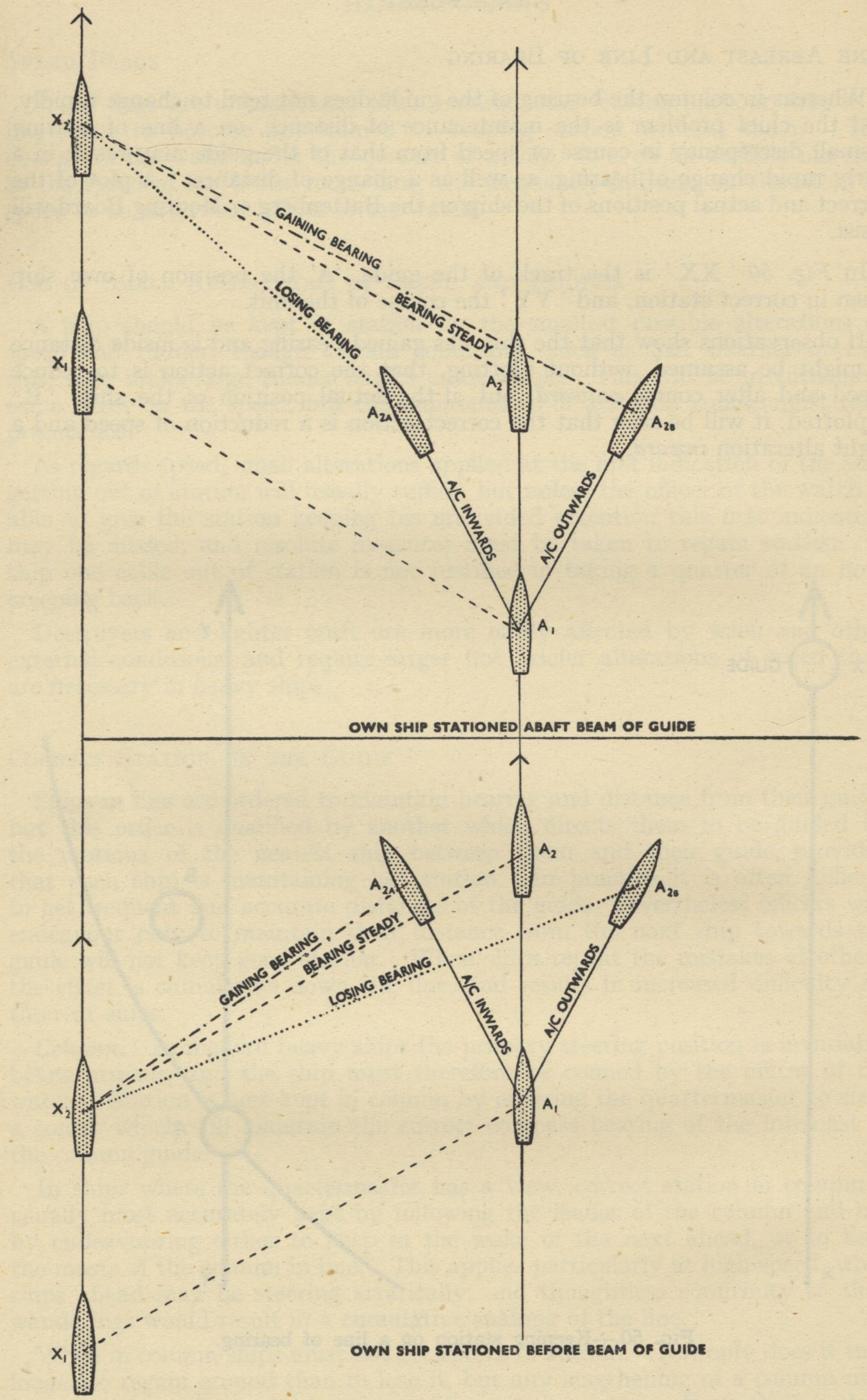


FIG. 51.—Keeping station on a line of bearing before or abaft the beam of the guide.

WHEN STATIONED ON A LINE OF BEARING AND PROCEEDING AT THE SAME SPEED AS THE GUIDE

A brief study of *Fig. 51* will indicate the rules to be followed, i.e.

If stationed before the beam of the guide—

An alteration of course inwards will gain bearing.

An alteration of course outwards will lose bearing.

If stationed abaft the beam of the guide the reverse will be true.

The common fault when station keeping on a bearing is the use of too large alterations of course. Once the ship is on the correct track 'YY' it should be possible to keep her there with not more than 2° alterations either way.

OPEN FORMATION

Modern tactics will more frequently require the adoption of diamond or circular formations rather than standard distance and manoeuvring interval. Although ships may not be in line, the maintenance of accurate station remains important if the purposes for which the formation is designed are to be fulfilled.

It is essential that the position of own ship and the guide should be kept on the Battenberg or Mooring Board, not only for convenience in maintaining or changing station, but also in order that alterations of course and changes in the direction of the axis may be executed correctly and at short notice.

Altering course

TACTICAL DIAMETER

A type or unit Commander may specify in orders or by signal the tactical diameter which he will use, but if these have not been specified, ships use such rudder as will enable them to run with the standard (or reduced) tactical diameters laid down in the Manoeuvring Instructions.

Though ships of different types may adjust their rudders to turn with the same tactical diameter, they will not necessarily turn on the same arcs owing to differences in their ratios of Advance to Transfer. Their rudder angles must therefore be varied during the turn in order that their turning circle may conform to that of the O.T.C. or Senior Officer of their unit.

ALTERING COURSE BY WHEELING

The correct execution of a Wheel by a single column will depend largely on the station keeping of ships in column at the time the Guide starts to turn.

If ships are in correct line, and put their rudders over at the same point and on the same heading as did the Guide, little difficulty should be experienced in turning in her wake.

Ships in column should be steadied by compass on the bearing of the Guide at the moment she starts to turn, and endeavour should be made to get each ship perfectly steady as the turning point is approached. A swing, or large rudder angle either way, will upset the estimation of the right moment to start the turn, and will alter the normal turning path of the ship.

The exact moment to put the rudder over may be judged by the position of the 'kick' made by the rudder of the next ahead, if she is turning correctly in the guide's wake. If the ship ahead is turning badly, endeavour must be made to turn in the wake of the Guide, provided this can be done without closing the next ahead unduly.

The correct position of the 'kick' of the next ahead, relative to own ship's compass platform at the time the order is given to put the rudder over, may be calculated for various speeds of ship. For example, at 15 knots, if the distance

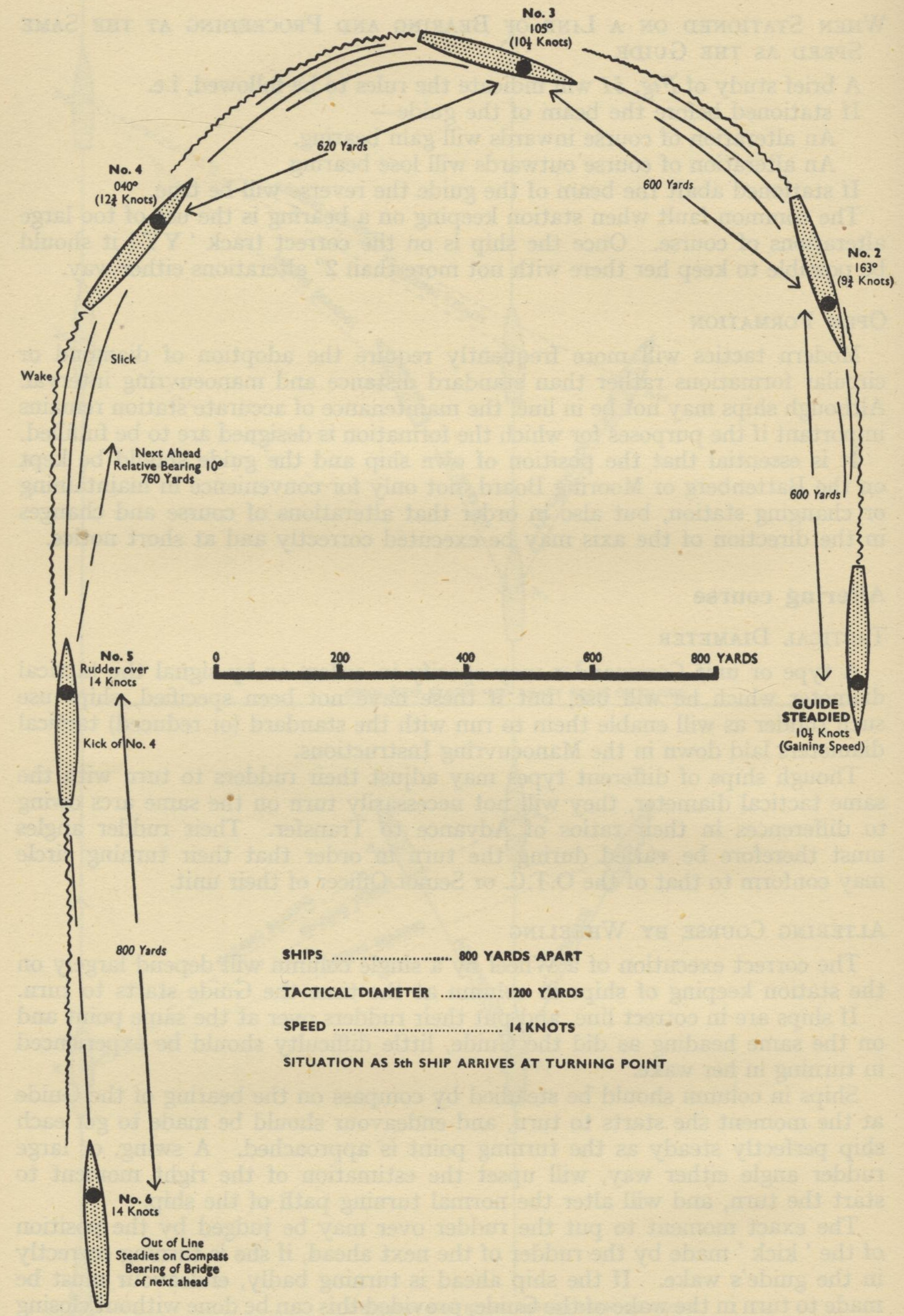


FIG. 52.—A column of heavy ships altering course 180° by wheeling.

from bridge to rudder is 400 ft. and the time taken to put the rudder over is 15 seconds, the next ahead's kick should be just abaft the compass platform. (Own ship will travel 375 ft. in 15 seconds.) At 30 knots the ' kick ' should be 350 ft. before the compass platform.

This method presupposes that the ' kick ' does not develop until after the rudder has been put over, which is not strictly the case. It is only by constant practice that the correct moment can be judged under varying conditions.

Another method is by relative bearing of the bridge of the next ahead, or of the Guide, calculated for various speeds and positions in the line.

These methods are illustrated in *Fig. 52*.

A common mistake before the start of a turn is to steady by compass outside the true turning point. The outward swing of the next ahead's stern, combined with her loss of speed when turning, gives the impression that she is falling across own ship's bows. The natural temptation to steer outside her at this stage must be resisted, as she will soon draw clear, and will remain so during the completion of the turn.

The bows must, however, be kept well inside the *wake* of the next ahead, i.e. inside the path traced out by her stern. The bows should in fact be kept somewhat inside the middle of her slick.

When completing the turn, especially when ships ahead are turning badly, it is well to watch the bearing of the Guide and bring the ship on to the correct bearing as she arrives on the signalled course.

No column of ships can turn in succession satisfactorily unless the leading ship steadies accurately on the new course. She should habitually ease the rudder at the same moment, and meet with about the same amount, so that other ships may learn what to expect.* It is even more important that she should not swing past her course and thus ruin a manoeuvre otherwise carried out perfectly by the remainder of the column.

If the correct moment to start the turn has been misjudged, and the rudder put over too late, more must be given and speed increased. If despite these measures the ship turns outside, she will fall astern of station, and it is then important to remember the instruction that the ship must steady outside the track until she can edge into her place at the correct distance. Ships which cannot be relied upon to observe this instruction will be a continual source of embarrassment to those astern.

Turning too early, and inside, is a fault which can more easily be rectified in the early stages. The rudder should be eased promptly, otherwise in a large turn the ship will soon find herself in an uncomfortable position. It may not be necessary to reduce speed if the rudder is eased as soon as the bow is seen to be drawing across the stern of the next ahead, for the ship will subsequently require to turn in a smaller circle with increased rudder, and will lose distance in the process. An unnecessary reduction of speed will inevitably hamper the next astern.

The Guide will normally adjust her rudder angle to allow for the effect of weather conditions on her tactical diameter, and ships in column will require to make allowance for their individual peculiarities in bad weather.

Wheeling when in Column Open Order

The instructions for this manoeuvre state that ships are to form column immediately the signal is executed. The literal interpretation of this instruction

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* See *Table VI*:—Procedure for steadying ships after altering course (p. 159).

may not always be attempted, ships steering instead for the turning point, in which case those whose station is away from the direction of the turn will evidently require less rudder to keep in the Guide's wake than those stationed on the side towards which the turn is being made.

Handling a Column

The speed of a column should not be altered during the execution of a wheel, if it can be avoided. In particular it should not be reduced.

Similarly, the large turns should not follow one another so rapidly that ships are not steadied after one turn before starting the next.

Altering Course Together

Discrepancies between the Advance and Transfer ratios of individual ships are usually most apparent, and are most difficult to adjust, when ships in line execute a turn together.

The example, the O.T.C. may indicate that the tactical diameter to be used is 1,200 yards. At the speed of the fleet the Guides advance for a 90° turn may be 1,000 yards, whereas the remainder of the line, using rudder for a tactical diameter of 1,200 yards, may advance only 900 yards, and must vary their rudder angles accordingly during the turn. (*Fig. 53.*)

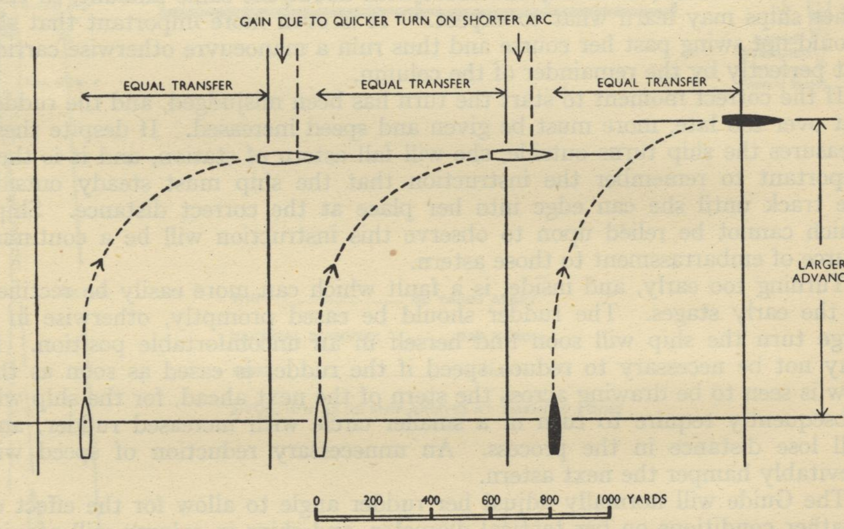


Fig. 53.—Turning 90° together. Effect of variations in advance.

Even when executing a 180° turn together it will be undesirable to attempt to use the same rudder angle throughout the turn if the advance of the guide differs greatly from the remainder, for although ships may complete the turn either in correct line *or* at correct distance, they will not achieve *both*. (*Figs. 54 and 55.*)

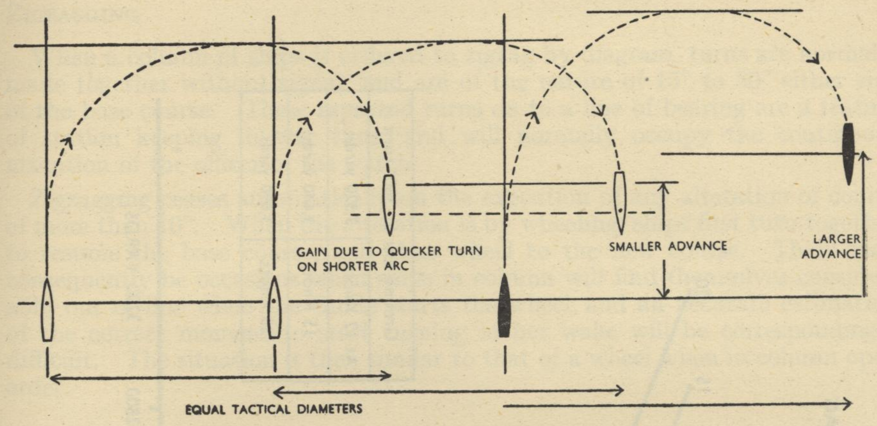


Fig. 54.—Turning 180° (line abreast).

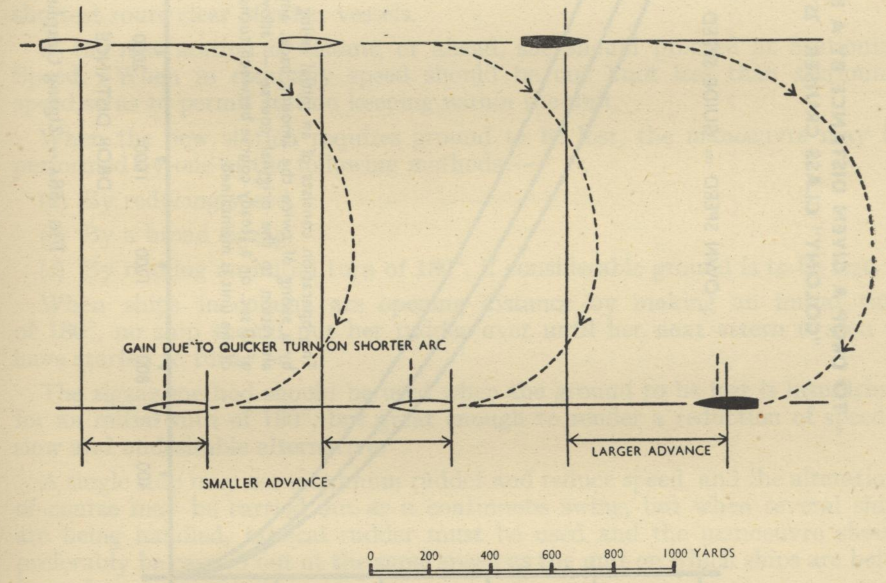


Fig. 55.—Turning 180° (line ahead).

The remedy in the above cases is to start the turns under small rudder and increase the rudder angle considerably later, though the estimation of the rate at which the guide is turning is by no means easy. Thus, in addition to maintaining the correct compass bearing and distance during the turn, the inclination of the guide must be judged and compared with the heading of own ship.

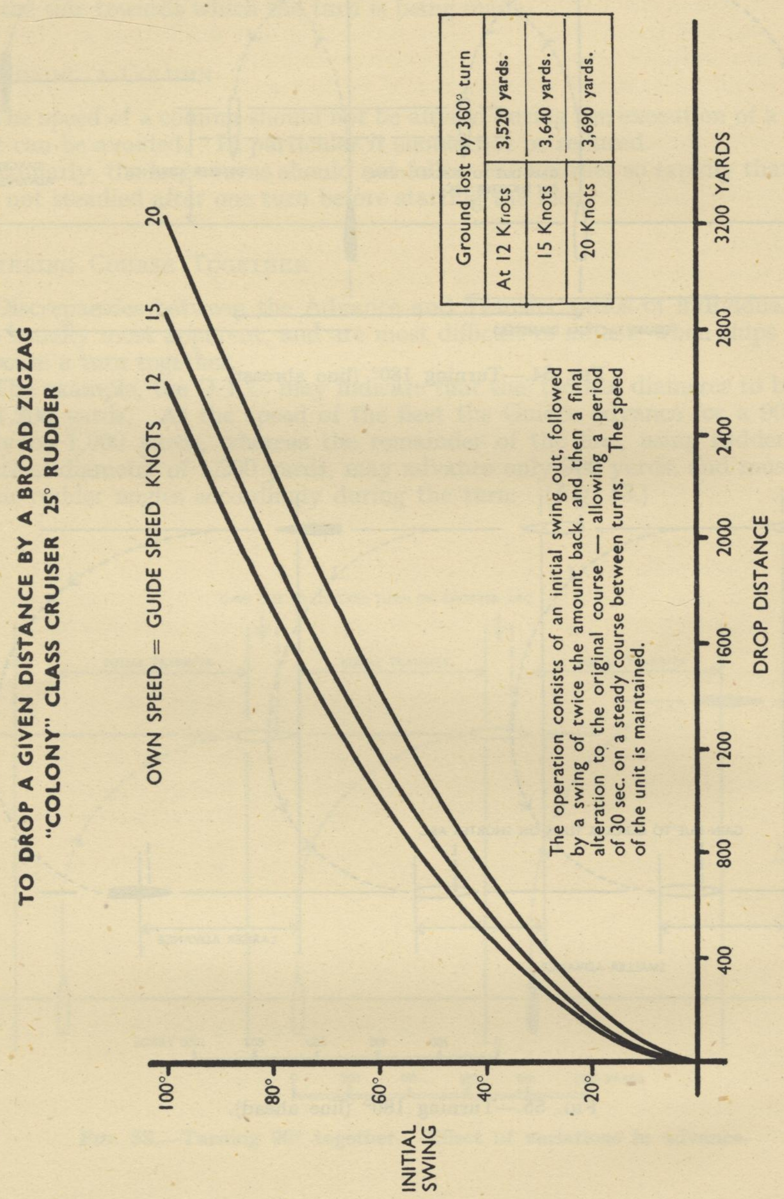


Fig. 56a.—Zigzag Graphs.

Zigzagging

When a column of ships is ordered to zigzag by diagram, turns are normally made together without signal, and are of the nature of 15° to 30° either side of the base course. These repeated turns on to a line of bearing are a feature of station keeping in war time, and will normally occupy the continuous attention of the officer of the watch.

Zigzagging ceases automatically on the execution of any alteration of course of more than 10°. When the alteration is by wheeling, ships first turn together to resume the base course, and then wheel to the new course. There may consequently be occasions when ships in column will find themselves considerably out of line when the Guide starts the wheel, and an accurate estimation of the correct moment to start turning in her wake will be correspondingly difficult. The situation is then similar to that of a wheel when in column open order.

Taking up and Changing Station

A new station must be taken up promptly unless the O.T.C. indicates to the contrary by giving a definite time at which the ship is to be in station, or otherwise controls the action to be taken. The ship should proceed by the shortest route clear of other vessels.

If the new station is distant, or ahead, she should proceed at Stationing Speed. When in company speed should be one knot less than stationing speed so as to permit station keeping within the unit.

When the new station requires ground to be lost, the manoeuvre may be performed by one of the following methods:—

(*a*) By reducing speed.

(*b*) By a broad zigzag.

(*c*) By making an initial turn of 180°, if considerable ground is to be lost.

When ships in column are opening distance by making an initial turn of 180°, no ship should put her rudder over until her next astern is seen to have started to turn.

The zigzag method should be used when the ground to be lost is insufficient for an initial turn of 180°, but great enough to render a reduction of speed a slow and undesirable alternative.

A single ship may use maximum rudder and reduce speed, and the alterations of course may be carried out as a continuous swing, but when several ships are being handled, tactical rudder must be used and the manoeuvre should preferably be carried out at the same speed as the unit on which ships are being formed.

Graphs may be constructed similar to that illustrated in *Fig. 56a* for a *Colony* class cruiser.

If the actual path of the ship for different alterations of course can be plotted from turning trial data, and if the distances lost relative to a ship proceeding on a steady course at various speeds are then calculated, the results may be plotted graphically. A table giving the ground lost by a 360° turn at various speeds of guide should also be shown. For this the factors to be considered are the time taken by own ship to turn 360° at the speed in use (and hence the distance run on by the guide during the turn), the advance, and the distance correction for the speed lost in turning.

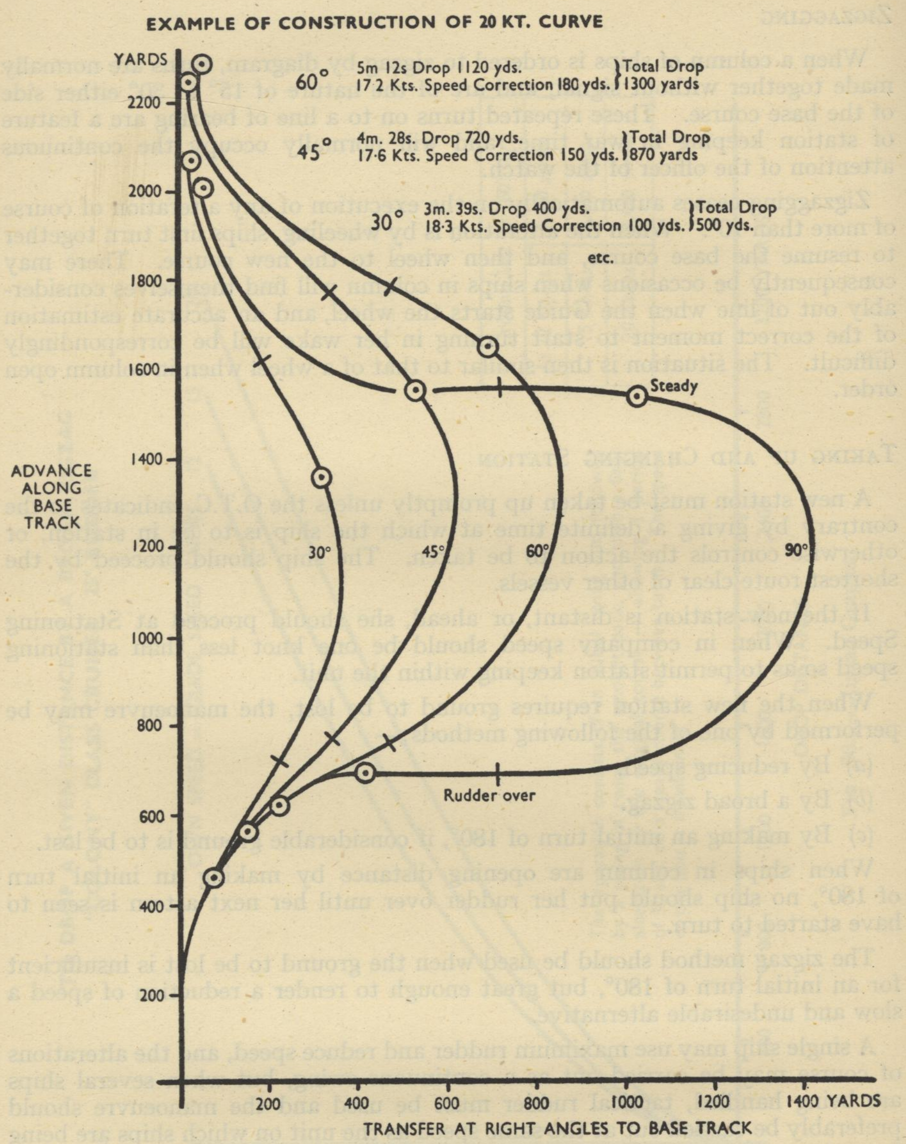


Fig. 56B.—Zigzag Curves

At best, such a graph can only be a very rough approximation, observing that the precise behaviour of the ship when the rudder is eased or reversed during a turn cannot be deduced from turning trial data.

When constructing graphs or diagrams from turning trial results, it is recommended that the precise figures on which the construction is to be based should first be separately tabulated together with a note as to their source. By this means much subsequent duplication of work can be avoided, especially when interpolation is necessary for plotting turning circles at intermediate speeds and rudder angles.

PARTICULAR MANOEUVRES

Reversing the order of ships in column

A description of this manoeuvre when carried out from rest, e.g. when leaving harbour, will be found in *Chapter XII*.

If carried out when steaming, the manoeuvre will take longer to complete, and correspondingly more sea room will be required.

When a column is ordered to invert the line, all ships except the rear ship reduce speed to 7 knots, unless some other speed is specified in the signal. The rear ship hauls out to the side indicated and increases to one knot less than the maximum, remaining ships forming astern of her at this speed in succession from the rear. (*Fig. 57.*)

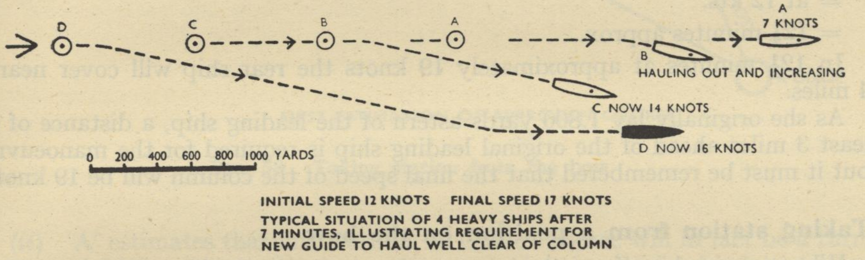


FIG. 57. Inverting the line.

It will be found virtually impossible to evolve a rule for determining the correct moment for the remaining ships to increase speed so that they fall into correct station on the new guide. For instance ship 'C' in the Figure will probably require to increase before 'D' draws abeam, but the speed of neither ship can be accurately forecast at this time, as they may not yet have attained their new speed of 7 knots and one knot less than the maximum respectively.

Ships 'A' and 'B' should accordingly base their timing on the position and estimated speed of the new guide ('D'), rather on the movements of their next astern, who may have misjudged the manoeuvre.

When the manoeuvre is being executed by ships with slow acceleration, ships may find themselves steaming very nearly abreast for several minutes. The new guide should therefore haul well clear of the line on increase of speed, so as to allow sufficient room for other ships to haul out before she has passed them.

Similarly, when considering the time and sea room required to complete the manoeuvre, the following factors must be taken into account:—

(*a*) The rear ship does not at once attain her new speed of one knot less than the maximum.

(*b*) The leading ship does not at once drop to her new speed of 7 knots.

(*c*) The original leading ship, in order not to fall astern of station when completing the manoeuvre must start increasing speed again before she has dropped to the correct distance from the new leading ship.

The manoeuvre is completed when all ships are in station at the new speed on the new guide. The original speed of the fleet may then be resumed by signal.

The time required for the manoeuvre may be found by calculating the time taken to cover, at the difference of the speeds for which revolutions are ordered, a distance of 2L + 2(S × C) yards

where L is the length of the line in yards

S the difference of speeds in knots for which revolutions are ordered

C the distance correction, in yards per knot, for gain and loss of speed for the class of ship concerned.*

For example, a column of four *Colony* class cruisers, steaming at 12 knots with steam for 20 knots, is ordered to invert the line. Ships are 600 yards apart.

The rear ship will increase to 19 knots, remaining ships reducing to 7 knots.

The distance correction for this class of ship is 60 yards per knot.

The time taken to complete the manoeuvre will be the time taken to steam 2 × 1,800 + 2(12 × 60) yards at 19 – 7 kts.

= at 12 kts.

= 12½ minutes approx.

In 12½ minutes at approximately 19 knots the rear ship will cover nearly 4 miles.

As she originally lay 1,800 yards astern of the leading ship, a distance of at least 3 miles ahead of the original leading ship is required for the manoeuvre, but it must be remembered that the final speed of the column will be 19 knots.

Taking station from a position on the bow

When approaching from the bow to take station in the line or in a specified position, the estimation of the point at which to put the rudder over requires fine judgment, which can only be developed by constant practice.

In general, when sufficient time is available for the necessary calculation and plotting, the best results will be obtained by a combination of a graphical method and the use of the trained eye, rather than by complete reliance on the latter.

The factors in the calculation are:—

(*a*) The time taken to turn from the approach course to the course of the fleet.

(*b*) The Advance and Transfer during this turn.

(*c*) The speed remaining after the turn.

The attainment of the calculated turning point is much simplified if it is possible to approach on the exact reciprocal course of the fleet, but at whatever angle the approach is made some previous preparation is essential if the plotting is to be completed in time for the eye to be used to assist in the manoeuvre.

The following example of plotting the turning point from first principles will illustrate the difficulty of achieving the necessary quick solution by this method under seagoing conditions.

In *Fig. 58*, the Guide 'X' is steering 340° at 14 knots.

Own ship 'A', stationed 300°, 5 miles from the Guide, is ordered to take station in column 800 yards astern of her.

Speed available 20 knots.

(*i*) 'A' plots interception course as *095*° at 20 knots, and alters course and speed acordingly.

* If the column consists of ships of different performance, the mean value of C for leading and rear ships must be used.

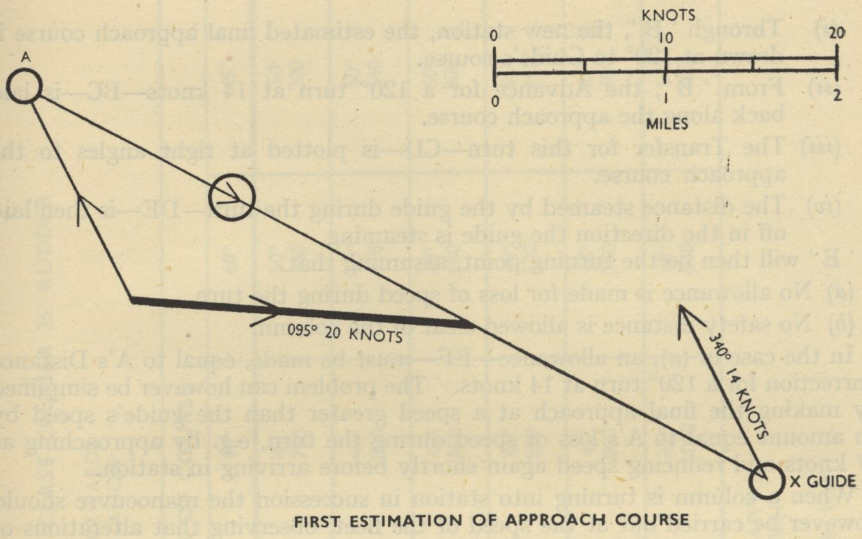


Fig. 58. Taking station from the bow.

(*ii*) 'A' estimates that final turn on to Guide's course will in fact be a turn of *120*°. ('A' anticipates gaining some bearing during his initial turn towards: moreover interpolation would be required to obtain Advance and Transfer for a 115° turn.)

(*iii*) 'A' starts plotting the final turn, which he intends to carry out at 14 knots. (*Fig. 59.*)

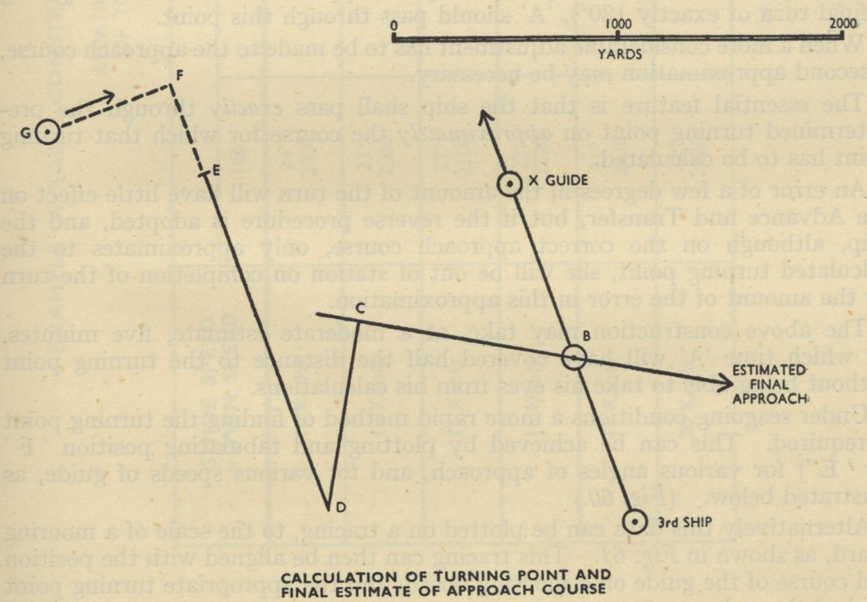


Fig. 59. Taking station from the bow.

(*i*) Through ' B ', the new station, the estimated final approach course is drawn at 120° to Guide's course.

(*ii*) From ' B ', the Advance for a 120° turn at 14 knots—BC—is laid back along the approach course.

(*iii*) The Transfer for this turn—CD—is plotted at right angles to the approach course.

(*iv*) The distance steamed by the guide during the turn—DE—is then laid off in the direction the guide is steaming.

' E ' will then be the turning point, assuming that

(*a*) No allowance is made for loss of speed during the turn.

(*b*) No safety distance is allowed clear of the column.

In the case of (*a*), an allowance—EF—must be made, equal to A's Distance Correction for a 120° turn at 14 knots. The problem can however be simplified by making the final approach at a speed greater than the guide's speed by an amount equal to A's loss of speed during the turn, e.g. by approaching at 17 knots and reducing speed again shortly before arriving in station.

When a column is turning into station in succession the manoeuvre should however be carried out at the speed of the fleet, observing that alterations of speed are not recommended when wheeling in column.

In the case of (*b*), a lateral safety distance—FG—of between a quarter and one-third of the tactical diameter for the wheel it is intended to use should be allowed when turning into column, to allow for misjudgment or miscalculation. If during the turn it is seen with certainty that a correct estimate has been made, the rudder can be eased without jeopardising the success of the manoeuvre. Should this precaution have been neglected, the ship may find herself compelled to resort to full rudder, and a dangerous situation may develop.

' G ' therefore becomes the correct turning point in this example, and it is found, fortuitously, that by adjusting the approach course to 100° (giving a final turn of exactly 120°), 'A' should pass through this point.

When a more considerable adjustment has to be made to the approach course, a second approximation may be necessary.

The essential feature is that the ship shall pass *exactly* through the predetermined turning point on *approximately* the course for which that turning point has to be calculated.

An error of a few degrees in the amount of the turn will have little effect on the Advance and Transfer, but if the reverse procedure is adopted, and the ship, although on the correct approach course, only approximates to the calculated turning point, she will be out of station on completion of the turn by the amount of the error in this approximation.

The above construction may take, at a moderate estimate, five minutes, by which time 'A' will have covered half the distance to the turning point without being able to take his eyes from his calculations.

Under seagoing conditions a more rapid method of finding the turning point is required. This can be achieved by plotting and tabulating position ' F ' (or ' E ') for various angles of approach, and for various speeds of guide, as illustrated below. (*Fig. 60.*)

Alternatively this data can be plotted on a tracing, to the scale of a mooring board, as shown in *Fig. 61.* This tracing can then be aligned with the position and course of the guide on a mooring board, and the appropriate turning point pricked through.

EXAMPLE OF TABLE CONSTRUCTED FOR A "COLONY" CLASS CRUISER 25° RUDDER

RELATIVE BEARING AND DISTANCE IN YARDS OF TURNING POINT FROM NEW STATION

GUIDE SPEED =OWN SPEED	ALTERATION OF COURSE					
	180°	150°	120°	90°	60°	45°
10 Knots	24° 2000	29° 1600	38° 1160	41° 760	50° 360	50° 200
12 Knots	23° 2080	29° 1660	38° 1200	42° 800	50° 420	50° 240
14 Knots	22° 2200	28° 1760	37° 1300	42° 860	49° 460	50° 300
16 Knots	22° 2320	27° 1860	37° 140	42° 920	49° 520	51° 340
18 Knots	21° 2420	27° 2000	36° 1480	42° 960	48° 560	51° 360
20 Knots	20° 2520	27° 2100	35° 1600	42° 1000	48° 600	51° 380

A SAFETY DISTANCE SHOULD BE APPLIED WHEN TURNING INTO COLUMN

FIG. 60. Taking station from the bow.

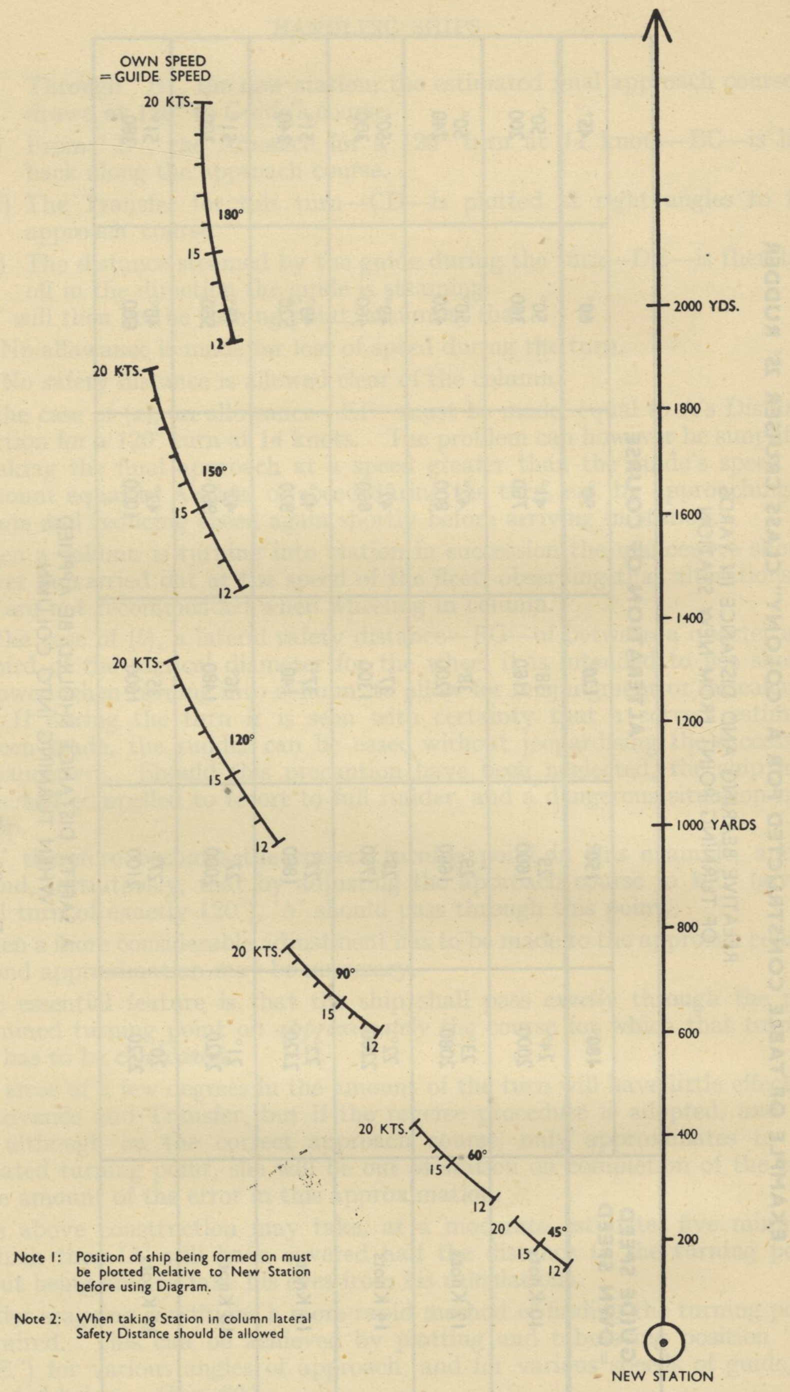


FIG. 61. Taking station from the bow. Showing positions, relative to new station, of rudder over on various approach courses. *Colony* class cruiser 25° rudder.

Man overboard or breakdown at sea

The standard procedure in the event of man overboard or breakdown, when at sea in formation, is laid down in the Manoeuvring Instructions.

It is important that the officer of the watch should be fully prepared for either of these eventualities, and should constantly review in his mind the immediate action necessary in the prevailing conditions.

With regard to avoiding the man overboard, it will frequently be the case that the ship losing the man will not be able to take effective action unless he falls from well forward and the incident is observed from the bridge. For instance, a man falling overboard from amidships in a cruiser steaming at 15 knots would be in the vicinity of the propellers in about 10 seconds. Unless seen to fall by the officer of the watch, it cannot be expected that the necessary information, including the essential words 'port' or 'starboard', will be received on the bridge in less than 5 seconds, in which case it is unlikely that the 5 seconds remaining before the propellers reach him will be sufficient in which to take action to throw the stern clear.

With regard to stopping engines on the appropriate side, the time taken to bring a turbine to rest from ahead revolutions for 15 knots varies from 45 seconds in a battleship to 20 seconds in a destroyer.

The above paragraphs should not be construed as a recommendation that a ship losing a man over-board should take no steps to throw her stern clear, nor to stop the engines on that side. In certain circumstances such action may be effective.

When steaming in formation in peace time, any ship from which a man falls overboard has complete freedom of manoeuvre to recover the man provided she does not endanger other ships, which are instructed to keep clear.

When in column, ships ahead of the one losing the man are instructed to hold their course and speed, while ships astern are instructed to haul out of line, odd numbers to starboard and even numbers to port, counting from the van of the column.

When steaming in other formations, other ships are instructed to maintain the course and speed, the picking up ship being manoeuvred so as to keep clear.

In wartime, large ships are instructed not to stop in waters where enemy submarines may be encountered. Recovery of a man overboard then becomes the duty of the nearest small ship.

In the event of a breakdown, such as loss of steering control or failure of main engines, the instructions state that the first requirement is to avoid endangering other ships in company, and that as a means to this end the necessary signals and information to the other ships should be passed as nearly concurrently with the orders to the wheel and engines as is possible.

CHAPTER XII

FLEET WORK IN PILOTAGE WATERS

LEAVING HARBOUR IN COMPANY

The preparatory signal for leaving harbour will normally indicate the time by which ships are to complete heaving in to short stay, or at which they are to be ready to slip, and the speed for which steam is to be raised.

Unmooring and shortening in cable

One of the objects of mooring being to enable ships to berth more closely together, corresponding care is necessary to avoid inconveniencing one another when unmooring, particularly when ships are lying in the line of their anchors. In this case, when a ship is weighing her lee anchor, she will usually fall over the weather anchor of her next astern, so that the latter must delay shortening in until her next ahead has started to do so.

The mooring plan of a squadron should be so arranged that any ship may unmoor independently whatever the direction of wind and stream, and for this reason, although the lengths of adjacent ships will usually be the first consideration, the span of the anchors must also be taken into account. Ships unmooring in a strong wind or stream may require to swing to nearly the full scope of their weather cable as soon as their lee anchor has been weighed, so that unless adjacent lines are spaced at the span of anchors plus the length of the longest ship, difficulty may be experienced in unmooring independently under certain conditions.

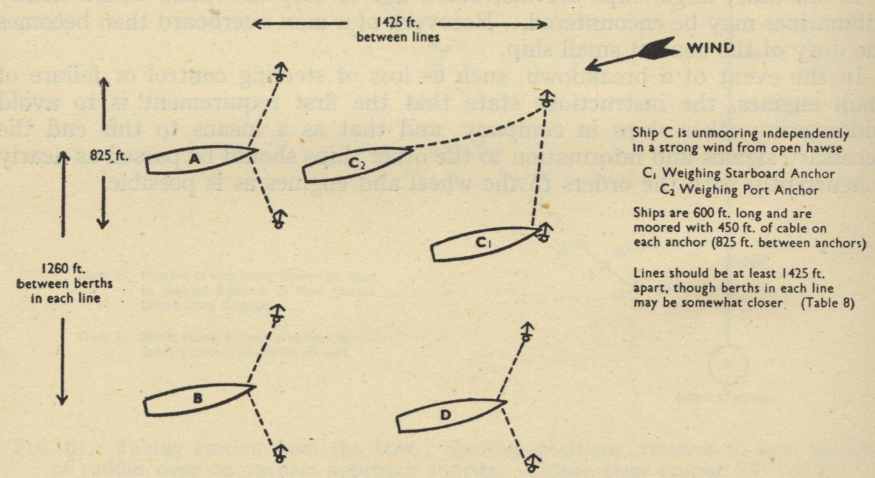


FIG. 62.—Spacing of Mooring Berths to allow swinging room when unmooring independently.

A summary of the minimum circles for anchoring and mooring berths is given in *Table VII*.

When power has been ordered by signal for working cables, steam should also be available on main engines.

Weighing

Instructions for this manoeuvre direct that whenever a unit weighs together, ships should, until otherwise ordered, preserve their true bearings and distances from the O.T.C., each ship keeping her head in the direction in which she was lying when her anchor broke ground.

The object of shortening in cable preparatory to weighing in company is to ensure that anchors break ground at about the same time, but in case any ship should be delayed the O.T.C. will usually maintain his position relative to the land until all ships have weighed, particularly in a strong wind or in a tideway. Ships may otherwise drift down on those whose anchors have not broken ground or who may be hampered by proximity to shoal water.

Casting

When weighing in company, the O.T.C. may indicate the course to which he is turning, and order remaining ships to cast as requisite for leaving harbour; or he may order all ships to turn together to the same course. Whichever method is used, it will often save time if the signal is made shortly after the signal to weigh is hauled down, so that ships will not maintain their heads unnecessarily in the wrong direction should they have taken a sheer when weighing.

When a unit is turning at rest, ships should endeavour to regulate their rate of turning to that of the O.T.C., who in turn may adjust his own rate to that of the slowest ship; but in circumstances such as a crowded tidal river it may be desirable for each ship to turn as quickly as possible. In a strong ebb tide it may be preferable to order ships to weigh in succession from the rear. When leaving an open anchorage, the O.T.C. may dispense with the point ship or turning signal, and merely hoist the formation, course, and speed; proceeding ahead under rudder as soon as the signal is executed.

Inverting the line when leaving harbour

If the O.T.C. led the squadron into harbour, he will probably order columns to invert the line when leaving. In these circumstances it is preferable to turn together 20° short of the course for leaving harbour so that each ship, when her turn comes, can go ahead into clear water without having first to turn to avoid her next ahead. (*Fig. 63.*)

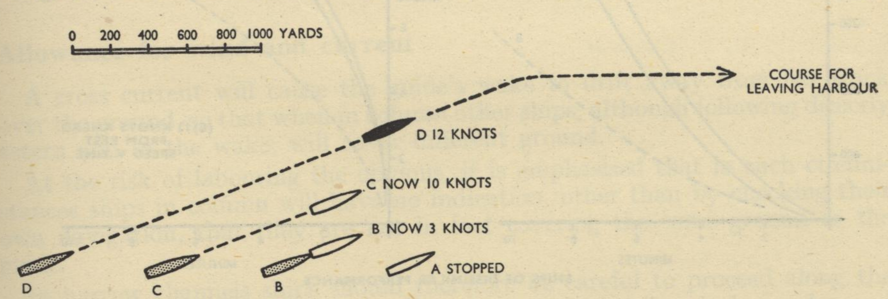


FIG. 63.—Inverting the Line. Ships initially Stopped. Speed ordered 12 knots. Typical Situation of 4 Heavy Ships after 8 minutes.

The speed at which the manoeuvre is to be carried out will be indicated by signal. Until experience has been gained, a time interval should be used for determining the moment to go ahead when forming astern. An estimate based solely on the relative position of the new guide will not always be reliable, as she may well have been out of station at the start of the manoeuvre, so that at any given point she will have attained more or less speed than expected.

Considering the two ships C and D in *Fig. 63,* C's problem is to let D gain station keeping distance (say 3 cables) plus the distance CD measured at the time D was seen to go ahead.

Assuming this total to be 6½ cables, and the speed ordered to be 12 knots, then if the ships are of similar class each will attain this speed after covering a similar distance and the time interval required is simply the time C would need to remain stopped while D is covering 6½ cables at 12 knots. In this case C should therefore go ahead 3¼ minutes after D.

If ships are of dissimilar class, the difference in the distance required by each to attain the speed ordered must be added to or subtracted from the relative distance the overtaking ship has to travel. For example, if in the above case D is known to reach 12 knots from rest after covering 2,000 yards, whereas C does not reach 12 knots until she has covered 2,400 yards, the time interval required is the time D will take to cover 4½ cables at 12 knots, i.e. C should go ahead 2¼ minutes after D.

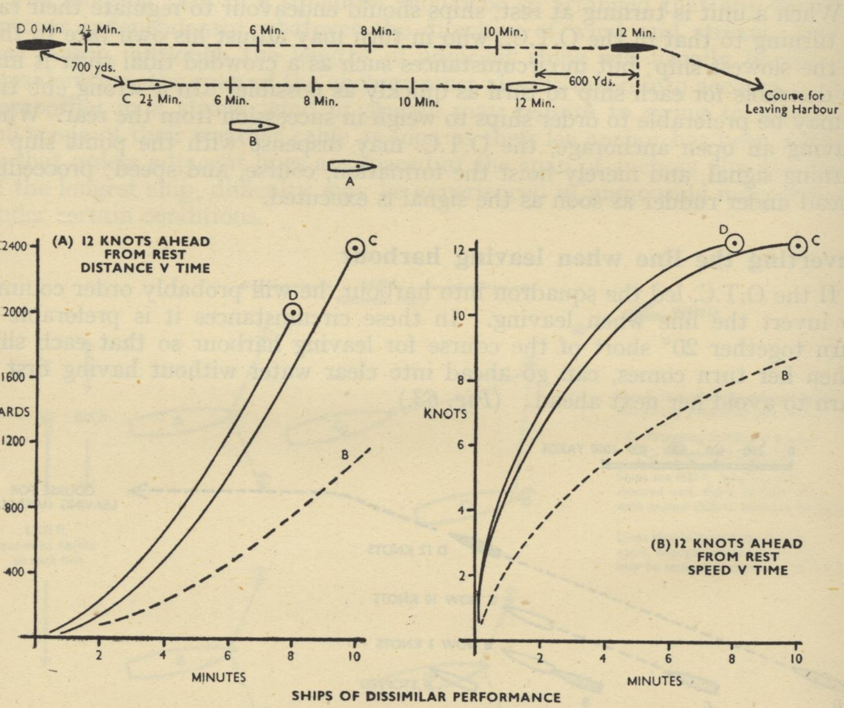


Fig. 64.—Inverting the Line from Rest—Ships of Dissimilar Performance.

If acceleration curves as in *Fig. 64* are not available, a simple approximation may be made from the respective allowances for gain and loss of speed. For instance if D's allowance is 100 yards per knot, and C's 130 yards, then the corrected distance to be covered by D is 6½ cables less 12 × 30 yards = 4½ cables approximately (at 12 kts.), as before.

A slide rule can be constructed to give a rapid solution to the problem for various classes of ship, but it is open to doubt whether such a refinement will justify the effort involved.

When the manoeuvre is being executed by ships of slow acceleration, the situation is similar to that described when reversing the order of ships in column in the previous chapter, and several miles of sea room, on the course to which ships were initially turned, may be required by the new guide before she can turn to the course for leaving harbour.

For instance ship B in *Fig. 64* would require to go ahead immediately the signal was executed, and would not fall into her correct station astern of C for nearly 20 minutes, during which time she would have covered some 2½ miles.

To ensure the manoeuvre being well performed, ships should therefore have ample speed in hand. If the speed ordered is one knot less than the stationing speed, leaving ships with only this margin to correct errors of judgment, the time taken to complete the manoeuvre may be considerably prolonged. Should it be evident that a ship has gone ahead too late, she should be able to make a large increase of speed without delay.

The manoeuvre will also be prolonged if ships are premature in gathering way, so that they find themselves bunched up, or even abreast of one another, when they have attained the speed ordered. Thus the temptation to start going slow ahead in order to be certain of not falling astern should be resisted. Unless the engines are ordered direct to the speed of the fleet at the correct moment, the ships falling in astern will be faced with a more difficult problem.

CONDUCT OF A FLEET IN NARROW WATERS

Responsibility for safe navigation

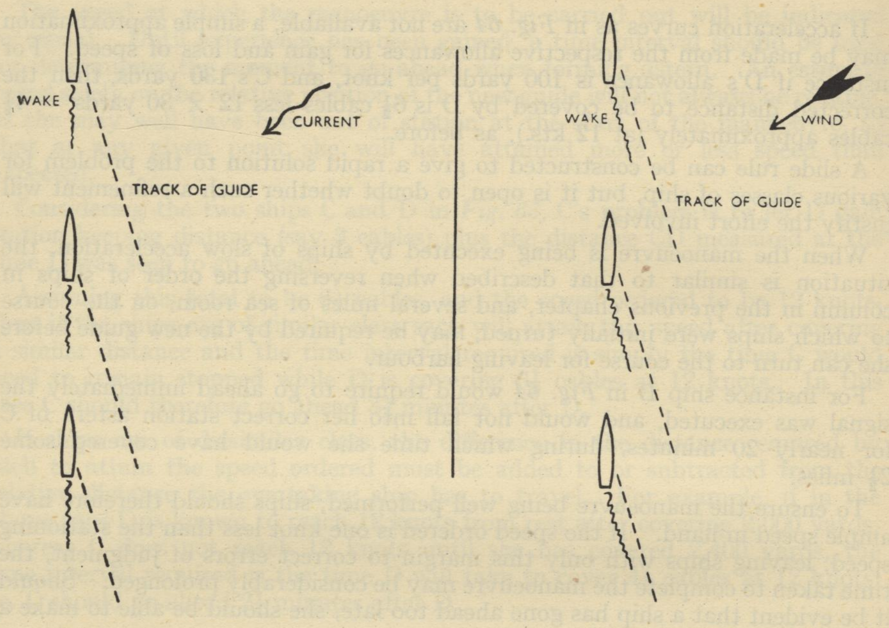
When a unit is in a formed state, the maintenance of correct station on the guide does not relieve individual ships from responsibility for their own safe navigation. It is not only their duty to check the navigation of the unit, but also to ensure that, in narrow waters, their own path, if different from the guide's will lead clear of dangers.

Allowance for wind and current

A cross current will cause the guide's wake to drift away from her track over the ground, so that when in column other ships, although following directly astern and in the wake, will cover different ground.

At the risk of labouring the obvious, it is emphasised that in such circumstances ships in column will have no indication, other than by checking their own navigation, that they are not in fact covering the same ground as the guide.

In narrow channels ships should therefore be careful to proceed along the same track as the guide of their column, rather than follow in her wake, and for this reason ships will sometimes be formed on a line of bearing.



(A) EFFECT OF CROSS CURRENT ON TRACK AND WAKE

(B) EFFECT OF CROSS WIND ON TRACK AND WAKE

FIG. 65.

Similar considerations apply in a strong cross wind, with the exception that in this case the guide's wake *is* an indication of her track. (*Fig. 65b.*) In order to follow in the wake, ships will find that they have to keep on a line of bearing, and this will ensure that they cover the same ground as the guide.

When passing through tide rips, or from slack water into a strong current, a column may be thrown into some confusion, heavy ships having been known on occasion to yaw as much as 90° from their course in areas such as the Pentland Firth.

The distance apart of ships in column may be increased by the O.T.C. before entering such disturbed water, and they will require to anticipate the difficulties in steering which may lie ahead of them.

A FLEET ENTERING HARBOUR

Anchoring in formation

When a fleet or unit is to anchor together, and the O.T.C. intends to make use of the signal ' Anchor Instantly ', the maintenance of accurate station up to the moment of letting go is of paramount importance. The guide can therefore contribute greatly to the success of the manoeuvre by steady steering on the signalled course, and conversely will add considerably to the difficulties of other ships by steering erratically or by adjusting her own course and speed without signal.

On the other hand, if ships are disposed in several lines, the line guides may require to adjust their distances from the squadron guide without signal. Ships should take care to maintain correct compass bearings, and should not follow in the wake when anchoring in column.

Station keeping when anchoring in formation

The ideal to be aimed at is to be in station and steady on the guide at the moment of stopping engines. The whole appearance of the manoeuvre is spoilt by bad station keeping during the approach, moreover strict compliance with the anchoring signal will not be possible if ships are much ahead or astern of station.

Of the two faults, to be astern of station is probably the least objectionable, for although holding on a few seconds after the guide stops engines may result in slightly too much way at the moment of anchoring, it will at least be *possible* to anchor in correct station, if a trifle late. On the other hand, a ship ahead of station may find it difficult to reduce her way; moreover if still ahead at the time the correct berth is thought to have been reached she is placed in something of a dilemma, especially if ships are formed in column.

Nevertheless there are many officers who consider it preferable to be ahead at the moment of stopping, for speed will by this time have been reduced in order to adjust distance, so that the ship will be carrying less way than the guide. This can be corrected later by a few revolutions ahead without embarrassing ships astern.

Whichever school of thought is supported, the case for being in station and steady on the guide is unassailable, and special measures to this end may be considered necessary. For instance, when the approach is made in column, it is a good practice to divide the separate tasks of keeping distance and line between two officers.

When on a line of bearing it will be preferable for only one officer to con the ship, the other assisting by keeping a relative plot on a Battenberg or Mooring Board. The navigating officer will normally be fully employed in fixing the ship's position on the chart up to the moment of anchoring.

When anchoring in company a small adjustment will often be necessary to allow for any difference in the stem to foremast distances of own ship and guide.

Speed when approaching an anchorage

The speed at which a squadron approaches an anchorage must be regulated to suit the requirements of the heaviest ship, who will carry her way longer than the remainder. A heavy ship should be the guide of a squadron consisting of both heavy and light units. The latter will reduce speed and stop engines later than the heavy ships, and in such cases the O.T.C. will make use of the signal ' Intend to stop engines '. When the light ships are formed in separate lines, their commanders may be directed to make their own signals.

Anchoring in pre-arranged berths

When pre-arranged berths have been allocated, the method of anchoring should be indicated by signal, but whichever method is intended, bearings should invariably be laid off on the chart in case they are needed.

If ships are to anchor independently the usual procedure is for the O.T.C. to lead the squadron into harbour so formed and disposed that each ship will pass through her allotted berth. The signal ' Anchor in accordance with previous instructions ' is then made when convenient. Ships maintain station as far as is practicable up to the moment of anchoring, but they are at liberty to steer for their assigned berths after the signal has been executed.

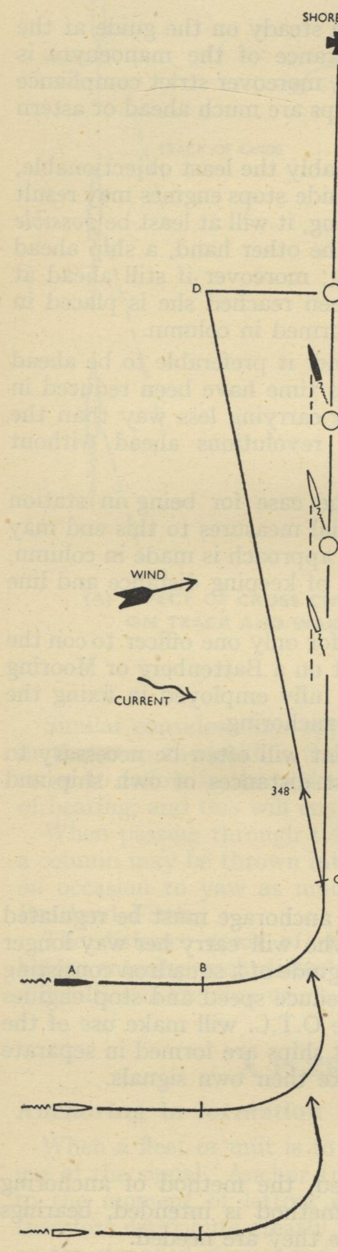


Fig. 66

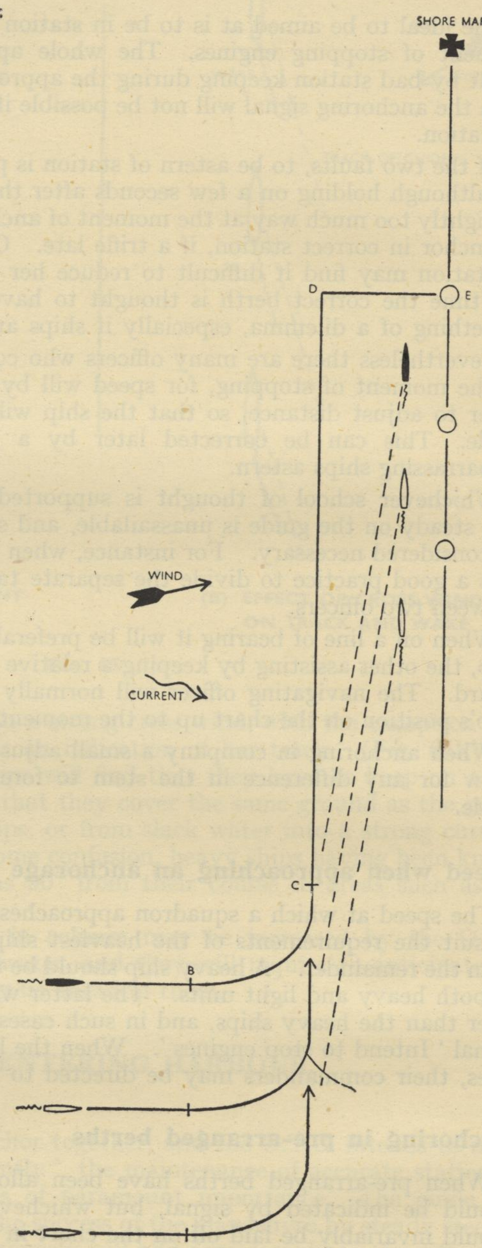


Fig. 66a

Anchoring a column in a cross current or wind.

Anchoring a column in a cross current or wind

In *Fig. 66* the circles indicate the berths to be occupied. The guide approaches the anchoring course steering 090° along the line AB, with ships on a line of bearing 180°.

Allowing for reducing speed and stopping engines it is estimated that wind and current will set the unit three cables to leeward during the final approach. A position D is therefore plotted three cables to windward of the guide's berth, and the unit turned together on to the anchoring line CE, but steering a course of 348°.

If the estimate has been accurate, ships will find themselves slightly to windward of the anchoring line on stopping engines, but as the speed through the water falls, the increased drift should carry them on to the correct line by the time the signal to anchor is executed.

It is important that the guide should proceed accurately along the penultimate course AB as drawn on the chart, otherwise the position of the point D will require reconsideration.

Fig. 66a illustrates an alternative method by which the final approach can be made in column in order to simplify station keeping.

The unit is turned together on to the anchoring course, but three cables short of the anchoring line, so that ships should arrive on the correct line at the moment of anchoring. Ships should take care to maintain correct compass bearings when maintaining their position in column. In this case, in a cross wind, the guide will drift to leeward of her wake.

The first method has the advantage that less sea room is required during the final approach, which is made approximately along the line CE. Moreover the bearing of the shore mark ahead will indicate at once whether the desired line of approach is being maintained.

In both cases, if it becomes apparent that the guide may not arrive in her correct berth, and it is not vital to anchor the unit exactly in the allotted berths, it may be preferable to sacrifice accuracy rather than to upset the station keeping by altering course during the last mile.

Preparation of an anchorage plan

In arranging anchor berths, the allowance necessary to ensure that ships will swing clear of dangers will vary with the degree of shelter afforded by the anchorage, the nature of the holding ground, the suitability of marks for anchoring accurately, the reliability of the survey, etc.

When preparing mooring berths for heavy ships, allowance must be made for ships lying as much as 80 yards to leeward of their line of anchors when at open hawse, and the anchors must be so placed that ships can safely weigh either anchor when heading in any direction.

A summary of the minimum distances between anchor and mooring berths is given in *Table VII* (*Appendix I*). It should be remembered that adjacent ships of different types are liable to drag out their cables in opposite direction under certain conditions of wind and tide.

CHAPTER XIII

CAPABILITIES AND LIMITATIONS OF MACHINERY

The following remarks concerning the characteristics of propulsion machinery are intended as a guide to Commanding Officers in the operation and handling of H.M. Ships. Specific data for individual ships can be obtained from records held on board besides instructions that are issued from time to time in various Admiralty publications. The provision of such data here is outside the scope of this chapter.

GENERAL

Authorised full power

The Authorised Full Power is the power quoted in the Captain's Ship book unless provided for in the detailed instructions issued to the ship or otherwise specifically authorised by the Admiralty and should not be exceeded except in circumstances of emergency during actual war service.

In general the propulsion machinery of H.M. Ships is designed so that the design stresses are not exceeded at authorised full power and the machinery can withstand continuous operation at full power. On trials this power may be exceeded. On service, however, it may not be possible to maintain the A.F.P. indefinitely or it may be undesirable from the maintenance aspect. If the prevailing conditions, i.e. displacement, sea water temperatures, state of the hull, etc., differ considerably from the design conditions it may prove impracticable to achieve this power. In certain vessels fitted with high speed I.C. engines, this power can be developed continuously only for a limited period if undue wear and tear and risk of damage is to be avoided.

Maximum continuous sea going power/rating

The expression is self explanatory and for steam propulsion machinery this power is usually 90 per cent. Authorised Full Power and allows for the vagaries referred to under Authorised Full Power. Vessels fitted with coal fired boilers are limited to 60 per cent. A.F.P. from considerations of the physical capabilities of the personnel. For I.C. engines this power/rating is the same as the A.F.P. except for high speed engines referred to above and for which special instructions are issued. The speed obtained at the maximum continuous sea going power will, of course, vary with conditions of the hull and the displacement of the ship.

Turning at high speed

High speed turns are liable to induce axial propeller shaft vibrations which may be objectionable. In some large vessels this has been a serious problem but its effects have been mitigated by changes in the number of blades of the propellers, and limitation of revolutions on certain shafts. Where such objectionable vibrations are known to occur special instructions will be issued to the ships concerned.

Critical speeds

In most ships there is a propeller speed or speeds at which the frequency of vibration resulting from the action of the blades in the water coincides with the natural frequency of the transmission system, and hull vibrations which can be most apparent and unpleasant may be induced. Such a critical speed is common at about 90 revolutions per minute in Destroyers. If experience shows that ships suffer badly from this effect this critical speed should be avoided whenever possible.

Stresses due to reversals of torque

Trials on the effects on propeller shafts and gearing resulting from rapid reversals of power indicate that extremely high peak loads occur when going from "full astern" to "full ahead" and vice versa, the former being the more severe. In service, however, such 'engine orders' are extremely rare and the stresses induced are acceptable in circumstances necessitating such severe treatment. Stresses of proportional magnitude are, of course, induced by manoeuvres of the lesser order, although the prime factor is not the power employed but the rate at which reversal of the power is carried out.

There appears, however, no need to impose specific limitations on any existing ships but the use of "full ahead" should be avoided while the ship is still moving astern.

Steaming on reduced number of shafts

Trailing of one or more shafts is warranted when failure of the related power unit occurs while under way, for reasons of fuel economy, and for reduction in watchkeeping personnel in peace time. In general the maximum speed obtainable under such circumstances will be limited by the permissible torque in the shafting and gears of the operating units and the degree of vibration experienced at the higher speeds. Thus with two shafts out of four trailing, the maximum speed will be less than that obtained when the ship is being driven by four shafts each of which is developing half power.

In some ships, arrangements are fitted to hold the shaft locked when damage rules out the possibility of 'trailing'. Due to the drag of the propeller under these conditions the speed obtained will be less than that with shafts 'trailing'. In a Cruiser fitted with four shafts, the shaft revolutions, for the same speed, with two shafts locked may be 15/20 per cent. more than those required with the two shafts 'trailing'.

In general, if a choice can be made, it is advisable to trail the outer shafts so that loss of speed in heavy weather due to the outer propellers rolling out of the water can be avoided. The use of the inner shafts may also result in better manoeuvrability due to the effects of the slip stream impinging on the rudders. Some loss of manoeuvrability is to be expected as a result of 'trailing' a proportion of the shafts, most noticeably in the reduction of astern power. This latter fact will, of course, affect the liveliness of the ship compared with the use of all shafts when manoeuvring at rest. It may be of interest to note that H.M.S. *Dido* has been reported as being more lively and more easily handled when using two shafts than either H.M.S. *Newcastle* or H.M.S. *Cumberland* on four shafts.

STEAM PROPULSION MACHINERY

Rates of alteration in power

In extreme cases of rapid increase in speed, the increase in water level in the boiler may result in water passing over with the steam with consequent damage to the engines and superheaters of boilers so fitted, while a similar decrease in speed may result in a fall in the water lever sufficient to interfere with boiler circulation. To avoid such mishaps and the long term effects due to suddenly imposed temperature differences, arbitrary limits for changes in power are usually imposed above about 50 per cent. full power (equivalent to approximately three-quarters full speed), e.g. increase/decrease of one sprayer per minute per boiler, or increase/decrease of ten propeller revolutions every two minutes. Such limits do not, of course, apply when manoeuvring in an emergency, but continued manoeuvring with very rapid rates of alteration in power will result in increased maintenance to steam pipe joints and boiler brickwork, particularly in older ships. It is advisable, when convenient, to avoid pausing at ' stop ' between two engine orders as this obviates difficulties with change in water level from ' high ' to ' low ' to ' high '. This is of particular advantage when going from ' ahead ' to ' astern ', as it will result in the ' astern ' power being provided more rapidly.

It must be appreciated that although it is possible to have all boiler sprayers alight within six to seven minutes of receipt of an order for ' Revolutions for Full Ahead ', the machinery will not develop full power until some considerable time after this period, due to the time required for the design temperatures and pressures to be reached, and to a lesser effect, the time for the ship to gather speed.

In projected installations a considerable degree of automatic control may be provided. This is not expected to result in any marked increase in the rate of working up over existing designs, except insofar as the machinery will be designed to ensure that the Authorised Full Power will be well within its capabilities.

At low powers, when the limitations referred to above are not necessary from machinery requirements, it may be expected that ships of comparable size and power engined with steam reciprocating machinery, will lose speed more rapidly than turbine ships due to the braking effect of the former.

Use of additional boilers

When additional boilers are required it is desirable that they should be connected about half an hour before large outputs of steam are demanded from them. This will prevent cold boilers and the associated steam piping experiencing sudden large temperature differences with its attendant deleterious effects on steam pipe joints and brickwork. This is of particular importance in vessels now coming into service using steam at high temperatures, and when the machinery is arranged in units.

Factors governing full power conditions of boilers and main engines

Owing to alterations made to ships in service, which have affected displacement and equipment it is necessary when developing full power to avoid exceeding safe limits of stress in various parts of the propulsion machinery. Ships or classes of ship in which caution is necessary will have their particular instructions.

The reciprocating main engines of the following classes of ship are of commercial design intended for prolonged operation at moderate power, coupled with short bursts of high speed running:—

Frigates—' Loch ', ' Bay ' and ' Castle ' Class.
Surveying Ships—*Dampier* Class.
L.S.T.(3)'s.
H.M.S. *Woodbridge Haven.*
H.M.S. *Surprise* and *Alert.*
Minesweepers—*Algerine* Class.

Experience has shown that in these ships the Maximum Continuous Speed under average conditions of hull and weather must be restricted to considerably less than that of turbine driven vessels if undue wear and tear of the main reciprocating engines with consequent heavy maintenance is to be avoided. Detailed information on this aspect has been issued to the ships concerned.

Standing by awaiting orders

With steam turbine machinery, if prolonged periods at ' stop ' are envisaged and the order ' Finished with Main Engines ' not passed to the Engine Room, guidance should be given of the probable duration of such a period. This will allow the Engine Room to reduce the vacuum and so ease the possibility of turbine distortion, and at the same time decrease the frequency with which movement of the engines will be necessary. For short periods at immediate notice it is necessary to rotate the engines every 2–5 minutes according to the size of the turbines.

Although it may, under unusual circumstances, be necessary for turbines to remain in a state of instant readiness without periodical movements under steam, it must be realised that such conditions involve grave risk of damage. If such risk is considered justified, the turbines should, if possible, be moved cautiously under steam for a period of 15 minutes after steam is first admitted to the engines and large increases in power avoided during this period.

Astern running

During prolonged running astern special attention has to be paid to the expansion of L.P. turbines, in which the astern turbine is incorporated. The temperature reached in the last rows of the ahead L.P. blading, on which the astern steam can impinge, and the increase in temperature of the ahead H.P. turbine blades due to churning has to be carefully watched to prevent heavy distortion and possible damage. In certain ships, notably Aircraft Carriers, continuous running at high revolutions astern can lead to risk of damage, either when actually going astern, or when changing to ahead revolutions. This danger does not arise until 30 minutes have elapsed and is dependent on the revolutions ordered. Each class of ship where caution is necessary has its particular instructions.

If a shaft is held stopped with astern steam while the other shafts continue to steam ahead, there will be risk of damage to the stationary turbines, the danger from which will increase with increase of speed of the ship. To mitigate this it is necessary to move the stationary shaft a few revolutions ahead as frequently as possible, the intervals not exceeding five minutes. When the operations necessitating the holding of the shaft are completed this shaft should be allowed to trail for at least 10 minutes before power is developed.

The above remarks on Astern Running and Standing By do not apply to Reciprocating Steam Engines.

Astern power

In Naval Ships fitted with steam turbines the astern power is approximately one-third of the ahead power (Merchant Ships two-thirds ahead power) but due to the inefficiency of the astern turbines, the steam consumption or boiler power at full power astern is similar to that required for full power ahead. In other words Slow Astern will require three times the boiler power/steam required for Slow Ahead for similar speeds. With reciprocating steam engines the astern power is practically the same as that ahead and maximum power astern can be developed almost as quickly as for ahead.

In 'Weapon' Class Destroyers the astern power is limited to about one-sixth of the ahead power due to a weakness in the design of the turbines. Another class of ship in which astern power is noticeably poor is the *Black Swan* Class Frigates fitted with steam turbines. This weakness is due to the small power installed in these ships in relation to the size of the vessel, although the normal ratio of astern to ahead power is maintained. It is in view to equip these vessels with Controllable Pitch Propellers so as to overcome this weakness.

INTERNAL COMBUSTION ENGINE PROPULSION MACHINERY

Full power limitations and maximum fuel rating

The Authorised Full Power of an I.C. engine can only be obtained at the designed maximum revolutions if overloading and risk of damage to the engines is to be avoided. To obtain designed maximum revolutions under adverse conditions of weather, displacement, time out of dock, etc., will almost certainly overload an engine. To avoid such a danger I.C. engines are given a Maximum Fuel Rating in terms of Fuel/Hour/Revolutions per minute, which can readily be observed and must not be exceeded.

Rates of alteration of power

The rate at which power can be increased is often governed automatically to prevent overloading the bearings, etc., or damage to pistons and cylinders resulting from the injection of quantities of fuel which may not be burnt in the cylinders; the risk of such damage being less when the engines are warmed up than when increasing speed from cold or after prolonged operation at low powers. The time required to obtain full power from Stop, under normal circumstances, varies with the type and size of engine but 10–15 minutes is a representative figure for the larger powers fitted in ships and for high speed craft this period would be reduced to about 4 minutes.

Large decreases in power can be made without reservations and compared with similar ships engined with steam turbines of comparable power the ship will lose speed more rapidly due to the braking effect of the engines.

Running on a reduced number of engines

Extensive running at low powers causes wear and tends to carbonise exhaust systems and valve gear. In vessels fitted with more than one engine per shaft and where suitable clutches are included, every effort should be made to operate on the minimum number of engines to meet the speed required, provided a margin is available to cover operational requirements. Notable improvement in fuel economy and endurance may be expected by such a procedure together with an extended life of engines between overhauls. In all vessels so fitted additional engines can rapidly be connected and run up to high powers required in an emergency.

Manoeuvring

In ships fitted with high speed diesels coupled to the shafting through a reversing gearbox, it is important to realise that when the Engine Telegraph is put to 'stop' the engines are declutched and the propeller is free to trail resulting in a loss of the braking effect of the engine.

Some Fleet Auxiliaries are fitted with direct drive reversing diesels in which the engines are reversed by a process involving stopping the engines and hence the propeller shaft, and re-starting with compressed air in the opposite direction. Manoeuvring will therefore be comparatively slow in this type of vessel. The number of 'starts' is limited to the capacity of the air starting bottles which by regulations is not less than 12. It may not be possible to start the engines in the reverse direction while the ship still has considerable way on her.

An important characteristic of diesel engines is their relatively high idling speed which limits the minimum speed of the ship with the engine clutched in to between one-half to two-thirds of full speed. This must be borne in mind when manoeuvring or when towing to avoid 'snatch' on the towing wires, etc. The use of controllable pitch propellers avoids this undesirable feature.

Astern power

In practically all diesel-engined ships and craft, the astern power available is the same as the ahead power, the noticeable exception being Fast Patrol Boats fitted with a combination of diesels and gas turbines. In such craft the diesel engines only can provide astern power.

APPENDIX I

RESULTS OF TURNING TRIALS

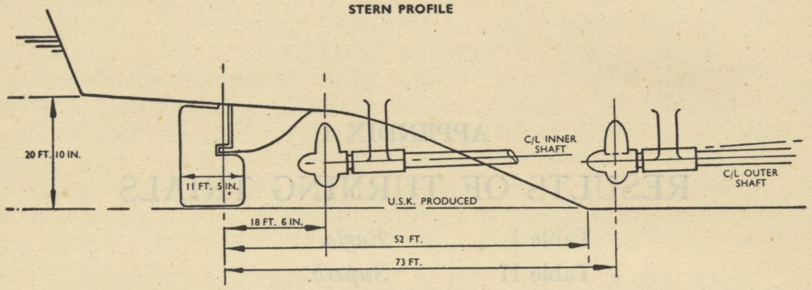
MISCELLANEOUS TABLES

TABLE I. H.M.S. *EAGLE*

DIMENSIONS

Length on Waterline	750 Ft.	Displacement	44,450 Tons
Length Between Perpendiculars	720 Ft.	Rudders — Twin	170 Sq. Ft. Each
Beam	112 Ft. 8½ Ins.	Propellers — Four	15 Ft. Dia.
Mean Draught	32 Ft. 5 ins.		17 Ft. 2 ins. Pitch

STERN PROFILE



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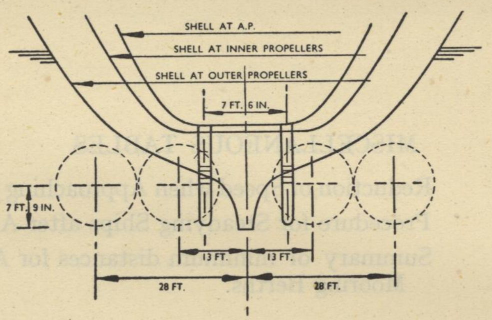
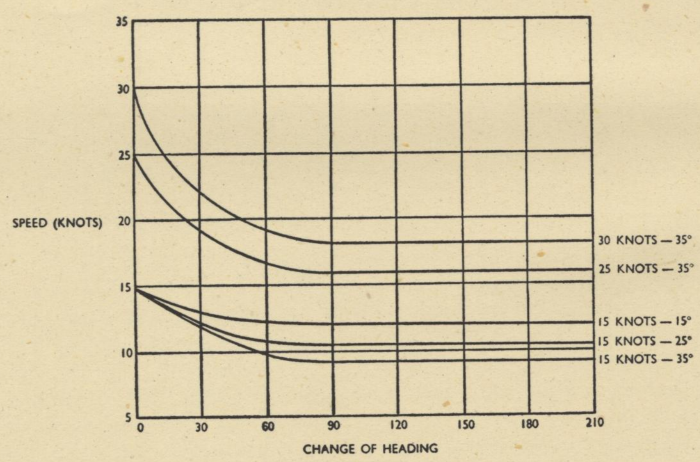


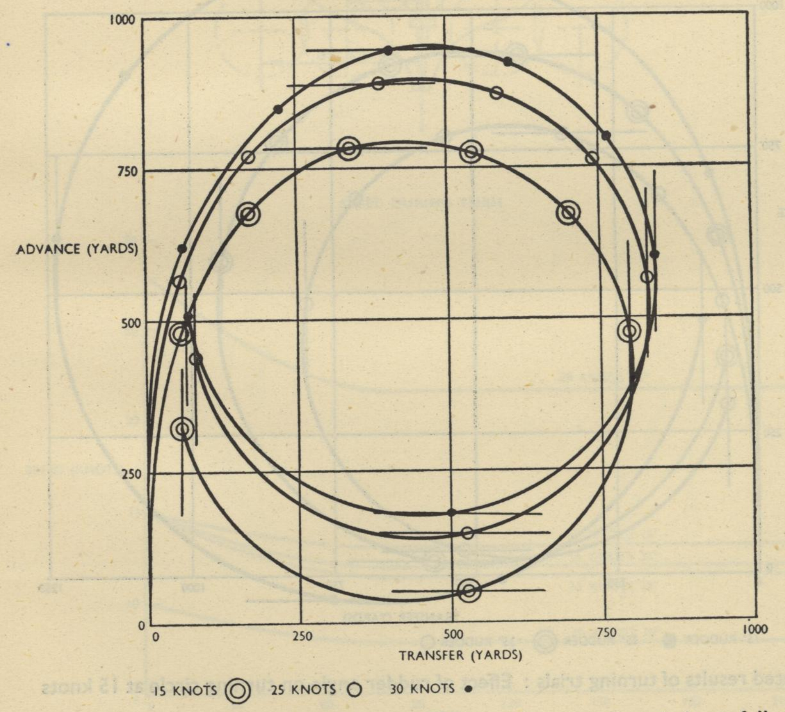
SPEED DURING TURN



Performance Curves

TABLE I. H.M.S. *EAGLE*

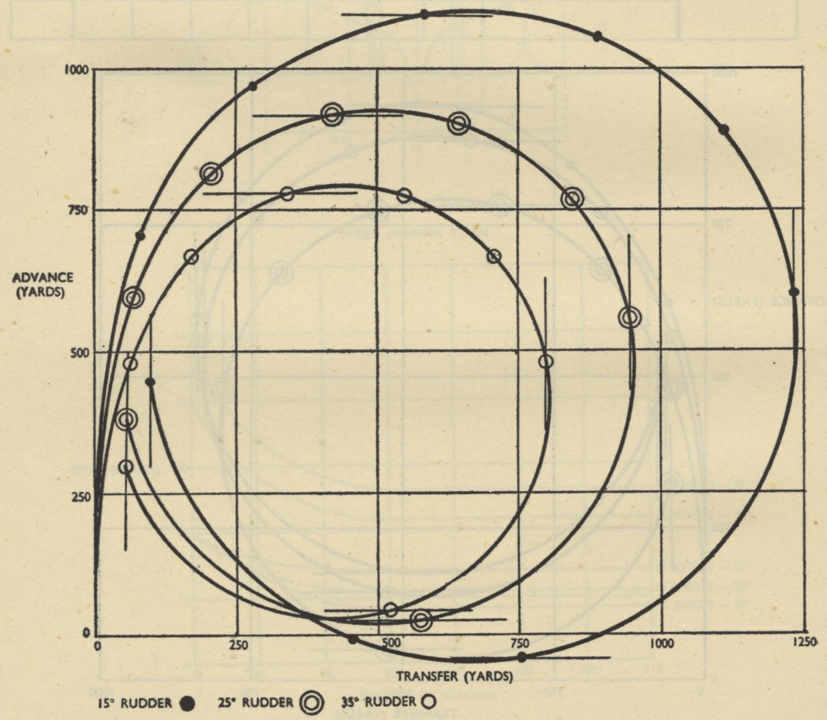
APPROACH SPEED	CHANGE OF HEADING	30°	60°	90°	120°	150°	180°	270°	360°
15 KNOTS	TIME, MINS., SECS.	1-3	1-36	2-12	2-48	3-23	4-0	5-53	7-46
	ADVANCE, YDS.	480	672	776	770	665	488	30	317
	TRANSFER, YDS.	52	164	342	542	708	802	518	56
	SPEED, KNOTS	12·0	10·1	9·5	9·5	9·5	9·5	9·5	9·5
25 KNOTS	TIME, MINS., SECS.	0-40	1-3	1-25	1-48	2-12	2-36	3-48	5-2
	ADVANCE, YDS.	565	764	877	860	747	570	133	440
	TRANSFER, YDS.	54	168	386	583	742	824	520	77
	SPEED, KNOTS	19·6	16·6	15·6	15·6	15·6	15·6	15·6	15·6
30 KNOTS	TIME, MINS., SECS.,	0-43	1-3	1-23	1-44	2-5	2-26	3-32	4-42
	ADVANCE, YDS.	621	847	943	916	791	603	166	505
	TRANSFER, YDS.	68	230	407	608	769	847	506	66
	SPEED, KNOTS	22·9	19·5	18·6	18·6	18·6	18·6	18·6	18·6



Tabulated results of turning trials : Effect of speed on turning circle at full rudder

TABLE I. H.M.S. *EAGLE*

RUDDER ANGLE	CHANGE OF HEADING	30°	60°	90°	120°	150°	180°	270°	360°
15°	TIME, MINS., SECS.	1-15	1-55	2-37	3-22	4-9	4-55	7-18	9-45
	ADVANCE, YDS.	707	977	1094	1059	880	607	−42	442
	TRANSFER, YDS.	80	281	577	878	1117	1237	750	97
	SPEED, KNOTS	13·1	11·9	11·6	11·6	11·6	11·6	11·6	11·6
25°	TIME, MINS., SECS.	1-7	1-42	2-18	2-55	3-33	4-13	6-12	8-15
	ADVANCE, YDS.	601	820	912	894	763	553	23	382
	TRANSFER, YDS.	61	203	417	650	844	947	584	55
	SPEED, KNOTS	12·6	10·9	10·2	10·2	10·2	10·2	10·2	10·2
35°	TIME, MINS., SECS.	1-3	1-36	2-12	2-48	3-23	4-0	5-53	7-46
	ADVANCE, YDS.	480	672	776	770	665	488	30	317
	TRANSFER, YDS.	52	164	342	542	708	802	518	56
	SPEED, KNOTS	12·0	10·1	9·5	9·5	9·5	9·5	9·5	9·5



Tabulated results of turning trials : Effect of rudder angle on turning circle at 15 knots

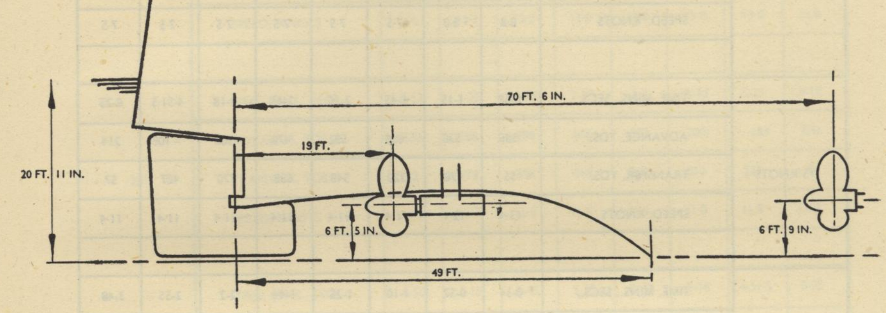
TABLE II. H.M.S. *SUPERB*

DIMENSIONS

Length on Waterline .... 550 Ft.
Length Between Perpendiculars .... 338 Ft.
Beam .... 64 Ft.
Mean Draught .... 20 Ft. 11 ins.

Displacement .... 11·467 Tons
Rudder — One .... 188·5 Sq. Ft.
Propellers — Four .... 11 Ft. Dia.
14 Ft. Pitch

STERN PROFILE



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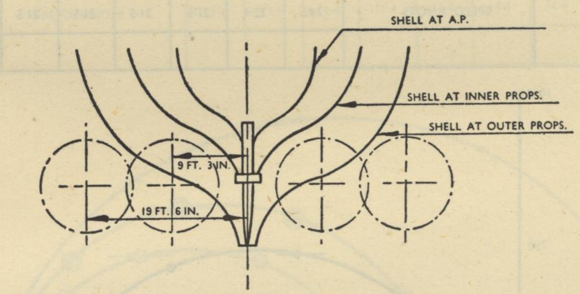
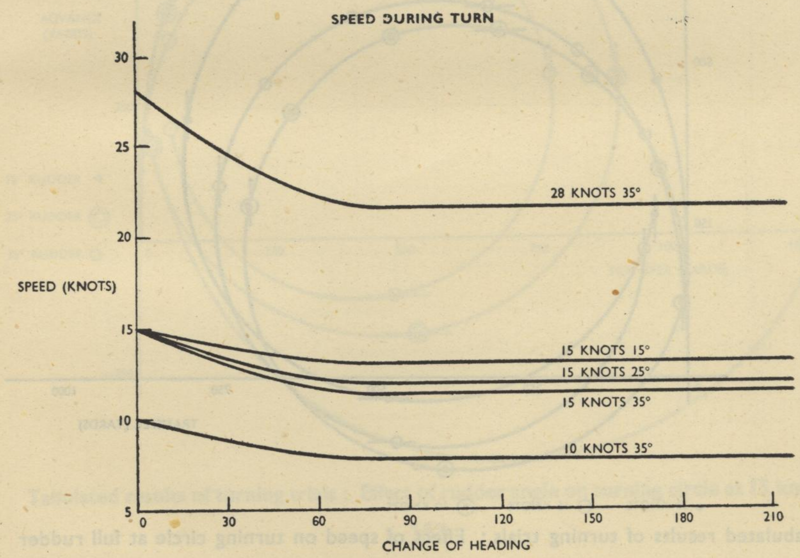


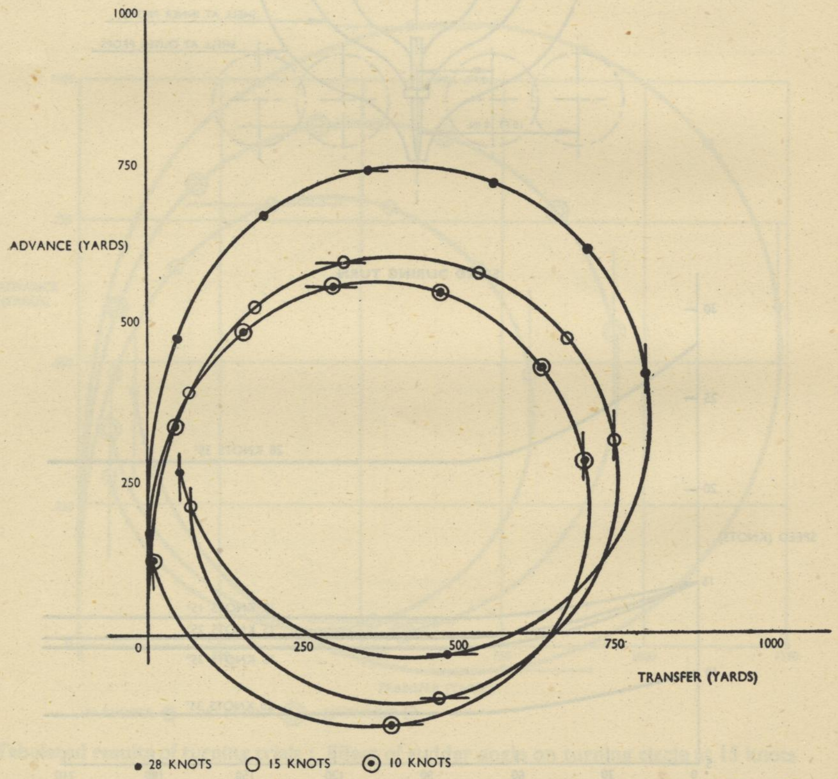
SPEED DURING TURN



Performance Curves

TABLE II. H.M.S. *SUPERB*

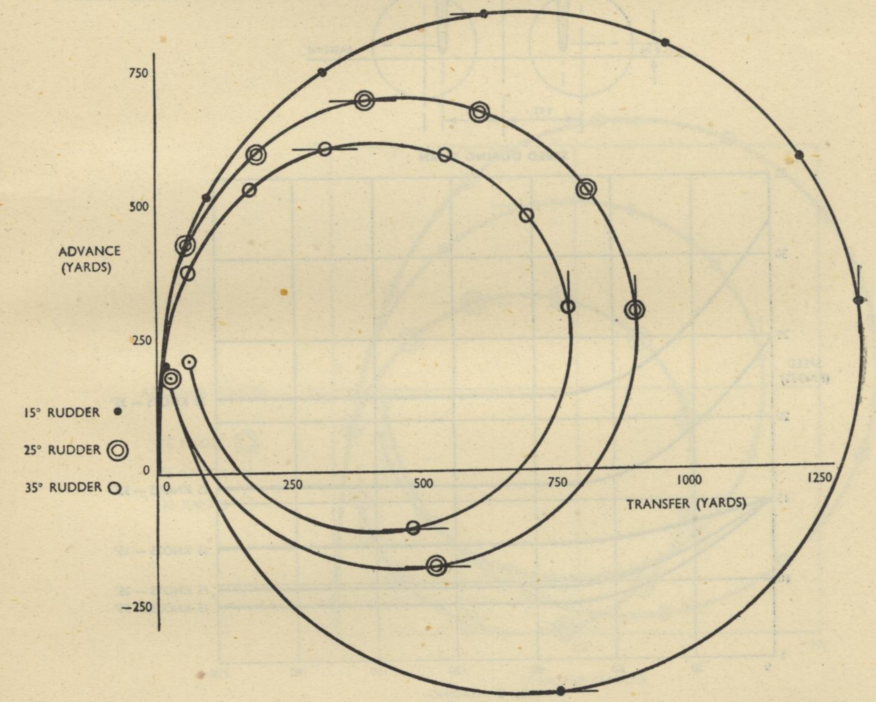
APPROACH SPEED	CHANGE OF HEADING	30°	60°	90°	120°	150°	180°	270°	360°
10 KNOTS	TIME, MINS., SECS.	1-35	1-45	2-27·5	3-12	3-57	4-42	6-57·5	9-14
	ADVANCE, YDS.	330	482	556	546	438	215	–150	146
	TRANSFER, YDS.	32	140	310	500	650	721	405	3
	SPEED, KNOTS	8·8	8·0	7·5	7·5	7·5	7·5	7·5	7·5
15 KNOTS	TIME, MINS., SECS.	0-50	1-15	1-45	2-16	2-47	3-18	4-51·5	6-25
	ADVANCE, YDS.	386	536	606	592	479	308	–108	214
	TRANSFER, YDS.	55	176	320	549	698	770	487	57
	SPEED, KNOTS	13·4	12·1	11·4	11·4	11·4	11·4	11·4	11·4
28 KNOTS	TIME, MINS., SECS.,	0-34	0-52	1-10	1-26	1-44	2-2	2-55	3-48
	ADVANCE, YDS.	475	678	755	727	605	408	–45	294
	TRANSFER, YDS.	45	179	364	569	737	820	497	44
	SPEED, KNOTS	24·5	22·4	21·5	21·5	21·5	21·5	21·5	21·5



Tabulated results of turning trials : Effect of speed on turning circle at full rudder

TABLE II. H.M.S. *SUPERB*

RUDDER ANGLE	CHANGE OF HEADING	30°	60°	90°	120°	150°	180°	270°	360
15°	TIME, MINS., SECS.	1-7	1-50	2-37·5	3-26	4-14	5-2	7-27·5	9-52
	ADVANCE, YDS.	515	765	868	804	593	312	–422	178
	TRANSFER, YDS.	86	303	624	974	1225	1333	762	18
	SPEED, KNOTS	14	13·2	13·0	13·0	13·0	13·0	13·0	13·0
25°	TIME, MINS., SECS.	0-53	1-22	1-55	2-30	3-5	3-40	5-25	7-10
	ADVANCE, YDS.	420	598	696	666	522	300	–183	200
	TRANSFER, YDS.	42	178	396	616	809	910	525	8
	SPEED, KNOTS	13·5	12·4	11·8	11·8	11·8	11·8	11·8	11·8
35°	TIME, MINS., SECS.	0-50	1-15	1-45	2-16	2-47	3-18	4-51·5	6-25
	ADVANCE, YDS.	386	536	606	592	479	308	–108	214
	TRANSFER, YDS.	55	176	320	549	698	770	487	57
	SPEED, KNOTS	13·4	12·1	11·4	11·4	11·4	14·4	11·4	11·4



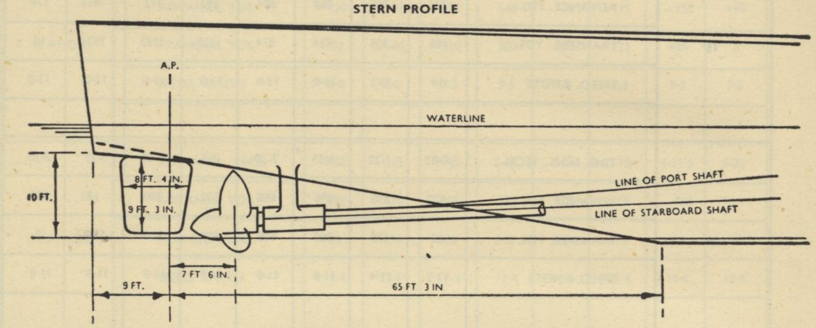
Tabulated results of turning trials : Effect of rudder angle on turning circle at 15 knots

TABLE III. H.M.S. *DARING*

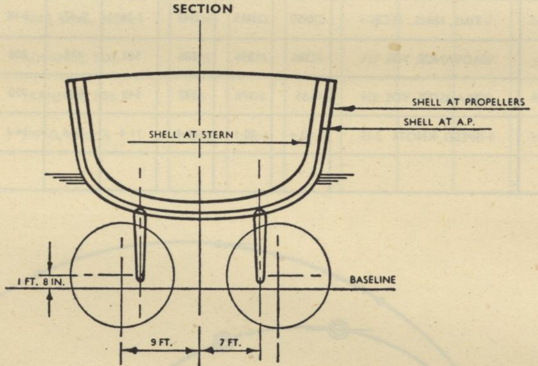
DIMENSIONS

Length on Waterline	375 Ft. 3 ins.	Displacement	3,030 Tons
Length Between Perpendiculars	366 Ft	Rudders — Two	67 Sq. Ft. Each
Beam	43 Ft.	Propellers — Two	12 Ft. Dia.
Mean Draught	11 Ft. 4 ins.		14 Ft. 4 ins. Pitch

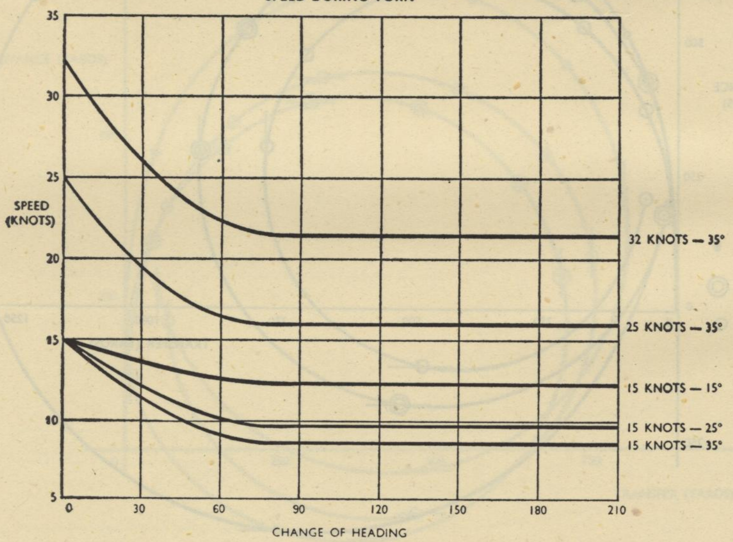
STERN PROFILE



SECTION



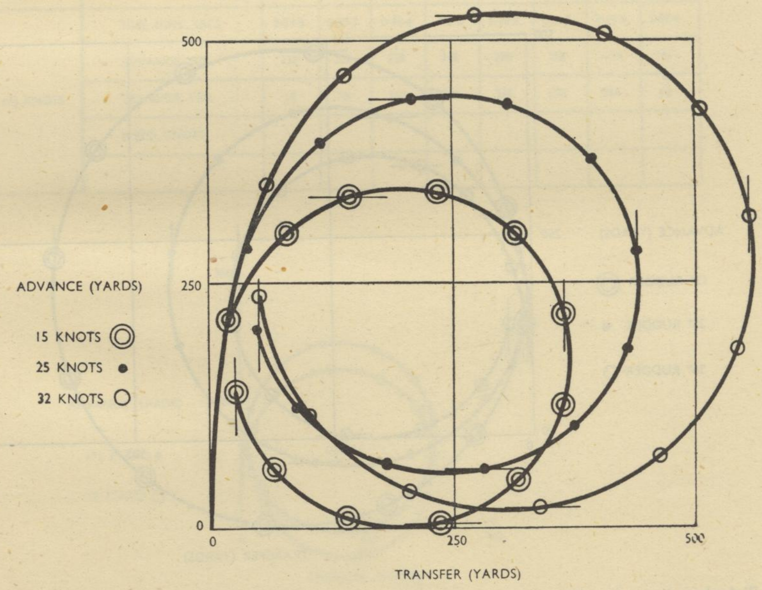
SPEED DURING TURN



Performance Curves

TABLE III. H.M.S. *DARING*

APPROACH SPEED	CHANGE OF HEADING	30	60	90	120	150	180	270	360
15 KNOTS	TIME, MINS., SECS.	0-28	0-42	0-59	1-19	1-39	1-58	2-57	3-56
	ADVANCE, YDS.	212	304	346	344	298	220	7	133
	TRANSFER, YDS.	21	77	149	240	317	362	234	22
	SPEED, KNOTS	11 2	9·0	8·5	8·5	8·5	8·5	8·5	8·5
25 KNOTS	TIME, MINS., SECS.	0-18	0-29	0-40	0-51	1-1	1-13	1-46	2-19
	ADVANCE, YDS.	280	389	436	430	375	286	57	209
	TRANSFER, YDS.	38	115	209	309	391	435	283	56
	SPEED, KNOTS	19·8	16·9	16·0	16·0	16·0	16·0	16·0	16·0
32 KNOTS	TIME, MINS., SECS.	0-18	0-29	0-40	0-51	1-2	1-14	1-47	2-21
	ADVANCE, YDS.	344	465	526	511	432	311	23	237
	TRANSFER, YDS.	59	143	272	402	507	560	345	57
	SPEED, KNOTS	26·0	22·6	21·5	21·5	21 5	21 5	21 5	21·5

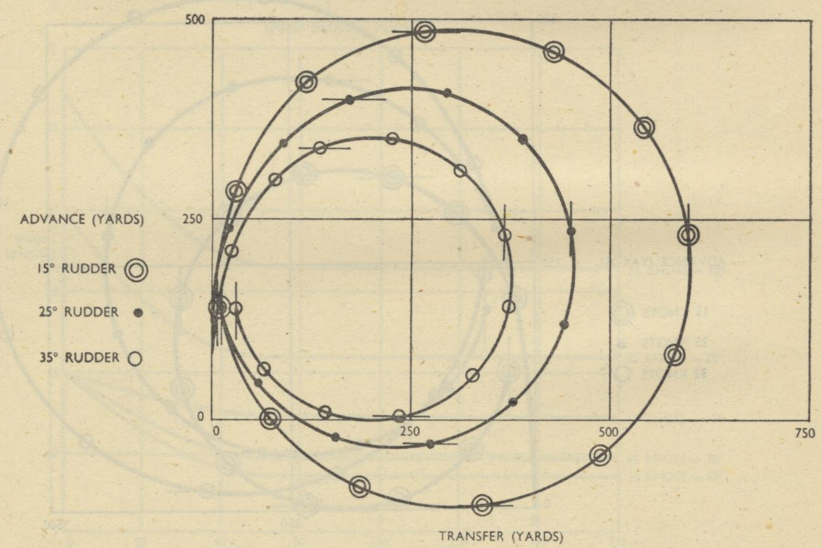


Tabulated results of turning trials: Effect of speed on turning circle at full rudder

(SO 6541) F

TABLE III. H.M.S. *DARING*

RUDDER ANGLE	CHANGE OF HEADING	30	60	90	120	150	180	270	360°
15°	TIME, MINS., SECS.	0-40	1-0	1-20	1-43	2-5	2-28	3-36	4-43
	ADVANCE, YDS.	284	421	485	468	375	235	–107	144
	TRANSFER, YDS.	30	119	261	414	539	602	352	9
	SPEED, KNOTS	13·6	12·5	12·4	12·4	12·4	12·4	12·4	12·4
25°	TIME, MINS., SECS.	0-30	0-46	1-3	1-24	1-44	2-5	3-7	4-9
	ADVANCE, YDS.	240	350	401	395	333	231	–29	140
	TRANSFER, YDS.	25	91	179	293	390	441	270	12
	SPEED, KNOTS	12·0	10·2	9·8	9·8	9·8	9·8	9·8	9·8
35°	TIME, MINS., SECS.	0-28	0-42	0-59	1-19	1-39	1-58	2-57	3-56
	ADVANCE, YDS.	212	304	346	344	298	220	7	133
	TRANSFER, YDS.	21	77	149	240	317	362	234	22
	SPEED, KNOTS	11·2	9·0	8·5	8·5	8·5	8·5	8·5	8·5

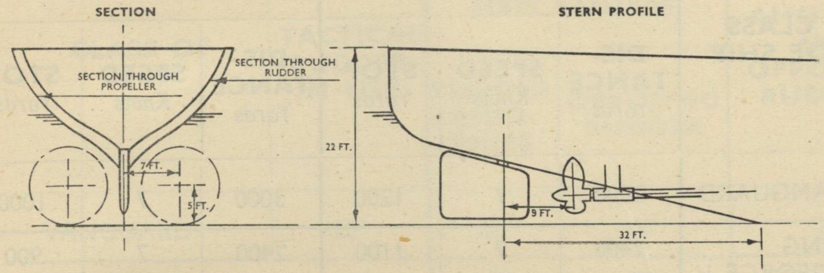


Tabulated results of turning trials : Effect of rudder angle on turning circle at 15 knots

TABLE IV. H.M.S. *MORECAMBE BAY*

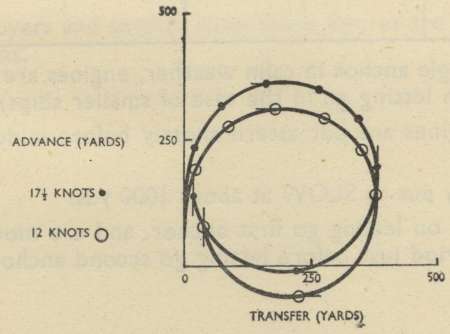
DIMENSIONS

Length on Waterline	299 Ft.	Displacement	1960 Tons
Length Between Perpendiculars	286 Ft.	Rudder — One	89·4 Sq. Ft.
Beam	38·5 Ft.	Propellers — Two	9·75 Ft. Dia.
Mean Draught	11·05 Ft.		13·42 Ft. Pitch



Performance Curves.

APPROACH SPEED	CHANGE OF HEADING	30°	60°	90°	120°	150°	180°	270°	360°
12 KNOTS	TIME, MINS., SECS.	0-29·4	0-47·2	1-6·7	1-2·3	1-44·3	2-3·5	2-59·2	3-56·3
	ADVANCE, YDS.	190	270	304	293	239	155	–52	83
	TRANSFER, YDS.	23	84	172	264	340	381	237	25
	SPEED, KNOTS								
17½ KNOTS	TIME, MINS., SECS.	0-24·8	0-36·1	0-48·4	1-2·8	1-16·9	1-31·2	2-14·5	2-58·4
	ADVANCE, YDS.	239	320	356	345	290	199	–14	141
	TRANSFER, YDS.	18	78	162	258	335	376	224	10
	SPEED, KNOTS								



Tabulated results of turning trials : Effect of speed on turning circle at full rudder

TABLE V. REDUCTION OF SPEED WHEN APPROACHING AN ANCHORAGE

CLASS OF SHIP	SINGLE ANCHOR			MOORING		
	DIS-TANCE *Yards*	SPEED *Knots*	STOP *Yards*	DIS-TANCE *Yards*	SPEED *Knots*	STOP *Yards*
VANGUARD	3000	7	1200	3000	7	1000
KING GEORGE V	2400	7	1100	2400	7	900
ARK ROYAL	2000	8	1000	2000	8	1000
IMPLACABLE	2000 1000	8 Slow	400	2000 800	8 Slow	200
COLOSSUS	2000	10*	800	2000	10	600
SUPERB	2000	10	600	2000	10	400
SOUTHAMPTON	2000	10*	400	2000	10	400
DIDO	1600	10	500	1600	10	300
BATTLE CLASS	1000-2000	10	300	400	4	0†
LOCH CLASS	1000	8	300		Cannot Moor	
MOD. BLACK SWAN	1000	8	300-400	1000	8	300

(*a*) When coming to single anchor in calm weather, engines are put astern just before letting go (on letting go in the case of smaller ships).

(b) When mooring, engines are put astern shortly before middled position is reached.

* Engines are normally put to SLOW at about 1000 yds.

† Engines are stopped on letting go first anchor, and are moved slow ahead again for a short period just before letting go second anchor.

TABLE VI. PROCEDURE FOR STEADYING SHIPS AFTER ALTERING COURSE

CLASS OF SHIP	TACTICAL RUDDER IN USE	DEGREES FROM NEW COURSE		AMOUNT OF OPPOSING RUDDER
		RUDDER AMIDSHIPS	OPPOSING RUDDER	
VANGUARD	20°	20°	8°	10°
ARK ROYAL	15°	20°	10°	15° below 15 knots. 10° above 15 knots.
IMPLACABLE ETC.	20°	20°	10°	10°
KING GEORGE V	15°	20°	10°	10°
HERMES	15°	20°	10°	10°
COLOSSUS	15°	12°	5°	10°
SOUTHAMPTON	20°	12°	6°	10°—15°
SUPERB	25°	12°	5°	15°
DIDO	20°	10°	5°	10°
DESTROYERS†	20°	10°—15°	5°—10°	10°
FRIGATES†	15°	12°	5°	10°

† In destroyers and smaller ships these figures are markedly affected by weather conditions.

TABLE VII. SUMMARY OF MINIMUM DISTANCES FOR ANCHORING AND MOORING BERTHS

ANCHORING

CLASS OF SHIP	LENGTH IN FEET	MINIMUM RADII OF CIRCLES	
		SINGLE ANCHOR (YARDS)	MOORED (YARDS)
VANGUARD	814	322	292
KING GEORGE V	745	299	269
ARK ROYAL	804	318	288
IMPLACABLE	766	306	276
COLOSSUS	693	281	251
SUPERB	555	235	205
SOUTHAMPTON	591	247	217
DIDO	512	221	191
DARING	390	180	150
BATTLE CLASS	379	177	147
LOCH CLASS	307	153	123

For the minimum radii of circles allow the length of ship plus:—
20 yds. when moored.
50 yds. when at single anchor.

APPENDIX II

GROUNDING OF H.M.S. *NELSON* IN THE PORTSMOUTH CHANNEL

The following are extracts from a paper by Mr. R. W. L. Gawn, O.B.E. R.C.N.C., published in the Quarterly Transactions of the Institute of Naval Architects, January, 1950, and giving an account of the investigations carried out at the Admiralty Experiment Works, Haslar, relating to the grounding of H.M.S. *Nelson* in the entrance to Portsmouth Harbour on January 12th, 1934.

'The ship was proceeding out of harbour at high tide under tow from three tugs. One tow parted and in order not to miss the tide it was decided to carry on without tugs. At the South Railway Jetty the order was given for revolutions for 15½ knots. The mean speed by land fixes from the South Railway Jetty to the Point was 7 knots over ground. The Commanding Officer estimated that speed over ground was 9 knots at the Point. When the ship's bow was at the point X shown on the chart in *Diagram 1*, the order was given to wheel to port 15 degrees, and to reduce revolutions to those for 12 knots. The ship turned against the rudder to starboard and after proceeding about 2½ lengths grounded on the Hamilton Bank at a bearing of 10½ degrees starboard compared with the initial course before the rudder was put over . . . other relevant factors were a following current of 1 to 1½ knots in the narrow entrance and a westward current of about 1 knot clear of the entrance. The height of tide was 10 ft. above the mean low water spring tide shown on the chart. The wind was force 4, direction 240 degrees, and therefore about two points before the starboard beam at the time the rudder was ordered over. The draught of the ship was 30 ft. 6 in. forward and 32 ft. 4 in. aft.

'Preliminary experiments were made on a model of *Nelson* about 4 ft. long to a scale of 1/175 full size, in a model of the channel of Portsmouth Harbour. . . . Tests were made with the model on each of the five initial courses, namely:—

A Centre of channel.
B 38 yards to the East of A, i.e. course of *Nelson* on 12.1.34.
C 16 yards to the East of A.
D 30 yards to the West of A.
E 20 yards to the West of A.

'Some of the results obtained . . . are shown in *Diagram 2*. . . . When the model was on the centre course A the steering response to port rudder angle was normal as regards direction. With rudder amidships the model maintained course more or less in the centre of the channel turning slightly to port, following the natural bend of the fairway. . . .

'When on an initial course to the east of the centre of the fairway and consequently on the inside of the bend of the channel there was a strong tendency to turn to starboard. This tendency was so powerful on the eastern course B that for speeds of 7 to 15 knots the steering bias could not be corrected even by full port rudder and the model grounded on the starboard side of the channel, i.e. Hamilton Bank after a travel of one to

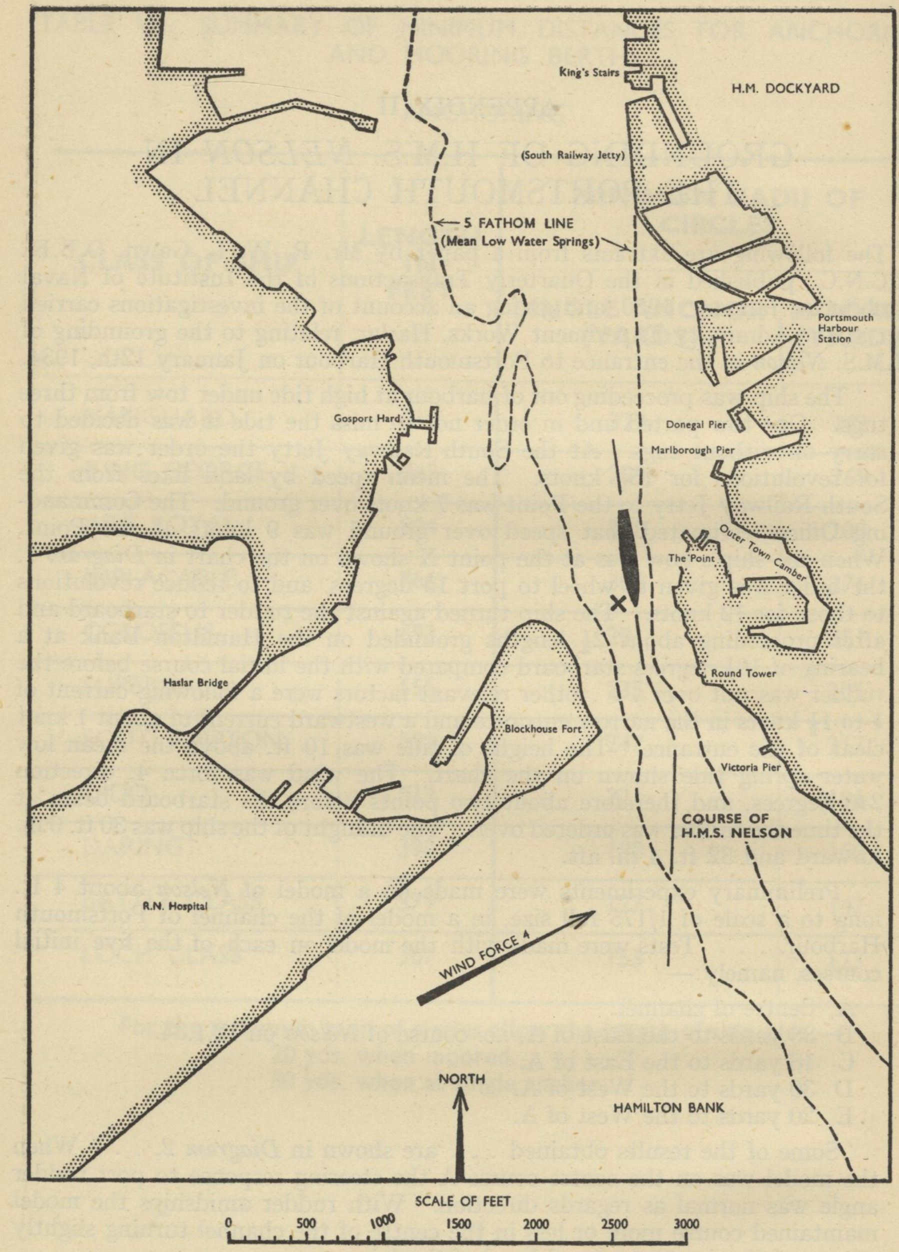
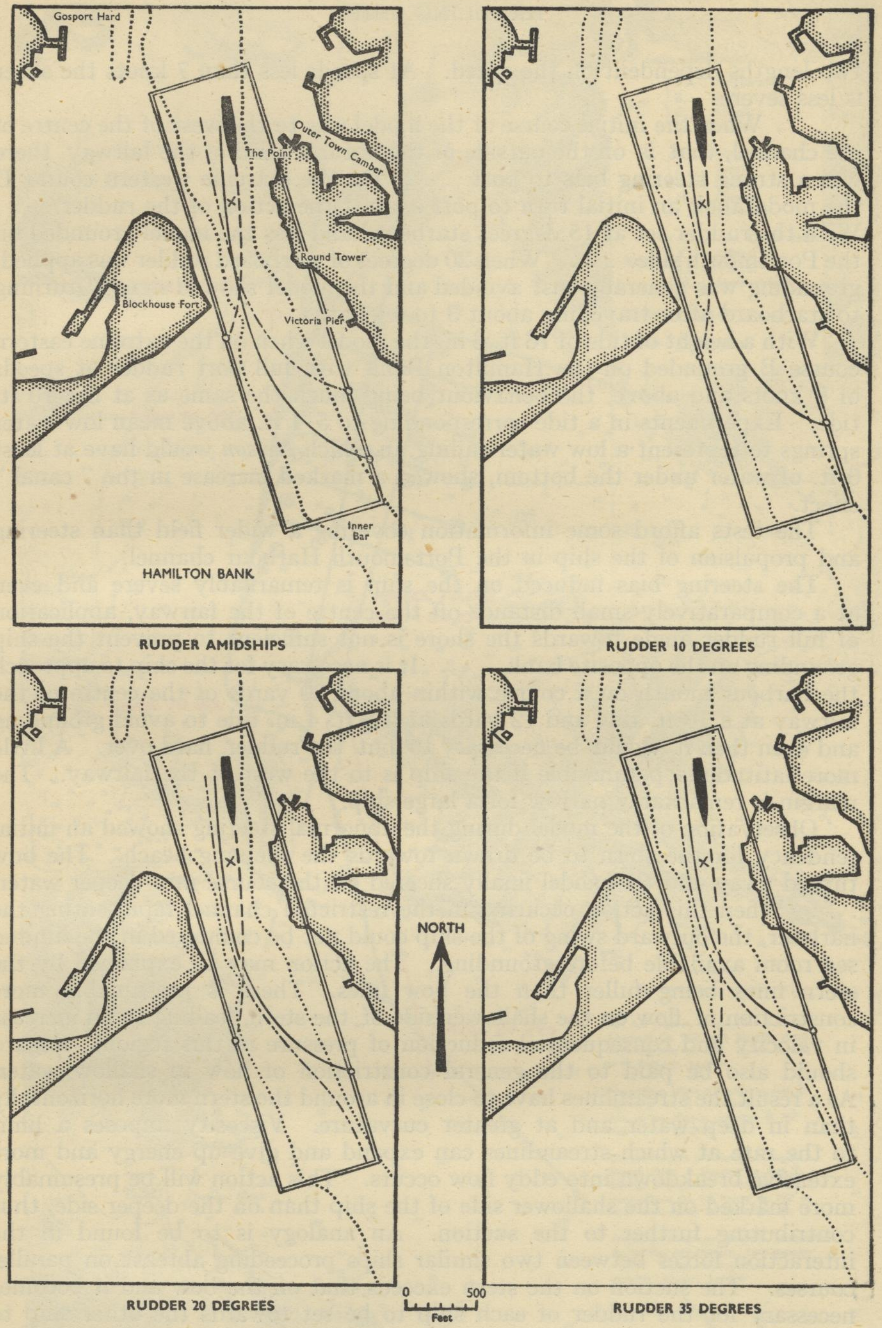


DIAGRAM 1.—Chart of Portsmouth Harbour and Course of *Nelson*.

Note.—X is position of ship's bow when order was given " Wheel to Port 15 degrees."



COURSE A ——————— RUDDER TO PORT
COURSE B — — — — — RUDDER TO PORT
COURSE D —·—·—·— RUDDER TO STARBOARD
RECTANGLE THUS ═══════ SHOWS LIMIT OF PLAN OF MODEL OF HARBOUR ENTRANCE

DIAGRAM 2.—Course of Model of *Nelson* in Portsmouth Harbour Entrance. Initial Speed 11 knots.

two lengths dependent on the speed. At speeds less than 7 knots the sheer is less severe.

'. . . When the initial course of the model was to the west of the centre of the channel, that is on the outside of the natural bend of the fairway, there was a strong steering bias to port. . . . On the extreme western course D the model took an initial turn to port against the action of the rudder. . . . With the rudder set at 15 degrees starboard and less the model grounded on the Portsmouth side. . . . When 20 degrees of starboard rudder was applied, grounding was generally just avoided and the model showed signs of turning to starboard after travelling about 3 to 4 lengths.

'With a height of tide of 16 ft. 6 in. the model when on the extreme eastern course B grounded on the Hamilton Bank with full port rudder at speeds of 9 knots and above, the behaviour being much the same as at the 10 ft. tide. Experiments in a tide corresponding to 5·4 ft. above mean low water springs to represent a low water sailing, in which *Nelson* would have at least 6 ft. of water under the bottom, showed a marked increase in the "canal" effect.

'The tests afford some information covering a wider field than steering and propulsion of the ship in the Portsmouth Harbour channel.

'The steering bias induced on the ship is remarkably severe and even at a comparatively small distance off the centre of the fairway, application of full rudder angle towards the shore is not sufficient to prevent the ship grounding on the opposite bank. . . . It is necessary for the ship to approach the harbour mouth on a course within about 20 yards of the centre of the fairway at a 10 ft. tide and 12 yards at a 5 ft. 4 in. tide to avoid grounding and even then it would be necessary to put the rudder hard over. A little more latitude is permissible if the ship is to the west of the fairway. The margin is remarkably narrow for a large ship.

'Observation of the model during the abnormal steering showed an initial tendency for the stern to be drawn towards the shelving beach. The bow turned away and the model finally sheered off the course into deeper water. . . . When this action occurred in the restricted channel representing the harbour, the outward swing of the ship could not be countered in the limited sea room available before grounding. The action may be explained by the stern lines being fuller than the bow lines. There is presumably more constriction of flow on the shallower side of the stern, leading to an increase in velocity and consequential reduction of pressure in this region. Regard should also be paid to the general constriction of flow in shallow water. As a result the streamlines have to close in around the stern more horizontally than in deep water and at greater curvature. Viscosity imposes a limit to the rate at which streamlines can expand and give up energy and more extensive breakdown into eddy flow occurs. This action will be presumably more marked on the shallower side of the ship than on the deeper side, thus contributing further to the suction. An analogy is to be found in the interaction forces between two similar ships proceeding abreast on parallel courses. The suction on the stern exceeds that on the bow and it becomes necessary for the rudder of each ship to be set towards the other ship to maintain a steady course.'

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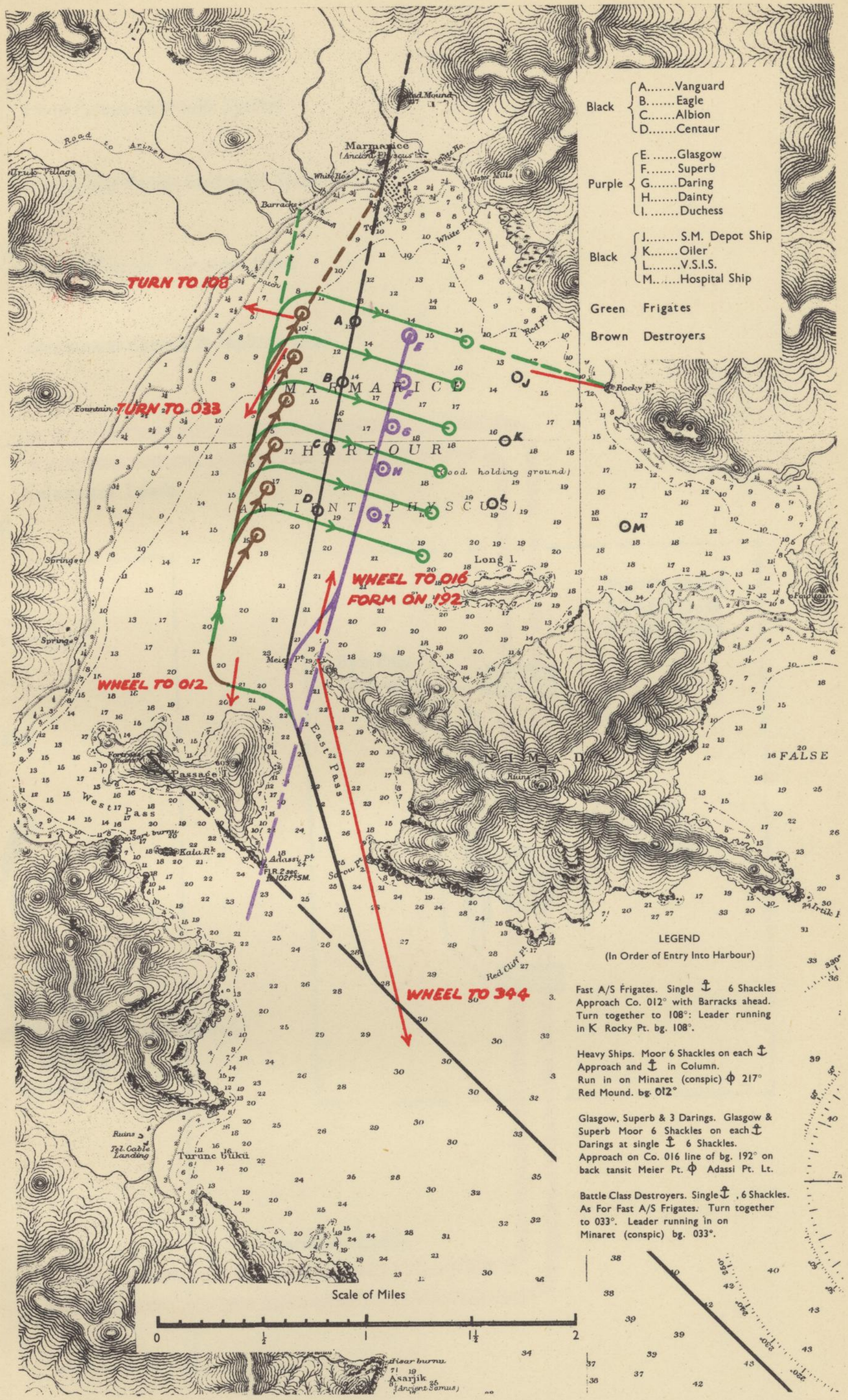
(SO 6541) Wt. 28706–D/7511 2300 1/55 H & S. Ltd. Gp. 578



APPENDIX III — EXAMPLE OF FLEET APPROACHING AN ANCHORAGE

C.B.H. 24599 - Wt. 28706 - Dd. D./7511 -2300 - 5/54

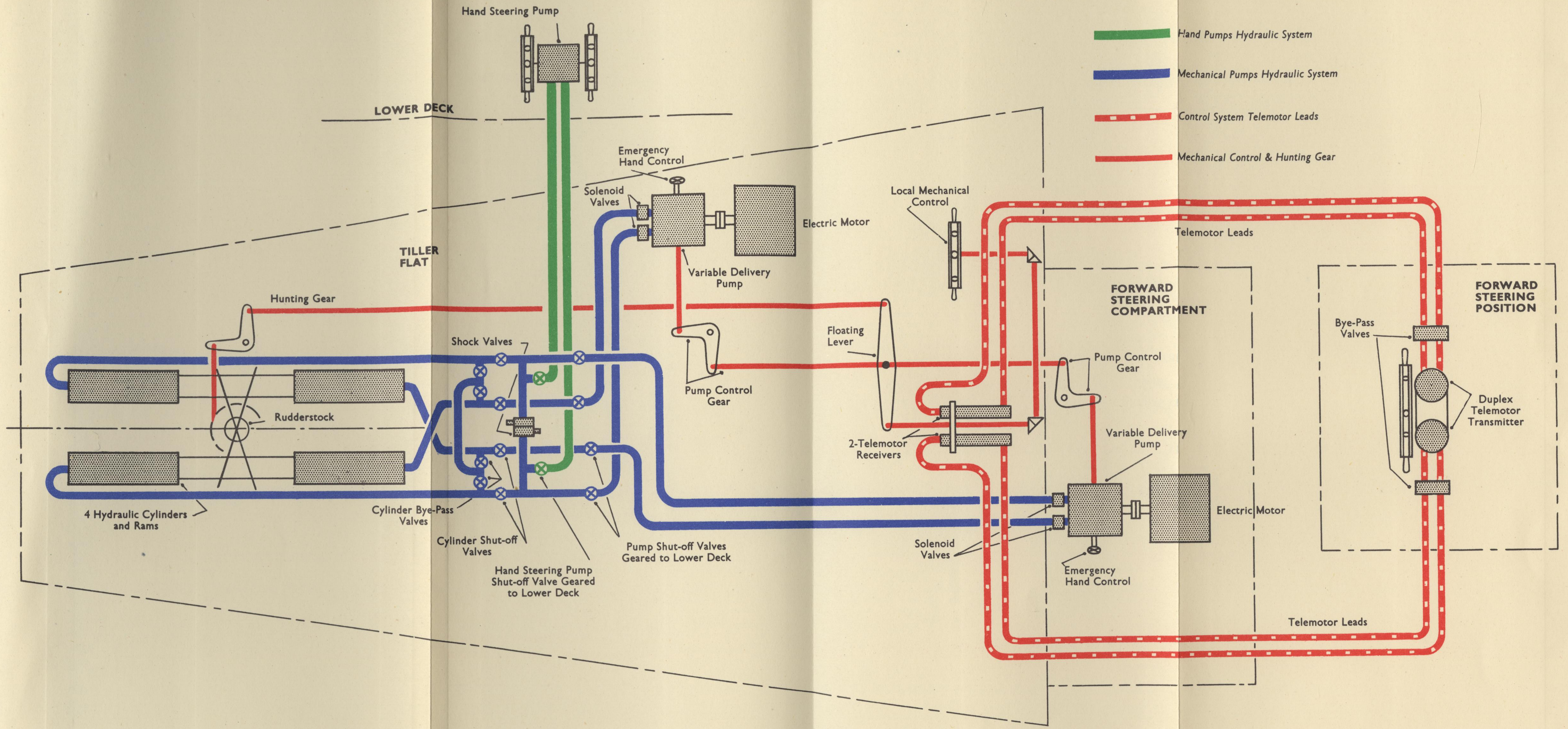
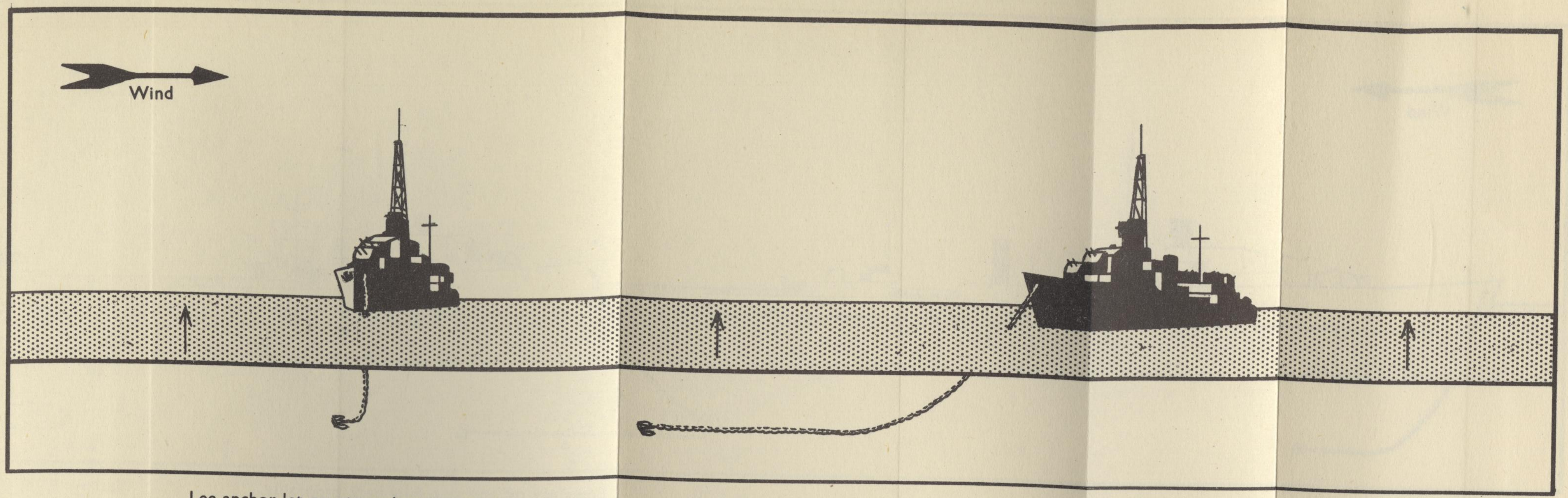


FIG. 9. DUPLEX TELEMOTOR SYSTEM – TYPICAL ARRANGEMENT

C.B.H. 24599 - Wt. 28706 - Dd. D./7511 -2300- 5/54

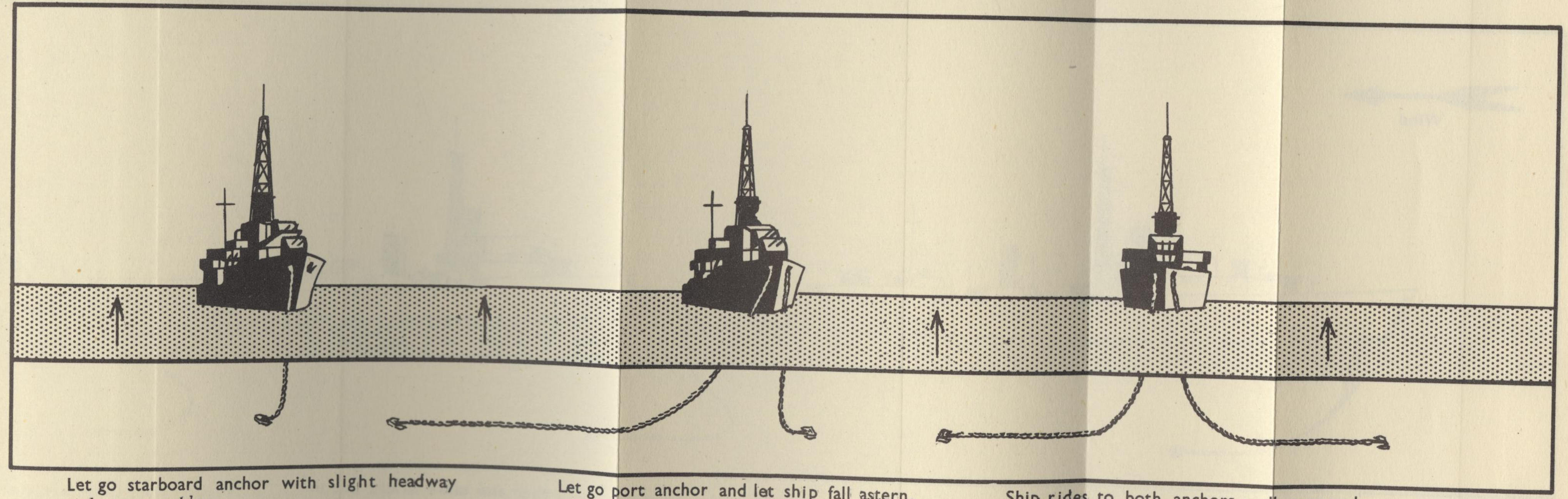


Lee anchor let go, stemming current

(SMALL ARROWS INDICATE DIRECTION OF CURRENT)

Ship falls back athwart wind and current with cable at open hawse

FIG. 19. ANCHORING HEAD TO STREAM IN A BEAM WIND



Let go starboard anchor with slight headway and port rudder.

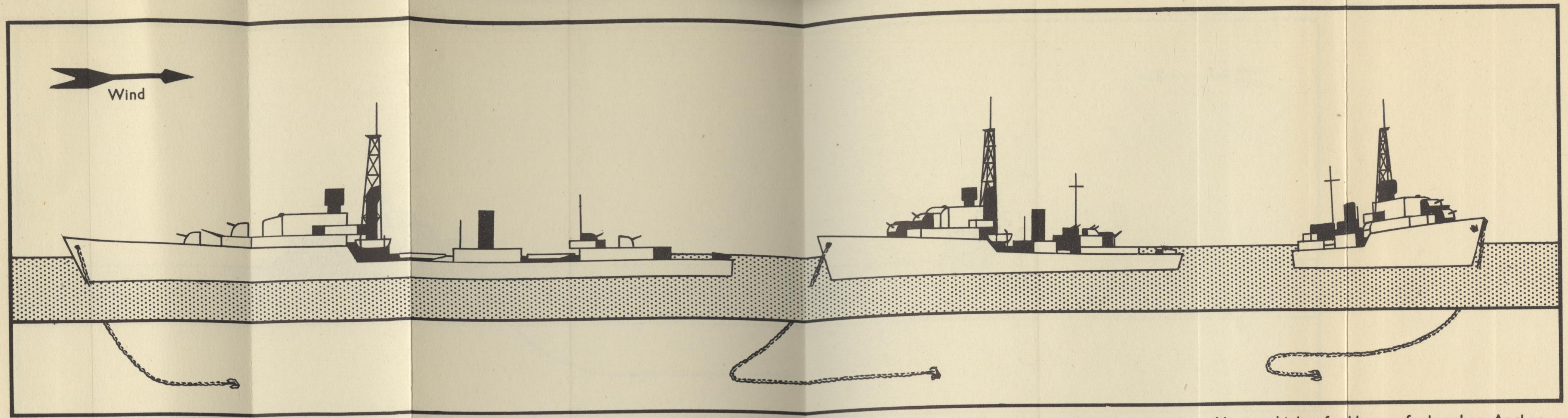
Let go port anchor and let ship fall astern.

Ship rides to both anchors well spanned.

(SMALL ARROWS INDICATE DIRECTION OF CURRENT)

C.B.H. 24599 - Wt. 28706 - Dd. D./7511 - 2300- 5/54

FIG. 20. SPANNING ANCHORS IN A STRONG RIVER CURRENT

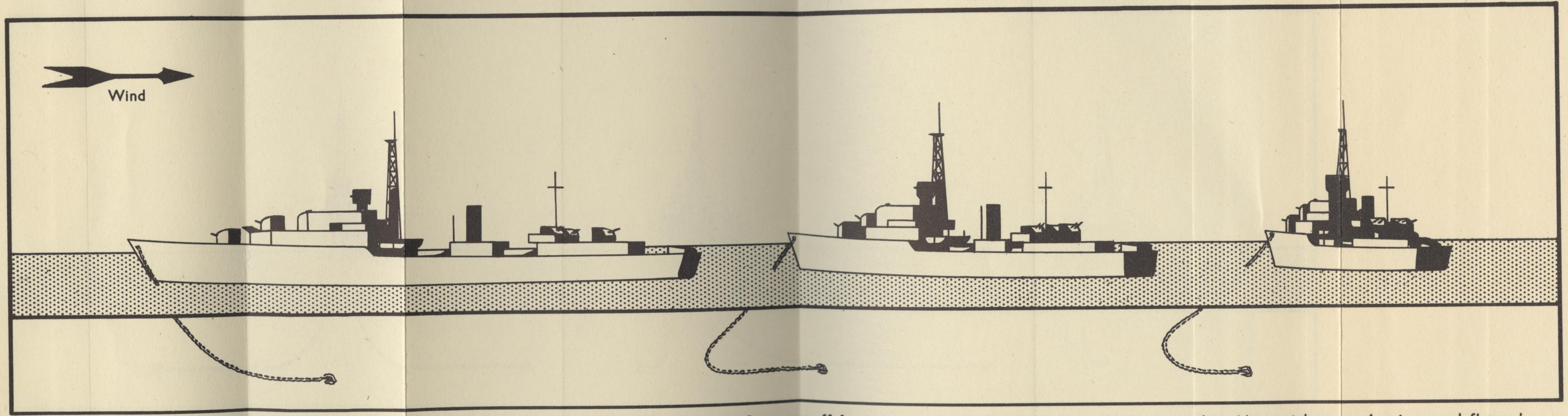


Laying out cable into wind.

Bows pay off and ship falls back broadside.

Narrow bight of cable may foul anchor. Anchor about to be somersaulted.

FIG. 21 (a) ANCHORING IN A STRONG WIND (WRONG)



Laying out cable across wind

Bows pay off further and cable is laid out in wide bight

As cable straightens anchor is turned flat and not somersaulted

C.B.H. 24599 - Wt. 28706 - Dd. D./7511 -2300 - 5/54

FIG. 21(b) ANCHORING IN A STRONG WIND (RIGHT)

Commanding Officer
Clyde Division RNR

H.M.S. CLYDE
26th March. 1972

H.M.S. CLYDE - REPORT OF PROCEEDINGS

References A. MCMSO Annex A to Part 1 Section 5 Para 7
2. Clyde Division's RNR's 2260 of 14th March. 1972

Serial	Remarks
2509	Not completed when loop gash discovered
2510	Cancelled
2604	Cancelled prior to sailing
Additional	Main generator switched off to effect complete power failure. Pulse generator started and power provided. All services restored. Dory lowered and sent away with diesel driven fire pump. Foam made.

Defects

1. 619 (Tx) developing intermittent fault on CW
2. Severe gash in Loop
3. No. 2. Foden Generator non operational

Lieutenant Commander RNR
Commanding Officer

To/ R.H. Craig.

ENCLOSURE TO HMS GRAHAM'S
LETTER NO. 2260 DATED
14 MARCH 1972

PROPOSED PROGRAMME FOR 24/26 MARCH 1972
HMS CLYDE - WEEKEND TRAINING

The following programme is intended for weekend 24/25/26 March 1972.

Serial	Time	Event
2401	2000Z	Ship's Company joins
2402	2130	Exercise emergency stations
2403	2150	Exercise liferaft stations
2404	2200	Sail Glasgow River Passage
2405	2359	Complete River Passage
2501	0001	Night steaming and navigation
2502	0300	Night pilotage Lamlash Bay
2503	0330	Anchor Lamlash Bay
2504	0400	Anchor Watch for Junior Officers
2505	0745	Special Sea Dutymen : Radar Calibration
2506	0800	Weigh and Proceed to Exercise Area E & K
2507	0900	Stream CTA Rig 1 and check wire markings
2508	1100	Operate AD
2509	1130	Stream loop. Check insulation, lashings, gaiters renew as required.
2510	1300	Pulse
2511	1330	Navigate by Parallel index and practise turns
2512	1430	Recover all gear
2513	1615	Gyro Breakdown
2514	1700	Berth Campbeltown
2601	0800	Sail
2602	0830	Exercise Steering Gear Breakdown
2603	0900	Exercise Man Overboard
2604	0930	Surface Shoot in Area D 509
2605	1100	Complex NBCD Exercise conducted by MEA(H)2 COPELAND (specially borne)
2606	1500	River Passage
2607	1700	Berth Glasgow

(R.H. Craig)
LIEUTENANT COMMANDER, RNR
DESIGNATED COMMANDING OFFICER

NOTE: P/A EA2 BROWN will be borne for training. He hasn't been to sea since NE. — Special attention pse.

RESTRICTED

(FOR OFFICIAL USE ONLY)

P.415—B.R. 2092 (Restricted) Handling Ships—Amendment No. 1

(D.N.D. 192/56.—9 Nov. 1956.)

Page 32. Second paragraph. *Amend to read :—*

From *Fig. 12* it will be seen that the radius of curvation is greater at the stern than at the pivoting point to an extent depending on the drift angle. This factor . . . .

(*Amendment No. 1*)

Page 35. Line 5.

Amend " prefrably " *to read* " preferably ".

3rd line from bottom of page. *Amend* " and " *to read* " an ".

Page 37. Line 17. *Delete* " weather " *insert* " lee ".

Page 54. Line 23. *Delete* " or stern ".

Page 65. Line 16 after ". . . . not touch first " *insert :—*

In certain foreign ports underwater ledges or projections may exist at alongside berths. It is advisable to make thorough investigations through the Port Authorities or Pilots before going alongside unless information on the allocated berth already exists.

(*Amendment No. 1*)

Page 82. Second line from bottom of page. *Amend* " finds " *to read* " fins ".

Page 84. Paragraph 2. Line 4. *Insert* " a " after " half ".

Page 90. Line 12. *Amend* " ever " *to read* " over ".

Page 91. Line 9. *Amend to read*
" any class of ship, in whatever circumstances, when she is . . . .".

Page 93. Line 17. *Delete* last sentence " For instance . . . . to wind ".

Page 98. Last line. *Amend* " beam " *to read* " bow ".

Page 100. 5th Line from bottom of page. *Insert* comma after " follow ".

Page 110. Maintaining Station. Line 5. *Amend* " of " *to read* " or ".

Page 114. Line 8. *Amend to read.* " This will in turn have . . . .".

Page 114. 7th Line from bottom of page. *Amend* " confirmity " *to read* " conformity ".

Page 117. Line 7. *Delete* " YY ".

Page 117. Tactical diameter. Line 3. *Amend* " run " *to read* " turn " and *amend* " circle " *to read* " circles ".

Page 120. Altering course together. Line 4. *Amend* " The example " *to read* " For example " and *amend* " Guides' " *to read* " Guide's ".

Page 125. Line 17. *Insert* " than " after " rather ".

Page 142. Line 22. *Amend* " effect " *to read* " extent ".

APPENDIX III. In legend. Line 7. *Amend* " 217° " *to read* " 217 ".

Pages 145 and 146. *Insert* " Propulsion Machinery Breakdowns ", as follows :—

PROPULSION MACHINERY BREAKDOWNS

When machinery failures occur, there is a correct action to be taken for each. If this is not done quickly, serious damage to the machinery installation may result. Moreover, the great advances in performance of machinery in modern designs puts a premium on rapid and effective action in the event of breakdown and calls for enhanced vigilance on the part of all concerned.

Nothing in the following notes is intended to relieve Commanding Officers of the need to seek the advice of their Engineer Officers on all necessary occasions, vide Q.R. and A.I. Article 4011 (1).

Breakdowns may be divided into three categories, according to the urgency with which the machinery must be stopped to avoid damage. The safety of the ship must obviously be weighed against the probable damage to the machinery.

AMONG THE MORE SERIOUS BREAKDOWNS WHICH MAY OCCUR IN PROPULSION MACHINERY ARE :—

1. Those requiring immediate action to stop the ship or unit concerned. (*a*) *Loss of Lubricating Oil Pressure.*—If all lubricating oil pressure is lost, serious damage to the machinery will result in a matter of seconds. The Engine Room Watchkeeper must stop the affected shaft or shafts without waiting for permission from the Bridge. If this happens while steaming at high powers, the damage may be done even before the watchkeeper is able to stop the shaft and hold it stopped with astern steam. In such a case, an examination of the bearings, etc., should be made before using the engine again ; this may take several days. Failure to carry out such an examination may result in irreparable damage to the machinery concerned.

(*b*) *Failure of Feed Water to a Boiler.*—If all feed water supply to a boiler fails, the boiler must be shut down instantly to prevent burning out. At high powers, serious damage can be caused in a few seconds if this is not done. This damage may result in complete destruction of the boiler by combustion of its steel in steam—a type of fire almost impossible to fight. If more than one boiler is in use, shutting down will result in an immediate reduction in speed ; if only one boiler is in use, all steam power will be lost temporarily.

Slight damage to boiler tubes due to overheating can be made good in two or three weeks, but more extensive damage may take months to remedy.

2. Those requiring urgent action to reduce power.—(*a*) *Failure of Main Feed Pump or Main Extraction Pump.*—The auxiliary feed pump will continue to feed the boilers at full power (half power in destroyers) for a limited time only owing to the small capacity of the reserve feed tanks. If the fault cannot be rectified quickly, it will be necessary to stop the affected unit.

(*b*) *Rapid Loss of Vacuum.*—Failure of the main circulating pump, main extraction pump or gland steam supply, or choking of a main condenser inlet, will cause rapid loss of power and overheating of the condenser. This may result in contamination of the feed system by salt water, or bursting of the condenser. If the fault cannot be rectified quickly, the affected unit must be stopped ; the shaft can then be locked, or trailed with turbines disconnected.

(*c*) *Loss of Circulating Water Pressure.*—Failure of the circulating water pump or choking of the main inlet will cause overheating of the cylinder jackets of diesel engines with loss of power leading to possible seizure of the engine. If the fault cannot be located quickly the engine affected must be stopped and declutched from the shaft.

3. Breakdowns which will cause serious damage if remedial action is not taken quickly.—(*a*) *Contamination of Feed Water by Salt Water*—Any defect allowing contamination of feed water by salt will cause an accumulation of salt deposits in the boilers if steaming is continued for an appreciable period. These accumulated deposits cause a form of corrosion which, once started, is difficult to arrest, even after the deposits are removed ; unless speed is severely reduced, they are carried over into the turbines, where they start a similar wasting disease of turbine blades, etc.

The damage done by continuing to steam in this condition may not become fully apparent for months, or even years. Cleaning the various systems after such an occurrence may take about a fortnight, but the more serious damage may take months to rectify.

(*b*) *Lubricating Oil Contaminated by Salt Water.*—If this occurs, rust forms on bearings and journals and causes damage, including a loss of lubricating properties in the oil. If steaming under these conditions is continued for more than 24 hours or so, the damage may necessitate removal of machinery and gearing from the ship for repair.

(*c*) *Furnace Fuel Oil Contaminated by Salt Water.*—Modern fuels easily form a stable emulsion with sea water. Combustion of fuel so contaminated results in a short time in serious damage to boiler brickwork. In ships where limited water ballasting of Furnace Fuel Oil Tanks is necessary to maintain stability, it may be a requirement to clean the tanks before refuelling.

(*d*) *Lubricating Oil Contaminated by Diesel Fuel* (*Diesel Engined Ships Only*).—If this occurs the properties of the lubricating oil will be affected and may lead to serious damage to bearings."

(5055) Wt. 8029/P.P.6842 2,800 11/56 Hw.

RESTRICTED

(FOR OFFICIAL USE ONLY)

P.426.—B.R. 2092 (Restricted) Handling Ships—Amendment No. 2

(D.N.D. 78/58.—25 Jul. 1958.)

(*Previous amendment No. 1—A.F.O. P.415/56.*)

Page. 12 Execution of engine orders, Half astern (a) *delete* " A predetermined number . . . boilers and engines " and *substitute* :—

The number of revolutions ordered by the telegraph for whichever shaft is at half astern.

(*Amendment No. 2*)

Page 21. Penultimate line, *delete* " battleships and ".

Page 24. *Delete* " King George V class battleships and ".

Page 25. Cruisers (e) and (f) *delete* " King George V " *insert* " earlier fleet carriers ".

Page 32. Line 5, *delete* " 12 " *insert* " 11 ".

Page 37. 5th line from bottom, *delete* " This effect . . . steam picket boats ".

Page 48. Lines 5 and 6, *delete* " although they suffer . . . . twin-screw tugs " penultimate line, *delete* " offshore " *insert* " onshore ".

Page 79. Line 1, *delete* " encouter " *insert* " encounter ".

Page 105. Line 1, *delete* " B.R.1742 " *insert* " A.T.P.16 ". Lines 2–3, *delete* " amplify the section . . . . that book, and ".

Page 107. Add after line 8 :—

or a tug in position (A) which has dropped back to recover its tow if the assisted ship increases speed too quickly.

(*Amendment No. 2*)

Page 110. Line 8, *add* " and to avoid the angled deck ".

Page 111. Line 22, *delete* last sentence and *insert* :—

The markers on distance lines are indicated at night by small red, white and green lights except when replenishing with ships of other navies when all the lights are red.

(*Amendment No. 2*)

Page 126. Line 15, *delete* " = at 12 knots " *insert* " i.e. 5,000 yd. at 12 kts ".

Page 129. Fig. 60, column 4, *against* 16 knots *delete* " 140 " *insert* " 1400 ".

Page 130. Fig. 61, line 2, *delete* " rudder " *insert* " wheel ".

Page 151. Dimensions—length between perpendiculars—*delete* " 338 Ft." *insert* " 538 Ft. ".

Page 153. Table II, last line, under 180° *delete* " 14·4 " *insert* " 11·4 ".

Page 158. }
Page 159. } *Delete* " King George V " and information on this class of ship.
Page 160. }

(73667) Wt. 8072/P.P.2940 2,800 7/58 Hw.

RESTRICTED

(FOR OFFICIAL USE ONLY)

P.652.—B.R.2092 (Restricted)—Handling Ships—Amendment No. 3
Also Adden " – 1

(D.N.D.120/59.—6 Nov. 1959.)

Page 155, Line 3.

Delete 'on' and *substitute* 'or'

Page 156.

First Heading. *Delete* 'MANOEUVRINGS' *substitute* 'MANOEUVRES'

Number the existing *Note* as *Note 1*.

Insert new *Note 2*:-

Note 2. The above explanations of screening manoeuvres show merely how to proceed directly from old to new station; they do not take into account either the preservation of an unbroken sonar front or any special instructions for screening vessels when reorienting screens. *(Amendment No. 3.)*

(Previous amendment No. 2—A.F.O. P.426/58.)