2

FORCES ON THE SHIP

USS *Mason* (DDG 87) had just secured from special sea and anchor detail after tying up alongside the pier in its home port of Norfolk, and the ship's officers had assembled in the wardroom. To get the most training benefit from each shiphandling opportunity it was the captain's policy to have a brief hot wash-up meeting after each significant evolution, chaired by the officer who had the conn. Today's meeting was chaired by Lt (jg) Roger Kingsbury.

"Let's get started," said the commanding officer, Cdr. Welsh Jones. "Roger, how did you think it went?"

"I screwed it up skipper," replied a somewhat embarrassed Lieutenant (jg) Kingsbury.

"Don't worry about it," said Commander Jones. "Nothing got bent, and we always learn more from our mistakes than from things that go perfectly. What do you think went wrong today?"

"I think I understand it now. I failed to properly anticipate the effect the current would have on us. I knew that with a strong ebb tide we would have a current setting us to port. Since we were going starboard side to, I planned to make a close approach to compensate for the current. What I didn't anticipate was that as we entered the slip the current would no longer work on the bow but would continue to push our stern to port. That rotated our bow to starboard and brought us in closer to the pier than I intended. If it hadn't been for the tug we had made up on the port bow, we could have been in real trouble. As it was, we just didn't look very sharp."

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"If we learned something, it was worthwhile," said the skipper. "I completely agree with your analysis—and you did a good job of using the tug to sort things out. The lesson we all need to take away from this is that a whole variety of forces act on the ship, and we need to anticipate, understand, and make use of them. Any questions?"

The ship is suspended in a fluid medium. At very low speeds it is almost frictionless, but as speed increases, the force required to move the ship goes up sharply. It moves in response to the vector sum of all of the forces exerted upon it. Some of these forces are under our control, some are not. A prerequisite to becoming a competent shiphandler is to understand all of these forces, how they affect the ship, and how they interact. For our purposes it is useful to group these forces into those directly controllable from the bridge, those which may be controlled by voice communication to a remote location, and those which are not under our control.

Directly controllable forces include those exerted by the ship's engine or engines, normally through propellers, rudders, and auxiliary power units or thrusters. With knowledge of the appropriate ship's characteristics, the timing and magnitude of these forces is subject to relatively precise control. Forces directly controllable from the bridge only through remote communications include lines, anchors, and tugs. These forces, while controllable, are not subject to the same precision as the engines and rudders. Forces not under our control include wind, current, and channel configuration. These forces need to be understood in order to compensate for them or, sometimes, make use of them (see fig. 2–1). In controlling those elements that are under our control, it is essential that standard commands be used to avoid the possibility of misunderstanding. Chapter 3 is devoted to these standard commands.

Directly Controllable Forces

Engines

The ship's engines, working through the propellers, generate force primarily along the axis of the ship. The water offers a resistance to the ship's motion that is proportional to the square of our speed. At rest very little power is needed to move the ship. If we ring up an ahead bell on our engines, the ship will accelerate to a speed at which the thrust generated through the propellers is balanced by the resistance of the water to the passage of the ship.

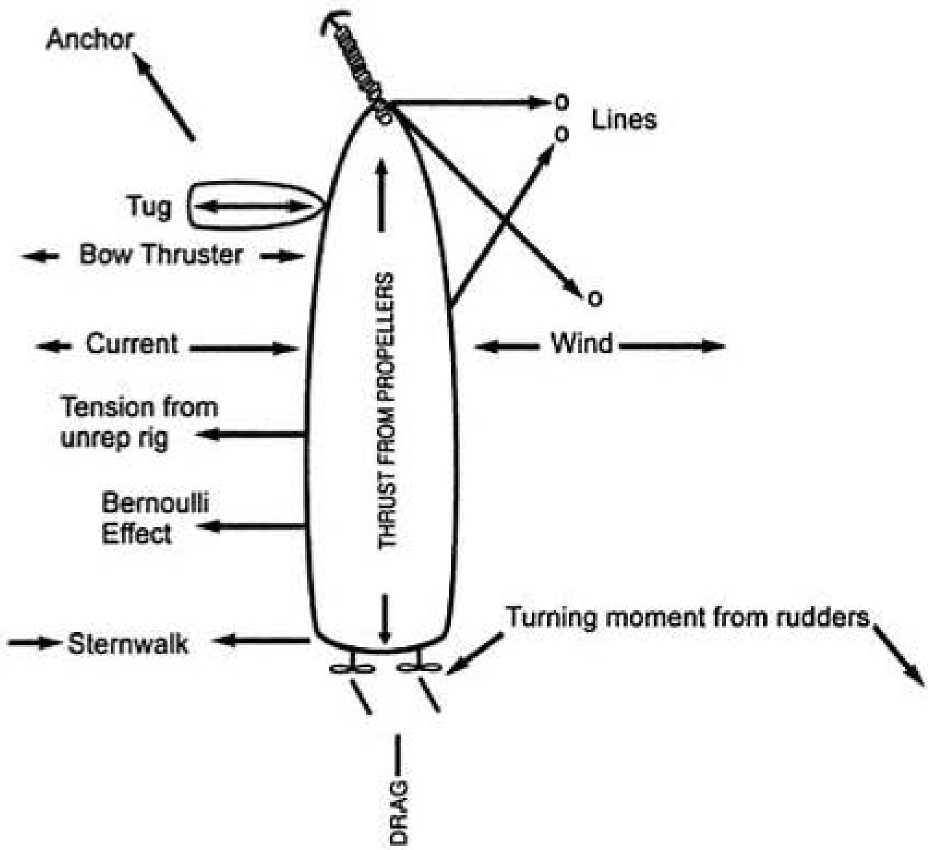

Figure 2-1. Forces on the ship.

Because the resistance of the water to the ship's motion increases so steeply with increases in speed, a ship using half of its power can make about 80 percent of its maximum speed. A destroyer capable of thirty-two knots can typically make twenty knots using only a quarter of its power.

Engines in naval vessels can be gas turbine, steam turbine (either conventional oil fired or nuclear), diesel, or electric. In the case of electric drive, the required electricity can be generated by any of the other power plants. Steam turbines and electric propulsion systems usually drive through fixed-pitch propellers. Gas turbine and diesel plants usually use controllable-pitch propellers. Naval vessels can have one, two, or four shafts. There is no technical obstacle to having three shafts or more than four, but the only known naval examples existing at present are the Coast Guard *Polar Star*– and *Mackinaw*-class icebreakers, which have three shafts.

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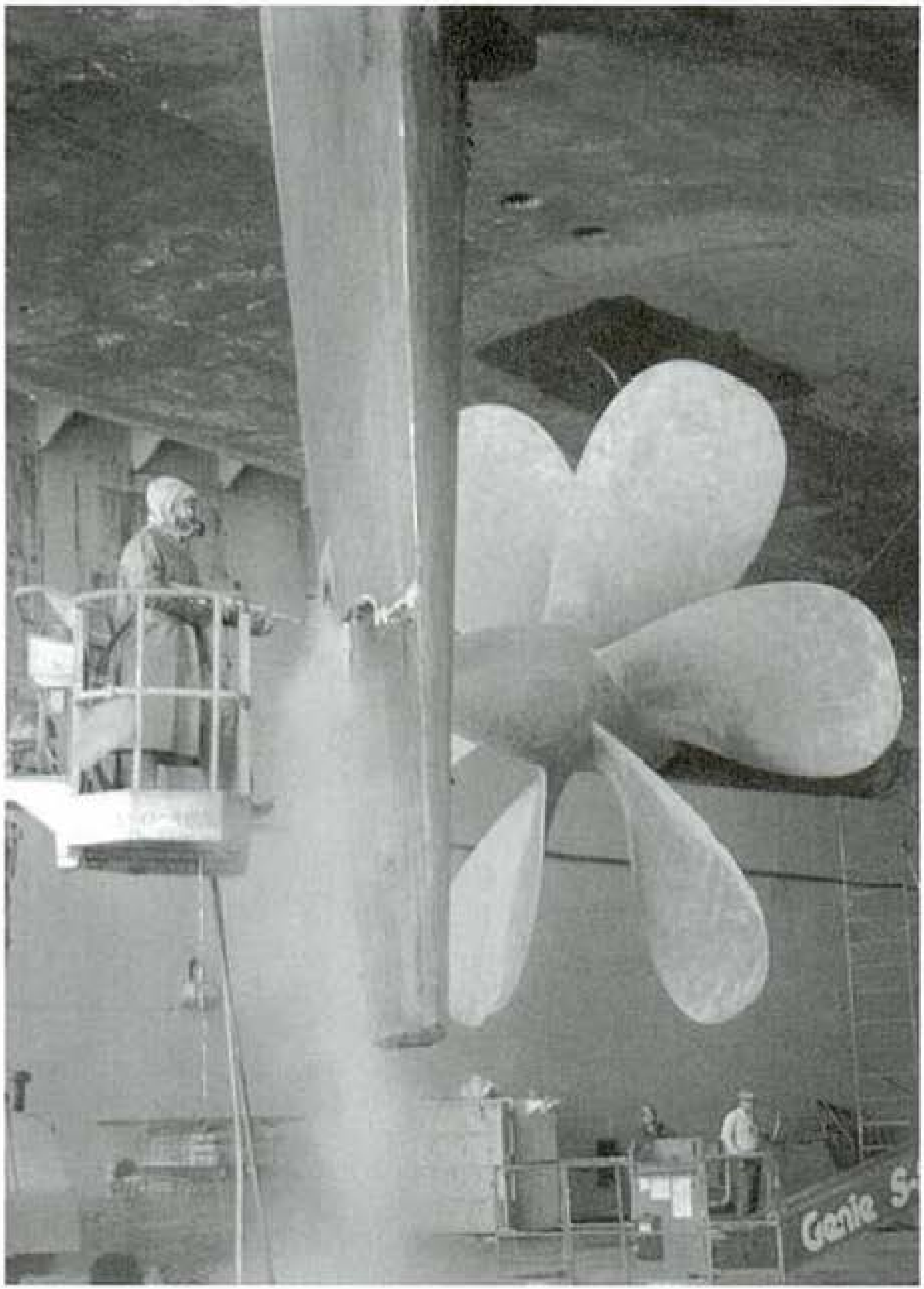

Figure 2–2. Conventional screw and rudder on USS *Belleau Wood* (LHA 3). *U.S. Navy photo*

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Propellers

The propellers are the means of transmitting the power generated by the ship's engines to drive the ship through the water. The pitch of a propeller is the distance its rotation would drive the ship through the water if there were no slippage. Most single-screw propellers rotate in a clockwise direction, as viewed from the stern. Ships with two or four shafts generally have out-turning screws, that is, when going ahead the starboard screw rotates clockwise and the port screw rotates counterclockwise as seen from astern. The *Spruance* and *Ticonderoga* classes, which have their shafts rotating inboard when going ahead, are believed to be the only notable current exceptions to this rule.

Besides the thrust ahead or astern generated by the screw, a side thrust is also generated. The amount of side thrust generated varies greatly from one ship class to another, depending upon the design of the propellers and configuration of the ship's underwater body. It is most notable in single-screw ships, since ships with more than one screw invariably have their propellers rotating in opposite directions. The direction of the side thrust depends upon the direction of the screw's rotation. This may be visualized by thinking of the screw as a wheel resting on the bottom (see fig. 2–3). Sternwalk is more notable in gas

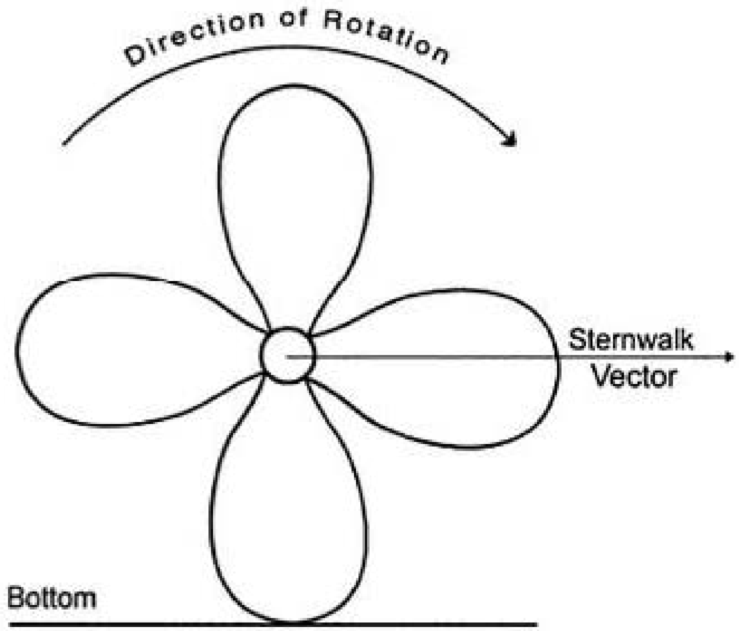

Figure 2–3. The direction of the sternwalk vector created by propeller rotation is as though the propeller were a wheel resting on the bottom.

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turbine ships than in others, because the shafts continue to turn even when a stop bell is ordered. When the engines are ordered to stop the variable-pitch propellers are set for minimum pitch, but the shafts continue to rotate and thus induce sternwalk.

With a gas turbine twin-screw vessel with controllable-pitch propellers, sternwalk is not an issue, since the shafts continue to turn in opposite (and counterbalancing) directions even when one engine is ahead and the other astern. With other propulsion systems, the rotation of propellers and shafts is reversed when the engines are ordered astern. If engines are opposed, both shafts will turn in the same direction, generating a sternwalk vector. Since this sternwalk vector is in the same direction as that generated by the lateral twisting force generated by the opposed engines, it is usually unnoticeable, but does assist the ship to twist.

It is with single-screw vessels that sternwalk demands the shiphandler's attention. Most single-screw vessels have propellers that rotate clockwise as viewed from astern. With a single-screw gas turbine ship such as the *Oliver Hazard Perry*–class frigate, whose shaft and propeller continue to rotate in the same direction whether set for ahead, stop, or back, this generates a notable tendency for the stern to walk to starboard under all circumstances unless balanced by the auxiliary propulsion units. This tendency must be taken into account in planning any evolution. Most other single-screw ships reverse the propeller and shaft when backing. These ships generate a side-walk vector that moves the stern to port when backing. In contrast to the variable-pitch ship, however, no sternwalk vector is generated when the engines are ordered to stop, since the shafts and propellers cease to rotate.

Rudders

The first thing to understand about rudders is that they generate a force on the ship only when water is flowing past them. The flow past the rudders can be generated by the motion of the ship, the discharge from the propellers, or both. Ships have one or two rudders. They are always located aft of the propellers so that when the propellers are turning ahead, their wash is directed at the rudders. This means the rudders will always be more effective when going ahead than when going astern. Control of a backing ship is almost always less precise than when going ahead.[1]

The rudder, located well aft on the hull, works by moving the stern of the ship in the opposite direction from the intended turn. To turn right, the rudder swings to the right. This creates a pressure differential on the rudder, with higher pressure to starboard, reduced pressure to port. The resulting

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Figure 2–4. Controllable-pitch propeller, here on USS *McInerney* (FFG8). *J. Bouvia*

force moves the stern to port. This creates a drift angle creating pressure on the port bow of the ship. The pressure on the port bow combined with the rudder force pushing the stern to port causes the ship to turn to starboard. Note that this force generated by the rudder causes the ship to move initially slightly off track in the direction opposite to the turn (see fig. 2–6).

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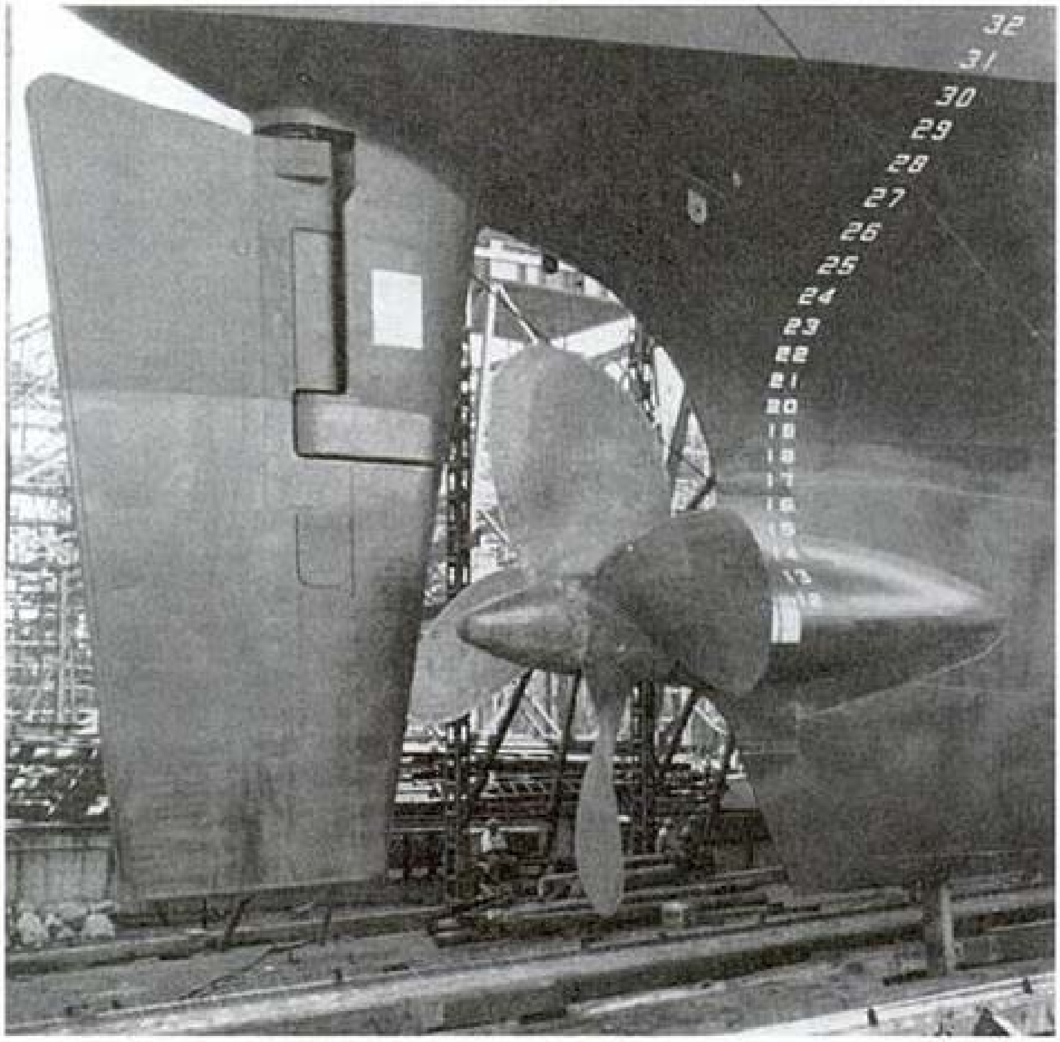

Figure 2–5. Rudders generate a force only when water is flowing past them. Note the way in which a wash from the propeller will be directed at the rudder. *U.S. Naval Institute photo archives*

The turning force generated by the rudder depends upon the rudder's size, angle, and the velocity of the water moving past it. The velocity of the water in turn depends upon both the motion of the ship through the water and the velocity of the propeller wash generated by the ship's screws. Ships with rudders located directly behind the propellers are more responsive than those with offset rudders (as, for example, a twin-screw ship with a single rudder). For a stopped ship, an ahead bell against the rudder can generate substantial turning force before the ship gathers much way. Thus the tightest turns can be made from a dead stop.

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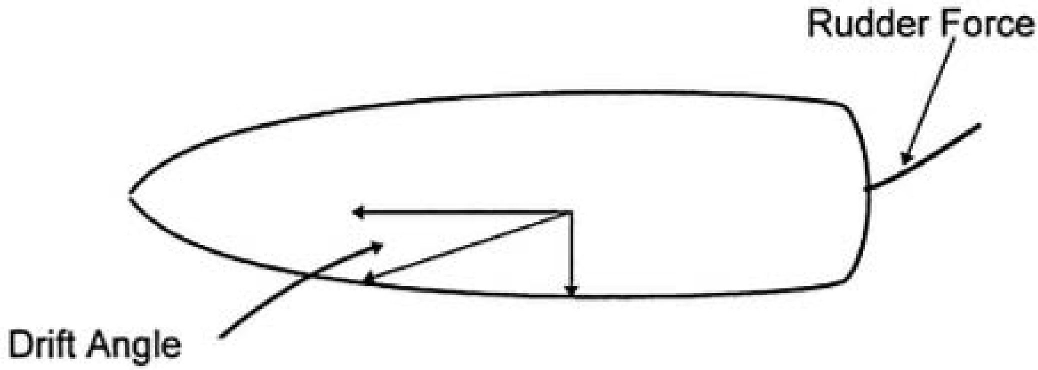

Figure 2–6a. Right rudder for a starboard turn creates a force to port. The result of the ahead force and the rudder force to port creates a drift angle, initially moving the ship to the left of the track.

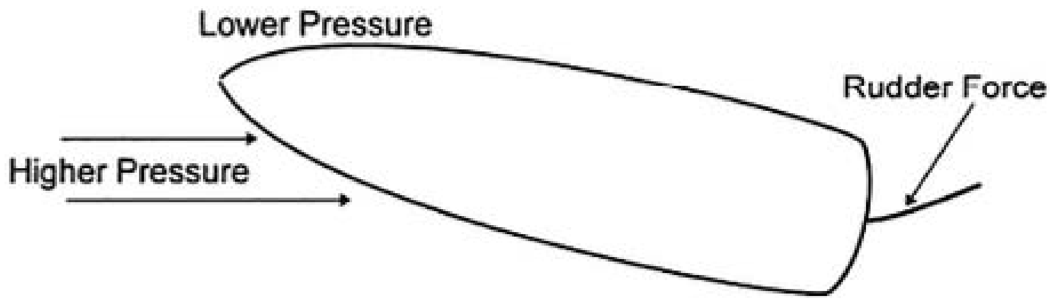

Figure 2–6b. As the stern moves to port, hydrodynamic pressure on the port bow, combined with reduced pressure on the starboard bow, turns the ship to starboard.

A rudder generates both turning force and drag. Both increase as the angle of the rudder increases, but not in a linear way. The amount of turning force is incrementally less as the angle increases, while the amount of drag is incrementally more (see fig. 2–7). Because of the possibility of damage if a rudder is slammed into its stops, it is best to limit hard rudder to emergencies, or to first order full rudder, then move the rudder gently the last few degrees to hard rudder.

The rudder is less effective when going astern than when going ahead. The propellers turning astern do not generate an effective flow across the rudder. Thus the rudder does not become effective when going astern until significant sternway is gathered. This varies substantially with ship type, but most ships do not steer reliably astern much below five knots of sternway. It is important for the shiphandler to understand that the disturbed flow a backing bell creates for the rudders can negatively affect steering, even while

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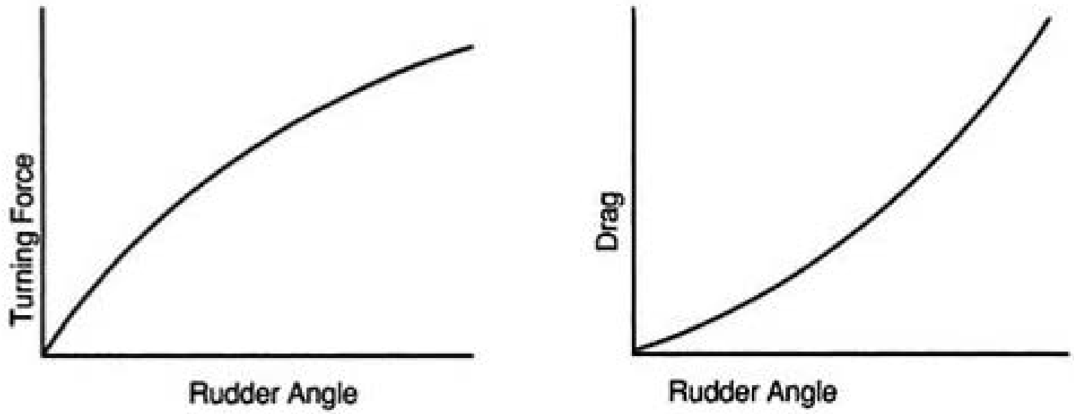

Figure 2–7. The increase in turning force becomes relatively less with each degree of increase in rudder angle, and the increment of drag generated by the rudder becomes relatively greater.

the ship still has substantial headway. In some circumstances, you have to choose between being able to stop or being able to steer, but not both.

It is important to know how your ship responds to various angles of rudder at various speeds. Two important aspects of this are called advance and transfer. Advance is the distance that the ship will move forward in a 90-degree turn in response to a specified rudder angle. Transfer is the lateral distance the ship will move during the same maneuver. Tactical diameter is the lateral distance the ship will move in a 180-degree turn with a specified rudder angle. Standard tactical diameter is specified so that ships in formation will turn at the same rate during tactical maneuvers (see fig. 2–8).

The Moving Pivot Point

In turning, the ship rotates about a pivot point. Forward of that point the ship when turning moves in one direction, and aft of the pivot point moves in the opposite direction. Any ship's pivot point is not fixed; it varies with circumstances. It is not unusual to be told something like "On this ship the pivot point is slightly aft of the bridge." Sometimes it is, sometimes it is not. What is really being said is something like "When this ship is going ahead with substantial way on, and has no tugs, lines, or anchors exerting forces, it will respond to the rudder by rotating about a point slightly aft of the bridge." In fact, the pivot point can move over almost the entire length of the ship as circumstances vary.

A ship's center of lateral resistance is determined by the shape and area of its underwater body, and is the point at which there is as much underwater area forward as there is aft. If a lateral force is applied to the ship at this point,

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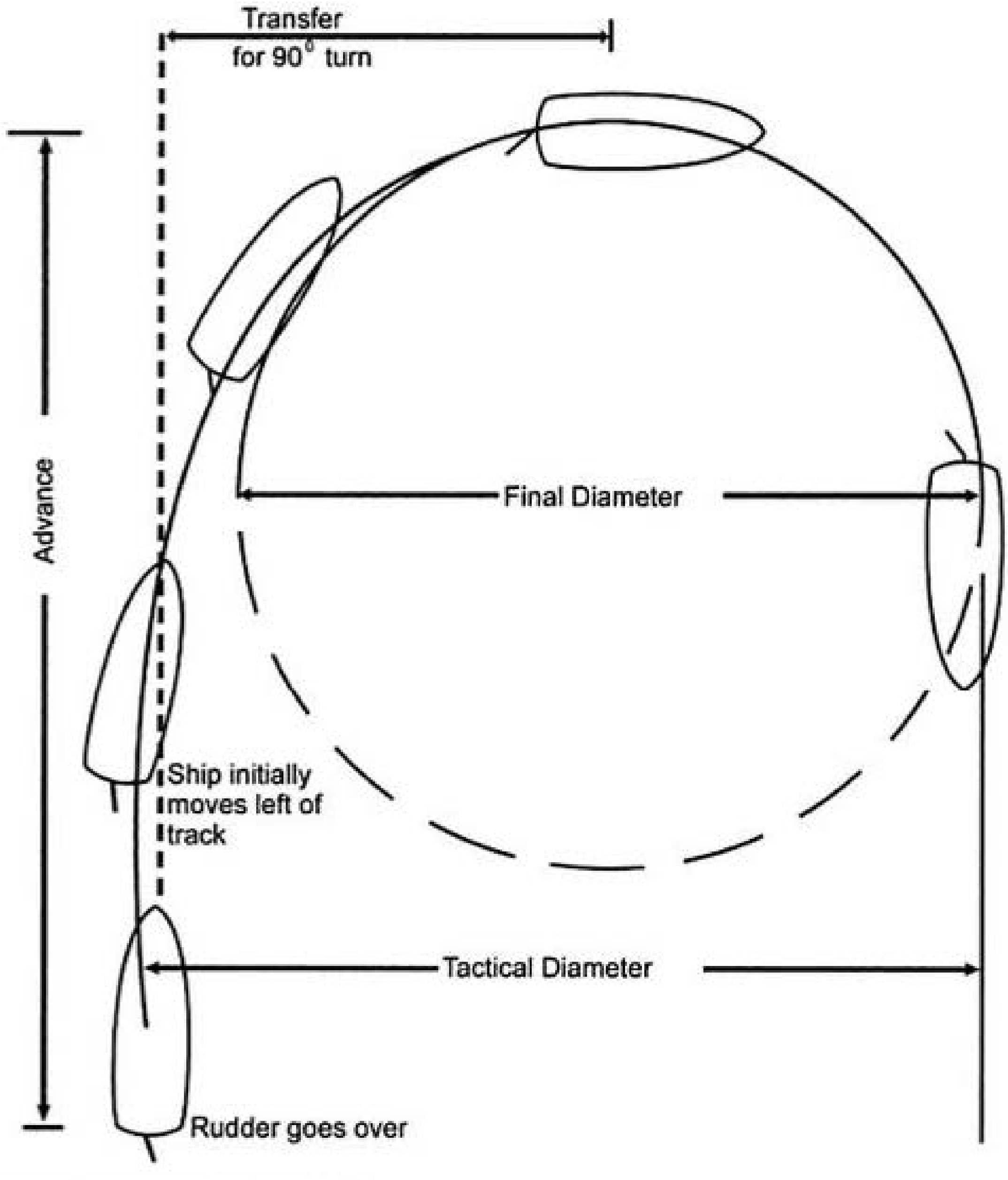

Figure 2–8. Advance and transfer.

as by a tugboat, the ship will move sideways without rotating. If a lateral force is applied forward or aft of this point, the ship will rotate in addition to moving sideward. The pivot point of this rotation will be offset from the center of lateral resistance in a direction opposite to the offset of the applied force. If the tug pushes near the stern, the pivot point will be toward the bow. The

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further the applied lateral force is from the center of lateral resistance, the further the pivot point will move in the opposite direction, and the more the applied force will tend to rotate the ship rather than move it laterally. Thus if you want a tug to move a ship laterally without rotation, it should be made up amidships near the center of lateral resistance. If you want the tug to rotate the ship, it should be placed near the bow or stern. See figure 2–9, which illustrates how the pivot point moves in various circumstances.

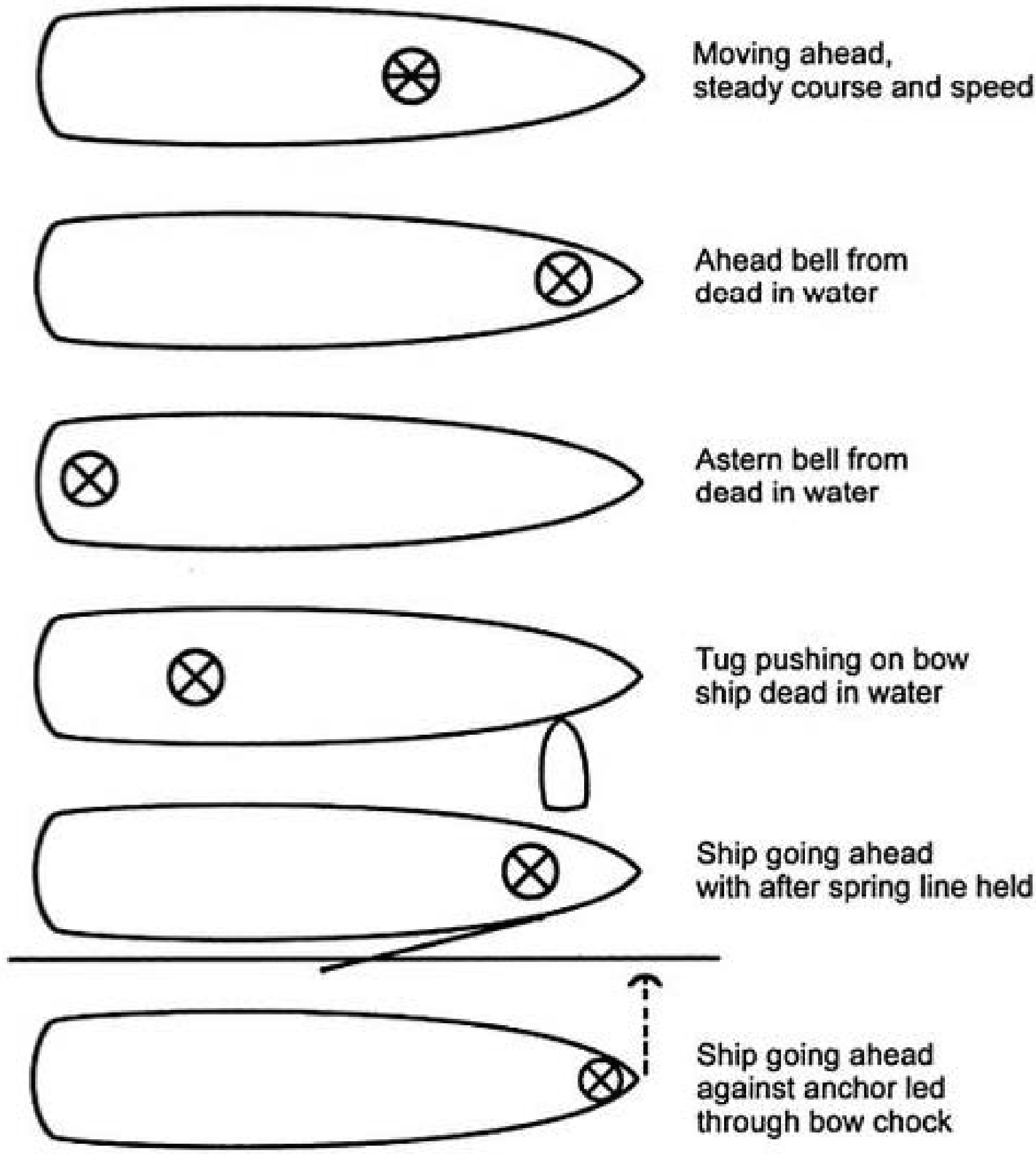

Figure 2–9. The movable pivot point.

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The use of mooring lines or the anchor also can move the pivot point. If the ship moves ahead against the anchor, the pivot point moves to the bow. Under these circumstances the ship's engine(s) and rudder may be used to obtain precise positioning of the stern, while the anchor holds the bow in place. Similarly, a spring line (a mooring line that makes an acute angle to the ship and to the pier) can be used to move the pivot point. The most frequent use of this is in moving the stern away from the pier to get under way. To do this the ship's engines are worked ahead against a mooring line run from the bow to a place well aft on the pier. (The correct nomenclature for this line is "forward after spring line," usually line number two.) This moves the pivot point well forward, so that the propeller discharge against the rudder full over toward the pier moves the stern away from the pier while the bow remains in place. The line in this case serves the dual purpose of moving the pivot point well forward and restricting the ship's forward motion. Line-handling terminology is covered in chapter 3. Diagrams of standard mooring line configurations for destroyers and aircraft carriers are provided in figure 2–10.

When the ship is moving though the water it encounters resistance from the water. As is the case with lines or anchor, this resistance moves the pivot point away from the center of lateral resistance toward the retarding force. Thus a ship moving forward will have a pivot point well toward the bow. When going astern the pivot point moves toward the stern. The moving pivot point can be used to advantage when maneuvering in tight quarters. When the ship is dead in the water, and an ahead bell is used against the rudder, the pivot point of the ship moves well forward, amplifying the effectiveness of the rudder in moving the stern.

Auxiliary Power Units and Thrusters

Count yourself fortunate if your ship is equipped with auxiliary power units (APUs) or thrusters. Properly used, they permit even a fairly large vessel to carry out all needed maneuvers without the use of tugs, so long as the wind and current are within their power limitations. The basic difference between the two is that APUs are trainable while thrusters are not. As the name indicates, the principal purpose of the APU, such as found on *Oliver Hazard Perry*–class frigates, is to provide a "get home" capability in the event that the ship's single shaft or propeller is disabled. However, it also is a very useful aid to shiphandling. By opposing the APUs to the ship's engine, it is

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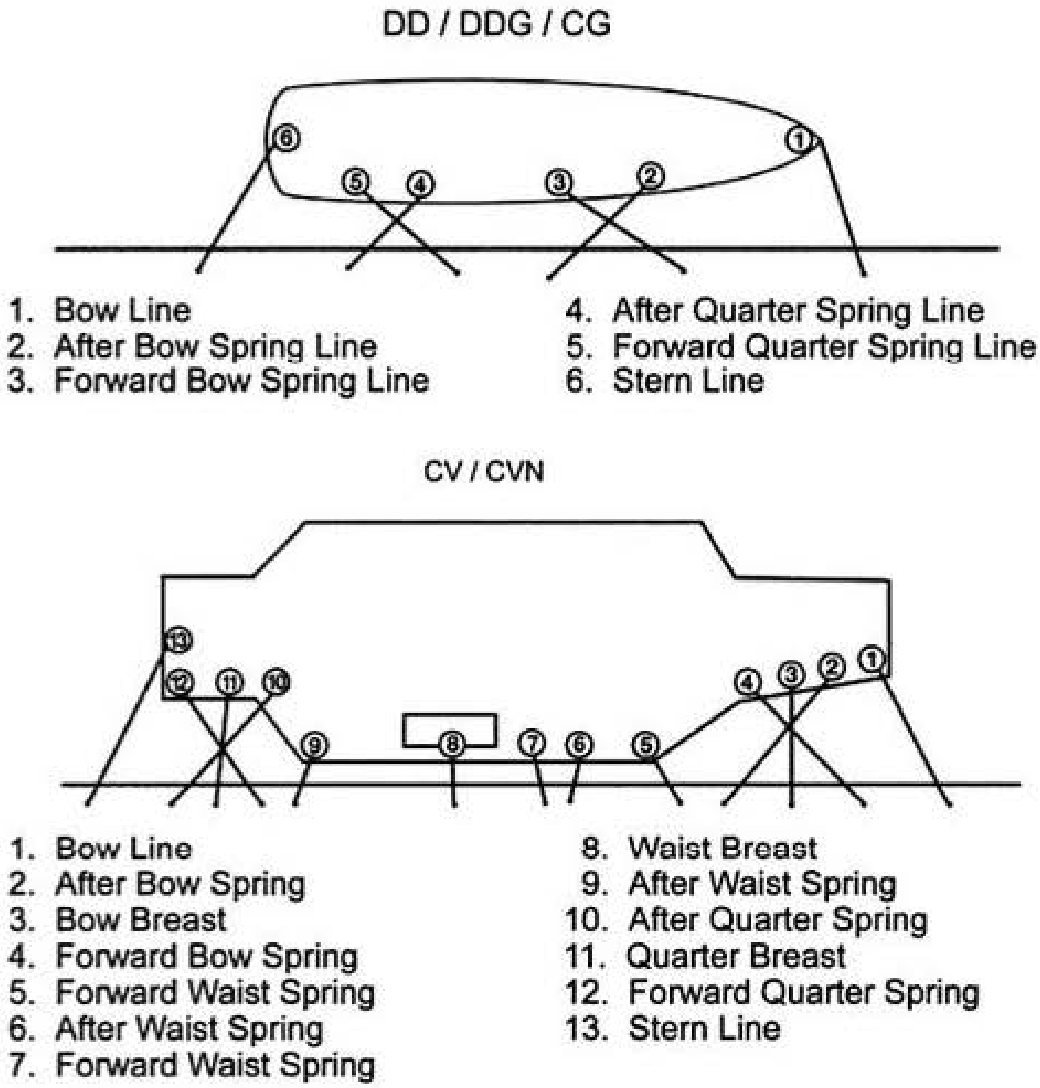

Figure 2–10. Standard destroyer and carrier mooring lines.

possible to walk the ship sideways into a slip. The bow thruster, although it cannot be opposed to the ship's screws, does provide a means of moving the bow to port or starboard under precise control. Both the APUs and the bow thrusters lose effectiveness when the ship is proceeding at any significant speed through the water. The use of both of these aids will be discussed in greater detail later on.

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Indirectly Controllable Forces

Mooring Lines

A ship's lines are, of course, used to hold the ship securely while moored. They also are an important element of shiphandling. Lines are numbered in order from the bow with regard to their position on the ship. Figure 2-10 shows typical lines as used by a destroyer or cruiser as well as those used by the largest naval vessel, the aircraft carrier. The smaller the vessel, the more use is likely to be made of the lines for shiphandling purposes rather than just for mooring. For larger vessels, the strain that would be placed on the lines could become excessive, so that for these ships the mooring lines are usually used just to hold the vessel in place. The utility of lines is greatly enhanced by line-handling winches fore and aft.

Anchors

The ship's anchors can be used for a great deal more than just tethering the ship to an assigned anchorage. They can serve, within some very important limits, to get us out of tight spots in an emergency, such as loss of propulsion power or rudder control, or where wind and/or current are preventing a desired maneuver. Anchors can also serve as very handy auxiliary means of shiphandling, particularly for single-screw ships. The techniques for doing this are set forth in chapter 6.

Tugs

The larger our ship, and the greater the wind and current, the more important tugs become for handling the ship in restricted waters. Tugs often come as a package with the services of a pilot. The use of tugs and relations with the pilot are discussed in chapter 8.

Uncontrolled Forces

Wind

Although wind is perhaps not now as overriding a factor for the seaman as it was during the days of sail, it remains a major factor in the control of ships. It is perhaps next only to the ship's engines and rudders as a force affecting our ship. Air operations, underway replenishments, under ways and landings, and

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our ability to twist or turn the ship in restricted waters are all greatly affected by the wind.

The wind is outside our control, and it can change quickly. Weather predictions and the ship's anemometers can give us a preliminary indication of what to expect, but nothing takes the place of immediate observation. The shiphandler needs to learn to read flags and the surface of the water to determine wind direction and velocity. Time spent in a sailboat provides excellent practice in reading the wind and understanding its vagaries. Structures and other ships can cause eddies and can block the wind either partially or entirely. You have probably noticed the flags above a football stadium flying in different directions, with the wind on the field being different yet. The same thing can affect our ship.

Ships vary greatly in their response to the wind. The more sail area the ship presents to the wind, the more it will be affected. A deep-draft ship with relatively low sail area, such as a submarine, will be moved much less by the wind than will a shallow-draft ship with a large sail area, such as an amphibious ship. Most warships have more sail area forward than aft, so that a beam wind pushes more on the bow. Since this pushes the bow down wind more rapidly than it does the stern, a rotating force is developed tending to cause the ship to back into the wind. This tendency makes it more difficult to twist the bow of the ship through the wind.

The wind is often the determining factor in deciding whether tugs are needed when going alongside or getting under way from a pier. It is not possible to state a given wind velocity that requires the use of tugs. If the wind is blowing straight down the pier, we can accept higher winds than if the wind is from the beam. A wind from directly ahead or astern is relatively easy to balance with our engines. A beam wind is more likely to present a problem.

Current

Current is water in motion, and it affects our ship in much the same way as does the wind. Currents can be generated by tides, rivers, or prevailing winds. To add a degree of difficulty for the shiphandler, it is not at all unusual for the wind and the current to come from different directions. The relative importance of wind and current varies from ship type to type. Often a ship will adopt a rule of thumb, such as thirty knots of wind equals one knot of current. As with wind, a current is more difficult to compensate for when it is from the beam than from ahead or astern. A current from ahead is also easier to deal with than one from astern, since the ahead bell used to offset the current improves the effectiveness of our rudder.

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As with the wind, the shiphandler needs to know in advance what current to expect and to augment this knowledge with direct observation. You should never take the conn to operate in restricted water without knowing the state of the tide. The *Tidal Current Tables*, which the navigator has, give the velocity of flow and the times of slack water (no flow), maximum ebb (current flowing outward), and maximum flood (current flowing inward). In addition to this you need to check current visually. Currents can be observed on the surface of the water by the visible wakes and eddies from navigation marks, pier pilings, crab pots, and so on (see fig. 2–11). Anchored ships will lie to the current, or the wind, or somewhere in between. Currents tend to cause can and nun buoys to lean down current, although this observation must be made with caution: buoys can also sometimes lean because they have taken on water, or for idiosyncratic reasons of their own.

In the case of both wind and current, there are additional pitfalls of which you need to be aware. Either or both can affect the turning point when con-

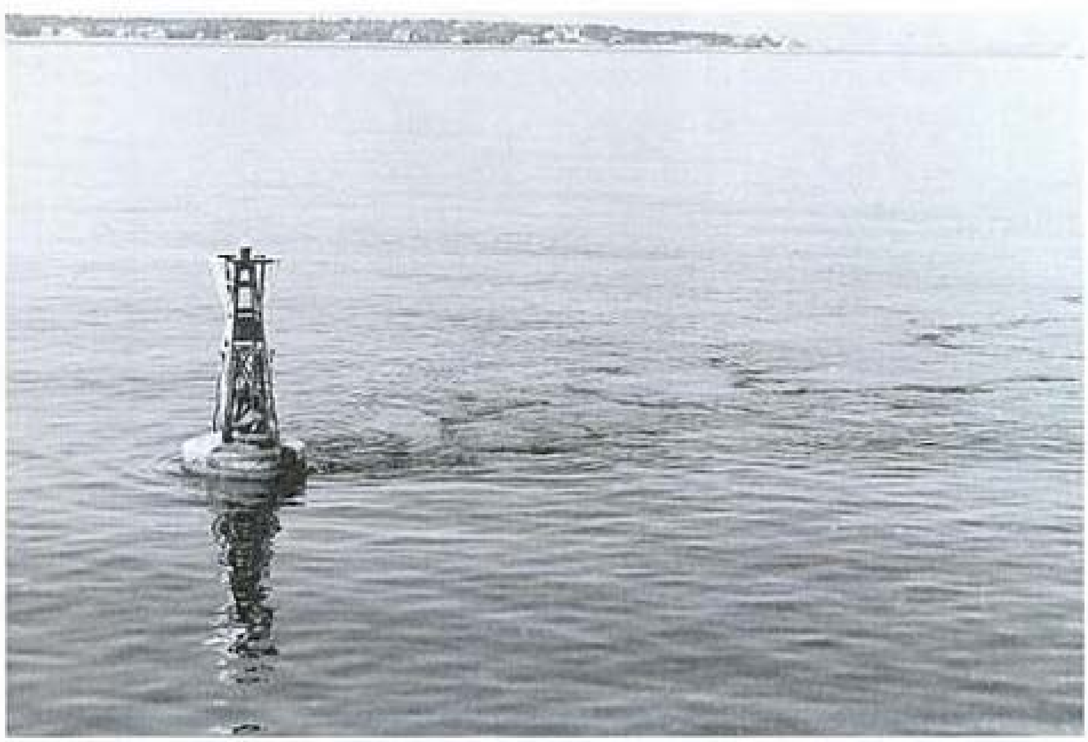

Figure 2–11. With a little experience the direction and speed of the current can be accurately estimated by observing buoys and pilings. *U.S. Naval Institute photo archives*

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forming to a channel, or require the use of more or less rudder than would be appropriate in their absence. If the wind or current is across the channel, the ship will have to steer an offsetting course (called "crabbing") to remain in the channel. The slower the speed of the ship, the more offset will be required. If there are screening objects such as a building that blocks the wind or a solid face pier that blocks the current, we may find that part of our ship is still exposed while the remainder is protected. This can trip up the unwary shiphandler by imparting an unexpected rotation.

Bernoulli Principle

In 1738, Swiss physicist Daniel Bernoulli published his most famous work, *Hydrodynamica*. In it, he formulated the principle that within a fluid under conditions of steady flow the sum of the energy of velocity, the energy of pressure, and the potential energy of elevation remains constant. This was one of the earliest formulations of the principle of the conservation of energy. One of the most important implications of Bernoulli's principle is that an increase in the velocity of a fluid, whether liquid or gaseous, causes a decrease in pressure. This is the basis on which rest the lift of an airplane wing, the measurement of flow in a pipeline, ground effects in a race car, the ability of a sailboat to sail to windward, and the force of attraction between two ships steaming in parallel. The Venturi effect is a derivative of the Bernoulli principle.

Venturi Effect

Fluid speed increases when the fluid is forced through a narrow or restricted area. The increased speed of fluid flow results in a decrease in pressure. There are several circumstances in which the Venturi effect creates a force on our ship. During an underway replenishment, two or more ships steam on parallel courses in close proximity. As the water flows between the ships, it must pass through a narrower passage, speeding the flow as it does so. The consequence is a reduction in the pressure on the inboard sides of both ships, tending to suck the ships together. The greater the speed of the ships, and the closer they are together, the stronger is the force trying to bring them together. How to take this force into account is covered in more detail in chapter 9 on underway replenishment.

Channel Configuration

Narrow channels or shallow water can contribute forces of their own. Shallow water effect can greatly reduce the responsiveness of the ship to its rud-

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der. Shallow water can also create a squatting effect reducing the ship's clearance over the bottom and increasing the power required for a given speed. This is a special example of the Bernoulli principle, in which the water flowing between the sea bottom and the ship's keel is accelerated with a resultant decrease in pressure, causing the ship to sit lower in the water. A narrow channel with steep side gradients can also create both suction and cushioning effects that the shiphandler needs to understand. These are discussed in chapter 7.

The controllable forces listed here are the ship's engines, propellers, rudders, auxiliary power units or thrusters, mooring lines, anchors, and tugs. The forces not under our control are wind, current, Venturi effects, and channel configuration. Having identified these forces, subsequent chapters develop how the shiphandler uses them or compensates for them in order to maneuver the ship to the intended place.

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3

STANDARD COMMANDS

In the wardroom of USS *San Antonio* (LPD 17), Ens. Dwight Cunningham was completing his assigned teaching session on standard commands to the rest of the ship's officers. The senior watch officer, Lt. Rosemary Stewart, was playing devil's advocate.

"Dwight, you've told us what standard commands are, but you haven't said why they matter," said Lieutenant Stewart. "Isn't this just another case of military insistence on formality, whether it makes any practical sense or not? Who cares if I say, 'Give me 15 degrees of rudder to starboard' instead of 'Right standard rudder,' so long as the helmsman understands me?"

"It makes a lot of difference," replied Ensign Cunningham. "We use standard commands to minimize the possibility of misunderstanding. Ambiguity and misunderstanding of commands to the rudder, the ship's engines, to the anchors, to tugs, or to the handling of lines can lead to accidents and injuries. I've been impressed by the precision standard commands bring to orders. The more stressful the circumstances, the more important it is to use standard commands. Standard phrasing is a lot easier for people to recognize and understand than orders in an unfamiliar form. I've seen enough garbled phone communications even without complicating things with unfamiliar phrasing."

"Okay, that's what I wanted to emphasize," said Lieutenant Stewart. "But there is another good reason. Everyone in the Navy gets transferred with regularity. We shouldn't have to learn a new set of commands every time we change ships. Fortunately, standard commands apply to commissioned naval vessels, of all types, whether large or

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small. It can be tempting to develop shortcuts and individual variations, but this is a very bad idea. You've made your point well, Dwight. Thanks."

In classes on leadership, it is usual to identify a span of leadership styles ranging from participative-democratic to autocratic. The instructor generally concludes that there are no circumstances in which autocratic leadership is to be preferred. True as this may be in general, it is not so where conning a ship is concerned. Orders to the helm, lee helm, and line-handling stations are not matters to be discussed. Conning a ship requires autocratic leadership: crisp, sharp, clear, precise, and unambiguous orders. That is why we use standard commands.

In the interest of standardization, the commands set forth in this chapter are, unless otherwise indicated, identical to those published in *Watch Officer's Guide.*[1] Orders must not only be standard but also must be given in a tone and

Figure 3-1. Standard commands minimize the possibility of misunderstanding. *U.S. Navy photo*

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loudness that stamps them immediately as a command. Few things are worse than a timid or tentative order. The recipients of the order must be able to understand clearly and without possibility of ambiguity that an order is directed to them. To aid in this, and to avoid the possibility of misunderstanding, orders follow a standard and logical pattern.

Orders to the helmsman start with the direction the rudder is to go: "Right" or "Left." The second word indicates how far the rudder is to be turned. This can be in degrees or a predefined angle, such as "Standard" or "Full." The third word in the command is "Rudder." This sequence permits quick and accurate response, as the helmsman can start the rudder in the proper direction immediately, then stop the rudder swing on the ordered angle. The exception to this is that when maximum rudder is needed, we preface the order with "Hard" to indicate urgency. The order in this case is "Hard right (left) rudder."

Orders to the engine order telegraph (or "lee helm") are constructed in a similarly logical way. The first term, "All engines," or "Port (starboard) engine," tells the operator which handle is to be moved. The next word, "Ahead," "Stop," or "Back," tells in which direction they are to be moved. The last part of the command, "One-third," "Full," and so on, tells the amount of the speed change. Standard commands to the engines include

1. "All engines ahead one-third (two-thirds, standard, full, flank)," "All engines stop," or "All engines back one-third (two-thirds, full)";
2. "Starboard (port) engine, ahead one-third (two-thirds, standard, full)," "Starboard (port) engine stop," or "Starboard (port) engine, back one-third (two-thirds, full)."

Each ship will normally have standard acceleration tables to make the rate of acceleration predictable and uniform between ships of a class. In an emergency, when we want maximum acceleration or deceleration, the command is, "All engines ahead (back) emergency." In response to this command, the operator rings up "Ahead flank" (or "Back full") three or more times in rapid succession, ending with the handles at the flank or back full position.

In addition to the handles on the engine order telegraph that indicate desired speeds in five-knot increments, there is also a revolution indicator. When quick response in five-knot increments is desired, this is indicated by ringing up on the rpm indicator a speed well beyond the engines' range, such as "999." The order for this is "Indicate 999 revolutions for maneuvering bells." When a specific speed is desired, the exact number of revolutions to be made is indicated on the revolution indicator, and the corresponding speed

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(one-third, two-thirds, etc.) on the handles of the engine order telegraph. An example would be "All engines ahead standard, indicate 240 revolutions for sixteen knots." The term "revolutions" must always be included in these orders to prevent possible confusion with orders concerning course or bearings. When changing speed in small increments, resist the temptation to use terms such as "Add three turns" or "Take off two." Instead, say the exact number of revolutions to be rung up, as in "Indicate one one seven revolutions." If the speed change takes you across a division such as between one-third and two-thirds, the order will be "All engines ahead two-thirds, indicate one one seven revolutions."

If the conning officer is in a position from which he is unable to see or remember the revolutions required, he can substitute the command "Indicate turns for ——— knots," requiring a report back of the turns actually rung up, as well as a repetition of the command.

The report back after every order to the rudder or engines is an essential part of the system of standard commands to ensure that the command is properly understood. It also serves as a check on the officer giving the command to make sure that he has not given an incorrect command through a slip of the tongue. The final step in the system is a report from the helmsman or lee helmsman that the order has been carried out. This is acknowledged by the conning officer with a "Very well."

Steering Commands to the Helm

The following examples of steering commands to the helm are taken directly from the *Watch Officer's Guide* (14th ed., pp. 142–49):

> When a specific amount of rudder is desired:
> Command: "Right full rudder (or right standard rudder)."
> Reply: "Right full (standard) rudder, aye, Sir (or Ma'am)."
> Report: "My rudder is right full (standard), Sir (or Ma'am)."
> When the rudder order is given in degrees:
> Command: "Left ten degrees rudder."
> Reply: "Left ten degrees rudder, aye, Sir (or Ma'am)."
> Report: "My rudder is left ten degrees, Sir (or Ma'am)."
> (*Note:* When a rudder order has been given, but no course to come to, the helmsman should report passing each ten degrees: "Passing 270, Sir (or Ma'am)." Besides the information provided, this serves as

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a reminder to the conning officer that no course order has yet been given. Each report should be acknowledged with a "Very well." The conning officer may direct "Belay your headings" if he does not desire the reports, but this should be done with caution since it removes a useful reminder.

When the helmsman is to steady on a specific course:

Command: "Steady on course ———."

Reply: "Steady on course ———, aye, Sir (or Ma'am)."

Report: "Steady on course ———, Sir (or Ma'am). Checking ——— magnetic."

When maximum possible rudder is required:

Command: "Hard right rudder."

Reply: "Hard right rudder, aye, Sir (or Ma'am)."

Report: "Rudder is hard right, Sir (or Ma'am)."

(*Note:* The danger in using hard rudder lies in the possibility of jamming the rudder into the stops. For this reason it is rarely used except in emergencies. If hard rudder is chosen when there is no emergency, the conning officer may reduce the possibility of jamming the rudder by first ordering full rudder and then increasing the rudder to hard, allowing the helmsman more control of the rudder's movement.)

When the amount of rudder is to be increased:

Command: "Increase your rudder to ——— (right full, right ten degrees, etc.)."

Reply: "Increase my rudder to ———, Sir (or Ma'am)."

Report: "My rudder is ——— (right full, right ten degrees, etc.)."

When the amount of rudder is to be decreased:

Command: "Ease your rudder to ——— (standard, left ten degrees, etc.)."

Reply: "Ease my rudder to ———, Sir (or Ma'am)."

Report: "My rudder is ——— (standard, left ten degrees, etc.)."

When the rudder is increased or decreased while the ship is turning to an ordered course:

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Command: "Right standard rudder, steady on course 270."

Reply: "Right standard rudder, steady on course 270, aye, Sir (or Ma'am)."

Command: "Increase your rudder to right full, steady on course 270."

(*Note:* When the rudder is increased or decreased, the conning officer must restate the desired course. Otherwise the helmsman is to leave his rudder at the position last ordered and report passing each ten degrees until a new course is given.)

Reply: "Increase my rudder to right full, steady on course 270, aye, Sir (or Ma'am)."

Report: "My rudder is right full, coming to course 270, Sir (or Ma'am)."

When course change is less than ten degrees:

Command: "Come right steer course ———."

Reply: "Come right, steer course ———, aye, Sir (or Ma'am)."

Report: "Steady course ———, checking course ——— magnetic, Sir (or Ma'am)."

A command once standard, now obsolete, is "Come right (left) handsomely to ———." Its meaning is to do so slowly and carefully, but it has been dropped because easily misunderstood as meaning the opposite.

When the rudder angle is to be reduced to zero:

Command: "Rudder amidships."

Reply: "Rudder amidships, aye, Sir (or Ma'am)."

Report: "My rudder is amidships, Sir (or Ma'am)."

When the course to be steered is that which the ship is on at the instant the command is given:

Command: "Steady as you go."

Reply: "Steady as you go, course ———, aye, Sir (or Ma'am)."

Report: "Steady on course ———, Sir (or Ma'am), checking ——— magnetic."

(*Note:* This command should normally not be used if the ship's head is swinging rapidly. Injudicious use could cause momentary loss of control over the ship's swing if the helmsman is required to use a large rudder angle to carry out the order. To prevent this, the order

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should be preceded by "Rudder amidships." This, of course, requires anticipation on the conning officer's part to ensure a correct heading.)

When the swing of the ship is to be stopped without steadying on any specific course:

Command: "Meet her."

Reply: "Meet her, aye, Sir (or Ma'am)."

(*Note:* Immediately after the reply is given, the conning officer must order a course to be steered.)

Command: "Steady on course ——."

Reply: "Steady on course ——, aye, Sir (or Ma'am)."

Report: "Steady on course ——, Sir (or Ma'am). Checking —— magnetic."

When equal and *opposite* rudder is desired relative to that previously ordered:

Command: "Shift your rudder."

Reply: "Shift my rudder, aye, Sir (or Ma'am)."

Report: "Rudder is —— (a rudder angle equal but opposite to that previously ordered)."

When the heading of the ship is to be determined at a given moment:

Command: "Mark your head."

Report: "Head is (exact heading at that moment), Sir (or Ma'am)."

(*Note:* If the helmsman appears to be steering properly but the ship is not on its correct heading, the conning officer should use this command to compare the helmsman's compass with other repeaters on the bridge.)

When the helmsman has been given a course to steer but appears to be steering badly or is continually allowing the ship to drift from the ordered course:

Command: "Mind your helm."

Reply: "Mind my helm, aye, Sir (or Ma'am)."

(*Note:* No report necessary.)

When the ship is in a situation where minor deviation from an ordered course may be permitted to one side, but none may be per-

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mitted to the other side (for example, when alongside another ship for refueling):

Command: "Steer nothing to the left (right) of course ———."

Reply: "Steer nothing to the left (right) of course ———, aye, Sir (or Ma'am)."

(*Note:* No report necessary.)

It is generally poor practice to order a course to steer when the ship is maneuvering, since this relinquishes control from the conning officer to the helmsman. By giving rudder orders the conning officer retains control. It makes no sense to give a course to steer when the ship is maneuvering in a slip, when engines are backing, when the ship has no way on, or when twisting. Best practice is for the conning officer to bring the ship to the desired course through rudder orders, and only then relinquish control to the helmsman by giving him a course to steer. This is also excellent practice in learning precise control of your ship.

Whenever ordering a course change, the conning officer should perform the following activities:

1. Check the side to which he or she intends to turn to make sure that it is safe to turn in that direction.
2. The ship's speed determines how quickly its head will swing. At very low speeds, a large angle of rudder may be required to bring about a course change. At very high speeds, a large rudder angle may cause it to swing so rapidly that it cannot be safely controlled. All conning officers should be familiar with the tables of turning speeds and turning diameters for their ship. This information is contained in the ship's tactical data book. Generally, the sum of rudder order plus speed in knots should not exceed thirty or else there will be a probability of fairly heavy rolls. On the other hand, at very slow speeds it is appropriate to use large amounts of rudder: full or even hard rudder at speeds below five knots.
3. After giving a rudder order, the conning officer should monitor its execution by checking the rudder angle indicator to ensure there was no misinterpretation of the command.

Engine-Order Commands to the Lee Helm

Engine orders are always given in the following order:

1. Engine: Which engine is to be used. If both engines are to be used, the command is "All engines." On single-screw ships the command is always "Engine."

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2. Direction: Ahead, back, or stop.

3. Amount: Ahead one-third, two-thirds, full, flank. Back one-third, two-thirds, full.

4. Shaft revolutions desired: Number of revolutions in three digits for the desired speed in knots. (Shaft revolutions are not used for backing orders.)

The following are examples of commands to the lee helm:

When a twin-screw ship is to go ahead on both engines to come to a speed of six knots:

Command: "All engines ahead one-third. Indicate zero eight eight revolutions for six knots."

Reply: "All engines ahead one-third. Indicate zero eight eight revolutions for six knots, aye, Sir (or Ma'am)."

Report: "Engine room answers all ahead one-third. Indicating zero eight eight revolutions for six knots, Sir (or Ma'am)."

When different orders are given to port and starboard engines, revolutions should not be specified:

Command: "Port engine ahead one-third, starboard engine back one-third."

Reply: "Port engine ahead one-third, starboard engine back one-third, aye, Sir (or Ma'am)."

Report: "Engine room answers port ahead one-third, starboard back one-third, Sir (or Ma'am)."

When the order is to only one engine, the report must include the status of both engines:

Command: "Starboard engine ahead one-third, port engine back one-third."

Reply: "Starboard engine ahead one-third, port engine back one-third, aye, Sir (or Ma'am)."

Report: "Engine room answers starboard engine ahead one-third, port engine back one-third, Sir (or Ma'am)."

Command: "Starboard engine stop."

Reply: "Starboard engine stop, aye, Sir (or Ma'am)."

Report: "Engine room answers starboard engine stop. Port engine back one-third, Sir (or Ma'am)."

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When there are to be small changes in speed, for example when the ship is alongside another for refueling or to keep station on the formation guide:

Command: "Indicate one zero zero revolutions."

Reply: "Indicate one zero zero revolutions, aye, Sir (or Ma'am)."

Report: "Engine room answers one zero zero revolutions for three revolutions over eleven knots, Sir (or Ma'am)."

On many gas-turbine ships with controllable reversible-pitch propellers, at speeds below twelve knots (the exact break point varies between classes), the ship's speed is controlled by varying the pitch of the propeller blade, measured as a percentage. This requires additional orders at lower speeds, as in:

Command: "All engines ahead one-third. Indicate ——— revolutions, ——— percent pitch for ——— knots."

Reply: "All engines ahead one-third, indicate ——— revolutions, ——— percent pitch for ——— knots, aye, Sir (or Ma'am)."

Report: "All engines answer one third. Indicating ——— revolutions, ——— percent pitch for ——— knots, Sir (or Ma'am)."

(*Note:* This unfortunately will vary from ship to ship, even within a class. Check the captain's standing orders. It is time for the type commanders to convene a panel to recommend and promulgate new appropriate standard commands for ships with adjustable pitch propellers.)

When maneuvering in restricted waters, getting under way, docking, or mooring, ships usually use what are known as maneuvering bells. Under these circumstances, only engine, direction, and amount are given. Revolutions are not specified. Depending on the type of ship, each engine amount is equivalent to a standard number of knots, the most often used example being one-third equals five knots, two-thirds equals ten knots, and so on. When maneuvering bells (or "maneuvering combination") are desired, the conning officer must order as follows:

Command: "Indicate maneuvering combination (bells)." (By convention, this is usually an engine order for nine nine nine revolutions.)

Reply: "Indicate (nine nine nine) revolutions for maneuvering combination (bells), Sir (or Ma'am)."

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Report: "Engine room answers (nine nine nine) revolutions for maneuvering combination (bells), Sir (or Ma'am)."

Line Handling

Standard commands to line handlers are as important as are rudder and engine orders. In a sense they may be even more important, since orders to line handlers are typically transmitted through phone talkers or handsets. This means that the conning officer is often not in a position to observe whether the order has been correctly understood and carried out. Thus it is of particular importance that line-handling commands be standard to minimize confusion and misunderstanding. Many an excellent landing has been ruined by line-handling problems.

Orders to line handlers begin with the action to be carried out, followed by an identification of the line or lines by number, as necessary. Lines are

Figure 3-2. Standard commands apply to line handling as well as to all other aspects of ship control. *U.S. Navy photo*

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numbered from bow to stern in the order in which they are attached to the ship (see fig. 2–6). Lines which run perpendicular to the ship are breast lines. Lines which run at an angle from the ship to the pier are spring lines: those which tend aft are after springs; lines which tend forward are forward springs. If an amidships breast line is used, it is not assigned a number. Typical lines for a destroyer are

Line 1: bow line (usually a breast line, or led somewhat forward);
Line 2: after bow spring line;
Line 3: forward bow spring line;
Line 4: after quarter spring line;
Line 5: forward quarter spring line;
Line 6: stern line (usually a breast line, or led somewhat aft).

Standard commands to the lines, following those set forth in *Watch Officer's Guide*, are as follows:

Command	**Meaning**
"Stand by your lines"	Man the lines, ready to put them over, cast them off, or take them in.
"Take in all lines"	Slack off lines and signal people tending lines on the pier or on another ship to cast off our lines (men of war normally use their own lines. On occasion lines may be taken from the pier or another ship. In this case, the command to return lines will be "Cast off all lines" or by number if appropriate, as in "Cast off line 3)."
"Over all lines"	Pass the lines to the pier or another ship, place the eye of each over the appropriate bollard but take no strain.
"Take a strain on (line 3)"	Put the line under tension.
"Slack (line 3)"	Take tension off the line, and let it hang slack.
"Ease (line 3)"	Let out enough of the line to lessen tension.

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"Take (line 3) to the capstan or to power"	Lead the end of the line to the capstan, take the slack out of it, but put no strain on it without further orders.
"Heave around on	Apply tension on the line with the capstan.
capstan or to power"	Follows the order to take the line to the capstan.
"Avast heaving"	Stop the capstan.
"Hold what you've got	Hold the line as it is.
on (line 3)"	
"Hold (line 3)"	Do not allow any more line to go out. ("Hold" commands should be used with extreme caution because they require the lines to be held even to parting.)
"Check (line 3)"	Hold heavy tension on the line, but let it slip as necessary to keep it from parting.
"Surge (line 3)"	Hold moderate tension on the line, but let it slip enough to permit the ship to move.
"Double up (all lines)"	Pass additional bights on all mooring lines so that there are three parts of each line to the pier or the ship alongside.
"Single up (all lines)"	Take in all bights and extra lines, leaving only a single part of each of the normal mooring lines.
"Cast off all lines"	Used when secured with *another* ship's lines in a nest. Cast off the ends of the lines and allow the other ship to retrieve its lines.
"Shift"	Used when moving a line along a pier. Followed by specification of the line and where it is to go, as in "Shift no. 3 from the bollard to the cleat."

Tug signals may be found in chapter 9 and appendix B.

The Future

For more than a century, the U.S. Navy has used a verbal process of conveying ship control orders to rudder and engines. With very little change over

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the years, the oral process provides (1) order, (2) acknowledgment of the order, and (3) completion/accomplishment of the order. A Navy officer with the conn learns, very early in shipboard time, that the way to change direction of ship's movement is to order "Right full rudder." The helmsman then acknowledges receipt of the order by repeating, "Right full rudder, aye, Sir (Ma'am)" and turning the wheel to the proper indication. When the rudder reaches the proper position as displayed by the rudder angle indicator, the helmsman reports completion of the order with "The rudder is right full, Sir (Ma'am)," and the conning officer responds, "Very well."

To vary ship's speed, the conning officer orders, "All engines ahead standard, indicate turns for sixteen knots." The lee helmsman acknowledges receipt by repeating the order and adding, "Aye, Sir (Ma'am)." When the console indicates that the order has been carried out, the lee helmsman reports, "All engines are ahead standard, indicating 83 rpm for sixteen knots, Sir (Ma'am)." The conning officer responds, "Very well."

It is a long process of many precisely spoken words, long proven effective, reliable, and useable under all conditions of environment, including combat. Over the past century every individual who has served in and handled a Navy ship has learned and used this well-established process. As long as verbal/oral orders are used, it is most likely that the process of order, acknowledgment, and completion will be retained, even with the Integrated Bridge System.

One portion of the verbal/oral order process of ship control that may change in new ships is the method of ordering ship's speed or engine/propeller thrust. New ships are being equipped with ship control consoles including thrust indicators using Programmed Console Logic (PCL).

The *Arleigh Burke*–class (DDG-51) destroyer ship control console utilizes PCL numbers from 0.0 to 10.0 for speeds from 0 to more than thirty knots. Logic built into the controls sets the appropriate rpm and propeller pitch for the desired speed. For example, if a conning officer desires sixteen knots he/she could order, "All engines ahead five point two." The console operator would set PCL at 5.2 and the ship would develop sixteen knots with 71 rpm and 100 percent pitch on both engines. To produce the equivalent of "All engines back two-thirds," a conning officer could order, "All engines back one point eight." The console would be set –1.8 and the ship would develop ten knots of reverse speed with 69 rpm and negative 45 percent pitch. There are separate PCL indicators for each engine, so that the port engine can be set at 1.2 and the starboard engine –0.6 for the equivalent of "Port engine ahead one-third. Starboard engine back one-third."

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In most common use, the conning officer still speaks the traditional language of ship control—ahead, back, one-third, two-thirds, full, and so on—and the lee helmsman or console operator dials in the appropriate PCL number. Each ship has a speed chart used by the console operator to convert traditional orders to PCL settings, and in the future conning officers may make the conversion and give thrust orders by PCL numbers.

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started Phase 5, the egress from San Diego Bay via the main shipping channel.

"When Buoy 28 is abeam to port, recommend coming left to 312 for next leg. Next leg three miles, eighteen minutes at ten knots." The navigator's recommendation was acknowledged as *McClusky* continued her harbor transit.

Captain Lynch sipped his coffee and looked at Jim. "Looks like you didn't get that windbreak you expected from those amphibs, Jim," he said.

"No, Sir, but I didn't plan on having to loiter between the piers. I guess I should have gone upwind more, closer to the amphibs, against the wind and current."

"Yes, maybe so, but you had full control with your Phase 2 dance. Nice use of engine, rudder and APUs."

"Thank you, Sir. It was just like in the simulator."

Some of the most interesting and challenging shiphandling is getting under way and landing. The proximity of solid objects demands precision from the conning officer. As with all shiphandling, advance planning is the key to execution. It would be impossible to count the number of times commanding officers have instructed apprentice shiphandlers, "Tell me what you plan to do." This has now been expanded to a formal navigation brief at which a "voyage plan" is presented for each event. Yet as the opening vignette illustrates, the commanding officer is still likely to ask the conning officer for his intentions. For most evolutions there are several different ways to accomplish your purpose, and the number of variables ensures that no example is exactly like another. The key is to understand and use the various forces working on the ship

Knowing Your Ship

Your plan needs to be based upon both general and specific information. General information is that which remains the same. It includes the turning characteristics of your ship, how quickly she accelerates and stops, and how she reacts to wind and current. Specific information is that which changes from one evolution to the next, including wind, current, mooring location, and traffic in the channel.

It is particularly important to have a feel for the lag time between when an order is given and when it takes effect. The engine response time for a ship

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with variable-pitch propellers is generally faster than for ships with fixed-pitch propellers. When alongside a pier, you usually do not want to wait until the ship starts to move in response to an engine order before ordering a stop.

You also need to know how your ship behaves with opposed engines. While in theory opposed engines should balance, this is often not the case. When you are twisting with one engine ahead one-third and the other engine back one-third, do you gather headway or sternway? This may vary with other combinations. For example, a ship that gathers sternway with a one-third twist, may gather headway with a two-thirds twist, or vice versa. If your ship has auxiliary propulsion units, you need to know what amount of thrust from the main engine is needed to counterbalance the thrust from the APUs at various angles of train. There is no substitute for having experimented with your ship to determine how she behaves under a variety of circumstances.

The greater the wind and current, the more important it is to know how your ship responds to these. If your ship, like many warships, is reluctant to twist into the wind, this must be taken into account in your plan. Otherwise

Figure 4–3. Guided missile destroyers USS *Milius* (DDG 69) and USS *Higgins* (DDG 76) nested alongside the pier in Singapore. *U.S. Navy photo*

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you may find yourself being blown sideways toward shoal water, while ineffectively trying to twist your bow up into the wind.

The View from the Bridge

If your ship has been designed with the needs of the shiphandler in mind, the bridge wings will extend far enough that you can see the sides, the jackstaff at the stem, and sometimes even the stern flagstaff. On even the best designed bridge, however, there is a distance forward of the bow and aft of the stern that is out of sight. This becomes increasingly important as we have to place our ship alongside between obstructions, such as other ships, dolphins, or the shore end of the pier. To handle the ship with precision we have to know accurately distances to objects both ahead and astern. Yet there is always an "invisible distance" which is the distance ahead or astern which is obscured by your own ship's structure. You need to determine the invisible distances for your ship. With this knowledge you can determine exactly the distance to an object ahead at the moment it begins to disappear from view. Obviously this will vary somewhat with the height of the observer, but for all practical purposes an average height of eye can be assumed (see fig. 4–4).

It is helpful to have an experienced person on both forward and after line-handling stations send up estimates of distance to objects of interest. With the advent of laser rangefinders these reports have become more accurate. Still, no shiphandler prefers to be completely dependent upon relayed information. As with virtually everything having to do with shiphandling, it is good to have

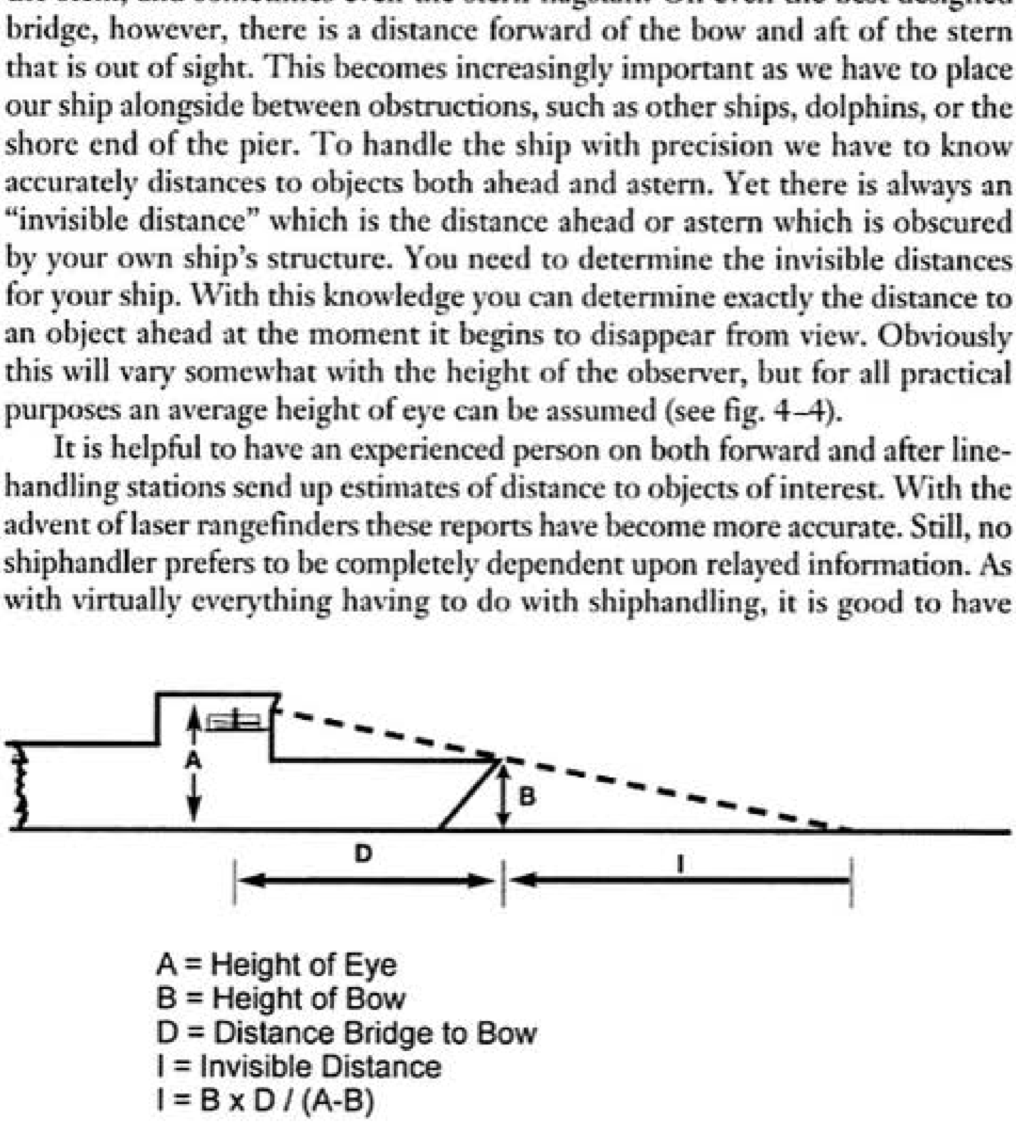

Figure 4–4. Invisible distance.

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multiple sources of information. Many ships place marks on the jackstaff that provide range estimation when approaching objects ahead. These marks are placed so that when standing in the normal conning position the line of sight through the marks to the waterline of an object ahead corresponds to preselected ranges, such as 1,000 yards, 500 yards, 250 yards, and so on.

Visibility astern is usually considerably worse than ahead, but it is vital to know when the stern is free of an obstruction. To develop a visual reference, when circumstances permit place an object in the water lined up laterally with the stern. Then from the conning position on the bridge wing select a fixed point on the ship that lines up with the object. It can be useful to paint a reference mark at this point. Once this reference is determined, any obstruction astern whose waterline is above the reference point is clear of the stern.

Evolution-Specific Information

Specific local information you can collect ahead of time includes the heading of the pier at your assigned berth, depths of water and any navigational hazards along your intended track, whether the pier is pilings or solid face, and the predicted wind and current. Your plan will be affected by the ship's position alongside the pier. Are you headed bow out or bow in? Alongside the pier or tied up alongside another ship? At the end of the pier or toward the head? What other ships are moored in locations that can affect your plan? Once under way, what maneuver must you perform to wind up headed fair in the channel? All of these considerations and more must be taken into account in your plan for getting under way.

Once you have made your plan it is a good idea to brief the line handler supervisors of your intentions, if this has not already been done at the planning conference. If everyone knows what to expect, the likelihood of a smooth and professional operation is greatly increased. It is also always a good idea to make sure of your communications with the line-handling parties well in advance, to include talkers thoroughly familiar with the line-handling standard commands to be expected.

No two circumstances are ever exactly the same, but if you understand the principles involved they may be used in almost any situation that arises. The first rule of planning to get under way or make a landing with a ship is to leave yourself a margin. If you plan a maneuver that requires full rudder and large backing bells, there is little you can do if you have miscalculated, if response is not instantaneous, or if there is a material casualty. Murphy's

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Law, which states that if something can go wrong, it will go wrong, applies to shiphandling as to other things in life. If, on the other hand, you have planned your maneuver so that it works with less rudder and smaller bells, you have a much better chance to recover if you have miscalculated or if Murphy puts in an appearance. There are times and places where operational necessity or extremes of wind or weather require a shiphandler to run a calculated risk. These times are rare, and there is no excuse for risking damage to your ship in an attempt to appear dashing.

We will concentrate in this chapter on evolutions to be carried out by the ship alone without the assistance of tugs. The larger the ship or the more difficult the evolution, the more likely tugs will be involved. The use of tugs is discussed in chapter 8. The discussion here proceeds in a rough order of degree of difficulty, from getting under way with no wind or current to somewhat more difficult situations, for both single- and twin-screw ships. To simplify the discussion the term "pier" is used generically to refer to any shore structure to which the ship is moored. More precise definitions are set forth below:

Bitt: Pair of short steel posts or horns on board ship used to secure lines.

Bollard: Steel or iron post on a dock, pier, or wharf used in securing a ship's lines.

Bullnose: Closed chock at the bow of a vessel. Has the appearance of a large flared nostril.

Camel: Float used as fender between two ships or a ship and a pier. Also called breasting float.

Chock: Metal fitting through which hawsers and lines are passed. May be open or closed. Also blocks used to prevent aircraft or vehicles from rolling or blocks used to support a boat under repair.

Cleat: An anvil-shaped fitting for securing or belaying lines.

Dock: Large basin either permanently filled with water (wet dock) or capable of being filled and drained (drydock or graving dock).

Dolphin: A cluster or clump of piles used for mooring. A single pile or a bollard on a pier is sometimes called a dolphin.

Pier: Structure for mooring vessels which is built out into the water perpendicular to the shore line.

Piling: Wooden, concrete, or metal poles driven into the river or sea bottom for support or protection of piers or wharves.

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Quay: A solid stone or masonry structure built along the shore of a harbor to which boats and ships make fast, load, unload, etc.

Slip: A narrow stretch of water between two piers.

Wharf: Structure parallel to the shoreline to which ships moor for loading, unloading or repairs. Sometimes called a quay, which is usually a solid masonry structure.[1]

Getting Under Way

Your plan for getting under way must encompass more than just getting clear from alongside. Only rarely is it possible to move directly from alongside to headed fair in the channel. More normally you must thread your way past other piers and other ships. Frequently a sharp turn is necessary as you clear the pier and turn into the channel. Shoal water may be close along the way. Thus your plan must include the sequence of maneuvers that will move your ship smoothly from the pier into the channel. You also need to anticipate the "what ifs." What if traffic in the channel interferes? Will wind or current present a problem if you have to wait? What would you do if an engineering casualty caused a loss of power or steering? With luck, none of these things will happen. But if they do, you will be better prepared for having thought them through in advance.

No Wind or Current

Dead calm conditions are rarely encountered in the real world but are a good place to start gaining an understanding of how to get a ship under way from alongside a pier or another ship. Getting under way is usually easier than making a landing, if only because in the course of the maneuver you get progressively further away from danger in the shape of the pier or the ship alongside. The first consideration is whether you will be getting under way bow or stern first. If stern first, and there is no wind, current, or obstruction, this is a relatively simple evolution of getting the ship's stern out far enough to be able to back clear.

If yours is a single-screw ship, make sure to anticipate the stern walk you will experience when backing. The stern will walk to port when backing for most single-screw ships. The *Oliver Hazard Perry*–class frigates are an exception, in that they experience starboard sternwalk under almost all circumstances, even when at zero pitch.

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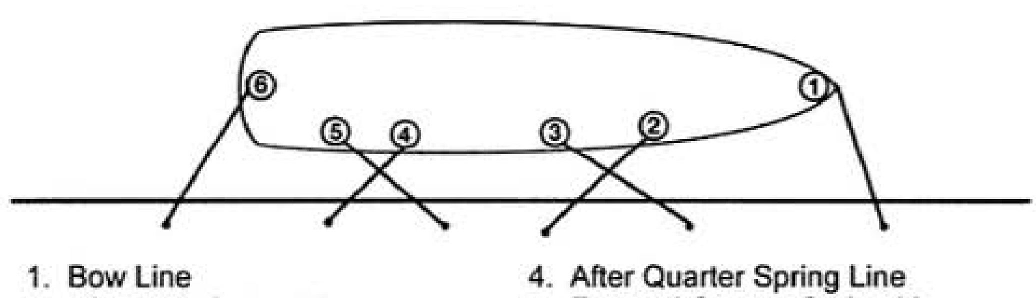
There are several ways of moving the stern away from the pier, most of which involve moving the bow toward the pier. Make sure properly rigged fenders are in place at the point at which the forward part of the ship will contact the pier or camels. If your ship has a large bow mounted sonar dome caution is necessary to avoid bringing the bow too close to the pier while getting the stern out. A good camel between the ship and pier makes this easier. If you are alongside another ship, or if there are ships moored aft, in addition to fenders make sure the anchor on the side toward the pier is dipped.

After singling up, try slacking all lines. This will give you a feel for how the ship will move when the lines are taken in. Some of the ways of moving the stern out follow:

1. Slack or take in all lines except the bow breast line (line number one) and the forward after spring line (line number two) (see fig. 4–5). Using the capstan, heave around on number one to bring the bow in to the pier, moving the stern away from the pier. If this brings the stern out far enough to be well clear of any obstructions astern, take in all lines and back clear. If this does not bring the stern out far enough, hold line two and go ahead gently on the outboard engine with the rudder turned toward the pier. This same thing can be done with a single-screw ship, going ahead gently with the rudder turned toward the pier and holding line number two to keep the ship from moving forward.

2. With a twin-screw ship, the stern can be twisted out by backing one-third on the engine next to the pier and going ahead one-third on the outboard engine, with the rudder full toward the pier. It is important not to get way on the ship before you are properly positioned. It is a good idea to keep lines one and two available until you are satisfied with the ship's alignment



1. Bow Line
2. After Bow Spring Line
3. Forward Bow Spring Line
4. After Quarter Spring Line
5. Forward Quarter Spring Line
6. Stern Line

Figure 4–5. Mooring lines.

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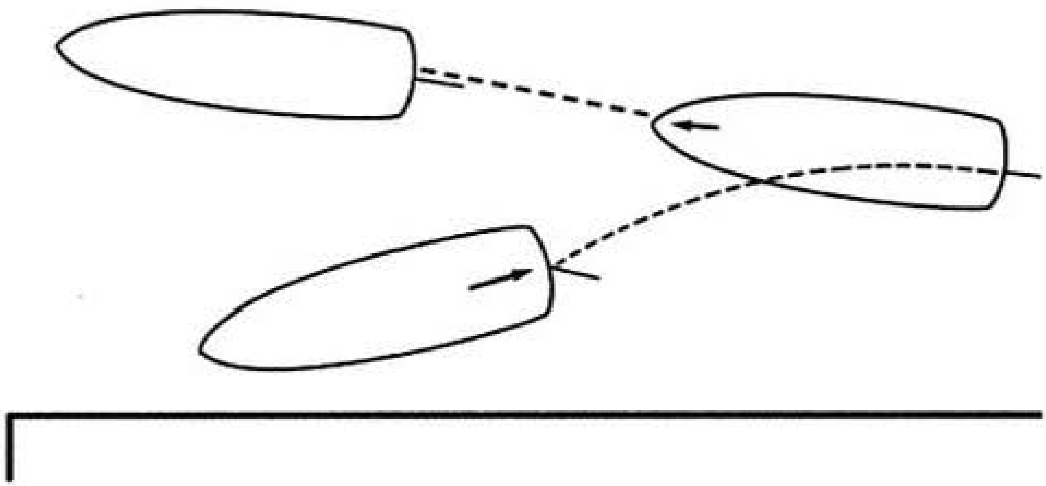

Figure 4–6. Going out ahead.

for backing clear. If the pier is solid, the wash from the backing engine will help to move the ship away from the pier.

Going out ahead is somewhat more difficult, if only because the propellers turning ahead draw water from between your own ship and the ship or pier alongside. This means that you need more separation before going out ahead. You can try taking line six to the capstan while slacking lines one, two, and three, to see if this can get you enough of an angle to go out ahead. If room astern permits, one way to get clearance from the pier or ship alongside is to get the stern out, as described above, then back away with the rudder full toward the pier to swing the bow away from the pier (see fig. 4–6). When the bow is pointed sufficiently away from the pier you can then go out ahead. As soon as your ship's pivot point passes the end of the pier or the bow of the ship alongside, rudder can be used to swing the stern out for additional clearance, if needed.

An Offsetting Wind or Current

It is simple to get under way with an offsetting wind and or current. After singling up all lines, if going out astern slack the after lines to bring the stern out to the desired angle, then take in all lines and back clear. The potential hazard here is that as you back out of the slip your stern will come into the full effect of the current before the forward part of the ship. If not anticipated, this can create a strong rotating force on the ship, swinging the stern

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away from the pier, and thus moving the bow toward the pier. The stronger the current, the more power should be used in backing clear of the slip, in order to minimize the length of time the ship is subjected to this rotation. If going out ahead, slack the forward lines until the bow is out sufficiently to take in all lines and go out ahead. In this case, the bow will enter the stronger current first, and the resulting force rotating the stern toward the pier needs to be taken into account. As before, once the pivot point is past the end of the pier or ship alongside, rudder may be used as needed to swing the stern away from the pier.

An Onsetting Wind or Current

One of the most difficult circumstances for getting under way is when a strong wind or current is holding the ship to the pier. In this situation, the means discussed above for moving the stern out may be used, but it is necessary to get a larger angle with the pier before starting to back, since the ship will be set to leeward. It is also desirable to use substantial power, generally all back two-thirds, or in the case of an exceptionally strong current even a back full bell may be indicated. If a safe angle with the pier cannot be achieved prior to taking in your lines, it may be time to wait for a lessening of the current, or call for the services of a tug.

Going out ahead is even more difficult under these circumstances, and most times she will require the services of a tug. If an onsetting wind or current can be anticipated, an anchor can be dropped during the approach to the pier and used later as an aid to moving the bow away from the pier. See a discussion of this in chapter 6.

Wind or Current from Astern

If getting under way stern first with the wind or current from astern, bring the bow in using the bow breast line (number one) to the winch. Hold the after spring lines (numbers two and four) to keep the ship from being moved ahead by the current. Slack the stern breast line (number six) enough to let the current move the stern out to the desired angle, then take in all lines and back clear. It is important not to lose control of the stern, since once the current is on the inboard side it will be trying to rotate the ship. Be ready to take in lines and get under way briskly when the desired angle is achieved.

To go out ahead with a current from astern, hold the after spring lines (numbers two and four) to keep the ship from moving ahead. Take in three

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and five. Slack the stern line (number six) enough for the current to start moving the ship away from the pier, then tend one and six to allow the ship to sail sideways away from the pier. If the stern begins to come out too far, a back bell into the current will help the alignment. When separation is sufficient, take in all lines and go out ahead. Remember that speed over the ground will be the sum of the current and the ship's own speed through the water.

Wind or Current from Ahead

Wind or current from ahead can be used to move the ship laterally away from the pier. The technique involved is to slack forward lines enough to get the current on the inboard bow, checking after spring lines enough to prevent the current from moving the ship aft. With the current on the inboard bow, the ship will sail away from the pier. When enough lateral distance is obtained, to go out stern first, go ahead with rudder toward the pier to swing the stern out, then back clear. Anticipate that the speed of the current will be added to the ship's sternway through the water. Steering control while backing with the current is not as predictable as we would like, so give yourself an extra margin when executing this maneuver.

To go out ahead with current from ahead, slack lines one, two, and three to allow the bow to come out under control. With the current on the inboard side, slack all lines to allow the ship to move laterally from the pier, with the bow coming out further. Come ahead on engines as needed to counteract the current. When alignment and separation are adequate, come out ahead.

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