Rudders—Rare to Medium Rare

For the fourth and final article in our series on steering systems, we look at high-lift rudders, articulated flap rudders, fishtail rudders, and steerable Kort nozzles—among other relatively novel gear.

Text and artwork by Dave Gerr
(except where noted)

Author's Note: *In* Professional BoatBuilder *Nos. 98, 99, and 100 we examined fairly standard equipment, as follows: how rudders are sized; their form; determining rudder and stock strength; installation considerations; steering gear; and optimizing performance.*

Over the years, a number of inventors have dreamed up all sorts of "improved" steering gizmos. Some of those inventions were downright silly, but others—though they may seem peculiar—are worth a closer look.

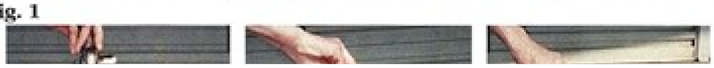
The Kitchen Rudder

A long time ago, British admiral John G.A. Kitchen sat down to create a better rudder. What he wanted was vastly improved steering at low speed (for maneuvering and docking), plus great simplicity. The rudder he came up with not only works, it completely eliminates the need for a reverse gear (**Figures 1** and **2**). The year Kitchen's patent was granted? 1916. You'd think that if it was so good, we'd be surrounded, in 2006, by Kitchen rudders. Instead, they've been virtually forgotten.

The accompanying illustrations show how a Kitchen rudder is set up. Basically, it consists of two half-circles (somewhat conically shaped) that surround the prop in a ring (not unlike the Kort nozzles seen on various tugboats and trawlers today). Rather than a single vertical rudder blade aft of the prop, the entire ring rotates in unison to steer. This actually slightly improves water flow into and out of the propeller disk, enhancing efficiency a bit. You slow the vessel down in the usual way, by cutting back on the throttle. But, the Kitchen rudder offers a remarkable option.

Each individual conical half-circle pivots aft and together to close up behind the prop. Half closed, for instance—without touching the throttle—reflects about half the prop thrust forward (allowing the other half

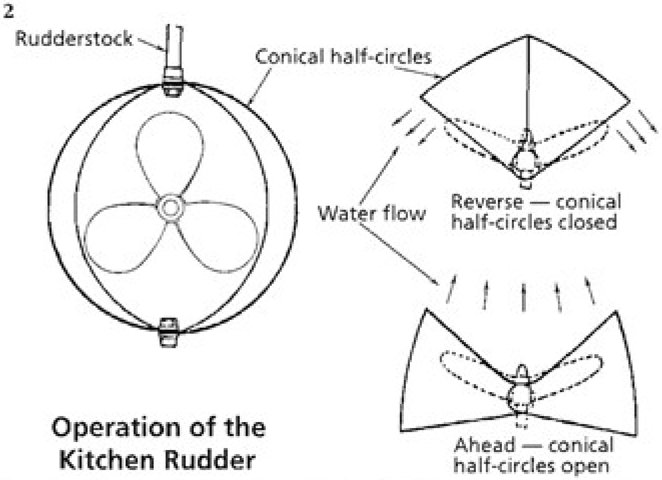
Fig. 1



The Kitchen rudder was patented in 1916 by British admiral John G.A.

Kitchen for improved performance during low-speed maneuvering. It consists of two conical half-circles that open and close on a vertical axis. The photos in **Figure 1** show the rudder open **(far left)**, closed **(center)**, and how the entire mechanism rotates for turning **(left)**. The drawings in **Figure 2** show the position of the propeller inside its enclosure, and how vessel direction is reversed when flow from the propeller is reflected from the closed rudder.

Fig. 2



Operation of the Kitchen Rudder

of the wash still to flow aft), and effectively puts you in "neutral." Fully closed, and you have solid, reliable reverse—fully steerable. What's more, there's no unpredictable "walk" to port or to starboard. In reverse mode—at docking speed—the Kitchen rudder acts like a true stern thruster.

Beginning around 1917 and continuing into the 1920s, the U.S. Navy conducted trials on a 38′ (11.6m) launch fitted with a Kitchen rudder. The examiners reported that at 10.4 knots this vessel could be stopped in just one boat length. Incredibly, they also reported that the Kitchen rudder enabled this launch to be turned around her own center—in other words, in place! You can't do better than that for low-speed, close-quarters maneuvering.

Just why the Kitchen rudder has been almost completely forgotten remains a mystery. Manufactured by Kitchen's Reversing Rudder Company Ltd, of Liverpool, England, the Kitchen rudder was extensively employed by the British and Canadian navies before World War II, and it won raves from those who used it. Sales and marketing here in the States, though—under U.S. Patent No. 1,186,210, dated 1916—were spotty. The McNab Company—first of Bridgeport, Connecticut, and later of Yonkers, New York—held the American license, but despite successful installations on everything from outboard boats to large ships, all traces of Kitchen gear seem to have vanished.

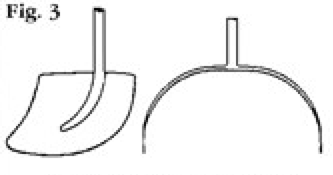
One possible difficulty is the steering mechanism. The two halves of the rudder are steered in unison with a more-or-less conventional tiller; but, that tiller is itself a worm screw that controls the closing and opening of the two conical half-circles. This is quite reliable, and apparently isn't subject to failures; however, back in 1916 that setup required some complex mechanical linkage to run controls up to a remote helm station. Now, with modern hydraulics, such controls would be inexpensive to install, and perfectly reliable. In fact, you would have one standard hydraulic steering cylinder, and one second half-circle closing (reversing) hydraulic cylinder—and a not-very-powerful one at that. If you installed a Kitchen rig, you'd have to add the cost of fabricating the rudder and the second hydraulic cylinder. (You could subtract the substantial cost and weight of a reverse gear, provided you could get a reduction gear only.) You'd also have effectively added—at no extra cost or weight—a complete stern thruster for incredible maneuverability in harbor.

Note that a Kitchen rudder isn't suitable for planing hulls or for most boats cruising at more than 15 knots or so, because the extra drag from the Kitchen rudder would be too much of a drawback.

Harrison Patent Rudder

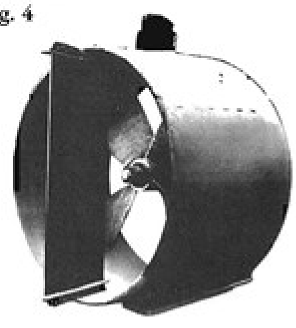
Interestingly, there is another rudder that shares a vague similarity with the Kitchen rudder—the Harrison patent rudder. **Figure 3** shows a rudder that is a half-circle surrounding the top portion of the propeller. Mounted on a single rudderstock, the Harrison unit was fitted to fast steam launches many years ago. It worked well, and gave slightly better water flow to and from the prop. Twin-screw vessels sometimes installed two quarter-circle Harrison rudders—one

Fig. 3



Harrison Patent Rudder

Fig. 4



MICHIGAN WHEEL CORP.

Steerable Nozzle Rudder

Figure 3—The Harrison patent rudder, shown in profile and cross-section, was installed on fast steam launches. ***Figure 4****—A steerable Kort nozzle, such as those found on modern tugboats, can be fixed, with a rudder aft, or rotated like the Kitchen rudder.*

on the outboard side of each rudder. This, too, worked well. While effective and worth noting, the Harrison patent rudder did not, however, generate the broad array of advantages that the Kitchen rudder did (and still does).

Note that a rudder very similar to the Harrison can be found on some surface-drive propeller installations, where it has been successful.

Steerable Kort Nozzles

A vaguely related type of ring-form rudder is the steerable Kort nozzle (**Figure 4**). This is the standard Kort nozzle commonly installed on tugs and trawlers to increase low-speed thrust. In a typical installation, the nozzle's position is fixed, with a rudder immediately behind it. The alternative, however, is to do away with the rudder and rotate the nozzle itself, just as the Kitchen rudder is steered. Usually, one, or a pair, of fixed "rudder" blades will be bolted to the aft end of the nozzle, which turn along with the rotating nozzle to further enhance steering. This does not give the reversing effect of the Kitchen rudder, but it does give very positive steering response. You get the additional low-speed thrust (higher bollard pull) of the Kort nozzle, which a Kitchen rudder does not create.

High-Lift Rudders

Standard airfoil-section rudders stall, and therefore stop generating effective lift at rudder angles of 35° or more. There are ways to modify the standard airfoil-section shape to induce the rudder blade to create useful lift (turning side force) at higher angles. This can be a fixed shape that doesn't change. The type is often called a fishtail rudder (technically, a *hydrodynamic* fishtail rudder); or, it can be a rudder fitted with a movable flap or other variable geometry—an *articulated* rudder. Fishtail high-lift rudders are also called *fixed-geometry high-lift rudders*. The Kitchen rudder is articulated, but it isn't in the form of a "blade" and so falls into a category of its own. In fact, the articulated rudders discussed here are more precisely termed *articulated flap rudders*. All such high-lift rudders can be thought of as "propeller slipstream diverters," since they get their low-speed, high-angle lift by radically changing the direction of the slipstream.

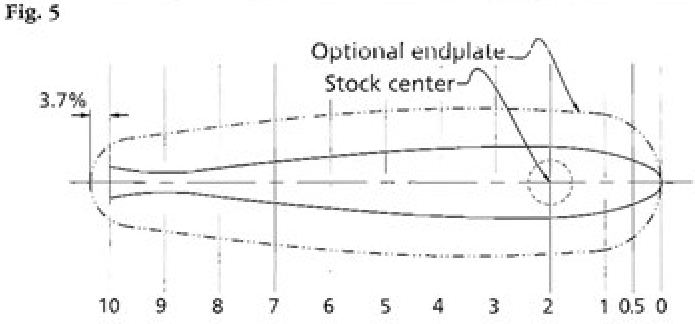
The MacLear Thistle Rudder

A good example of a fishtail rudder is the MacLear Thistle rudder (**Figure 5**). A much more recent development than the Kitchen or Harrison rudders, it was invented by the late Frank MacLear, president and chief naval architect of the firm MacLear & Harris Inc. (New York City)—where I once worked. MacLear had set out to improve low-speed maneuvering in close-quarters conditions, as well as to enhance steering response at speed.

As stated, almost all ordinary rudders are ineffective when the helm is put over more than 35° port or starboard. Turn a normal rudder farther than that and it just acts like an unpredictable brake. It can even create eddies that throw the stern about randomly. But what if you could turn the helm over more—say, 40°—and still get controlled, positive helm response? Reasoning it through, MacLear came up with a new rudder-section shape. As you can see in **Figure 6**, it starts off fat and rounded, swells out as it runs aft, then fines down at the middle, and—at the very end—flares out again. Indeed, the shape is much like the bulb of a thistle, hence the name. The shape is essentially a standard airfoil rudder section flared out in a fishtail at the trailing edge.

What does all this shaping accomplish? At normal cruising speed the rudder doesn't change vessel performance much, though it does increase steering response slightly at small course-keeping helm angles. But, during low-speed maneuvers, you can turn the MacLear Thistle rudder over as much as 40°. Water flow is guided around the leading edge and midsection by the rudder's section shape;

Fig. 5



MacLear Thistle Rudder Sections

Figure 5*—When viewed from above, the shape of the MacLear Thistle rudder resembles that of a fish: fat at the leading edge, tapering to a thin cross-section 80%–90% of the distance aft, and then flaring at the trailing edge or "tail."*


Infusion Molding
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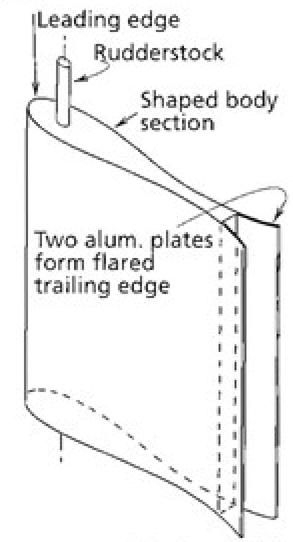
__Figure 6__—Developed by the late naval architect Frank MacLear, his thistle-shaped rudder improves low-speed boat handling. A singular feature is its ability to turn 40° port and starboard—or about 5° more than conventional rudders.

Fig. 6



MacLear Thistle Rudder

MacLear Thistle Rudder
Foil Thickness Dimensions

% Chord	Half-Breadth as a Percent of Chord: Rudder Blade	Half-Breadth as a Percent of Chord: Optional Endplate
Tip Radius	2.676	12.49
5.00	3.977	9.995
10.00	5.353	12.240
20.00	6.424	12.955
30.00	6.424	13.347
40.00	6.103	13.337
50.00	5.532	12.938
60.00	4.675	12.219
70.00	3.746	11.248
80.00	2.600	10.094
90.00	1.785	8.826
100.00	2.860	6.676
Tip Radius	N/A	8.030

then, the flared-out end makes water flow continue to do useful work at the higher angle. The result is a rudder that acts like a stern thruster, allowing very tight turns at low speed. Another plus: the MacLear Thistle rudder's trailing edges can be made of aluminum plate, and—optionally—left open and not welded at the trailing edge. These are pre-curved, pretty much as you see in the drawing; however, you can adjust them with Vise-Grip pliers, bending them in or out, either evenly from top to bottom, or to varying degrees from top to bottom and differently port and starboard. The rather clever advantage of this is that you can adjust the flare-out on each side by trial and error until your boat's handling is exactly predictable and exactly as you want it. Having worked on the design of several boats fitted with a MacLear Thistle rudder, I can attest that it performs exactly as advertised.

Figure 5 shows the section proportions (along with the optional endplates), and the table gives the half-breadths as a percent of chord, and the tip radii. Note that as the center of pressure is a bit farther aft on the MacLear Thistle rudder, the rudderstock is at 20% chord, giving 20% balance.

Trying the MacLear Thistle Rudder

On larger vessels, the entire rudder is usually fabricated from aluminum or steel. For smaller craft, you can make the forward three-quarters to seven-eighths of the rudder blade in the customary way, with a stainless steel or bronze stock through a wood or fiberglass blade. Add the flared-out trailing edges of simply curved aluminum plate, let in flush to the body of the rudder blade. You can retrofit almost any standard rudder installation this way. Even at the normal range (35° hard over), steering is more precise and predictable. The only improvement I've made to the MacLear Thistle rudder is—where possible—to add endplates over the top and bottom of the entire rudder. These are fastened to the body of the rudder blade but project aft over the curved flared ends, either attached or unattached. In this way you still have the endplate effect at the trailing edge, while retaining adjustability. Such endplates improve the MacLear Thistle rudder's already excellent helm response.

Thistle Steering

A MacLear Thistle rudder gives unusually positive steering, and my office has installed them on most of our single-screw displacement cruisers. Though you can turn the MacLear Thistle rudder over to 40°, all the installations I've done have gone only to the normal 35°. At speed, somewhat less rudder angle is needed to get the same course correction you'd achieve with a standard rudder. During low-speed maneuvering, these rudders really shine. Steering response is crisp and predictable. You can very quickly kick the stern of your boat around to exactly where you want it.

Here's what the skipper of one of my designs, *Imagine*, had to say about her handling with the MacLear Thistle rudder, in just his first week with the boat:

"*Imagine* is doing wonderfully! To date, my strongest impression is how easily she handles in close quarters. We've been staying at quaint, but small, marinas that are quite challenging for even a twin-screw to maneuver in. Two nights ago I was forced to dock stern-to. I gave the harbormaster my length and he asked for my beam. I replied, '14 feet 6 inches [4.4m],' and he said, 'Great. In that case, you can stay because I have one slip left with 16-foot [4.9m] width.' And then he told me I would have to follow marina custom and dock stern-to. I had 20 people watching, and I backed in with one try—without using the bow thruster. The response I got from the audience ranged from:

Fig. 7

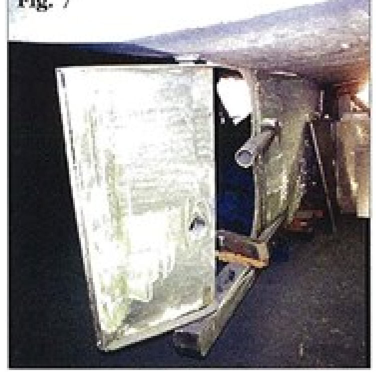


__Figure 7__—The Gerr-designed, single-screw motoryacht Imagine *is fitted with a MacLear Thistle rudder. Note the endplates top and bottom.*

'You must have been handling her several years' to 'Yep, I can always tell when a boat has twin screws.' Needless to say, I'm flattered. *Imagine* backs down quite straight with very little prop walk."

Well, *Imagine* is single screw. Her Thistle rudder has endplates top and bottom, as you can see in **Figure 7**, but it was set up only for the standard 35° hard over. The one drawback to getting larger rudder angles is that the hydraulic steering gear needs to be somewhat customized to accommodate the added travel.

Other Fishtail Rudders

Hydrodynamic fishtail rudders are commercially available for large vessels from companies such as Becker (whose Schilling Rudder may predate the MacLear Thistle), Ulstein, and others. Many of these rudders have proportionately fatter sections (even bulbous sections), with more balance and a more blunt, rounded leading edge than the MacLear Thistle. Such rudders are optimized for even better response at still higher rudder angles—as much as 65° hard over. Primarily intended for ships, these large-balance, fatter-section fishtail rudders pay a slightly higher penalty in drag at small rudder angles for nearly true stern-thruster response during maneuvering.

For both fishtail and articulated flap rudders, rudder-blade balance as high as 40% has been employed, with 35% common. That means the rudder projects forward of the rudderstock more than on a standard balanced rudder; adequate clearance must be checked and may require modifications on a retrofit. This greater-balance feature is also one cause of sometimes problematic steering on high-speed boats with articulated rudders.

Sizing Fishtail Rudders

The MacLear Thistle rudder, with 20% balance as indicated, should be sized according to the standard rudder area formula; however, many companies size fishtail rudders (and articulated flap rudders) as rectangles, with their height slightly greater than propeller diameter, and chord between 70% and 80% of propeller diameter. This should give good results so long as the propeller size and installation are within the normal range for a vessel of the type it's driving.

Fishtail Flat-Plate Rudders

Earlier, in Part 1 (PBB No. 98, page 76), I described the general construction of flat-plate rudders. Though flat-plate rudders are acceptable, they give less steering response and create more turbulence than any other rudder type. Flat-plate rudders are really just a cost-saving option.

Nevertheless, there is a way to get flat-plate rudders to perform better, and that is to weld a fishtail to the trailing edge. This is especially effective when done in conjunction with endplates. There are a few advantages: the fishtail increases rudder response at higher angles than a standard flat-plate rudder could function at, and slightly improves course-keeping, low-angle rudder response. The endplate increases the lift generated from a given rudder area (as it does with

Fig. 8

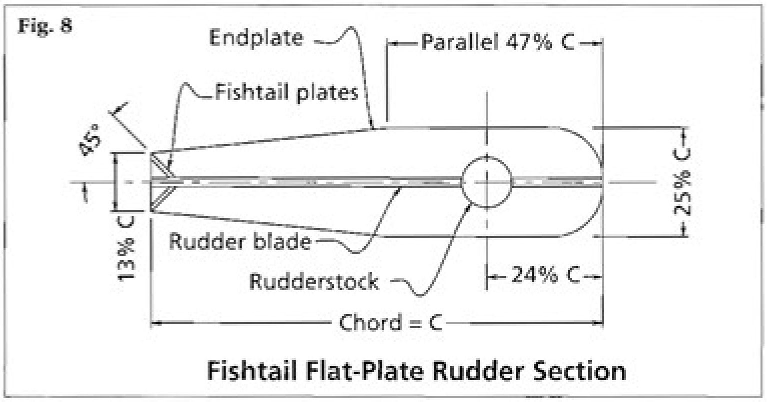


Figure 8—Flat-plate rudders are not as effective as shaped ones, but welding a fishtail to the trailing edge slightly improves course-keeping and rudder response at high angles.

any rudder foil form). At the same time, both the fishtail and the endplates are fabricated of flat plates themselves, simply welded onto the flat-plate rudder blade, and so construction remains inexpensive.

Such fishtail flat-plate rudders are really appropriate only for displacement vessels, since the additional drag of the flat-plate fishtail and endplates is too great at planing speeds.

Figure 8 shows a section through a typical flat-plate rudder with fishtail and endplates, courtesy of naval architect Charles Neville. The flat-plate blade thickness is determined by applying the formula for flat-plate rudders given earlier (PBB No. 98, page 88), as are the stiffeners and the stiffener spacing. Alternatively, you can install multiple endplates as stiffeners all along the height of the rudder blade (at the calculated stiffener spacing); endplates, though, are required only at the top and bottom of the blade.

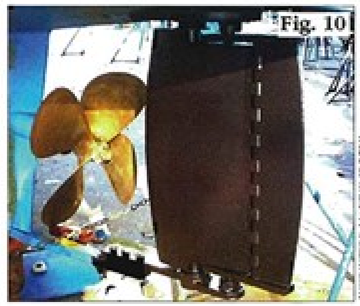
Note that where the MacLear Thistle rudder has the rudderstock at 20% of chord, the flat-plate fishtail rudder has the stock even farther back—at 24% of chord. This can be done only with angled fishtail plates installed. If they are not, then such high balance (about 24%) will cause the steering problems described earlier.

Endplate thickness = 75% of rudder blade thickness
Angled fishtail plate thickness = 50% of rudder blade thickness

Articulated Flap Rudders

I'm partial to the MacLear Thistle rudder and related fishtail rudders because they are more effective—for displacement hulls—than conventional rudders, and also very simple: no moving parts. Even so, with articulated rudders, aka articulated flap rudders, it's possible to get even more steering effect during low-speed maneuvering, and more pronounced stern-thruster effect (as good as the Kitchen rudder's, but without reverse).

What are articulated flap rudders? They're rudders that, rather than being one piece, have one or more movable flaps to increase effectiveness at high rudder angles, at low speed. (Some versions also have rotating drums at their leading edges.) These systems can be quite rugged. If you don't mind a bit more complexity and you have a displacement vessel that requires very precise handling at low speed, then an articulated rudder may be the answer.



DEFLECTOR MARINE (BOTH)

Figure 9—*Articulated flap rudders first appeared in the 1890s. A modern example is this unit manufactured by Deflector Marine, viewed from the side, turned hard to starboard.* **Figure 10**—*The Deflector rudder on centerline, viewed from astern. Operation of the flap is automatic.* **Figure 11**—*This drawing shows range of motion—45° for the main rudder, 90° for the flap.*

Articulated rudders can be installed on fast boats, but that takes careful engineering and setup. An example of this was a commercial vessel, *Te Kouma*, selected by the Royal New Zealand Yacht Squadron. This was a 25-knot boat, and the following, excerpted from *Professional Skipper* magazine (Jan./Feb. 2004), is a typical experience for higher-speed craft:

"*Te Kouma* was originally fitted with an articulated rudder for low-speed manoeuvrability. But this feature proved to be unmanageable, creating very tough steering on the hydraulics once she was up to her cruising speed. Had power steering been installed, this would not have been a problem. In trying to combat the stiff steering problem, [we] removed the articulator attachment to the rudder. On subsequent sea trials this has removed all the stiffness from the rudder operation, while maintaining good manoeuvrability at high speed, with little difference in her low-speed manoeuvrability."

Note that the trailing-edge flap on articulated rudders moves the center of pressure considerably aft. For this reason, most such articulated rudders have well over 24% balance—an unacceptable value for standard rudders. Balance as high as 40% can be employed, with 35% common. The high balance may be a contributing cause to potential problems for articulated rudders at high speed, though they can usually be tweaked to work. It's not clear that the extra cost and complexity of an articulated rudder make sense on a typical twin-screw planing hull, which has good maneuverability at low speed via backing-and-forthing the opposing propellers.

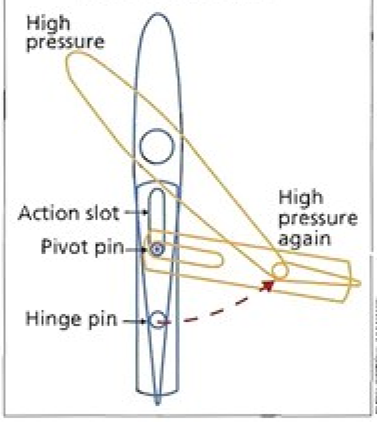
The idea behind articulated rudders is not new; indeed, these rudders have been around, in one form or another, since the 1890s. Because rudders are foils that generate lift in fluid flow, articulated rudders are properly termed variable-geometry foils. They've appeared on boats as well as on airplanes. Some of the best-known manufacturers of articulated marine rudders are: Rolls-Royce/Ulstein Hinze, Becker Marine Systems (the Becker rudder), Wartsila, Van der Velden Marine Systems' Barke rudder, and Jastram; the latter offers not only articulated flap rudders but rudders with rotating drums built into their leading edges. The companies named above manufacture rudders primarily for ships.

The Deflector Rudder

A U.S.-made articulated rudder is fabricated by Deflector Marine Rudder, of Naselle, Washington. **Figure 9** shows a side view of the Deflector rudder in a starboard turn; and **Figure 10** shows the rudder dead center. The basic workings of the rudder are automatic and require no external power to move the flap; that's accomplished by the geometry of the flap linkage and pivot location alone. Like most flap rudders, the Deflector articulates to a total of 90°. The main/forward rudder blade swings to 45°, and the trailing-edge flap swings to twice that: 90° (**Figure 11**).

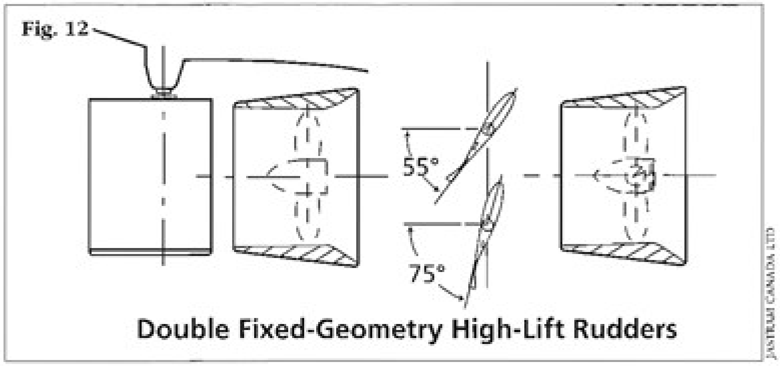
Fig. 11

Deflector Marine Rudder in Dead Ahead and Hard Starboard



DEFLECTOR MARINE

***Figure 12**—The Jastram Rotor rudder is an example of a double fixed-geometry high-lift rudder, featuring fishtails and endplates. Such rudders do not stall as early as conventional rudders; but, a differential mechanism is required because the inboard and outboard rudders must turn at different angles.*



Double Fixed-Geometry High-Lift Rudder

Yet another rudder configuration is the double fixed-geometry high-lift rudder (**Figure 12**). It consists of two balanced rudders (usually fishtail rudders) with endplates acting in unison behind a single propeller. Although the twin rudders turn in together, they do so by means of differential steering, similar to Ackermann steering, described in Part 3, (PBB No. 100, page 92). Thus, the rudder inboard on the turn turns to a greater angle than the outboard rudder. Researchers have found that these tandem-action rudders can turn effectively as much as 75° on the inboard-turn rudder and 55° on the outboard.

Variations of this configuration have been seen on vessels for years. Recent computer-controlled rudder systems enable the articulation of twin rudders behind a single propeller, in the same or opposite directions, and at varying angles, with independent but related control. The result is handling similar to the Kitchen rudder; however, the Kitchen rudder doesn't require any computer controller to generate the correct combination of rudder angles needed for a twin-rudder setup (**Figure 13**).

The Jastram Rotor Rudder and T-Rudder

Rudders begin to stall at surprisingly small angles of attack. By building in a hydraulically driven rotating drum, flush with and forming the leading edge of the rudder, flow separation can be greatly delayed

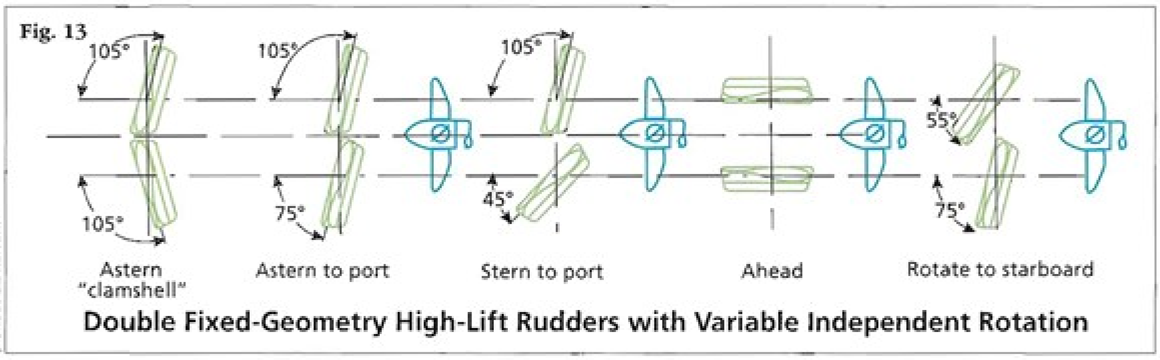


***Figure 13**—A double fixed-geometry high-lift rudder with variable independent rotation must be computer controlled. Such rudders generally are designed for ships rather than for boats.*

and, therefore, so is stall. That essentially means the rudder can be effective at higher angles (well over 45°). Jastram manufactures a version it calls the Rotor Rudder. Even greater rudder angles can be achieved by adding an articulated flap to the trailing edge combined with the rotor at the leading edge—Jastram's T-Rudder, which is truly equal to a powerful stern thruster.

As noted, the Jastram rudders, the Becker, and the Barke rudders are largely manufactured in sizes appropriate for ships; they're generally not suitable for boats. If you're looking for an articulated rudder for small craft, the Deflector fills the bill. It's a good option for a designer or yard seeking the maximum possible rudder response for low-speed maneuvering.

Comparing Fishtail and Articulated Rudders (Flap Rudders)

Both fishtail and articulated rudders have the same goal: to improve steering response. Is one better than the other? No. As with so many things, it's a matter of trade-offs. Rudder function can be divided into two modes of operation: course-keeping and maneuvering. We'll take a look at the pluses and minuses of each type of rudder in each mode of operation.

Course-Keeping. When running at normal speed, the purpose of the rudder is to keep the vessel on course—roughly defined as holding a straight course more than 95% of the time with minimum rudder action and minimum rudder drag. Course corrections will be small and should be positive and immediate. Occasional pronounced changes of heading may be required, but these are done gradually (compared to low-speed maneuvering) and, again, minimal rudder angle and rudder drag are optimal. With the correct rudder and steering gear installed, almost all course-keeping rudder angles will be less than 10°, with infrequent use of 15° helm for pronounced changes in heading. Seventy percent to 80% of the time, rudder angles during course-keeping will be 5° or less.

The optimal characteristics can be summarized as follows:

- good lift/drag ratio for minimum fuel consumption;
- minimum drag with rudder at or close to zero angle, for minimum fuel consumption;
- gradual and steady increase of lift at low to moderate helm angles. If the slope of the lift curve is too steep, it will result in oversteer. Oversteering then results in an added small reverse course correction, which is hard on the helmsman or the autopilot, causing additional drag and increased fuel consumption.

The lift/drag ratio at helm angles up to 10° is similar for both types of rudders. Since the flap on a flap rudder moves to twice the rudder angle, the lift/drag ratio is a bit more than a fishtail rudder at angles greater than 5°. Because the flap angle continues to be double the main rudder angle, it is more likely to generate oversteer reaction at cruising speed, particularly at higher speeds.

The conclusion? A fishtail rudder holds a slight advantage over articulated or flap rudders in course-keeping.

Maneuvering. At low speed in close quarters—such as during docking, anchoring, precise station-keeping, and the like—large, quick, accurate changes in course are required.

The optimal characteristics for maneuvering can be summarized as:

- maximum lift coefficient regardless of drag. Fuel economy is not a factor. And
- the capability to redirect flow from the propeller slipstream to the maximum angle possible, and to get as close to true stern-thruster response as practical.

At maximum rudder angles, the articulated flap rudder produces about 7% to 9% more lift than a fishtail rudder. Articulated flap rudders typically have a total rudder angle of 90° (45° main blade, 90° flap). Thus they work at near perpendicular to the slipstream. Fishtail rudders vary from 40° for the MacLear Thistle rudder to as much as 65° for the fatter-section rudders such as the Schilling. Fishtail rudders cover up to 65% of the slipstream, while the articulated flap rudder will cover almost 90%.

Note that both fishtail and flap rudders usually have greater balance than standard balanced rudders. In light of the above then, an articulated flap rudder will be somewhat more effective for maneuvering.

Summary. Both the fishtail and articulated flap rudders will provide a pronounced improvement in steering response. The fishtail rudder would generally be the best all-around rudder, as it has no moving parts and less drag during course-keeping (95% of operation for most vessels), while at the same time giving significant benefits in maneuvering.

Articulated flap rudders provide the maximum low-speed maneuvering response. For vessels that will be docking repeatedly in difficult conditions, or that have very precise station-keeping requirements, or that have considerable windage (making them difficult to handle), then articulated flap rudders offer a slight edge over fishtail rudders.

There is, though, one important exception: When going astern, articulated flap rudders stall earlier even than conventional rudders. That's because the flap—at twice the main rudder blade angle—stalls quickly in sternway conditions.

Still, the difference between the two rudder types isn't great, and both accomplish nearly the same results.

A Hierarchy of High-Lift Rudders?

Can we create a hierarchy of high-lift rudders, based on the relative size of the turning circle they make possible at maneuvering speed? Sure. The list below is arranged in order from largest turning circle to tightest turning circle. Bear in mind there are many variables in the rudder installation and in the boat itself, so what follows is, at best, a rough guide:

- MacLear Thistle rudder
- Schilling rudder and articulated flap rudder
- Rotor-rudder and double fixed-geometry unison rudders
- T-rudder (Rotor-rudder with articulated flap), Kitchen rudder, double fixed-geometry variable-control rudders

Again, broadly speaking, the complexity and cost of the rudder increases as the turning circle decreases. All of these rudder systems provide dramatically smaller turning circles and greater low-speed control than standard rudders on displacement vessels. PBB

About the Author: *In addition to serving as director of Westlawn Institute of Marine Technology, Dave Gerr maintains his long-standing design practice (Gerr Marine) based in New York City, whose projects include sail and power, monohulls and multihulls, yachts and commercial vessels. He is the author of* Propeller Handbook, The Elements of Boat Strength, *and* The Nature of Boats.