chapter 9

BUILDING FROM SCRATCH —DECKS AND SUPERSTRUCTURE

You'll want to give some thought to the sequence of the various steps needed to finish the deck and superstructure. The building sequence includes gritblasting, insulating the hull, and may include installing the engine and fitting out the interior. You may want to undertake some of these steps before you build the decks and superstructure, so you'll need to plan your own work schedule. You must also be prepared to make minor changes as you proceed with the work. You may be considering building the decks, and/or the superstructure, in a different material from that of the hull (usually *not* recommended by this designer). As most of you will be building the entire boat in one metal, however, we'll leave detailed discussion on alternative deck and superstructure materials until nearer the end of this chapter.

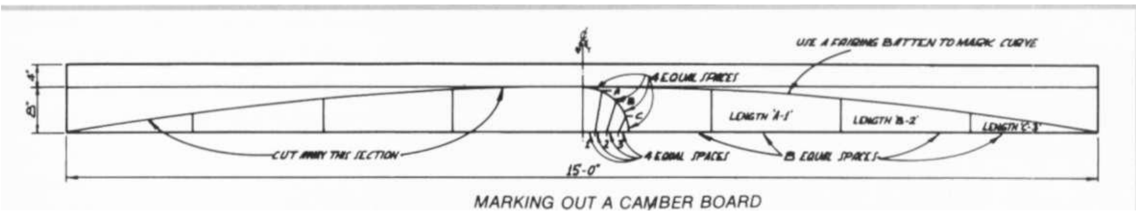
Before you start to build the decks and superstructure, you should consider installing all the bulky items that will need to be in the hull and which may be difficult, if not impossible, to install after the deck and cabin are in place. The engine, large tanks, bulkhead panels, the plywood sole, and similar items need to be in position before the hull is closed up by addition of the superstructure. You will have to balance this against the fact that you may need to gritblast the inside of the decks and superstructure, a practice that would not be recommended around your new engine! Again this is another reason why we recommend using all pregritblasted and pre-prime-coated steel.

If your hull is large enough, say over 35 feet (10.67 m), you may plan to set up a small workshop inside the hull where you can manufacture much of the joinery. This is worthwhile if you can fit in a small bench, a table saw, and a band saw, otherwise it may be better to consider one of the alternatives. For example, if your boat is smaller, or if you prefer to work outside the hull, then consider setting up a work area at the sheer or deck level, then you'll only have to climb a few steps to saw, plane, rout, sand, or temporarily assemble a piece of joinery. This can save a great deal of time and effort. Getting up and over and out of the boat to make each cut can soon become very tiring (and tiresome), so a better plan is needed.

You may find that some of the cabinets and joinery can be set up inside the hull and then taken out to a nearby bench for sanding, painting, and so forth, before being reinstalled in the hull. It's better to undertake as much preparation as possible before the deck goes on.

GRITBLASTING AND PRIMING

This brings us to the gritblasting that's necessary in steel boats. When is the best time to undertake this work? In our opinion, the best time is before the boat is started—yes, this means pregritblasting and priming all of the materials. If you opt to work with untreated steel, you'll have some problems with working out the sequence of fitting out. You can't install the insulation, the



Laying out a camber pattern for deck or cabintop beams *will be one of your first tasks before you start work on the decks and superstructure.*

engine, or other large items until after you've gritblasted and primed the inside of the hull. You certainly cannot gritblast the interior once these items are in place. You can see that if you work with untreated steel, you may create scheduling difficulties. Builders who choose steel as their building material should avoid these problems by either purchasing the steel already preblasted and primed, or by doing the job themselves before they start construction. (See Chapter 10, Painting a Metal Boat.)

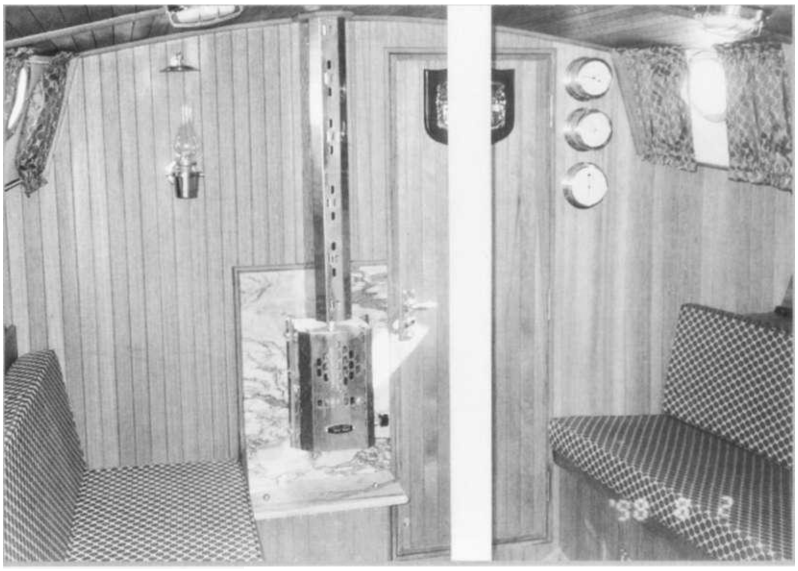
CAMBER BOARDS

Your plans and patterns may include either the measurements or an actual full-size pattern for the deck and cabintop cambers. Using this pattern, it's a simple matter to cut a hard pattern from plywood or suitable timber. If you get the balance right, you can cut a male and female pattern from one plank. The pattern will be used to obtain the correct camber when you're bending the deck beams and cabin beams.

On sailboats, the cabin and the pilothouse tops will usually have more camber than the decks. On powerboats, the opposite is sometimes the case, although quite often the same camber is used throughout. If your plans don't include full-size camber patterns, you can create patterns using the designer's recommended cambers, as shown below. For instance, in a powerboat that will be fitted with a flybridge, it is best to have a minimum (but still some) of camber in the cabin or pilothouse top as this will form the sole of your flybridge and too much camber is not desirable.

BULKHEADS

If you're building upright, you may have included some of the bulkheads as you were setting up the initial frames. It would also be possible to include bulkheads when you're setting up an inverted hull, but it may involve raising the whole struc-



The interior of John and Joan McDermott's Spray 33, Donegal Breeze.

ture so far off the floor that it would be impractical. Any setting-up method that makes you climb or walk more than is absolutely necessary is not recommended. In cases where the hull is built upside down, my preference is to wait until the hull is plated and upright before considering the installation of any bulkheads. That gives you an overview of the hull, so you can take stock of the available space before making firm decisions about placing bulkheads that will affect the layout of the accommodation.

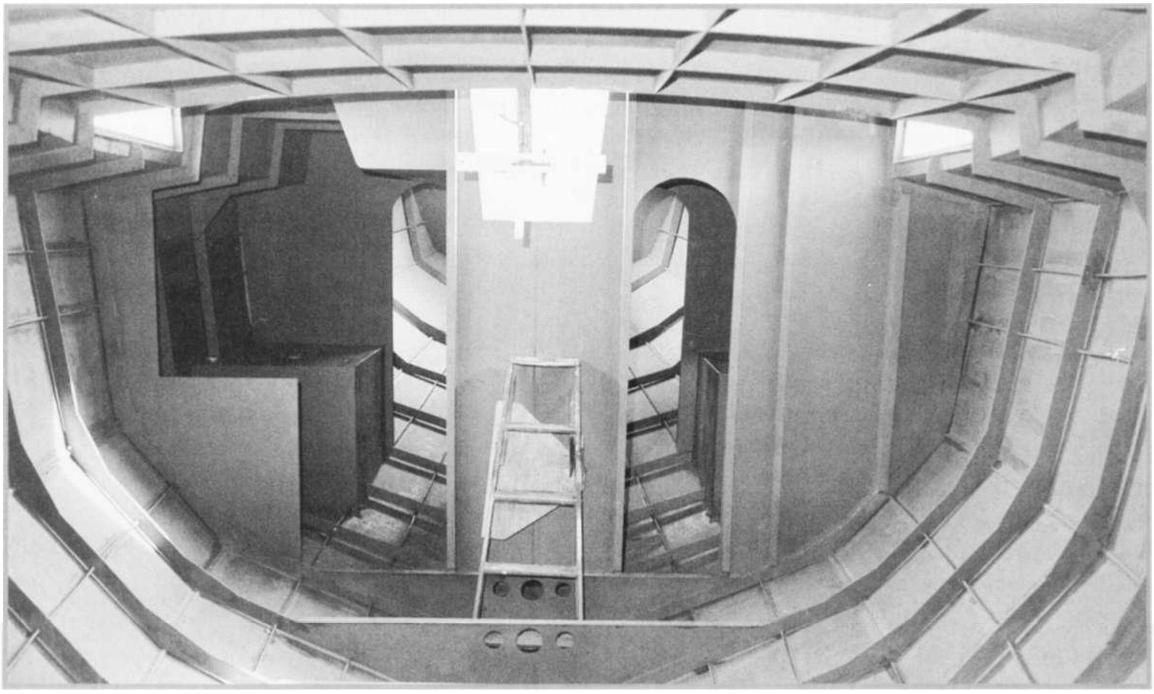
You'll need to decide which bulkheads will be metal and which will be plywood. The bulkheads that will be exposed to the elements should all be metal, including the aft bulkhead of the cabin and the bulkhead located at forward end of the aft cabin. If you have a pilothouse, the aft bulkhead should be metal. In Dutch powerboats, the aft end of the saloon or pilothouse is sometimes made partially of timber. This is acceptable if there is some awning or shelter over it to protect it from the elements. Bulkheads will usually be constructed from the same metal used for the decks. In boats under 40 feet (12.19 m), try to keep the number of metal bulkheads to a minimum, and use plywood where practical.

Metal Bulkheads

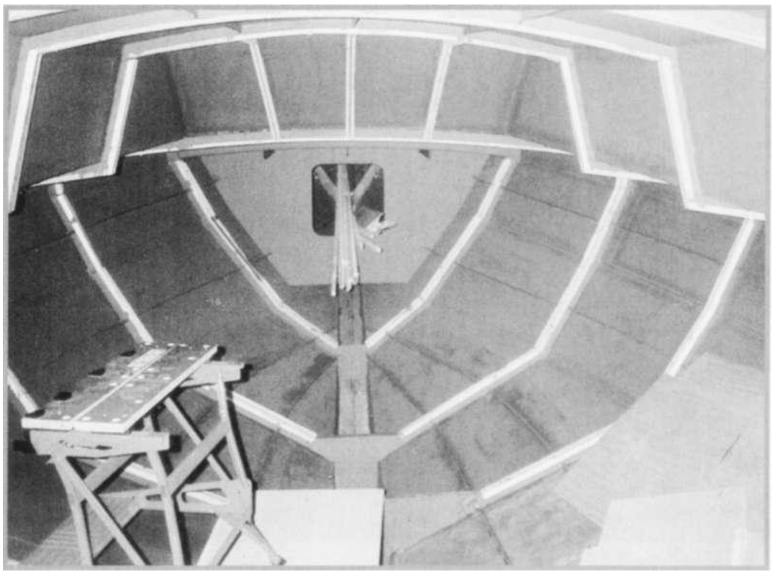
The bulkheads at the forward and aft ends of the engine room in both sailboats and powerboats should be constructed from the same metal as the decks but in some cases may be one measurement smaller in thickness. For instance, where the decks are 3/16 inch (5 mm) you may use 5/32inch (4 mm) steel for the bulkhead plate.

As was demonstrated in the Falklands War, aluminum can burn. For this reason, particular attention should be paid to insulating with fireproof material any aluminum bulkheads located where a fire may break out. The bulkheads that enclose the engine space, for example, will need special attention.

It's common practice to make the bulkhead



Steel bulkheads are usually placed each side of the engine room. In the case of a sailboat, they will often be at either end of the center cockpit, as shown here.



Timber "furring strips" for securing the lining material to the frames installed on a Roberts 34 built in Sweden.

adjacent to station 0 from the same metal as the hull. This "crash" bulkhead is usually at the forward end of the waterline. Some classification societies and authorities, including boats built to the U.S. Coast Guard survey and those built for sale and use in Europe, require this first bulkhead to be located 5 percent of the load waterline (LWL) aft of the forward end of the waterline. This is a sensible rule, but it sometimes takes up valuable space. Boats built to the Coast Guard survey will need the accommodation moved farther aft than would otherwise be necessary.

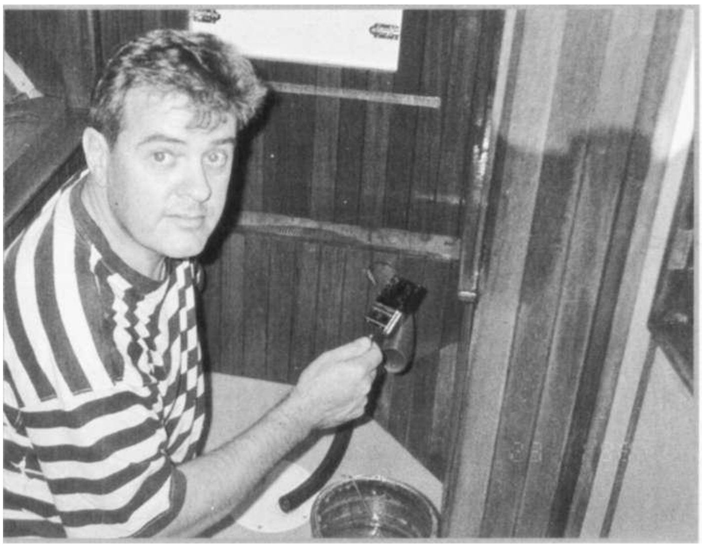
Some bulkheads may need stiffeners, depending on the size of the vessel, the metal used in the bulkheads, and the size of the particular bulkhead. These vertical L-angle or T-bar stiffeners are spaced about 12 to 18 inches (305 to 457 mm) apart and are installed with base of the L or T inward, thus making an excellent base for installing the cabin lining material. Some transverse stiffening also may be required. Check with the designer of your boat. The cavity formed by the L-angle can also be used to install the insulation.

Concerning those bulkheads that you're installing before the deck and superstructure are in place: make sure that the height above the sheer or deck will allow you to cut the correct cabintop camber later. We always recommend that you don't try to cut the shape for the cambered decks, cabin sides, and top camber at this stage; simply allow the top of the bulkhead to stand up square from the sheer. This advice applies to all metal and plywood bulkheads. Later, you can mark out the deck camber, the lay-in of the cabin sides, and the cambers for the cabintop and/or wheelhouse top. These cuts may be more difficult to make with the bulkhead in an upright position, but they'll be much easier to mark out with all of the bulkheads in place, rather than one at a time before the bulkheads are erected. More experienced builders may prefer to mark and cut the bulkhead tops as they install each one.

If you're building upright, and if many of the bulkheads are on a frame location, then it may be worth your while to include the basic bulkheads as part of the frame construction. Our advice is still to leave the tops square, as mentioned above. If you prefer, you may carefully work out the measurements and cabinside angles of each bulkhead, and cut them to shape before installation.

Plywood Bulkheads

Intermediate and partial bulkheads are best built from plywood. You can use any suitable grade that has a marine glue-line. One way to test the durability of plywood is to boil it. A widely used 8-hour boiling test will give you a clear indication of its quality. Plywood provides stiffening and strength in many directions and will keep the weight of the interior down. Plywood bulkheads should be installed with the tops left square, so the areas above the deck can be marked and shaped at the same time as the metal bulkheads. If your plans do not state the thickness for the plywood bulkheads,



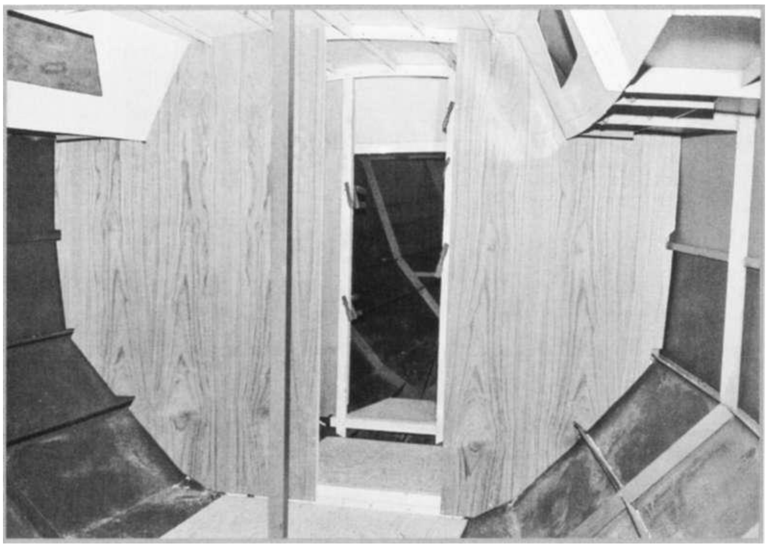
John McDermott varnishes the meranti tongue-and-groove bulkheads in his Spray 33, Donegal Breeze.

keep in mind that the adjacent furniture and joinery will add stiffness and strength.

The transverse plywood bulkheads will need to be bolted in place, either to existing metal frames or to short sections of framing material commonly known as *tags.* The tags are 6 to 12 inches (150 to 300 mm) long and they're spaced at the same intervals as their length. They're welded to the hull to accept the bulkhead. The tags become necessary if a transverse bulkhead is located between frames, or adjacent to a frame but not at its exact location. It may be possible to alter the bulkhead's location a small amount by bolting it to one side or other of the frame—but be careful not to create a space such as a berth that is too small or too long. You'd do better to install tags at a location between the frames. These tags provide more than adequate strength for bulkhead attachment. Don't forget to predrill the tags at 4- to 6-inch (100 to 150 mm) centers to accept the bolts that will attach them to the bulkheads.

As you're unlikely to be able to purchase plywood sheets large enough to make the bulkheads in one piece, you'll need to join or laminate the sheets somehow. The thickness of the plywood bulkheads will vary, depending on the size of the vessel as well as the purpose and location of the bulkhead. Transverse plywood bulkheads are generally thicker than longitudinal ones. The designer of your boat may have specified the thickness required.

To form one complete bulkhead, you can use plywood of the specified total thickness and have this scarfed to the correct sheet size, or you can scarf or half-lap the sheets yourself. Our preferred method is to divide the thickness into two or more parts and then laminate two or more sheets face to face. For maximum strength, the joins can be widely staggered by alternating the joins in each layer. Plywood bulkheads, with the exception of those in the area of the mast in a sailboat, will not be exposed to great strains. The



Plywood bulkheads can be attached to frames or to tags especially installed for the purpose.

bulkhead adjacent to the mast can be strengthened by the addition of framing as required.

Cored Bulkheads

If you are weight-conscious, you can consider one or more cored bulkheads. They can be used to divide the accommodation longitudinally, or to construct half-bulkheads such as those that form one end of a hanging locker or similar piece of joinery. The core material can be structural sheet foam, a light timber framing, or other suitable material that is both light and fire-resistant. The face plywood can be 3/16 inch (4 to 5 mm) and can be veneered with teak or a similar surface. The fiberglass bats used in house insulation are unsuitable for core material as they will soon shake down into a floppy mess when exposed to vibration and other marine operating conditions.

BENDING AND INSTALLING DECK BEAMS

The material for the deck beams can be flat bar, L-angle, or T-bar. It makes sense to use L-angle or T-bar, as either of these, when installed with the flange down, will provide an attachment point for the interior lining material. The insulation for the deck and cabintop will fit neatly in between the angle or T-beams.

The beams can be bent using the hydraulic-jack and steel-frame method, or you may prefer to have them bent by a professional metal shop. Your plan will at least give you a camber figure—for example, 6 inches in 13 feet (150 mm in 3.96 m). If you don't have a pattern, but you do have the numbers for the recommended camber, you'll have to make a pattern using the formula shown. If you have patterns for the various cambers, you should make a master pattern out of plywood or timber. You will use the pattern to check the beams as they're bent to the correct camber and also as a general pattern for cutting bulkhead tops.

In our designs, we recommend that you install the deck beams in one piece right across the hull. This method of installing the beams is much easier than trying to support short side deck beams while maintaining the correct sheer and curve of the deck/cabinside intersection. Later, you'll cut out the center of the beams and the section you remove will be rebent for cabintop beams.

You may need fore-and-aft intercostal deck stringers, depending on the spacing of the beams and the size of your boat. The intercostals are best cut from flat bar and should be snaped in at the ends and welded in between the deck beams, as required. You could use a lighter angle for the intercostal and have the flange level with the inside to provide a base for the lining material. The depth of the intercostal should be the same as that of the deck beams as you may need to weld the underside of the deck plating to the intercostal as well as to the deck beams themselves.

Once all the deck beams are in place right across the hull, then you can mark the position where the cabin sides intersect the deck, support the beams, and cut at the marked line on each beam. Next, install a carlin to accept the inner edge of the side deck plating. The carlin will be a vertical length of flat bar running around the inner edges of the cut inner ends of the deck beams.

You can, at this stage, make provision for hatches in the fore and aft decks or you can cut them out later and install any extra deck framing at that time. Once you're satisfied with the framing for your deck, you can go ahead and plate the foredeck, side decks, and the aft deck area. Remember at this stage you are still tacking everything together; no long, continuous welding should take place until the whole structure is tacked together. See also the welding recommendations that come with your plans; usually only the outside seams are fully welded while other areas have stitch or chain welds as the final welding.

FORMING THE CABIN

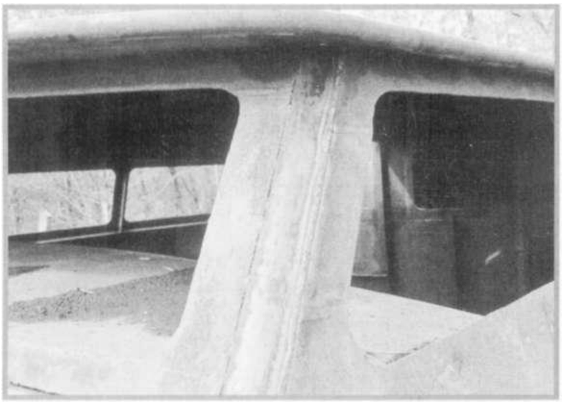
Cabinside Lay-In

At this stage, you'll need to consult your plans regarding the correct lay-in for the cabin and pilothouse sides. Lay-in of the cabin or pilothouse sides refers to the amount by which the sides are angled inward toward the centerline. In other words, the base (where the sides meet the deck) is slightly wider than the top (where the sides meet the cabin or pilothouse top). Too much lay-in will be most unattractive and be an invitation for leaky windows and may also interfere with your interior accommodation. Too little lay-in will make the superstructure on your boat look boxy and, at worst, can make it look as though it's actually leaning outward at the top. How much lay-in is correct? Never less than 5 degrees and usually no more than 15 degrees is appropriate. When you cut the angle for the side lay-in, you may leave the tops square and cut the cabin or pilothouse top cambers after the cabin sides are installed.

Setting Up the Cabin Sides

Your plans should provide measurements for the cabin sides, so that you can make a pattern of the sides and then raise the pattern into position to check the accuracy before cutting metal and welding the sides in place. In boats supplied as steel kits or cutting files, the cabin sides are already precut to the exact shape. If your design includes a pilothouse, it may be part of the cabin sides or installed as a separate item.

It's often preferable to have the sides of the pilothouse set slightly inboard of the line of the cabinside-cabintop intersection. This step inward or knuckle will break up the large pilothouse-cabin inside area, and reduce the apparent height of the combined structure. You can also change the paint color at this intersection, which will further enhance the appearance by avoiding the slab-sided look. Until you've installed the other parts of the superstructure, and to ensure that the sides remain at the correct angle and position when they are first installed, you'll need to use bracing from one side to the other, and to the bulkheads and other areas. If the windows are closer than, say, 4 inches (100 mm) from the edge of the cabin sides or pilothouse plating we recommend that you don't make any cutouts for windows or portlights at this time. If there is insufficient uncut metal between the cutout and edges of the plate you may have a problem and the cutout could cause the plate to buckle, and spoil the fair line of the sides. You may wish to mark out the windows and ports, as this will enable you to locate the correct position for any framing required in the sides.



Quarter of pipe used at corners of pilothouse. This boat would have been better built from preprimed materials that were not readily available at the time.

Cabinside Stiffeners

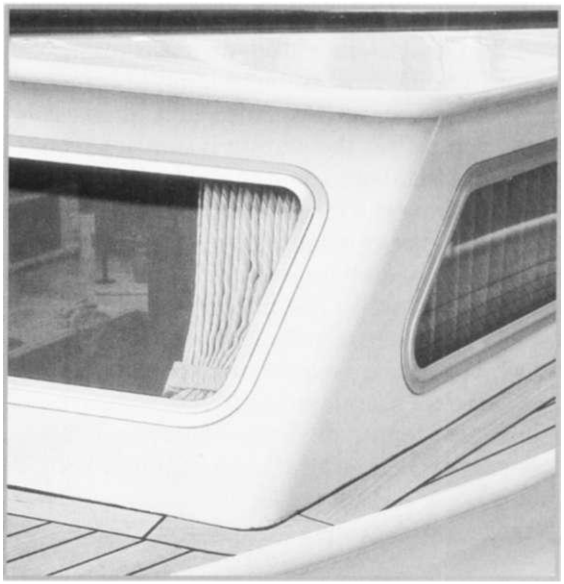
Depending on the size and type of boat, you may need some form of stiffeners installed in the sides of the cabin or pilothouse. If possible, always line up the cabinside stiffeners with deck and cabintop beams, so you have, in effect, a "ring frame" that will always be stronger than a discontinuous framing system. When designing our kit boats we always try to have all frames, deck beams, cabin sides, and top beams line up as suggested above. You can use the same material for framing the sides of the cabin or pilothouse as you use for the deck and cabintop beams. Assuming you're using angle, the flange of the L or T will face inboard, and will assist in providing a ground to attach the lining. Don't forget to arrange some form of insulation in the cabin sides, otherwise you'll have condensation problems in the future.

Rounded and Beveled Corners

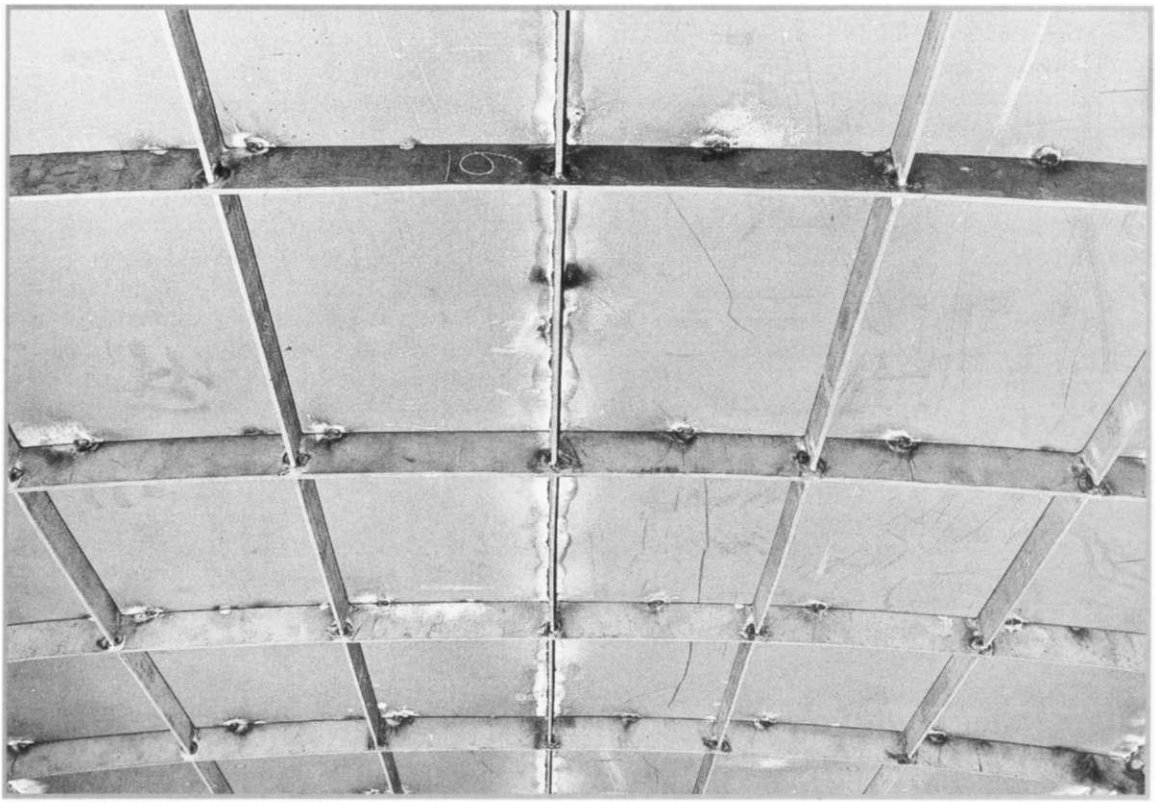
Rounded corners where the cabin sides meet the top, and where the cabin front meets the top and sides, are a nice touch. You can use sections of suitably sized pipe, say 3 inch (75 mm), cut into quarters, or have some plate rolled to a suitable radius. We like beveled corners; they're easy to install and give an attractive appearance when used at the intersection of the cabintop and cabin sides, and in similar areas. The hull-sides-transom intersection may be fairly sharp without spoiling the appearance of the vessel. Sharp corners are hard to keep painted, though, so all corners should have at least a small radius.

Installing Cabintop Beams

Installing the cabintop beams will follow much the same procedure as you have used for the deck beams. Hatches can be framed in now or cut out later and framed from underneath. We recommend that you frame up the main hatchway at this stage, as you'll need access to the interior when you plate the cabintop. As the surface area of the tops of the cabin and pilothouse will most cer-



Rounded corners can enhance the exterior appearance of any metal boat.



Cabintop beams and fore-and-aft intercostals tack-welded In position; see text.

tainly be greater than that of the decks (except in a flush-deck boat), you'll need intercostal beams in the top. The intercostals can be installed before or after the top plating. If you install the intercostals from inside, after the plating is in place, you'll have more welding to do from underneath; however, installing the intercostals after the plating will ensure that you don't have any ridges in the cabintop caused by improperly aligned and installed intercostals. The intercostals can be installed in the same manner as those for the decks. Your cabintop may receive considerable traffic, so make sure the framing is adequate. A relatively light, closely framed cabintop will serve you better than a few, widely spaced, heavier beams. Follow your plans or consult the designer of your boat if you're unsure regarding the framing.

Installing the Cabin Front

The front of the cabin will most likely be curved; about the same master camber as was used for the deck-beam camber will be about right. You only take a portion of the deck pattern. For instance, if the deck camber pattern is 6 inches (150 mm) in 15 feet (4.572 m) and the cabin front is, say, 6 feet (1.83 m), then the actual amount of round in the front will be about 2 inches (50 mm) in the 6-foot (1.83 m) of width. Cabin fronts on traditional craft can be flat. The problem with flat cabin fronts—or any part of a boat that is flat—is that they tend to look convex. For that reason, you should always have a slight amount of curvature in any flat area on your boat.

The cabin front will always have some layback. II a truly vertical cabin front were installed, it would look as though it were leaning outward (forward) at the top. Don't forget to allow for the camber when installing the cabin front. You are dealing with many angles in this area, and overlooking sufficient camber allowance in the front is not an unheard-of occurrence.

Plating the Cabintop

By now, you should have the cabin sides, cabin front, and cabintop beams and intercostals all installed and checked for accuracy and fairness in all planes. You'll need to decide if you're going to let the top overhang the sides or front of the cabin. These overhangs have many advantages and are commonly seen. While overhangs on a fiberglass or timber boat may present a potential weak point in the construction, this doesn't apply on a metal boat.

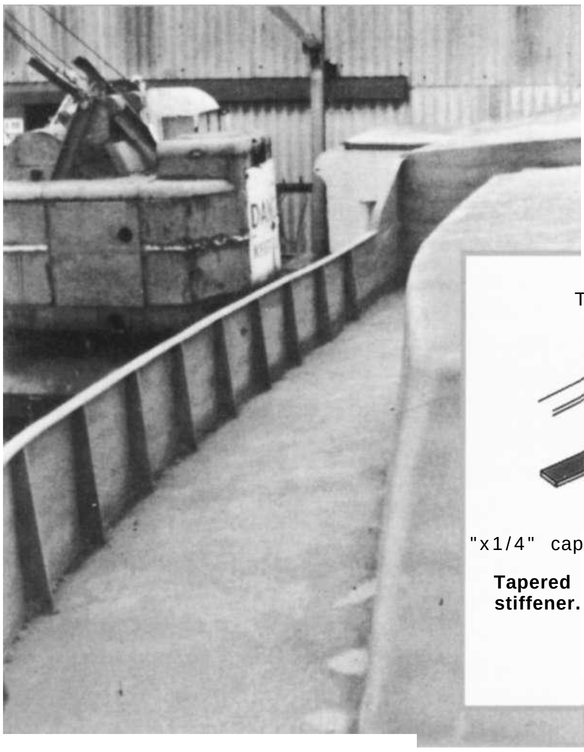
Check your plans regarding overhangs and "eyebrows," as the forward cabin and pilothouse overhangs are sometimes called. Overhangs must have a trim to complete the edge; you can use pipe, solid round bar, or flat bar depending on the design of your superstructure. Side overhangs, especially on powerboats, can carry the rainwater or spray from the top out past the windows. You can see that a careful balance of cabinside lay-in and top overhangs can improve the appearance and practicality of the design. Installing the deck plate will follow the same procedure as used for the decks. Plate flanges on overhangs can have about 5 degrees of outward angle at the bottom in relation to where the flange joins the top; this will tend to throw the water outboard away from the sides and windows and help avoiding dirty dust streaks on the cabin or pilothouse sides.

BULWARKS AND TOERAILS

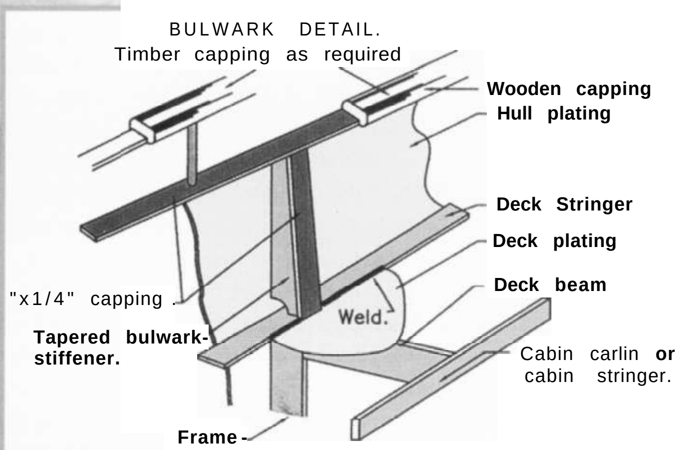
If you plan to have bulwarks, you'll have fitted a deck stringer at the appropriate height. The lines plan and/or the full-size frame patterns may show exactly where this stringer is to be installed on each frame.

If this information isn't on your plans, you can scale off the relevant measurements and use a batten to fair in the deckline on each frame from stem to stern. Before or after the hull is plated, you can taper the inside of the frame between the deckline and the sheer. Taper the frame so that it is the right width on top to accept a flat or round bar to be installed as a caprail.

If your bulwarks are less than say 8 inches (200 mm) at the highest point, and your hull is Winch (5 mm) plate, then the frames may finish under the deckline and it will not be necessary to have the frames extend from the deck to the sheer. You should install a pipe or solid round of a



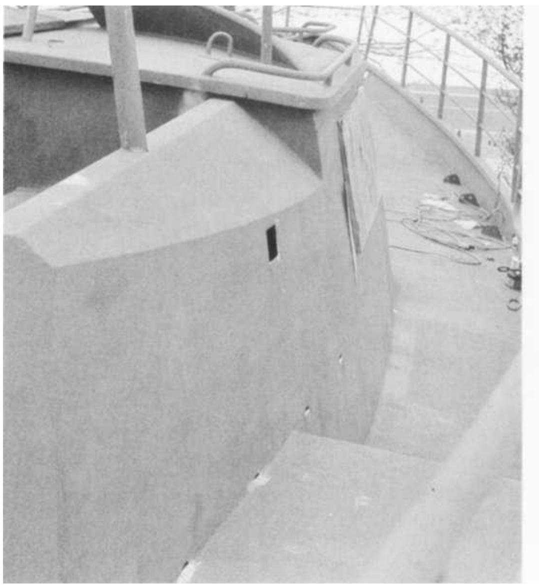
Steel decks and cabin on Roberts Spray, *built in England for Bruce Roberts UK, Ltd.*



Drawing of bulwark detail.

THE BEVEL

A beveled section makes an attractive intersection between the cabin or pilothouse sides and the top. There are other areas of the superstructure where a bevel can be an attractive alternative to a round edge or a plain right angle. The bevel is one of our favorite architectural features and we note that a few boat manufacturers are incorporating a bevel between the cabin sides and the top. The bevel can be of any size, but it's usually set at about 45 degrees to the vertical and could measure 3 to 6 inches (75 mm to 150 mm) depending on the size of the boat. The use of the bevel is also a good way to disguise cabin height. If your design calls for a high cabin structure, then consider the bevel. For the record, the bevel, when used in timber work, is often referred to as an arras, or small bevel taken off the corner of a post or other feature. The arras, or bevel, does soften the appearance of any area where it is used, and it's a great way to remove sharp edges from any object in your boat.



The beveled cockpit coaming adds to the attractive appearance of this Roberts 53 built in Canada by A. Skodt.

minimum of 3/4-inch (20 mm) diameter or flat bar, to complete the top edge of the bulwark plate and this may also be used to accept a wooden caprail on the top of the bulwark plating. In any case, you should stiffen up the cutouts; see below regarding reinforcing the edges of the apertures.

WATERWAYS AND FAIRLEADS

If your hull has bulwarks, you'll need to install waterways on the frames and freeing ports to allow water to flow between the frames as well as through the bulwarks and off the decks. The bulk of the freeing ports must be situated at the lowest point of the deck-bulwark intersection, and the apertures must be large enough to let the water out without delay. Usually, several freeing ports spread over the lowest area are better than one large hole. All openings made in the hull plating for treeing ports, fairleads, or any similar purpose must be reinforced with suitably sized solid round bar. II docking lines are used with fairleads, the reinforcing bar in a steel hull should be stainless steel. The movement of docking lines and the anchor rode would soon wear away any paint applied to mild steel reinforcing.

BUILDING OR ADDING A PILOTHOUSE

Consider a pilothouse if you want to improve the livability and comfort of your existing or future sailboat or powerboat. Pilothouses have gained in popularity over the past 30-odd years that we've been recommending these structures. Almost all of our sailboat designs feature at least one version that includes a pilothouse.

If you think your boat is a candidate for one, you'll need to consider the style and design carefully before starting the actual installation. We strongly recommend that you contact the original designers of your boat and request that they check the effect on stability and prepare plans for the structure. The addition of a pilothouse can not only provide more comfort aboard your boat, but it also can enhance its appearance and value.

The low *cabin on this Roberts 39 will receive adequate light and ventilation from the opening hatches and dorade vents.*

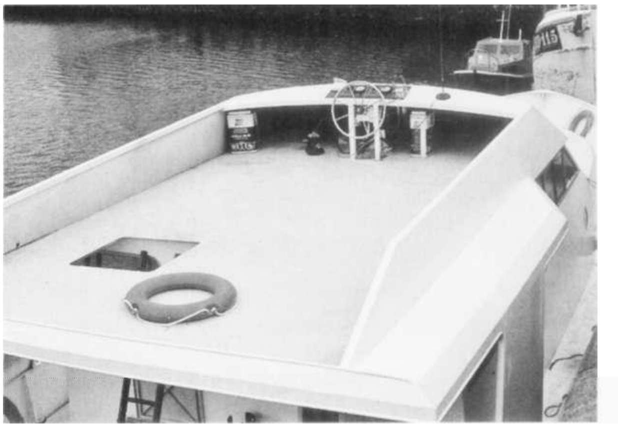
The pilothouse on the 28-foot Spray K*I*S*S *has reverse-sloping windows up forward, and while they may not be to everyone's taste, they do have many advantages, two of which are lack of glare and reflection and absence of moisture in light rain conditions.*

Conversely, a poorly designed appendage can totally destroy what you have set out to achieve.

One decision you'll need to make is whether you prefer forward- or reverse-sloping windows. Most fishing boats and workboats have reverse-sloping windows up forward; there is a good reason for this. When steering into the sun and under other difficult conditions, reverse-facing windows give you the best view. When the rain is light, the overhang at the top of the reverse-sloping windows will keep the windows clear. Reverse windows are practical, but their appearance is not to everyone's taste. Regular forward-sloping windows have a racier appearance and do enhance

ADDING A FLYBRIDGE

The main thing to consider when building a flybridge on any vessel is weight: keep it light. This structure is always high above the waterline, where weight is most undesirable. If you plan one of these items on your boat, be sure that the cabintop doesn't have excessive camber—usually the same camber as the decks is acceptable. No matter what material you used to build your hull, deck, and superstructure, you can use aluminum or fiberglass for the construction of the flybridge. Don't make the flybridge so large as to attract too many passengers. Keep in mind the stability of the vessel under all conditions. Some restriction on the number of seats available will help in this regard.



flybridge decks need less camber than regular cabintops. Note our favorite trim angle, the beveled edge of the overhang.

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the appearance of your boat. For the best vision where you need it most, keep the slope of these windows to a reasonable angle; an extreme angle will cause vision problems.

Building a pilothouse follows a procedure similar to that used to build your regular cabin structure. You must make sure that supports of adequate proportions are placed between the generous-sized windows often associated with this structure. Additional strength by way of side framing may be required, and the windows should be divided up into reasonably sized areas. If your boat is capable of offshore work, then you should make provision for shuttering that could be fitted in the event of one or more of the windows being broken. In order to keep the weight of these rarely used storm covers to manageable proportions, you could consider building them of fiberglass sandwich, fiberglass-covered plywood, or aluminum.

Hatches, Companionways, Portlights, and Doors

If your vessel was designed for offshore use, your plans should indicate the size and location of the various hatches. If you're the builder, the details of strength and suitability will lie in your hands. In the interests of safety, all hatches and companionways are best located on the centerline of the vessel. This is especially important for passage-making vessels. In the event of a knockdown, an open hatch on or off the centerline can admit tons of water before it can be closed.

You should take some time in deciding where and when to fit hatches. Before you start making holes in your decks, you need to have a firm idea as to the exact layout of your accommodation. You can simply plate the entire decks and superstructure, leaving the main hatchway available for access, and lay out your hatches at a later stage. Always keep in mind, however, that these areas need to be carefully planned and strongly constructed, especially in long-distance sailboats and power cruisers. The hatches that cover the openings in your boat may be called upon to withstand tons of water being dumped on the deck. Don't treat them lightly; they need to be as strong as the hull.

About the only places in which a steel boat can leak are around the hatches and other openings. It's important to construct and fit these hatches so that they are absolutely watertight. Strong hinges and closing devices are a must. There are many cases where boats have been seriously damaged and lost through the fitting of inferior hatches. Combining safety with livability, it's best to fit hatches with hinges on both the forward and the after edges.

Ready-made hatches can add a professional touch to any deck arrangement.

Commercially Made Hatches

Deciding whether you will make your own hatches or use commercially made ones may be a matter of economics. Careful shopping can often reduce the prices to an acceptable level. Professionally manufactured hatches may add a nice finishing touch to your otherwise self-built boat. Most commercially made hatches will be manufactured from marine-grade aluminum.

Unless you have your decks and superstructure built out of the same material as the hatches, you'll need to isolate the hatches from the metal decks. A good commercially made hatch will have a precision-cast body of high-tensile alloy that will not corrode in the harsh marine environment. Tinted glazing is preferred, and it must be capable of taking the weight of more than one person and able to withstand the force of a breaking wave without deforming or breaking. Larger hatches should have three hinges that have been cast as part of the body of the hatch. To ensure watertightness under adverse conditions, a hatch that uses a neoprene O-ring seal is preferable to one that uses soft rubber strips. The neoprene is far superior to the spongy type of rubber seal and it will not deteriorate as quickly; also the O-ring neoprene seals are more resistant to sunlight.

Making Your Own Hatches

If you decide to build your own hatches, you can save a some money. It may be possible to construct them from materials you would otherwise throw away. We recommend that you build your hatches of steel, aluminum, or fiberglass. Timber and plywood hatches require considerable maintenance and, if of insufficient strength, offer a weak link in the security of your boat, so if you choose timber, make them strong. On the other hand, timber hatches and skylights can give a metal boat a touch of warmth, so if you're prepared for additional work, both during and after installation, then timber hatches may be worth considering.

Metal deck hatches can be built easily with inner and outer coamings. You can weld the coamings directly to the deck, making sure you've installed either deck beams or intercostals (or both) to reinforce the deck plating from below. You can install the reinforcing beams from underneath after you've cut the aperture for the hatchway.

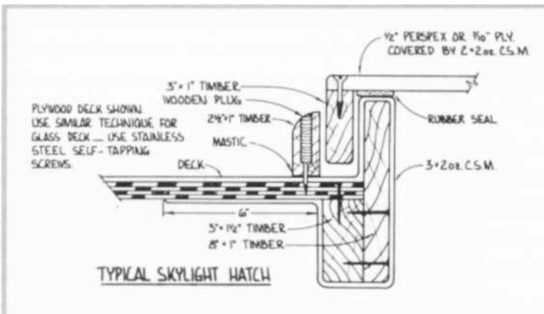
Metal Hatches

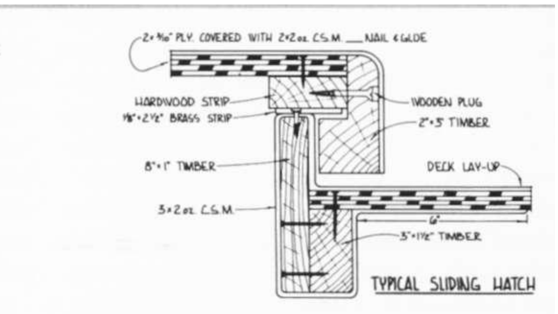
Obviously, it's best to construct the hatches from the same material as the decks and superstructure. You're more likely to have these materials on hand, and there will be no additional corrosion problems caused by mismatched materials. Arranging rounded corners on your hatches shouldn't present you with any problems as all metals are capable of being formed into, say, a 3-inch (75 mm) radius. If you build your own hatches, some of the money you save can be invested in extra-thick acrylic-sheet glazing. Make sure it's set in a suitable sealant and bolted in place with an adequate number of fastenings.

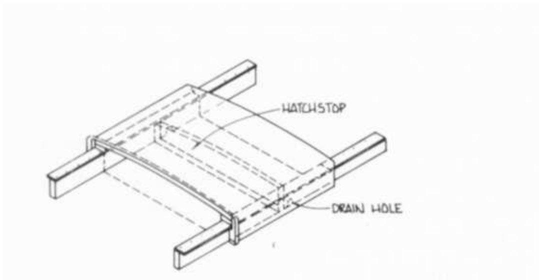
Metal hatches can be built with inner and outer coamings; this arrangement is like a box made with a fitted lid. The inner box that acts as the coaming can be welded directly to the deck around the cutout you've created in the deck or cabintop. The height of the inner coaming can be from 2 to 6 inches (50 to 150 mm), and higher in larger vessels. The hatch top can have sides of 2 to 3 inches (50 to 75 mm). The top will look best if it's cambered similar to the line of the deck. This will look more professional, but it's harder to build, especially if you plan to have acrylic, Lexan, or similar material included in the top of the hatch.

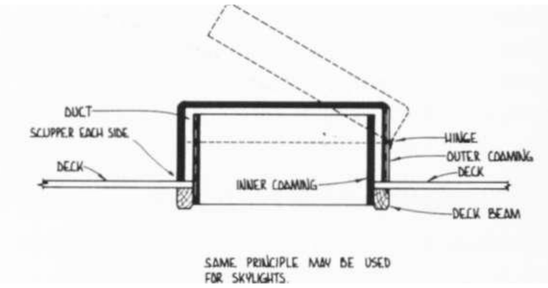
Hinges for metal hatches are simple and easy to construct. They are basically one set of square tangs welded on the hatch cover to face a set of lugs welded at a 90-degree angle from the deck. A suitably sized rod, usually 3/8- to Winch (10 to 20 mm), depending on the size of the vessel and the hatch in question, is inserted through the tangs and lugs and the hatch cover will pivot on the rod. The rod will need a right-angle bend, a nut, or some similar stopper at one end, and a removable retaining device at the other end. If you install hinges on both the forward and after edges of the hatch, it will open either way. At sea, you should always have the hinges on the forward side, but in port or sheltered waters it may be useful to be able to open the hatch in more than one direction. On our current powerboat we have a hatch in the pilothouse top that can open straight up or in any one of four directions—a wonderful arrangement when one is seeking relief from the heat and needs to catch some breeze.

Any one of a variety of locking devices can be arranged to work with a metal hatch. In serious offshore cruisers, both sail and power, it's im-









LEAK PROOF HATCH

These *plywood hatches can be used on timber or plywood decks and cabins, or adapted for use with a metal superstructure.*

portant that the hatch can be screwed down tight to prevent pressurized seawater from forcing its way into the interior of the vessel.

The top of the inner coaming will need to be fitted with a sealing strip, as with other types of hatches. The round neoprene O-shaped material is the most long lasting and, properly installed, gives a superior seal. A proper hatch should have a separate raised coaming of sufficient height placed ahead of it and on the two sides of it, to deflect the spray and rainwater streaming across the decks and/or cabintop. Don't underestimate the power of water and its ability to force its way into any weak areas of your deck openings.

Wooden Hatches

Wooden hatches are relatively easy to construct but a perfect fit will take some woodworking skills. The best way to build these hatches is to build two boxes, one being the inner coaming and the other, the hatch itself. Obviously, one box will fit neatly over the other. The inner box should be made of 2-inch-thick (50 mm) hardwood, and should be 4 to 9 inches (100 to 230 mm) in height. Usually, the larger the vessel, the higher the coaming. This box will be equal in size to the inner dimensions of the hatch opening. The minimum size to allow access by the average person is 20 inches (508 mm) square; however, you should decide what size hatches are most appropriate for you and likely crew members.

It's important the upper edge of this inner box (coaming) is perfectly square and level, as this is the edge that will contact the sealing material of the hatch itself. When you have constructed this basic square box for the inner coaming, you can cut a hole in the deck or cabintop to match the inner dimensions of the box. Next, add reinforcing intercostal and other beams underneath, around the perimeter of the hatchway.

Next, build the box that will be the hatch that will fit over the coaming. The hatch can be built out of 1 1 1/2 inch (35 mm) timber, and 3 inches

(75 mm) high is about right. This hatch will fit snugly around the coaming but will have sufficient clearance to allow the completed hinged hatch to be opened and closed. So far, you have no top to your hatch. You can use 3/4 inch (20 mm) marine-grade plywood for the top, and screw and glue it to the frame. For a fancy finish you can glue and temporarily staple 1/-inch (3 mm) mahogany or teak-faced plywood to the top of the hatch. In any case, the edges of the plywood top will need to have an outer timber strip to protect them.

You can have a Lexan or Plexiglas top instead of plywood, and you can have a combination of glazing and plywood for the top simply by fitting the ply top first, and then cutting out for the required amount of glazing. The glazed area should be of 1/2-inch Lexan or Plexiglas. When buying your glazing material, check the telephone directory and try to buy scrap material rather than specifying cut-to-size, for which you will pay a premium price.

You will need to take some special precautions when working with the plastic glazing fitted to your hatch tops and portlights. The holes you drill in the plastic must be slightly oversized. You must allow for the different expansion and contraction rate, as opposed to the timber framing. You will most likely use tinted plastic, and this will expand in hot weather; if the bolt holes or screw holes are too snug, the plastic will crack and need to be replaced. Usually, the next size up from the screw size is about right for the hole. The safest type of screw is round headed with a flat surface on the bottom of the head where it meets the plastic; self-tapping stainless steel screws are ideal. Fancy screws, such as hex-headed, sheet-metal, stainless steel screws will give you a good looking and strong fastener. Sheet-metal screws have larger threads than woodworking screws and therefore provide additional fastening surface.

The plastic should be bedded against the timber with as good a grade of silicone sealant as you can find. A small amount of the silicone sealant in each hole prior to screwing the glazing in place will ensure that the oversized holes remain watertight.

Hinges are fitted to the forward area of the outer coaming so that the hatch is aft-opening. The hinges should be heavy-duty and made of stainless steel or other noncorrosive metal. To secure the hatch from below, a number of catches and locking devices are available. One of the best is the type with screw-down devices, so you can dog the hatch down firmly onto its gaskets.

When fitting the wooden hatch, assemble it completely with gaskets and then lower it into position. The best way to make the fit between the coaming and the deck or cabintop is to first make sure the whole assembly is set up level. Next trace the shape of the cut required, allowing the coaming to make a good fit with the deck or cabintop. Now you can bolt or screw the coaming in place through the metal deck, working from underneath the deck. Make sure you bed the coaming in a suitable sealant.

Custom hatches can be made even more suitable for the rigors of cruising with a few simple additions. You can add an extra coaming on the deck or cabintop immediately adjacent to the hatch. This coaming should surround the forward edge and sides of the hatchway. It will be slightly lower than the entire hatch assembly and fit so as not to interfere with the operation of the hatch. The extra coaming will help keep water away from the hatch. The top of this extra coaming could be timber or metal. If you make it of timber, round off the top to give it the best appearance. In all cases, the sides can have holes in their bottom edges to allow for drainage.

Another improvement to any hatch is to install eyebolts close to either side of the hatch assembly. You can use them in extreme weather conditions to lash the hatch down even more securely. The eyes need to be close to the hatch so you don't stub your toes. Wood slats running fore and aft across the top of the hatch will strengthen Plexiglas tops and can improve the look of the hatch at the same time. These 1 by 1 inch (25 by 25 mm) timber slats can be screwed into the outer frame and then screwed to the acrylic from underneath. The slats will take some of the force and distribute the weight of persons standing on the hatch, or the weight of a heavy breaking wave. You can also make canvas covers for all of the hatches. Not only will you need these in hot climates, but they can also be a safety factor when included as part of the lashing-down arrangement.

Access Hatches

Access hatches, as opposed to hatches used only for ventilation, must be of a size sufficient to allow even a large person to enter and exit the boat in an emergency. The minimum size for an average person, as we've already seen, is 20 inches (508 mm) square, but don't make hatches unnecessarily large. They must be able to withstand all that the sea can offer. You should be able to open all your hatches from both outside and inside the vessel, and you should be able to lock them to deter unauthorized intruders. Hatches in accommodation areas should be built with some form of glazing to admit light and add a spacious feeling to the interior.

Companionway Hatches

The main access hatchway can be in the form of a sliding hatch, a hinged hatch, or a quadrant companionway type hatch. Sliding hatches should not be simply a sheet of plastic running in the simplest of aluminum tracks, even though this is sometimes seen on production powerboats. Build, or buy and install, a proper seagoing hatch as your main entry and exit point.

The companionway hatch consists of two main elements: the runners, which fit on the cabintop, and the hatch, which slides on or in the runners. The runners and the hatch may be constructed of timber or metal. If timber runners are used, you'll need 3-inch-high by 2-inch-wide (75 by 50 mm) timber. The timber runners could be deeper, and could be bolted directly to a set of intercostal beams situated around the perimeter of the hatchway. The runners will need to extend beyond the opening; the length is twice the hatch length plus 3 inches (75 mm). Where they extend over the cabintop, they'll need to be screwed from inside, through to the timber.

The tops of the runners are faced with heavy (say, 1/4 by 2 inch, or 6 by 50 mm) brass strips that act as runners for the hatch top. The brass strips are set in silicone and screwed to the runners with fiathead screws set flush with the surface. When it's properly set up, the hatch must run smoothly on the brass slider.

The sliding hatch is another box, with the frame built of 1 1/2 by 2 inch (35 by 50 mm) hardwood. The corners can be half-jointed. Considerable care is needed to ensure that the frame is a true rectangle and sits perfectly flat on the runners. Around this inner frame, an outer frame is constructed from l1/2 by 4 inch (35 by 100 mm) hardwood. The outer frame is glued and screwed to the inner frame, with the tops of both frames flush and the outer 4-inch-deep (100 mm) frame acting as a guide to allow the inner frame to slide on the runners. The whole arrangement must slide smoothly. A hatch that jams is in no way desirable aboard any boat. Now you need an arrangement to keep the hatch on the runners, and you can do this by gluing and screwing a 1/2 by *1/2* inch (12 by 12 mm) cleat inside the outer frame 1/8 inch (3 mm) underneath the brass runner. Now the hatch has to be slid onto the runners from the front.

The forward and after ends of the hatch are finished off with hardwood plates. The companionway end can have a handle or grip built into the top. The bottom of this facing board will need to be shaped to clear the cambered cabintop as it glides (we hope) forward to its fully open position.

If you have the recommended garage, then the front should be large enough to cover the aft end of this arrangement. Incidentally, the garage houses the hatch when it's open. The garage is particularly important in forward-facing sliding hatches, as it helps to divert water away from the open companionway. It also partly provides a neat cover for the runners and the open hatch, eliminating one area where lines can snag and toes can be stubbed.

The front facing of the hatch, with the handgrip built into the top, will also need to accommodate the hasp part of your hasp-and-staple locking arrangement. The top of the hatch can be finished with 1/8 inch (3 mm) teak plywood and the whole structure coated with epoxy and light fiberglass cloth for a long life.

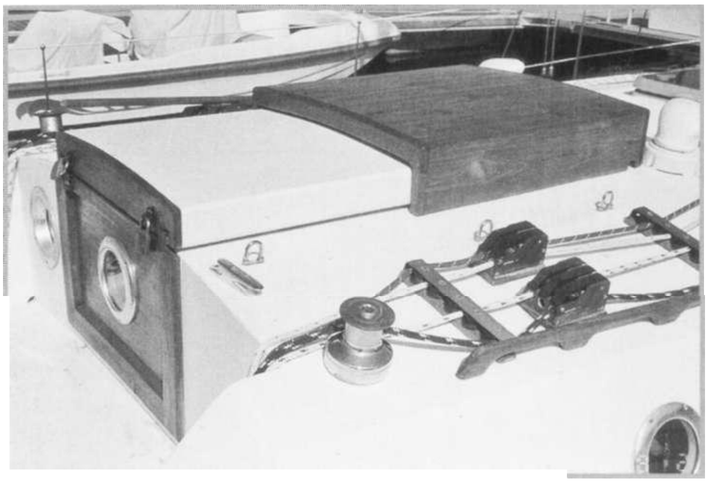
The top of the hatch can be three layers of Winch (6 mm) plywood, and if you've taken our advice and made the top match the cabintop camber, you'll find that the plywood will laminate into a strong and durable top. A trim strip will be required for the outer edges of the plywood top to seal them from the elements.

When you're building a timber or plywood sliding hatch above a metal cabin, the hatch opening can be finished off inside with a timber trim strip of suitable width. You'll also need washboards (vertical hatchboards or dropboards) that will fit in preinstalled metal channels to complete the closure of the main-access companionway.

It's worth noting here that any timber you attach to your steel hull or superstructure should be given at least three coats of epoxy resin, which will go a long way toward stabilizing and protecting the timber. All timber runners, hatch coamings, and the like must be set in silicone before they are either screwed or bolted in position. Space the screws or bolts at 3-inch (75 mm) intervals.

Deck Prisms

Another form of underused light-admitting device is the deck prism. These wonderful devices admit much more light than their size would indicate, and they can be installed to be absolutely watertight and secure from the ravages of man and the sea. Check with your local hatch manufacturer and other equipment suppliers to see what they have to offer in this area. If you fit prisms, make sure your crew is well protected from contact with the sharp inside edges—but do not let this last statement put you off; deck prisms are great for admittiting the most light with the minimum of hassle.



To soften the "garage" and steel exterior, John McDermott added this timber companionway door to his Spray 33.

Portlights and Windows

Portlights and windows can open or be fixed, but it's a fact that the opening variety, no matter how well constructed and maintained, will always be a source of leaks and worry for the crew. It's often desirable to have one or more windows or ports that can be opened; however, it's wise to keep their number to an absolute minimum. The plans for your boat will no doubt give you some indication of the size and location of the ports and windows. Our advice is to use only fixed portlights and rely on opening hatches to provide adequate ventilation.

If you're planning to use opening ports, they should be professionally made and of the highest quality you can afford. Most commercial ports are made from marine-grade aluminum, so if your boat is built of steel or copper-nickel you'll need to isolate the aluminum from the other metal. Neoprene is commonly used for this purpose. Don't forget to use sleeves in the boltholes where the ports are bolted to the hull or superstructure. Occasionally, you'll find steel-framed professionally made ports, but they're generally made for very large vessels so they may not be suitable for your boat.

There are many ways in which the windows can be fitted. One popular way is to set the win-

Recessed ports and windows always add a professional finish to any metal hull; these are fitted to a Roberts 64 built in Canada.

dows back into the cabin sides or into the hull. To achieve the latter result, the window aperture is framed with an inward-facing, L-angle, shaped flange. The bottom of the L is where the window or fixed portlight will be set in sealant and bolted in place.

As you will realize, this is a more complicated procedure than simply bolting the window into a hull or cabinside cutout; however, the results are worth the extra effort. Set-in ports and windows give a vessel that extra touch of quality that not only enhances pride of ownership, but one day will return dividends in a better resale value. Forward-facing wheelhouse windows that will be fitted with windshield wipers will need to be glazed with toughened glass instead of the usual acrylic favored for many other boat windows and ports.

If it's well made, the simplest portlight or window can have an appearance that belies its low cost. The design and method of installation is simple. You cut a hole 1 to 1 1/2 inches (25 to 35 mm) smaller than the overall size of your port or window and fit and bolt a larger piece of Plexiglas or similar plastic over the aperture. The glazing is set in silicone, the holes for the bolts are drilled slightly oversized, and the corners of the hole for the portlight, and the covering Plexiglas, are all radiuses.

You can use clear silicone, but it's preferable to use silicone that matches the color of the area of the boat into which the port or window is being installed. If the bolts have hexagonal heads, and you line up the slots in the heads, you'll improve the appearance of the glazed area. If the ports or windows are located in a high-traffic area, such as adjacent to the side decks, then you should have bolt heads that fit flush with the glazing and thus avoid scratching crew members who brush by the window. Be careful when making countersunk holes to allow bolts to fit flush. Acrylic can be induced to crack if it's handled too roughly during the shaping and assembly stage.

Make sure the windows don't have an overly large area without sufficient support in the underlying cabin or wheelhouse side. Plexiglas and similar acrylic materials come with a paper protective covering; never remove the bulk of this until the boat is completed and ready for launching. You'll need to remove a strip of the paper, of course, after you've drilled for the bolts but before you install the window or portlight. The thickness of the glazing will be between 3/8 and 3/4 inch (10 and 20 mm), depending on the size and area of the aperture.

For most windows and ports, you can use Plexiglas or the harder and more scratch-resistant Lexan. You can dress up the outer edges of these bolt-on windows by using timber, stainless steel, or other suitable metal frames that can be cut to, say, 1 or 2 inches (25 to 50 mm) wide and bolted in place at the same time as the window is installed. If you use metal, it can act as an outer washer for the fastenings and will generally enhance the appearance of the windows and ports on your boat.

With powerboats, where the boat is more or less always in an upright position, and where the boat is not designed or built for extended ocean voyaging, you can be more liberal with the expanse of glazed area. Most powerboats have at least one forward-facing opening window adjacent to the inside helm position. This opening window can admit copious quantities of fresh air, and when it's open it gives you better vision ahead in fog or poor visibility.

Even in powerboats, we find that opening windows, usually of the sliding variety, are a source of problems. Sooner rather than later, the rubber or other material used in the bottom track for the glass will deteriorate and allow water to enter. In some steel powerboats, it's common practice to have the large side windows fitted without any provision for insulation. Perhaps the designers and builders feel that the expanse of glass takes up so much of the available area that it is not worth insulating the remainder. The problem is that when plywood lining is attached directly to the steel cabin side, the resulting condensation can cause problems. In one case, it was natural (though wrong) to blame a leaky window for causing discoloration of the teak plywood lining. It took some time before the culprit was diagnosed as lack of insulation in the cabin side, which caused condensation. It would have been too expensive to remedy the situation, but luckily it was discovered that a dehumidifier would solve the problem. Lesson: Always insulate all areas of your accommodation.

Outer Doors

As a rule, outer doors are seen in powerboats, especially trawlers. If you wish to have a door opening in the side of the accommodation, usually near the helm location, make sure it's properly designed, fitted, and suitable for marine use. Marine doors are usually of a more robust construction than sliding windows and are therefore easier to maintain and keep watertight.

Side doors in a trawler yacht's cabin can be built of timber and may be arranged to slide; or, if you have a very large yacht and wide side decks, then it may be possible to have the door hinged at the forward edge, or perhaps open inward. On smaller boats, a half-height, side-access door adjacent to the inside helm position may be found useful. All doors, especially sliders that are either outside or inside the accommodation, should have a means to secure them in the open position, as well as when closed.

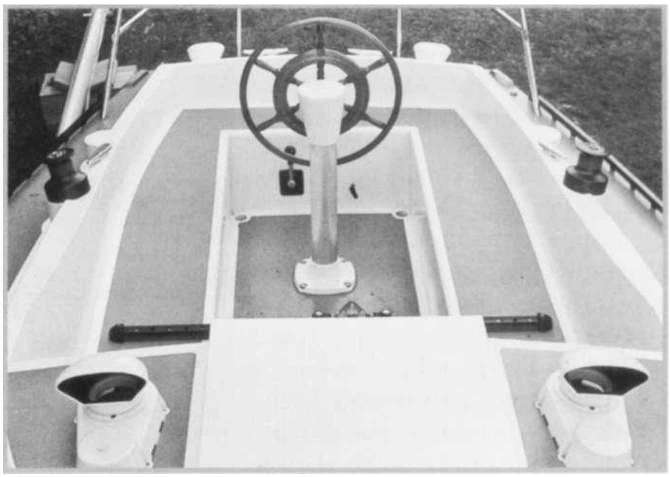
A recent report told of a boatowner receiving severe injuries to his neck from an unsecured aluminum sliding door. Patio-style aluminum doors at the aft end of a powerboat's main saloon? *Ugh! The* sliding variety, especially, are famous for lopping off fingers. And the large glass area is vulnerable to being broken in a variety of ways.

If your powerboat is of the aft-cockpit variety, then you'll most likely have a metal aft bulkhead in which you can fit a pair of timber doors. The top one-third of the doors can be glazed, and you'll have all the light you need. As the cockpit and after deck is usually well protected, the timber doors will need little maintenance.

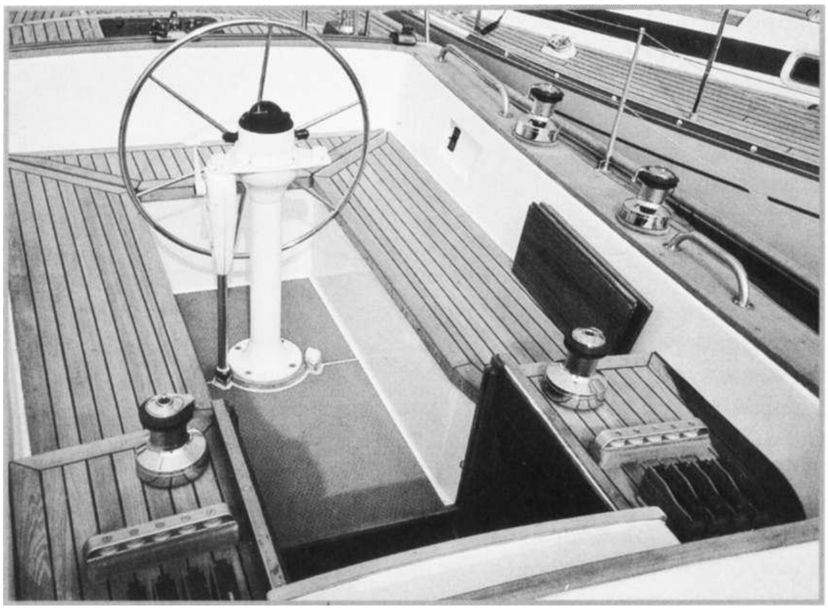
On a similar subject, you may wish to lock some of the interior doors; this may slow down an intruder.

COCKPITS

Not all boats have cockpits but most sailboats have, or should have this feature. Most of us prefer the security, real or perceived, offered by a well-designed, self-draining cockpit. They work particularly well when combined with protective coamings and comfortable seating.



This neat Roberts 34 cockpit was built in Sweden about 30 years ago.



This teak-trimmed cockpit is installed in a radius-chine Roberts 432 that sold in the UK for a handsome price.

The dimensions of this arrangement are most important and can influence the safety and comfort of the boat in many ways. It's desirable, but not always possible, to have the cockpit seats measure 6 feet 6 inches (2 m) in length to allow a person to lie full-length. The width of the cockpit is best arranged so a person can rest one or both feet on the seat opposite; this usually results in a well that is 2 feet 3 inches (686 mm) wide. The depth is best at 1 foot 6 inches (457 mm). Seats should be between 1 foot 3 inches (381 mm) and 1 foot 6 inches (457 mm) wide. For comfort behind your knees, the inboard edge—the intersection of cockpit side and the forward edge of seat—of the cockpit seat should be rounded, radiused, or beveled.

The height of the seat back (usually part of the coaming) will vary depending on the design; however, about 2 feet (610 mm) seems to work out well for most people; the back should lean backward about 5 degrees to be comfortable when sitting in a level cockit. All cockpits should be self-draining, with two separate outlets of generous size, a minimum of 2 inches (50 mm) in diameter. The cockpit drains should be fitted with seacocks that can be closed when required. Finally, you should have a reasonable view forward when you're seated in the cockpit. This is easier said than achieved, especially if there is a pilothouse ahead of your cockpit.

The choice between center cockpit and aft cockpit is usually governed by your choice of interior layout. This choice has become blurred with the advent of staterooms fitted beneath and around an aft cockpit.

This attractive cockpit is devoid of timber trim, but it can be dressed up with cushions and still retain its maintenance-free concept.

The steel deck on this Roberts 64 is now ready to receive a laid wooden deck or one of many other alternative treatments.

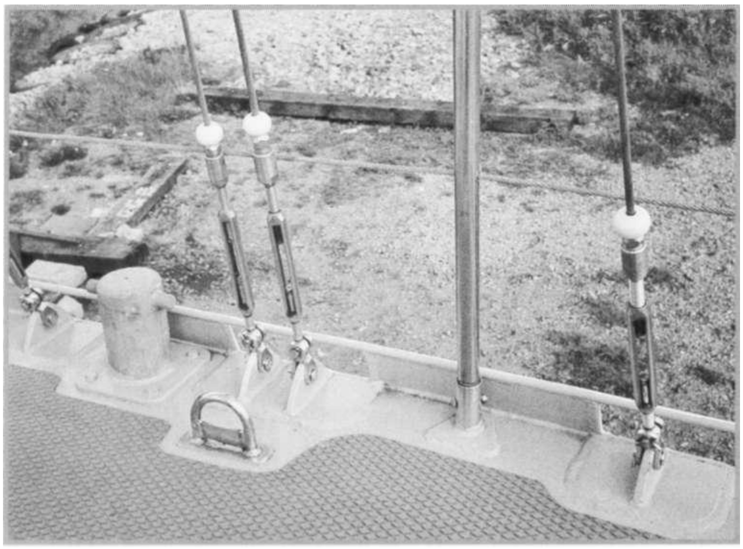
Metal cockpits can be framed up using L-angle or flat bar, depending on the size of the vessel. Boats under, say, 30 feet (9.14 m) can use flat bar, and larger boats can use L-angle placed flange-down. Provided the transverse framing is spaced the same as the hull's, a minimum of fore-and-aft reinforcing should be required. Most boats today have cockpit cushions, so these need to be considered when laying out the area. Self-draining arrangements for the well are obvious, but don't forget to drain the seats. Wet seats and continuously wet cushions make for very uncomfortable sitting, so consider how you can best drain these areas. A teak grating in the well adds a nice finishing touch to any cockpit.

DECK COVERINGS

Your metal deck will need some form of treatment to provide a nonslip footing as you move about the boat. The least expensive treatment is to apply a special paint that contains grit. Many metal boats use this paint-grit combination, and provided it's installed in a proper manner it can look attractive and it does work well in practice. When you're installing a painted nonskid surface, you should leave small borders around various fittings and alongside the cabin and inside the bulwark and so forth—places that do not have grit added. Be careful how you lay out these ungritted areas, though, as you don't want to leave skid-inducing shiny spaces in high-traffic areas. If the ungritted areas are no more than 1 1/4 inches (320 mm) wide around any feature, you shouldn't have a problem. You can always fill in any problem spaces with gritted paint.

The next step up in cost and appearance is to use a deck covering like Treadmaster or a similar product. These coverings are composite materials formed in patterned sheets suitable tor gluing to your deck. When laying out this covering, you should use a similar pattern as suggested for painting decks with gritted material. Available in a range of attractive colors, these products are bonded to your deck with special glue.

The diamond pattern on some of these sheet products can be hard on your bottom and other



Reinforced chainplates and deck fittings. Note that the Treadmaster deck covering is kept clear of the fittings to allow the free flow of water off the decks.

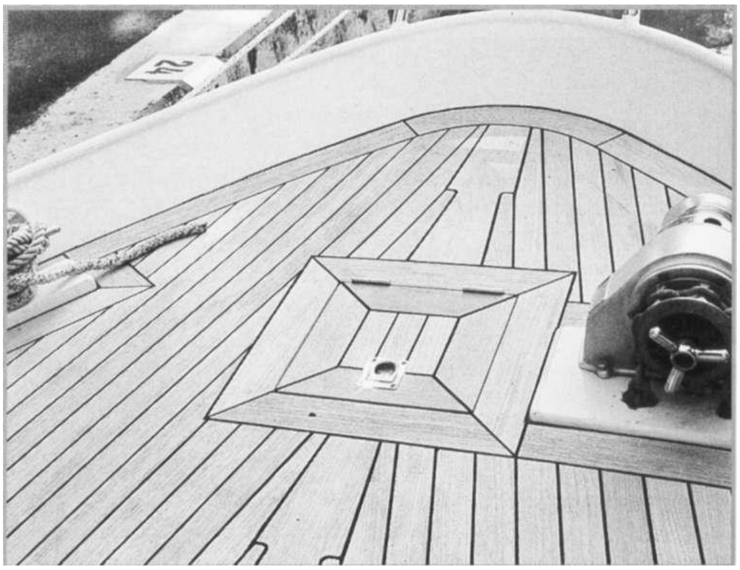
areas that may come into contact with the deck. So don't use it on cockpit seats or similar locations. There are alternative, less harsh patterns that can be used where a user-friendly, nonslip surface is required.

Personally I do not favor timber-laid decks on metal boats. If you plan to keep your boat longer than, say, 10 years, then you can expect have some problems if you install a laid timber deck on a steel boat. Problems with laid timber decks are not restricted to metal boats; many fiberglass boats that are manufactured by the most reputable companies also have problems with the laid timber decks once the boat has reached a certain age. The main problems are caused by the breakdown in the caulking materials. The caulking will develop hairline cracks after a few years and this allows water to seep through to the metal decks below. If you are installing or renovating a teak deck, under no circumstances stint on the quality of this caulking material.

Recently a simulated teak deck material has become available and this plastic-based (for want of a better description) material will be worth your investigation. It closely resembles teak and is laid in a similar manner, so check out this material before you consider a wooden deck.

However, some of you will settle for nothing but a laid wood deck. You may be surprised to learn that there are species of timber other than teak that are suitable for laid-plank decks. In Australia, beech is widely used, and in the United States quarter-sawn Douglas fir has been used for the same purpose. Nonetheless, teak is the premier material and the one you are most likely to be using to finish the decks of your metal boat in style.

After you decide that a laid deck is for you,



This 1-inch (25 mm) teak deck has been in place for 15 years; some recaulking has probably been necessary. Note the low bulwark, ably supported by a pipe caprail.

the next step is to determine if you're going to have a "wannabe" teak deck or the real thing. The "wannabe" type is usually 1/2 inch (12 mm) or less thick, and in most cases it will not do justice to your boat or to the craftsmanship needed to install any laid deck. A "proper" laid deck should have planks of at least 5/8 inch (15 mm) and preferably 3/4 inch (20 mm) minimum thickness.

There are many ways to install this deck on a metal boat but all will involve setting the planks in some form of bedding compound. Again, we can take a lead from Dutch builders who have been successfully installing laid decks on steel and other metal boats for a long time. The outer planks will need to be fastened to the steel deck itself. The inner planks may simply be set in the bedding compound and caulked.

The regular planks should be about 1 3/4 inches (42 mm) in width. The outer and inner covering boards, king plank, and other featured planks around hatches and vents will be wider, usually 4 to 6 inches (100 to 150 mm), depending on the size of the boat and the way the deck is installed. The outer covering board is a misnomer in this case, as there should be a space between the edge of the teak covering board and the edge of the deck to create a channel for water to run alongside the outer teak plank and on out through the scuppers.

The bulk of the fore-and-aft planking can be laid in several ways. It can follow the outer shape of the hull, generally known as the "swept" style of fore-and-aft planking, or it can follow the line of the cabin sides, or it can split the difference. The main effect of these various methods is the way the planks need to be "nibbed" into the outer and inner covering boards and king plank. It's also possible to lay the deck in a herringbone pattern; this has been done on more than one of our designs, but we prefer longitudinal planking that splits the difference. (Naturally, this is the most expensive form of planking!)

The deck and cabin of a very attractively finished Roberts 434 built in the UK. Note the recessed ports.

ALTERNATIVE DECKS AND SUPERSTRUCTURES

Although there are arguments for building a boat using all steel, all aluminum, and perhaps all copper-nickel, there are many reasons why some of you may prefer to take a different approach. In the case of copper-nickel, as this material is much more expensive than either steel or aluminum, it would make sense to have the hull built from copper-nickel; the hull is where the material is most beneficial; the decks and superstructure could then be built from an alternative, less-expensive material. If your metalworking skills are limited, and you have more experience with working in timber, you may consider a timber deck and superstructure. As you can see, there are a considerable number of options and you have to weigh up the benefits and disadvantages for yourself.

Plywood and Timber Decks and Superstructure

A good reason to install a plywood deck and superstructure on a small steel boat is to keep weight down. If you take the timber-and-plywood deck option, you'll need to select a point

Teak decks require a lot of maintenance; with any luck, your partner will be as willing to assist with the more onerous tasks as mine is.

where you make the transition from metal to timber. The choices are to have the hull built in metal and install a *margin plate* welded to the inside or sheerline of the hull, where the deck will join the hull. The margin plate will take the place of, and be installed in the same location as, the deck stringer in an all-metal boat. Another alternative is to have the hull and complete decks built from metal and include an up-stand in metal to accept the timber superstructure, located all around the inner edge where the cabin sides will be installed. In both cases, the timber and/or plywood would overlap the metal so that surface water or other moisture would be less likely to get between the metal and timber to cause corrosion.

If you're planning a laid teak deck, it may influence your decision. A teak deck is much easier to install over a timber and plywood deck than it is over a metal one. There's no doubt that a timber deck and superstructure is a beautiful sight from both without and within. You pay a price, though, at least for the beauty of the exterior. The maintenance requirements of external timber and plywood will be far greater than if the items were constructed from metal. This applies not only to large items, as in a pilothouse or cabin structure, but extends to timber hatches, handrails, caprails, and rubbing strips. These items, when built in timber and finished "natural," do improve the appearance of any boat, but the maintenance requirements can be horrific.

After you've installed either the metal margin plate to the hull, or the metal up-stand to the inner edge of the metal decks, then you should install a timber carlin to allow you to carry on the remainder of the construction in timber. You should rebate this timber in such a way as to discourage any water from becoming trapped in the joint and later causing rot in the timber. It's imperative that you make a watertight join between the timber and the metal.

Deck beams may be of timber or metal. In the case of a metal deck, then L- or T-metal deck beams will be used; however, in the case of an all-timber-and-plywood deck and superstructure, you may choose either metal or timber beams. If you use metal beams with a plywood deck, make sure you place the flange upward. This is opposite to what you would do for metal decks. The flange will provide a ground and will allow you to screw the plywood to the beams from underneath. Timber beams can be laminated or sawn, but laminated beams are recommended.

This is a good time to mention that you should use epoxy-based adhesives throughout the construction of any plywood decks and/or superstructure. Where the plywood is attached to the metal margin plate or up-stand, a suitable bedding compound will be used rather than an epoxy adhesive. An epoxy system such as the West System should be used to saturate all of the timber and plywood parts used to build your decks and superstructure, but not on teak decks.

It's usually preferable to laminate the decks and cabintops from more than one layer of plywood. If your deck calls for Winch (12 mm) plywood, then use two layers of Winch (6 mm) each. If the recommended thickness is Winch (20 mm) plywood, then use two layers of Winch (10 mm) or, better still, three layers of Winch (6 mm). Use either bronze nails or staples to apply pressure to the glue lines until the adhesive has cured.

If you're installing plywood decks, one labor-saving tip is to paint the underside of the first sheet before you install it. Make sure you don't paint the strips where the plywood will be glued to the beams. Fit the panels first, and, from underneath, mark where the beams will fall and where the plywood rests on the other timber supports. Now mask off those areas on the plywood and paint the rest.

There are several methods of finishing off your plywood decks and cabin structure but no matter how you do it, we recommend that you give the entire area a coat of fiberglass cloth in epoxy resin. Don't use polyester resin for fiberglassing over plywood or timber, always use epoxy resins. The only place for polyester resins is in the building of an all-fiberglass boat.

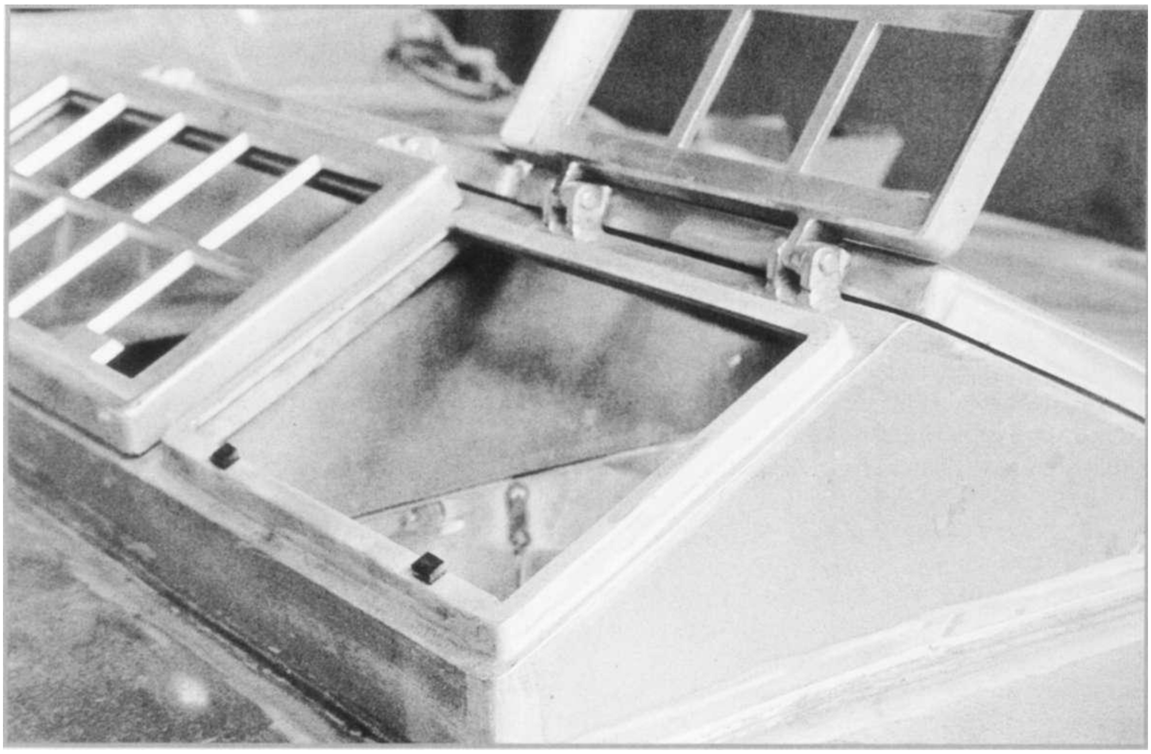
When you're using epoxy resins and adhesives, make sure that you follow all of the safety precautions recommended by the manufacturers. When handling these materials, always wear protective gloves and use protective skin creams. Keep in mind that epoxy stays toxic for several days while it's curing. When you're building timber and plywood decks and superstructures, you'll find the Gougeon brothers' West System book a good source of information. See Appendix 1 for more details.

Aluminum Decks and Superstructure

When you build an aluminum hull, you'll almost certainly install decks and superstructure of the same material. The benefits of installing an aluminum deck and superstructure on any metal boat include less weight up high, where it's detrimental. Aluminum is easier to form into small-radius sections such as those used on the corners of cabins, pilothouse fronts, coamings, and similar areas. A little forethought and a considerable amount of welding can be saved by combining seats to backs and so forth.

The aluminum decks and superstructure are somewhat more removed from the seawater elements than the hull is, and it's easier to avoid some of the electrolytic problems suffered by boats built completely from this material. The practice of installing aluminum decks and superstructures on steel hulls has been well proven over the past 30 to 40 years, so you can consider it an acceptable boatbuilding practice.

Aluminum decks and superstructures fitted to steel or copper-nickel hulls will need to have the different metals isolated from one another to prevent electrolysis. There are a number of methods you can use to achieve this isolation.



This attractive skylight is an example of what can be achieved by a dedicated metalworker.

Transoms can be customized to suit the owner's needs. Boarding from a dinghy was the major concern for the owner of this Euro 1200, which we overcame with transom steps.

The first that comes to mind is to insert a neoprene strip between the two different metals and bolt them together with bolts housed in nylon sleeves and nuts that are isolated with nylon washers.

The superior way to join aluminum and steel is to use the specially manufactured strip that has aluminum on one side and steel on the other. The two metals on this strip are explosively fused together so that when you weld the steel to the steel side and the aluminum to the aluminum side, no contact occurs between the two metals, and the possibility of electrolysis is eliminated, or at least reduced. Careful planning will be required so that the intersection of the two dissimilar metals is located in such an area as to reduce the chance of prolonged contact through salt water.

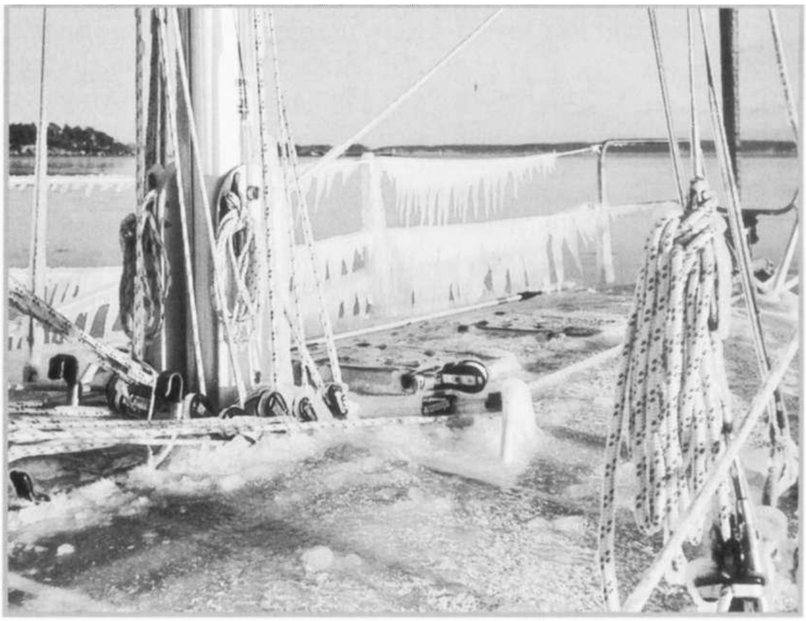
chapter 10

PAINTING A METAL BOAT

COLOR

This subject will probably be the first thing that comes to mind when you, or at least the family, are considering the paint job for your new or used metal boat. Even a simple matter like choosing the colors has its technical side. In my opinion darker hulls look better than white hulls. This may be especially true in powerboats. To my eye a dark blue hull adds "class" to any boat. That's just my opinion, but it's something to consider as you look at various other boats to help you decide on a color scheme for your metal boat.

In metal boats, a darker color for the hull also makes good sense. The darker color will absorb sunlight and drive off both the dew and some internal condensation. If the decks are painted, then you may choose a two-tone scheme of light beige for the larger areas and cream for the trim or unsanded areas. This arrangement will look smart and it will be easy on the eyes. You should never paint decks white, as the reflected light will cause too much glare. Except in the coolest climate, dark-colored decks will be too hot for bare feet and will also make the interior of the cabin unbearably hot.



This Roberts 370 built in Finland shows one reason good protective coatings are essential.

GRITBLASTING AND PRIMING STEEL

If your boat was constructed from raw steel straight from the mill you will need to gritblast the metal before attempting to apply any paint coating. This process is variously referred to as sandblasting and gritblasting. It's the only way you can provide a satisfactory base on which to apply your prime coating and subsequent layers of protective paint. Blasting is necessary to remove all contaminants and corrosion from the surface of the metal; and as this process slightly roughens the surface, it also provides an excellent "tooth" for the paint. For reasons that will become clear, we believe the best way to build a steel boat is to use preshotblasted and primed material, and to build under some form of cover. Nonetheless, some builders do blast their own steel.

The exact roughness of the surface will depend, for the most part, on the particular metal, the type and grade of grit used, and the force with which it's applied during the blasting process. The result is commonly referred to as the anchor pattern, and will vary between 1.5 mils (thousandths of one inch) and 4 mils (0.038 mm and 0.1 mm) in depth. Four thousandths (0.1 mm) is considered a heavy and deep blast, and may be satisfactory for tar-epoxy finishes. For most paints, however, you should aim for a 1 1/2-mil to 3-mil (0.038 to 0.076 mm) anchor pattern. Your paint manufacturer may have special recommendations in this area. Make sure you choose a warm and dry day with low humidity when you are blasting your boat.

For blasting, you'll need a powerful compressor; for instance, one that can deliver something over 350 feet (107 m) per minute would be perfect. You need manpower: two or three people plus yourself would be adequate. There are various specifications for the blasting of steel. For our purposes, near white blast-cleaning will deliver a successful, corrosion-free, and long-lasting paint job. Near white blast-cleaning produces a surface in steel that, when viewed without magnification, is free of all visible oil, grease, dirt, dust, mill scale, rust, and paint. Generally, evenly dispersed, very light shadows, streaks, and discoloration caused by stain of rust, stains of mill scale, and stains of previously applied paints may remain on no more than 5 percent of the surface.

Sand is the least expensive abrasive, but because of its high silica content and the health hazard presented by silica, you may find that your local contractor is not willing to use this material. If you're doing the job yourself, and you wear the correct protective face mask, then blasting one boat with this material should not represent an undue health hazard. It's your responsibility to decide on using sand as opposed to the more expensive alternatives. Sand can't be reused, so you'd need more sand than slag or grit.

Grit is a little more expensive than sand but contains none of the silica that, when used over a period, can cause respiratory and lung problems, among other things. In the United States, these products are marketed as Copper Blast, Copper Slag, Green Diamond, and Garnet. Similar products are available in Britain, Australia, and elsewhere.

Crushed-steel shot is more expensive than either sand or grit, but as it can be reused many times you may consider it to be worth the additional expense. It's formed from crushed iron or steel, and has irregular shapes with very sharp edges. It's one of the better blasting materials.

You'll need to consider matching the type and roughness of the blasted surface with the paint you plan to apply. A surface that's too rough will show through your paint finish, and a surface that's too smooth won't provide a good grip for that most important element in your paint job, the primer.

Many builders have found that it takes a lot of effort to undertake this job, and it saves very little in cost. By the time you hire the equipment, purchase the grit, and arrange for the help needed, it can cost nearly as much as a professional job. You need three people for this operation; one to operate the blasting gun, one to feed the material, and one to apply the primer. If you don't have three people, the job will take much longer. For instance, if the blaster has to feed his own abrasive, he has to remove and replace his bulky helmet each time more grit is needed: a time-wasting exercise.

In the case of steel hulls, the prime coating must be applied immediately after the blasting. This means that the painter has to follow the

Careful masking of the various parts of the boat will play an important part in ending up with a professional-looking paint job.

blaster as closely as is practical. Rust can form in a surprisingly short time; the actual time depends on the weather and humidity prevailing when the blasting takes place. It's usual for the owner or his employee, as opposed to one of the contractor's employees, to undertake the painting. If you control this critical job yourself, you'll be assured of its success. Make sure the paint is being applied to a perfectly clean and dry surface at a minimum temperature of 50°F (10°C). The paint is best applied within 30 minutes of the blasting. That way, as well as avoiding rust, you'll have the extra advantage that the steel should still be warm from the blasting. Finally, 3 to 4 hours is the absolute maximum time lag between blasting and prime coating. This is definitely not a one-person operation.

Estimating the time it takes to blast and prime coat is difficult, given all of the variables involved. However, about 50 square feet (4.65 square meters) per hour seems about average. No grit operator or painter can operate flat-out for extended periods. It's wise to divide the hull, deck, and superstructure into reasonably sized segments; say, quarters on a small- to medium-sized hull, and smaller proportions on larger craft. Keeping the blasting and the painting apart will take some organizing, but you will need to do it to ensure a clean and long-lasting priming job.

When you purchase preblasted and primed steel from a specialist supplier, then these materials have most likely been blasted by a wheel rather than blasted in the regular way This process is most effective in plate of 1/8 inch (3 mm), or 10-gauge, and larger thicknesses, but lighter plates may distort when exposed to wheel "blasting."

Wet blasting involves using water mixed with the grit or sand. This process keeps down dust, but afterward it leaves a great deal of heavy, wet grit or sand to be cleaned up. A rust inhibitor is used in the water, but you have to blow the hull dry and apply the paint before the effects of the inhibitor disappear.

The interior of the hull, under the decks, and inside the superstructure will all need to be gritblasted: a difficult and messy job. Don't forget to have all of the cutouts and openings for windows, ports, and hatches already completed before you gritblast and apply the prime coat. It will probably be best to blast the outside first; that

SPRAYING HOT METAL

This method of applying a protective coating is included here because we're still occasionally asked about its merits for a steel hull. Metal spraying was at one time popular with some steel builders. During the 1970s, when it was most popular, there were many who decried its use on the grounds that if it chipped or otherwise failed, water would creep underneath and cause considerable invisible corrosion problems. Time has proven these critics correct, in fact, and the method is infrequently used today. Another drawback was that the materials used for these coatings were notoriously averse to holding paints as intended. The development of modern epoxy and urethane protective coatings has allowed flame spraying (or metalizing, as it was popularly known) to fade from the scene. In the interests of thoroughness, however, here are the details.

Hot-metal spraying is accomplished by melting either zinc or aluminum metal wire in a special gun that drives it at high speed onto the bare steel in the form of molten droplets. Like a surface prepared for painting, the steel surface must be prepared by gritblasting down to white metal. Without this etched surface, the hot metal spray will either roll off or flake off after cooling.

Many advocates of this method claim a chemical bond forms between the aluminum or zinc and the steel; they claim that the metals are fused together. Actually, the hot metal spray forms a mechanical bond only. It depends on the correct spraying techniques, as well as a gritblasted surface, to maintain its grip on the steel. If you plan to metal-spray your hull, don't use sand as the blasting agent. Commercially manufactured grit is necessary to give the correct key for the metal ization process.

If you use a hot spray involving aluminum or zinc, then you should apply a special wash to the aluminum coating before applying any paints. An example of such a wash is Interlux Viny-Lux Primewash, which is specially formulated to adhere to bare aluminum and is a good primer for the other coats that will follow. If you are considering one of the hot metal spays for your boat, you should seek out the latest information on the subject. My advice is stick to the well-proven regular painting procedures for metal hulls.

way, you won't have any worry about grit coming through openings into an already prime-coated hull interior.

We have now come full circle. We've considered the alternatives and you can see that my advice to use preshotblasted and primed material makes sense. Even if you are building in the open, depending on the climate and the amount of care you take in covering the hull, you may find that the preblasted and primed materials are worth the extra cost and effort. Even so, covering your hull during nonwork periods will pay off.

If you use pre-prime-coated steel, then you'll need to clean up only in the area of the welds. You'll recoat these areas before proceeding with another prime coat of the entire hull, deck, and superstructure. The welds can be cleaned with a grinder, a wire brush, or a similar device to expose a clean surface that's ready to be touched up with matching prime coat.

Be careful when you're using solvents and other liquids to clean metal; be aware of the deposits they leave behind, so that you're not faced with a never-ending circle of cleaning and recleaning a particular area. Acids can sometimes be used to advantage to remove surface contaminates, including rust. Acids tend to etch the surface and thus improve the adhesion of the paints you apply afterward. Generally, acids are only used as cleaning agents in smaller areas such as those where welding has spoilt an otherwise prepared and primed hull.

FILLING AND FAIRING

For a perfect or near-perfect finish, almost all metal boats need some filling and fairing, but it's important that you do not rely on the filling compound to cover sloppy workmanship. The following advice will probably be ignored by the sloppy builder and resented as unnecessary by the perfectionist. It's to the greater proportion of you occupying the middle ground that we address this advice. Your aim should be to make every step of the building process produce a fair and smooth hull, deck, and superstructure. You should strive to build a boat that will require the minimum of filler. If you are building from a precut kit you will find that very little filler is required. Precut kits do make for a fairer hull than can ever be achieved by building from scratch. If your hull is truly fair you will only need to apply filler in the areas where the plate is joined or where welding and grinding has taken place. Often just a smear of filler will do the job.

Now, having established that all hulls and most superstructures need at least some filler to produce the near-perfect appearance, it's simply a matter of choosing and correctly applying the right material. Automotive body putty is not the correct filler for your boat. It won't withstand the rigors of marine use.

Incidentally, please let the recommendations of your paint manufacturer overrule any advice we give here. You must choose one manufacturer and use its products exclusively. If you mix brands, you'll have no protection if the product fails. Each manufacturer will blame the competitor's product as the cause of the problem.

The correct filler for your metal boat should be epoxy, not polyester based (as is usual) with automotive fillers. Your fairing compound should contain inert fillers such as microballoons. Many paint manufacturers have their own fairing compounds as part of the overall paint system. Make sure you choose a manufacturer who will give you local advice and technical assistance. This is not just a case of visiting your local marine store and taking what's on offer. You'll need to undertake considerable research to ensure you end up with a long-lasting and attractive paint finish on your metal boat. To quote our own experience, our 38-foot (11.58 m) steel powerboat was originally painted in 1991, and today the superstructure looks as good as new. Due to mishandling and neglect by the previous owner, the hull recently needed a blow-coat to cover scuff marks.

PAINTING

In the process of selecting the paint, you'll have to consider how it will be applied. Certain fin-

This Roberts 434 shows that a stripe can enhance the appearance of most hulls.

The long-lasting paint job on this early version of the Waverunner 34 proves the benefits of using pre-prime-coated steel.

ishes lend themselves better to one application method than another. Some paints can be applied in many ways, so this may influence your choice of paint as well as what equipment you either purchase or hire for the job. No matter what method you choose for applying the various paints, you'll need a selection of brushes, rollers, paint trays, scrapers, sandpaper, and all the usual tools one associates with painting any structure. We've seen many fine metal hulls painted with hand tools, including a combination of rolled and brushed finishes.

Airless or air-assisted spray equipment is favored by those experienced in painting hulls, and it's possible to lay on high-build paints in a way that could not be achieved by hand. If you elect to blast your boat, it's well worth considering using a professional team to at least apply the prime coating on your hull immediately after blasting. A team of, say, three or four professionals can blast and prime your boat in just a few hours and thereby ensure that you get the best cover for the blasted steel before it starts to rust.

The success of your paint job will depend on the care and attention you lavish on the preparation of your vessel before the first finish coat is applied. You must identify individual items that will be more prone to rust, and then give them additional attention. One way to identify potential problem areas is by studying other older steel boats. If you've followed our advice on layout and construction, then you will already have avoided most of these potential problems. Now, all you have to do is carefully check your own boat before you start to paint.

Usually, rust doesn't form on smooth areas of the hull. Irregular and sharp surfaces are often the culprits. For instance, we have always recommended that you avoid sharp corners on your hull or superstructure. To avoid creating rust traps and areas where paint is easily damaged, liberal use should be made of split pipe and/or rolled plate. When you eliminate the potential problem areas, you will also eliminate the corrosion problems that, at best, ruin the appearance of any metal boat, and at worst endanger its security. Therefore, no sharp edges, sharp corners, water traps, overlapping plates, or other bad practices that we have already covered in earlier chapters.

Don't attempt to paint areas of high wear, such as anchor fairleads, cleats, and similar fittings. They must have a stainless steel liner welded in place to accept the wear, and thus avoid any corrosion problems. All welds in areas above the waterline must be ground smooth and filled. This will ensure that no jagged edges or high spots are present. Sharp corners and jagged welds prevent the layers of paint from covering evenly, and thereby diminish protection.

As we've said already, we don't recommend that you grind smooth the welds below the waterline. This is a safety factor, and it means that these welds should be most carefully executed to give maximum strength and maximum smoothness, to enable them to accept a full quota of paint.

Aluminum

Many aluminum workboats are left unpainted and this is not a problem when the correct grade of marine aluminum has been used to build the vessel. The metal forms an oxide on the surface and further protection is unnecessary. But even these unpainted aluminum vessels need some protection below the waterline, so the underwater hull must be coated with a suitable antifouling paint. In France, we've seen many aluminum-hulled sailboats and powerboats with unpainted topsides, and quite frankly, they look unfinished. Unless you want your boat to look like an untidy workboat, you should accept the fact that you will be painting your aluminum vessel.

You'll need to abrade the surface of your aluminum hull by sanding it, or by using abrasive pads to roughen the surface of the metal. Next, thoroughly clean the surface with the chemical preparation recommended by your particular paint manufacturer. Now etch the surface. This is usually done with a phosphoric acid solution that changes the chemical properties of the surface of the aluminum, allowing better adhesion for the first coat of paint. Your paint manufacturer will recommend an etch primer or a wash. A primer coat will follow this. Needless to say, this primer coat is one of the most important of the whole system; if it fails, then the whole system will break down.

After you have applied the primer coat, follow it with two or more high-build barrier undercoats above the waterline. The finish coats will be applied above the waterline. A special tin-based antifouling is normally applied below the waterline. In some areas, a license is required to purchase and use toxic tin-based antifouling. Check locally to see if you require a permit to use this material. Because of galvanic corrosion problems, you must never use copper-based antifouling paint on an aluminum boat.

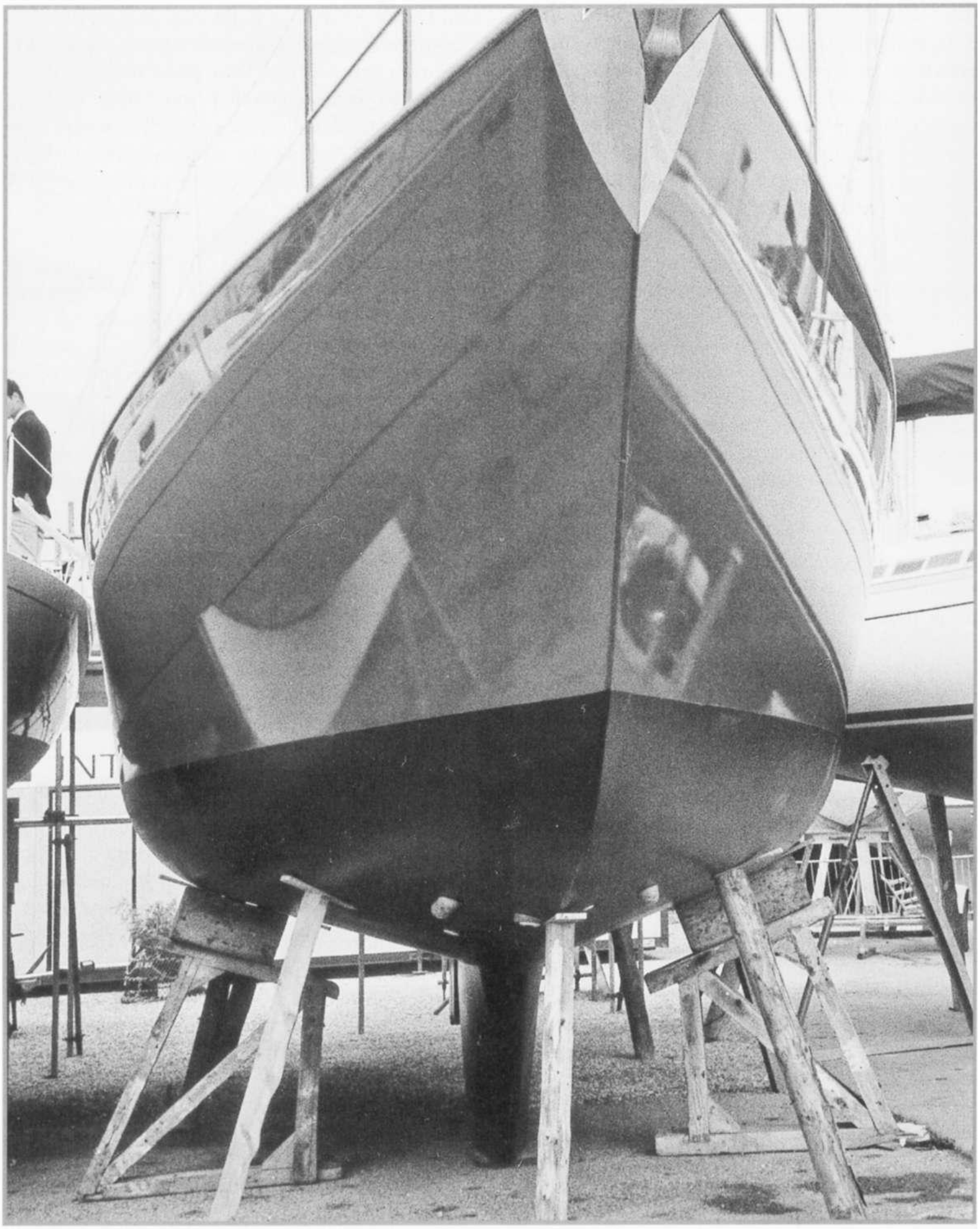
Copper-Nickel

Preparation for painting copper-nickel should include good-quality gritblasting or sandblasting followed by a high-build epoxy filler/primer or epoxy mastic. For final coatings, polyurethane-based coatings are recommended. As with the painting of all metal boats, advice and assistance should be sought from a local paint manufacturer, or at least one who has a readily accessible and knowledgeable technical department.

Finish Painting All Metals

Most paint manufacturers have their own specifications for painting the various metals. Many of the procedures are similar, and consist of roughening the hull surface, and/or using chemical preparations to thoroughly clean off any impurities. Next comes the application of prime coats, and more than one barrier coat. The process is completed with several finish coats to the hull topsides as well as to the decks and superstructure.

The bottom paint requires a thicker application. Paint located on and below the waterline must not only protect against corrosion, but also



This beautifully painted radius-chine steel Roberts 434 shows the excellent finish that can be achieved on a well-built steel boat. This hull has no filler.

must prevent excessive marine growth. Nature helps out; the area under the water has less exposure to oxygen, which is one of the agents needed to promote rust, and other corrosive elements. Your metal boat should be hauled at least once a year and the bottom should be given a thorough scrub.

The bottom paint must be checked for flaws and a new coat of antifouling applied. Make sure it's applied according to the paint manufacturer's specifications. Even if your boat is continuously moored in fresh water, you'll still need to antifoul the hull regularly. Details on the installation and replacement of anodes, together with other actions you should take to protect the underwater areas of your hull, are covered in Chapter 12, Preventing Corrosion.

Decks and Superstructure

In general terms, you'll use the same paint on the decks and superstructure as you have used on the hull topsides. The cabin sides and ends will almost certainly be painted in the same way as the hull. With a few exceptions, the preparation methods for the decks, cockpit, and cabintops will follow a similar routine. Don't have too many colored strips, and don't chop up the area into many small sections or you may end up with a pattern that looks fussy. It takes careful thought and some experience to lay out a successful two-color paint scheme for the decks and cabintops. The designer of your boat may give you some advice and assistance in this area.

If you're planning to install one of the composite patterned deck-covering materials such as Treadmaster, then obtain it in advance and carefully study the installation instructions. You must ensure that the adhesive used to install the decking will be compatible with the paint used on the deck. Having the decking material on hand will also allow you to make a better choice of color for the painted areas of the deck, that is, those areas that will remain exposed after the patterned material is in place. If you're planning a timber-laid deck, you'll need to make sure that the preparation is in keeping with the materials you'll be using.

No matter what arrangement you decide on for your decks and superstructure, make sure you give the area adequate coats of paint. Our steel power cruiser has five hand-applied finish coats; a perfect finish after many years of constant exposure to the elements proves the worth of a good paint job. Always carry a supply of primer, undercoat, and finish paints to touch up the dings and scratches that one gets from time to time.

Antifouling

The technology behind antifouling paints is constantly changing. On boats with copper-nickel hulls you won't have to worry; they don't need antifouling. The natural action of the metal keeps most marine growth at bay. But steel and aluminum boats need a preventive coating for the areas below the waterline.

Just when we believe we've found the answer to the antifouling problem, along comes an environmentalist to point out the toxic problems caused by the use of certain protective bottom paints. For this reason, it's hard to make specific recommendations. As is the case with the entire paint job, my advice is to select one manufacturer and use their system from the first etch primer through to the final coat of antifouling. When you're applying antifouling, you will need to estimate the load waterline and make sure your antifouling is carried to about 2 1/2 inches (60 mm) above this line. The reason for painting the antifouling above the true waterline is that the water is never static, and if you finish the antifouling right at the waterline, you'll soon have an ugly growth of weed at, and just above, the true waterline.

Boottops

You shouldn't paint the boottop until after the boat has been launched and trimmed. After you've conducted trials, loaded stores and water, and determined the exact load waterline, only then should you consider painting the boottop. Incidentally, they're not just a straight, parallel line; they need to be applied so the line, when

Fine signwriting puts the finishing touches to any well-painted metal boat; Sea Pea II *is a Spray 38 built in the UK.*

viewed from the side, appears parallel, or appears to have slightly more width at the ends. These lines are difficult to get right, especially on sailboats where the aft sections sweep underneath the hull and require quite a wide line to give the correct appearance. Avoid excessive upward sweeps of boottop at the bow.

If you start with a level line parallel to the load waterline, it can represent the bottom of your boottop; next, using a level, strike a second line above and parallel to the first, you will see how this line widens out at the stern. Study other boats that are out of the water, and you'll get the idea. Don't copy the ones that don't look right. Powerboats will not present the same problems, because the hull sides are more-or-less parallel. A boottop made of a tape of constant width can work with a powerboat, but it would look totally wrong on a sailboat hull.

chapter 11

ENGINES AND ACCESSORIES

In our opinion, engines powered by gasoline (petrol) have no place in any metal boat—or in any other cruising boat, for that matter. Those who build or buy metal boats are usually thoughtful individuals, and safety is one of the reasons they choose metal. Petrol or gasoline engines do not fit this profile. We recommend diesel engines.

ENGINE COMPARTMENT

When you're choosing your engine, make sure that there's sufficient room to install (or retrofit) it. It isn't just a matter of shoehorning the engine into a given space; you'll also need room for insulation and servicing. The engine must be accessible. If access is difficult, then there is always the chance you'll neglect essential maintenance work. Make accessibility one of your primary concerns when installing the engine(s) and arranging your engine room space.

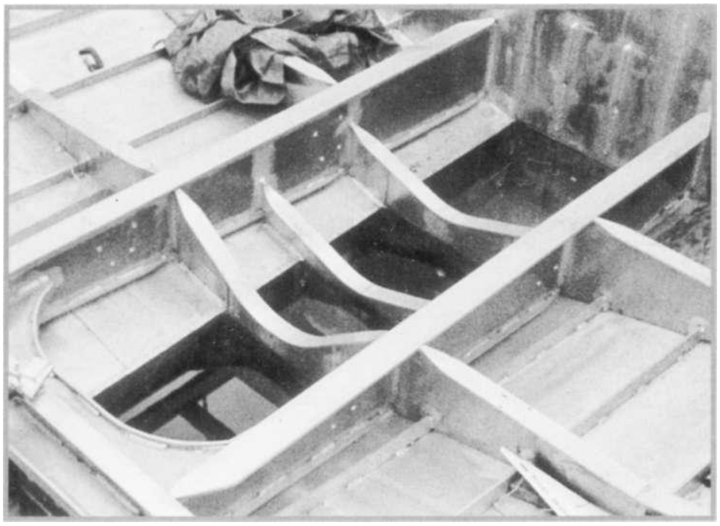
Out of the several boats we've owned, we have never been totally satisfied with the accessibility of all the items that need servicing on a regular basis. Unfortunately, total accessibility, although aimed for, is seldom achieved. For example, batteries need regular inspection, testing with a multimeter and/or hydrometer, and topping up with distilled water. These inspections are likely to be far less frequent if the batteries are in some difficult-to-reach location. The oil dipstick and the water filters should be inspected every day that the boat is in service. Primary fuel filters fitted with water traps need to be drained on a regular basis. Water impellers need to be changed occasionally, sometimes in a hurry. Main fuel taps should be easily accessible; and the list goes on. Can you easily reach the injectors, stuffing box, and fuel-tank inspection hatches?

Some single-engine, semidisplacement powerboats have insulated engine boxes in addition to an insulated engine room. This makes for very quiet running but it does restrict accessibility to some items on and around the engine. In sailboats, the engine often intrudes into the accommodation, where it is inaccessible and almost impossible to service. If you're building a new custom-designed boat, or rebuilding an older one, here's your chance to do yourself a huge favor: consider accessibility a number-one priority.

Engine room insulation in one form or another is essential if you want to keep noise down. In a sailboat, the engine box is usually a fairly close-fitting affair and the problem is also one of accessibility.

You can use several combinations of materials to insulate and quiet your engine, but however you do it, make sure the insulation won't give off toxic gases in the event of fire.

Here are some suggestions: aluminum-covered Styrofoam; fiberglass insulation with a lead insert; fiberglass and foam; and layers of lead, foam, and aluminum (or vinyl foam) sheeting. Most boatowners have found that a material that incorporates a layer of lead is usually the most effective in reducing noise. The classified pages of



These engine beds embody many of the features described in the text

boat, while an insulated sound box reduces the noise to almost a whisper, it does make access to the engine more difficult and it certainly earns its share of rude comments, especially during service checks.

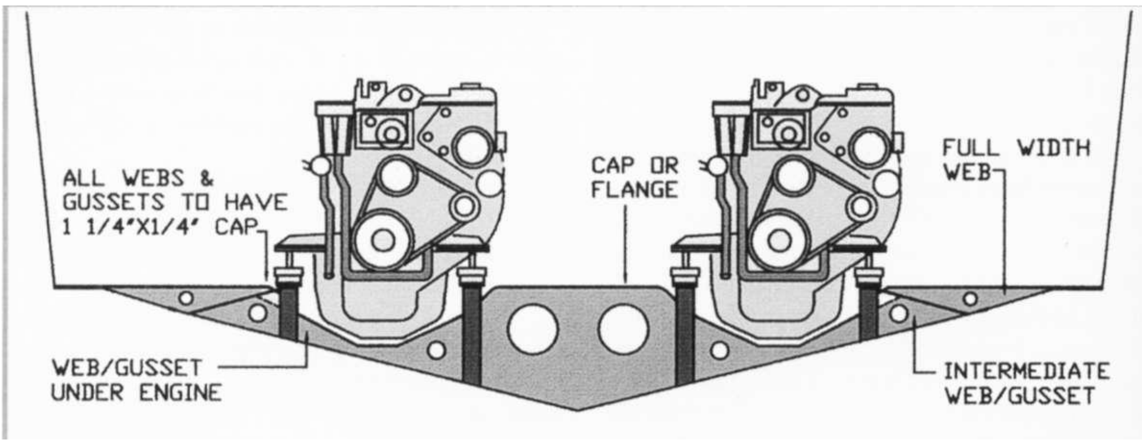
ENGINE BEARERS

The engine bearers, or beds, should be made as long as possible to spread adequately the various loads imposed by the engine. We recommend beds that are two or more times the length of the engine. Space restrictions may defeat this ideal, but make them as long as possible. In our powerboat designs, we always try to mate up the engine bearers with fore-and-aft webs that run almost the full length of the boat. These webs also add strength throughout the hull and have the secondary use of helping to support the sole.

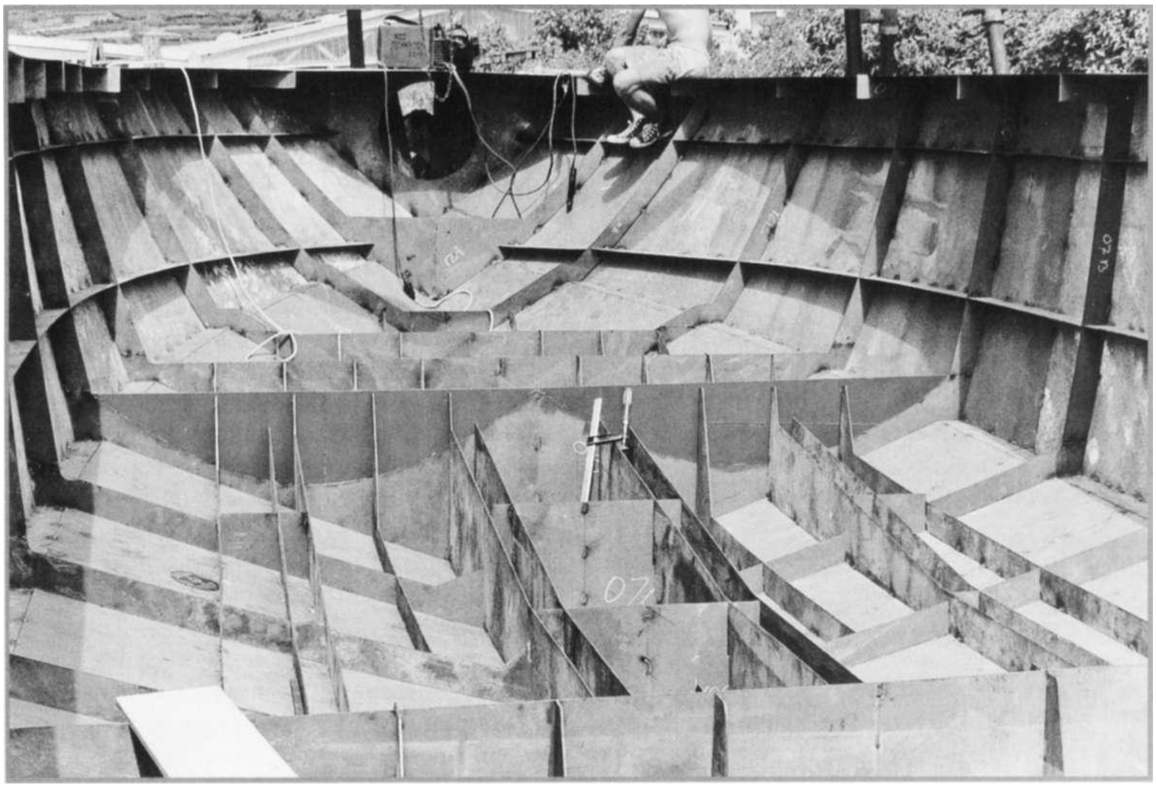
The engine bearers should be made of plate that is two to two-and-a-half times the thickness of the hull plating. Naturally, the exact thickness should be specified in your plans. The size and horsepower of the engine, and its size compared with the hull, will also have to be considered when designing the beds and their supports.

your local boating magazine or the advertising pages of your telephone directory will reveal many sources for these products.

Insulating the engine room in powerboats is relatively easy, as there is usually more room to lay out the insulation without interfering with access to the engine's vital organs. In some powerboats with relatively cavernous engine compartments, it's necessary to insulate the engine separately by having a separate, insulated box around the motor. In a single-engine power-



This twin engine-bed arrangement will fit most powerboats over 35 feet (10.67 m) and leave room for fuel tanks outboard of each engine.



The engine bearers in this powerboat kit are precut and only need the tops added to complete the beds.

The transverse web supports in our designs are part of the regular frame web construction sequence, with additional webs added as required by the spacing of the frames. For example, if the frames of the hull are spaced at ten frames to the waterline length, then additional webs will be required between the stations.

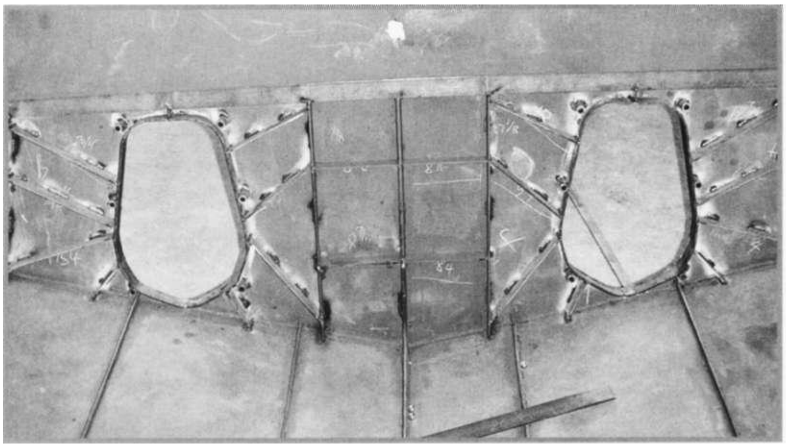
It's difficult to match the height of the beds with the line of the shaft and the stern bearing. If you don't already have the engine on-site, then using a three-dimensional plywood mock-up of the engine can help.

THE DRIVE TRAIN

You must consider the drive trainof your engine, from transmission to propeller, to be a singje, integrated unit. Most engines have flexible mountings and feature a suitable coupling, such as an Aqua Drive unit to complete the vibration-free installation. The Aqua Drive and similar units allow for slight misalignment between the shaft and the engine transmission. This is a necessary feature because when the engine is mounted on flexible mountings, there will be some movement between the engine coupling and the propeller shaft. Several marine engine manufacturers now have preangled transmission arrangements to allow the engine to be installed in a relatively level way; the shaft angle is allowed for in this arrangement.

Stuffing Box

You'll need some form of gland to prevent the water entering your boat where the propeller shaft passes through the hull. Your main choices will be between a traditional stuffing box and one of the newer devices, such as a Deep Sea Seal. If you choose a stuffing box, it may have an external grease-lubrication system or depend on the natural oils of the stuffing and the water for



This stiffener arrangement was used to beef up the transom when fitting a pair of diesel Volvo sterndrives to a steel Waverunner 342 built in Europe.

lubrication. Grease-fed stuffing boxes usually employ a remote cylinder that you have to pack with waterproof grease. One or two turns on the plunger each day forces enough grease through the line to the bearing; this helps to keep the water at bay. All stuffing boxes (also known as packing glands) will drip twice or so per minute and produce about a cupful of water per day. If they're overtightened, and don't drip, then the bearing and the shaft will probably suffer from excessive wear.

Patented Stern Bearings

Stern bearings, such as the unit marketed as the Deep Sea Seal, have long been used on large ships, but only in the past few years have they been installed in pleasure boats and workboats of all types. The Deep Sea Seal has an excellent reputation and has been fitted to many thousands of boats around the world. The basic DSS has been improved with the addition of an additional red clamp that allows the unit to be serviced while the boat is still afloat The basis of the Deep Sea Seal is a rubber bellows that is fitted with a bearing steel ring that runs on a bearing surface in such a way as to prevent water from entering the hull through the stern tube. The rubber bellows is adjusted to maintain constant pressure on the bearing surface. The unit is lubricated by some of the engine-cooling water being introduced through a spigot on the bearing surface.

The main advantage of installing a Deep Sea Seal-type stern bearing is that it doesn't drip, hence there's one less way for salt water to enter the hull and promote corrosion. Another advantage is that the unit needs only an occasional check to ensure that it's doing its job, as opposed to the constant attention required by the conventional stuffing box bearing.

There are other manufacturers of these devices, and you should investigate the various types, before making your choice.

If your boat has twin engines, it's a sure thing that on many occasions you will want to run on one engine. If your engines are equipped with Deep Sea Seals or similar water-lubricated stern bearings, you should consider the need to supplying water to the bearing of the shutdown engine. The Pedro 41 *Van Hoff,* a custom-built, steel trawler yacht with aluminum decks and superstructure, owned by our friends Mike and Caroline Hofman, is fitted with a cross-over water supply to both Deep Sea Seals. We confess we showed only moderate interest when Mike explained this system. The twin water supply was necessary, because, as with most twin-engine vessels, *Van Hoff is* often operated on one engine for the sake of fuel economy. In light of subsequent events not fully detailed here, we should have taken more notice! There follows a clue!

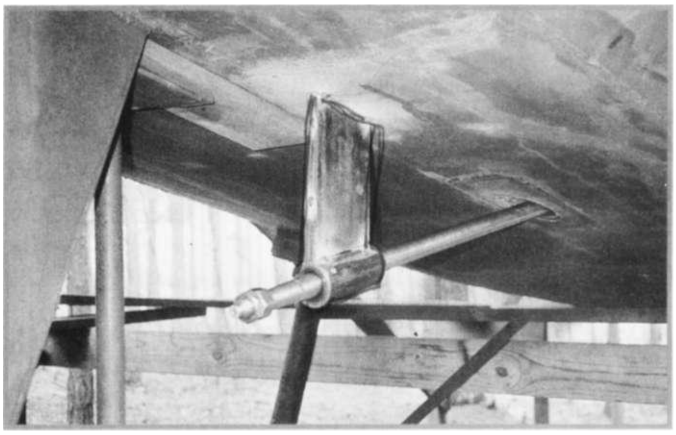
Even if you have only one engine, consider the possibility of engine failure. Then, when your vessel is towed, do you let the shaft rotate? If so, how do you provide water to the bearing? If the situation persists for more than a short time, unlubricated stern bearings can be damaged. It may even be wise to consider installing shaft-locking devices that are available to suit most size engine-shaft combinations.

Aft Shaft Bearings

Your boat will require a bearing where the propeller shaft leaves the outer end of the tube. The choice is between a fiber bearing, a Tufnol bearing, and a Cutless rubber bearing. Cutless bearings are well proven and when properly set up with two small water scoops at the fore end of the tube to introduce lubricating water, they will give long and trouble-free service.

If the distance between the inboard stuffing box (or seal) and the outboard end of the tube is over say 6 feet 6 inches (2 m), you may require an intermediate bearing generally known as a plummer block. This may be another Cutless bearing that has been slid down the tube to the midpoint location.

If your shaft protrudes from the tube by more than a few inches, you may need a Y-bracket bearing to support the outer end immediately ahead of the propeller. Decisions as to whether you need an intermediate bearing and similar questions are best addressed to the designer of your boat or a qualified marine engineer.



Either a V- *or P-bracket is required to support the shaft between the hull and the propeller.*

EXHAUST SYSTEMS

Most diesel engines do not come completely equipped with a suitable exhaust system. In the past, one exception was the range of diesel auxiliaries supplied by Vetus den Ouden. Unfortunately, the engines and equipment are now sold separately. Vetus does have a good range of exhaust systems that are available all over the world.

Diesel engines fitted to sailboats and powerboats will need a properly engineered exhaust system. Engines mounted below the waterline—and most are—will need special antisiphon devices. There are two basic ways to cool an engine and both have a bearing on the type of exhaust system required. Most air-cooled (noisy) engines have a dry-exhaust system, which means that no water is added to the necessarily heavily insulated (lagged) exhaust. In the confines of a sailboat, dry exhausts are hot and noisy but this type of exhaust can be used to good effect in some types of traditional powerboats. Dry exhausts, combined with a vertical stack, are often seen on fishing boats and workboats.

A wet-exhaust system cools the exhaust gases with water soon after they leave the engine. The water and gases are expelled together. This system is necessarily interrelated with the cooling system of your engine. A stainless steel water-lift muffler is a nice addition to any exhaust system and will dampen noise.

Sterndrive engines and outboards have the exhaust systems built in. Outboard engines are beyond the scope of this book, but you may be considering a diesel-powered sterndrive for your metal powerboat. Sterndrive exhausts usually exit via the center of the propeller, no doubt adding a minuscule amount of thrust in the process.

COOLING SYSTEMS

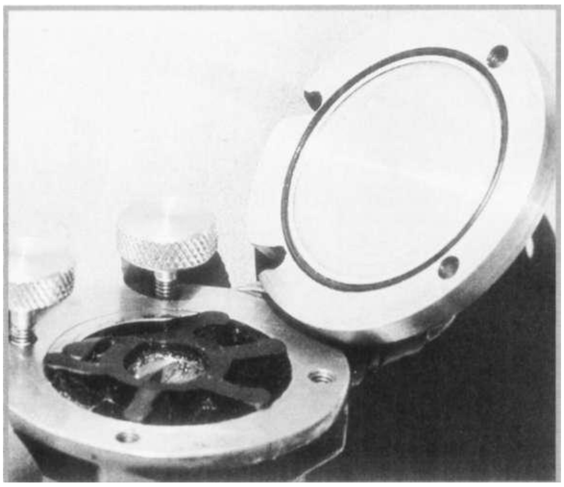
Heat Exchanger Cooling

Most modern diesel engines feature freshwater, heat exchanger cooling. This method uses a special tank of fresh water that runs through the engine's cooling system. The freshwater tank contains internal piping and is, in turn, cooled by seawater pumped through the pipes. This method prevents the internal cooling system of the engine coming into contact with salt water. Most modern diesel engines are cooled in this manner. One problem with this method is that if the outside intake for the cooling water becomes clogged, then the whole system overheats. A sensor in the system can warn you about this condition, before your engine overheats. Make sure each engine is equipped with this warning device.

Raw-water cooling is usually found on older diesels. The method is to pump outside water (seawater or fresh water) through the engine casing and then out through the exhaust, thus cooling the engine in the process.

Engine Water Pump

Most cooling systems include a water pump that draws water from outside the hull and forces it through the cooling system. The pump will include an impeller that will need replacing from time to time. Most water pumps, unfortunately, are located in inaccessible places. Make sure you know where yours is, and check that you have a spare impeller. Also, check the difficulty of removing the impeller and its cover plate. You can buy a special Speedseal cover plate that's attached with only two knurled screws. Because it can be removed and replaced quickly with one hand, you might want to replace your regular water pump cover with one.



This Speedseal cover plate makes changing the impeller a little easier and much faster; it's a handy addition to any engine installation.

Engine Water Filter

If your engine uses water drawn from outside, either directly as raw-water cooling or by way of a heat exchanger, you'll require a water filter to remove any foreign matter that could damage the water-pump impeller or otherwise clog the cooling system, and, in turn, cause the engine to overheat. The usual arrangement is to place the water filter immediately after the seacock where the outside water enters the system.

The filter should be easily accessible, as it should be checked daily—even more often if you're motoring in weed-infested waters. It's often made of clear plastic so you can see what's going on inside, but don't let this discourage you from removing the top for regular inspections. Plastic bags are one of the most common foreign bodies lurking in our waterways and they're not always visible without removing the top of the filter. Most filters have a rubber sealing ring, and you may find that a light coating of Vaseline will prevent the unit from sucking air. In any case, the rings will need replacement every two years or so. If you have a diesel-powered generating set, you should have a separate water filter for it. If possible, place the two filters close together so you can check both at the same time.

Keel Cooling and Similar Methods

There is a third method of cooling that requires no external water to be drawn into the boat. The most common of the self-contained cooling systems involves outside pipes that are usually tucked into the keel-hull intersection. Hot engine water flowing through them is cooled by the surrounding seawater. The most interesting version of this method is only possible with boats that have a hollow metal keel. It involves boxing off a section of the keel to store a 50-50 mixture of antifreeze coolant and fresh water. This mixture is run through the engines' cooling system, and provided that the surface area of the selected portion of the keel is adequate, the system works extremely well. This arrangement employs two header tanks, and works in a manner similar to the way your car's engine cooling system works.

There's another advantage to these engine cooling systems. You can incorporate an insulated hot-water tank, or calorifier. This tank has an internal pipe coil through which hot water from the engine cooling system is circulated. This pipe, in turn, heats the domestic hot water. In the sailboat we owned previously, *K*I*S*S,* we found that running the engine for about 20 minutes every other day was sufficient to provide hot water for 2 days of showers, plus other daily hot-water requirements.

Any internal cooling system that doesn't import raw water requires a lagged, dry exhaust. Considerable care is required in routing any exhaust line, especially the dry variety, which can get hot despite the lagging. If you have a dry exhaust, pay particular attention to the ventilation of your engine space and the surrounding area. The main negative feature of this arrangement is that dry exhausts are usually noisier than the water-cooled systems.

Mufflers

Many exhaust systems involve the use of a water-lift muffler. The engine cooling water is fed into the exhaust pipe just aft of where it leaves the engine, and then into the muffler, where the pressure of the incoming exhaust gases forces the water out of the boat. This system can be one of the quietest, and quietness in your exhaust system is a very desirable feature.

If you are purchasing a ready-built new or used metal boat, the engine cooling and exhaust systems will already be in place, and usually it's an expensive proposition to change from one system to another. If you're building your own boat, however, you should choose carefully. Check other boats; weigh up the advantages and disadvantages of each system before you make your final decision.

Raw-water cooling (no heat exchanger) is the least desirable because the innards of your engine are constantly exposed to the ravages of salt water or outside water containing all sorts of pollutants. Your choice should be between a system with a regular heat exchanger (using outside water to cool it) and a system that has outside piping to allow keel cooling. Alternatively, you can choose the fully internal system. The fully internal system is similar to keel cooling using external pipes, the difference being that a reservoir of coolant is arranged in a section of the keel instead of outside pipes. This system is not recommended for engines over about 120 hp or for the tropics, where the ousted water temperature would not have enough cooling effect.

No matter which system you choose, remember the advantages of having your hot-water tank (calorifier) as part of the engine cooling system.

SAILBOAT AUXILIARY POWER

You'll want to know whether your cruising boat has sufficient power to do the job. The auxiliary is often undervalued until you need it most. There are many formulas used to ensure it is up to the

ALTERNATIVE POWER

Hydraulic drives, electric drives, jet drives, and the like have no place in a sailboat. Over the past 30-odd years, we've been asked to design every imaginable type of "alternative" power arrangement. After completing many, sometimes long-winded, investigations, we've reached the conclusion that diesel power is the way to go. If you have a particular hobby, such as steam engineering, and you wish to combine this with your boating activity, then there may be an argument for installing an engine that allows you to indulge in your pet interest. But it's worth noting that you'll probably need to remove this unique installation before you sell the boat.

UNDERSTANDING HORSEPOWER

When you're considering horsepower, be aware that there are several terms used to describe the power generated by the engine at certain revolutions. One term you'll encounter is brake horsepower (bhp). This is the power produced by the engine without regard to the power loss caused by the transmission gearbox, or other losses from such items as the alternator, water pump, and general friction in the transmission system. Shaft horsepower (shp), on the other hand, represents the power available at the propeller.

Usually, more than one rating is shown. For instance, there's maximum power. This is the power you could get for a very short time before you burn up the engine. Then there's intermittent power, which is the power the engine can deliver for a limited period—usually 30 to 60 minutes—without problems. Continuous power is the rating at which the engine can operate for long periods without damage. This is the rating that will be of primary interest when you decide what horsepower you need to move your boat at the desired speed. Increasingly, you will find that the power ratings are given in kilowatts (kW). The Systeme International d'Unites, the overseeing body of the official metric system, gives the conversion as 1 kW = 1.341 hp and the reciprocal = 0.746; 746 watts = 1 hp.

task; for preliminary calculations, we use a power-versus-weight ratio. This calculation will reveal if your sailboat has enough power to propel it in the direction you want to go when, for one reason or another, the sails can't do the job.

We can start with a ballpark calculation and estimate that for any sailboat, 2 hp per 1,000 pounds (454 kg) displacement is a reasonable requirement. The addition or reduction of horsepower from the above calculation will depend on your philosophy. In general, American sailors prefer more power than their European counterparts.

Most inboard engines fitted to sailboats require gearing down by way of a transmission gearbox to produce the power required to drive the vessel in anything but a flat calm. We usually recommend a 2:1 reduction, thus halving the rotation rate of the propeller versus the engine revolutions. You'll find that most manufacturers have a range of reduction options between 1.9:1 and 2.15:1; any one of these can be considered to fall within the 2:1 recommendation. Generally speaking, the larger the reduction, the larger the propeller diameter required. For this reason, it's not practical to install a very small engine that is geared down to say 3:1 or 4:1. The large propeller required would destroy the sailing performance.

Single or twin engines? Unless your sailboat is over 55 feet (16.76 m) long, this is hardly worth discussing. And by over 55 feet, we mean considerably over!

METAL POWERBOAT ENGINES

Because of the variables involved, this is a much more complex subject than powering a sailboat. For want of space, we can only give a brief overview of this subject, but if you're interested in learning more, check out the recommended reading in Appendix 1.

Powering a Displacement Hull

Powering a displacement-hull motor vessel follows much the same rules as those used to calculate the requirements for sailboats. The exception is that while the sailboat has its sails to use in an emergency, the displacement powerboat relies totally on its engine. Most displacement powerboats are fitted with only one main powerplant, so you should select yours with care. To estimate the horsepower requirements, start with an estimate of 2 hp per 1,000 pounds (454 kg) of displacement. This should be taken as the minimum requirement.

You can gear down your engine to give max-

Table 11-1.
Brake horsepower for sailboat auxiliary engines.

This chart reflects data collected by the John Thornycroft Company (UK). The figures represent the various brake horsepower (bhp) requirements for auxiliary engines installed in sailboats. The calculations assume a three-bladed propeller. The bhp quoted is at the engine and allows 15 percent for engine and shaft losses.

Waterline Length	Tons Displ.	5 Knots	6 Knots	7 Knots	8 Knots	9 Knots
25 ft. (7.62 m)	2	5.0	5.0			
	3	6.5	6.5			
	4	8.7	8.7			
	5	12.0	12.0			
30 ft. (9.14 m)	2	1.9	3.6	6.4		
	3	2.5	5.0	9.7		
	4	2.9	6.4	13.0		
	5	3.3	7.7	16.0		
	6	3.5	8.8	19.0		
	8	4.0	11.0	26.0		
40 ft. (12.2 m)	4	2.8	5.2	8.5	13.0	
	6	3.5	7.0	12.0	25.0	
	8	4.0	8.4	15.0	26.0	
	10	4.4	9.9	18.0	33.0	
	12	4.6	11.0	21.0	40.0	
	14	5.0	12.0	24.0	46.0	
	16	5.2	13.0	27.0	53.0	
	18	5.6	14.0	30.0	59.0	
	20	5.9	15.0	33.0	66.0	
50 ft. (15.2 m)	8	4.1	7.2	13.0	19.0	28.0
	10	4.6	7.9	15.0	23.0	35.0
	12	5	8.8	17.0	27.0	42.0
	14	5.3	9.6	20.0	30.0	49.0
	16	5.6	10.0	11.0	34.0	56.0
	18	5.8	11.0	23.0	38.0	63.0
	20	6.0	12.0	25.0	41.0	70.0
	25	6.5	13.0	30.0	50.0	87.0
	30	7.0	14.0	34.0	57.0	105.0

imum performance at lower speeds and reduce the amount of power required to drive your vessel. This option results in a larger-diameter propeller, and there may not be room for it. There are also other disadvantages to taking this minimum-power route; one day you may need extra power to get out of a sticky situation, or tow another vessel. Conversely, a diesel engine likes to be worked moderately hard, so it's not advisable to have an installation where only 50 percent or less of the power can be used without driving the stern down to an unacceptable level. If you want more power, you may wish to consider a semidisplacement hull that can make better use of it.

Powering a Semidisplacement Hull

A fact you must consider is that it takes excessive power to drive a semidisplacement hull faster than 1.5 times the square root of its waterline length. For example, a semidisplacement hull measuring 36 feet (10.97 m) on the waterline would have a square root of 6. So 6 times 1.5 equals 9 knots. A broad definition of planing is when a boat reaches a speed in knots of twice the square root of the waterline length in feet.

Taking the 36 foot (10.97 m) example shown above, the square root of 36, times 2, gives us a 12-knot planing speed; at this speed, the necessary horsepower and fuel requirements will turn a comfortable, economical cruising boat into an expensive proposition. Please note that the formula given is only for the *start* of planing, and to make a semidisplacement hull reach a full (near-level) planing attitude will take considerably more power, and use more fuel than consumed by a similar-sized true planing hull. The point is that it makes no sense to grossly overpower any semidisplacement hull—you'll be just spinning your wheels or, in this case, your propellers. This whole subject will be fully covered in our e-book, *Choosing a Cruising Powerboat.* Go to bruce roberts.com for for details.

Next, we have to consider the weight of our vessel. Weight in this instance means *loaded* displacement. This includes not only the weight of the finished boat but also fuel, water, stores, and crew. In addition, there are all of those items that are brought aboard for a particular use or occasion and then never leave the boat.

Now, there are many kinds of semidisplacement hulls, ranging from a full displacement vessel through to almost a full planing hull. The degree of rise in the chine or buttock lines aft will determine how fast the hull may be driven. Simply put, the more stern there is in the water at rest, the faster the hull may be driven. Overpowering a hull will cause the stern to drop and create a large stern wave. In certain instances, this wave can overwhelm the vessel.

Powering a Planing Hull

Only a few years ago, it was thought impossible to build a successful small-to-medium-sized steel planing hull. Fortunately, modern building techniques and technical advances in design have not only made this possible, but practical as well. As mentioned above, planing occurs when the boat reaches a speed in knots equal to twice the square root of the waterline length in feet. A planing hull will then make the transition from "just about planing" to "full planing" with less fuss, less extra horsepower and less extra fuel than a similarly sized and equipped semidisplacement hull or semiplaning hull.

Aluminum has been used to build hundreds of thousands of small, medium, and large planing hulls. Although at first glance this material may appear to be the ideal metal for a fast hull, we have reservations about this material when used in any type of hull, preferring to recommend it for decks and superstructures. You'll find our thoughts on this material scattered through this book, so it's not necessary to repeat them here.

Now, for those who prefer aluminum: you'll find that the performance of planing hulls relates to *weight* and *power.* Unlike displacement hulls and (to a lesser extent) semidisplacement boats, waterline length plays a smaller part in the performance of a planing hull.

So, in simple terms, the more power and the less weight you have in your planing hull, the faster it will go. Fortunately for designers like us, however, it's not that simple. A well-designed planing hull with modest power will outperform an overpowered, poorly designed vessel.

"Get-You-Home" Engines

Before we consider the subject of single or twin engines, we should touch on the possibility of installing a "wing" engine, or using the diesel that powers the generating set as an emergency arrangement to get you home. Most owners prefer a separate wing engine consisting of a smaller diesel engine set off to one side and equipped with its own shaft and propeller. This engine is generally only required in the case of failure of the main engine, but of course it will need to be run from time to time for maintenance and testing purposes. For obvious reasons, the wing engine is only needed in boats with a single main engine. The wing engine and similar arrangements are often referred to as take-home engines. Some owners have installed an electric drive powered by the gen-set, and have used this as emergency propulsion.

Circumstances have caused us to give this matter considerable thought, and we have recently designed a range of long-distance power cruisers. These vessels are generally referred to as passagemakers and, to be successful, they need a minimum range of 3,000 miles. Some vessels in the 50-foot plus range (more than 15.25 m) can be built to cover up to 6,000 miles without refueling. For various reasons, most of these long-distance vessels are fitted with a single engine, hence the interest in alternative propulsion methods. As a safety factor, both for medium-distance and local cruising, my choice would be for a wing engine.

One or Two Engines?

As mentioned earlier, most displacement-hull vessels are traditionally fitted with a single engine. But many owners have twin installations, and the bulk of them quote safety as the prime reason for taking this route.

We've always maintained that when you install twin engines, as opposed to a single engine of the same total horsepower, you'll lose 20 percent in total output. More recently, we've decided that the effective loss of power may be even higher. Other examples show that the additional fuel consumption of the second engine is not justified by the small increase in performance when the two engines are used.

If you're considering a new boat, and you're considering twin engines in the interests of safety, you should be aware that in the interests of economy you might be operating only one engine for much of the time. You would be well advised to lay out your engines and systems with the above facts in mind. Owners who regularly take this course use each engine alternately on a 4-hour or daily basis.

PROPELLERS

It would be convenient if we could buy a propeller to match our hull material. Builders using copper-nickel are fortunate; the bronze propellers that are readily available are a close relative to the hull material, so the interaction between different metals that causes corrosion is at least reduced. Steel, or cast-steel, propellers are very difficult to obtain, so steel boat owners are forced to use the bronze versions, or to join their aluminum-boat-owning friends and opt for an expensive stainless steel "wheel." So there you have it: steel boat, bronze propeller; copper-nickel boat, nickel-aluminum-bronze propeller (must be more noble than the copper-nickel hull); aluminum boat, stainless steel propeller.

Propeller nomenclature is simple, but choosing the correct size and pitch of the wheel is somewhat more difficult. The *diameter* refers to the size of the circle scribed by the tips of the propeller blades. The *pitch* is the distance the propeller would travel in one full revolution if it were rotating in a solid. *RPM* refers to the revolutions that the shaft achieves in one minute; this figure is usually a factor of the engine rpm, but due to the transmission reduction (1.5:1, 2:1 and so forth) the shaft rpm will be different from the engine rpm. When calculating propeller sizes, it's the shaft rpm that is important. The *slip* refers to the loss of forward motion due to the fact that the propeller is rotating in a liquid, not a solid. Slip is the theoretical difference between what a propeller of a given pitch would travel, and what it actually is expected to achieve, usually expressed as a percentage. The *pitch ratio* is figured by dividing the pitch by the diameter. Fast powerboats sometimes have a diameter and pitch of the same number; this is referred to as a "square wheel."

Propellers for Powerboats

In powerboats, you'll want to install the most efficient propellers that will allow the engine to reach its operating and top rpm when required. In some designs, the propeller aperture is not sufficiently large enough to allow the correct propeller to be installed, and in this case a change from a three-bladed to a four-bladed wheel may prove successful. If you're experiencing cavitation because the tip clearance is too small, or because of the shape of your particular hull, then a change to four blades or even five blades may remedy the situation. You may need to discuss your particular problems with both the designer of your boat and the propeller manufacturer or supplier.

The design and matching of a propeller to the hull, engine, and reduction ratio is something of an occult art. As designers, we do our best, but even the most detailed calculations can result in a propeller match that can be improved during trials conducted over a variety of conditions. You can also contact one of the many well-known propeller manufacturers in the United States, Australia, the UK, and elsewhere. They will usually be most helpful. If you have a propeller problem, don't disregard it; seek assistance as required.

Propellers for Sailboats

The most efficient propeller from a sailing point of view is the two-bladed folding variety. Two blades mean a larger diameter, and this can cause problems where space is restricted. These may be considered if you're building a high-performance metal sailboat. Some of these two-bladed folding propellers are inefficient and others have a reputation for not always opening on demand, which could be disastrous. If you do decide to choose a two-bladed type, make sure you are able to get a first-hand recommendation from another person who has already had experience with the brand you favor.

The elimination of drag is the aim of every sailboat owner. One way around the problem is to use a *feathering* propeller. These units are complex and expensive. Finely engineered feathering propellers may be suitable for larger yachts, where the owners have the resources to cover the initial expense and possible high maintenance costs. Unless you have very deep pockets, you're best advised to accept a small loss of speed under sail and select -*A fixed* three-bladed wheel.

Rope Cutters

These devices are mentioned here because they may require a slightly longer shaft to be fitted. Suitable for both sailboats and powerboats, rope cutters are designed to be clamped on your shaft just ahead of the propeller. They can be very effective in cutting rope or a similar obstruction that would otherwise foul your propeller.

FUEL FILTERS

Does your engine have a separate primary fuel filter? Not all boatbuilders or manufacturers supply or fit these essential items as standard. The fuel filter that comes with the engine is basically a secondary filter, so at least one good primary fuel filter that incorporates a water trap is needed between the fuel tank and the engine. The filter should have the capacity to handle a considerable amount of dirt and water. Twin primary filters can be arranged so one can continue while the other is unclogged or changed. The installation of twin primary fuel filters should be a serious consideration even in single-engine craft.

Filters with glass bowls have pros and cons. The sealed-filter units have expensive cartridges that need to be replaced completely, rather than simply replacing the internal filter. A major advantage of glass is that one can quickly observe if water is present. However, the glass-bowl filters are now outlawed in Europe for all boats and in the United States in gas-powered vessels, the argument being that in case of fire they present an additional danger.

Recently, we met the owner of a motor cruiser, a Dutch-built steel vessel of 34 feet (10.36 m), who got into trouble because of the glass bowl. This fellow, an experienced boater, was alone off the Spanish coast, near Barcelona, motoring along in heavy seas, when his single engine stopped. Upon investigation, he found that the glass bowl on the primary fuel filter had shattered. This had allowed diesel fuel to spray in all directions—and of course the engine stopped for lack of fuel. Fortunately, there was no fire. No replacement bowl was available and the engine was too hot, and the motion too violent, to allow the owner to deal with the situation. He was forced to swallow his pride and call out the Spanish Coast Guard, who responded promptly. Within an hour, the disabled vessel was safely in port. The owner believes he overtightened the glass bowl on the filter and when it expanded, due to the heat from the engine, it shattered. There are two lessons here: reconsider the use of glass-bowl filters, and don't overtighten them.

You'll need to change the filters at regular intervals. In the case of a fuel blockage, you'll need to change them as required. This is a very messy job and is one area of boat maintenance that you must understand. You should practice preventive maintenance wherever possible. When you're reassembling filter units, make sure you have the sealing O-rings in the correct order and position; sometimes the top and bottom rings look similar but are different enough to allow fuel or oil to leak out when the engine is fired up. Start the engine with caution after servicing these items.

VENTILATION

In all boats, ventilation of the engine space is an important feature. Your engine needs a considerable amount of fresh air. Install two vents of adequate size, one ducted below the engine to bring the fresh air in, and the other ducted high up in the engine space to take the hot air out. Generally, a blower is not required in northern latitudes. In hot climates, however, you may need one to turn the air over at the correct rate. An engine-space blower is simply a ducted fan that is designed to either import or export larger quantities of air than would circulate naturally.

INSTRUMENT PANELS

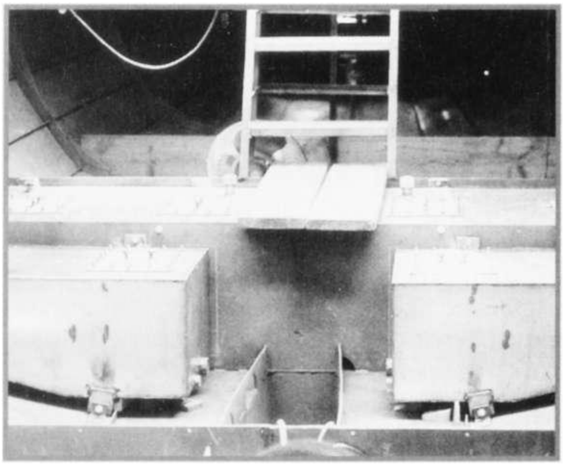
Your engine will usually be equipped with an instrument panel, but you may want to add to the instruments supplied in the standard package. The minimum engine instrumentation should include a tachometer (revolution counter), an engine-hour meter, a fuel gauge (notoriously inaccurate in boat installations; have a dipstick handy), and a volt/ampere meter. Regarding fuel gauges, we have always preferred a sight-glass gauge that is attached to the fuel tank and allows the level of fuel to be seen at a glance. For two reasons this feature may not be available to you; in some areas they are illegal (fire hazard) and if your tank is hidden from view then a sight gauge would be impractical. You'll require an instrument light switch, including a dimmer control for night use, an audible alarm to indicate if you fail to switch off the ignition after the engine has been stopped, an engine stop control, and a water-temperature gauge. Warning lights and or buzzers may indicate some potential problems; in our opinion, warning lights are not as effective as proper gauges. Audible alarms are recommended for water temperature, alternator output, and the other vital life signs. Your electrical panel, complete with fuses, is usually located in a separate box; however, in some boats with inside steering, it may be incorporated in the main panel.

BILGE PUMPS

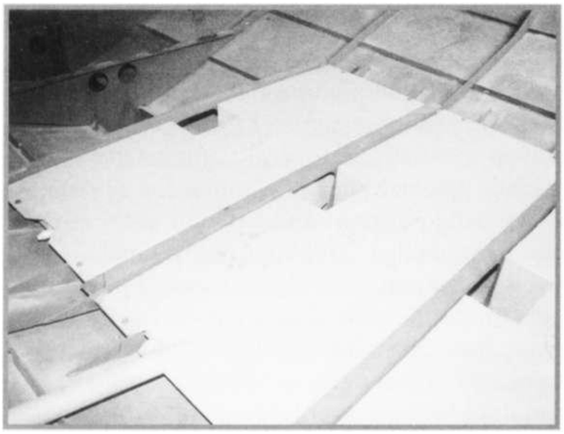
Take some time planning and laying out your bilge-pumping systems. Bilge pumps can be driven manually, electrically, or mechanically. Usually, the first line of defense is the automatic, electrically powered unit situated in the lowest point of the bilge. This bilge pump should be fitted with a strum box. This is a special perforated box, or strainer, fitted over the end of the bilge pump hose that is installed low in the bilge. If you have an automatic shower pumpout system, this can double as another bilge pump. The shower and toilet pumps will often be located in a different compartment to the main unit.

You'll need at least one, preferably two, hand-operated bilge pumps and one of these should be a large-capacity, portable unit mounted on a board, thus allowing it to be operated in any part of the vessel. The Edson 18 and the Whale Titan are both excellent hand-operated pumps.

You'll also need to arrange a sump or suitable collection point for bilge water. This sump is usually under, or nearly under, the engine so that any spilt diesel fuel and other unwanted liquids can be pumped or sponged out. A hand-operated bilge pump with a hose attached is useful in this area so that you can pump any contaminated water into a separate container for proper disposal ashore. U.S. federal law prohibits the pumping of oily bilge water directly into the surrounding water. For instance, in Florida a heavy fine can be the result of pumping even the smallest amounts of polluted water into the local canals. Any bilge pumps located in the sump or elsewhere should be fitted with a strainer. In the event of any large particles being present, you need to ensure that they will not find their way into, and totally block, the pump.



These tanks were fabricated and tested outside the hull and then installed as shown. As it is usually Impossible to remove tanks without destroying interior joinery, you must make sure that your tanks are thoroughly tested before installation.



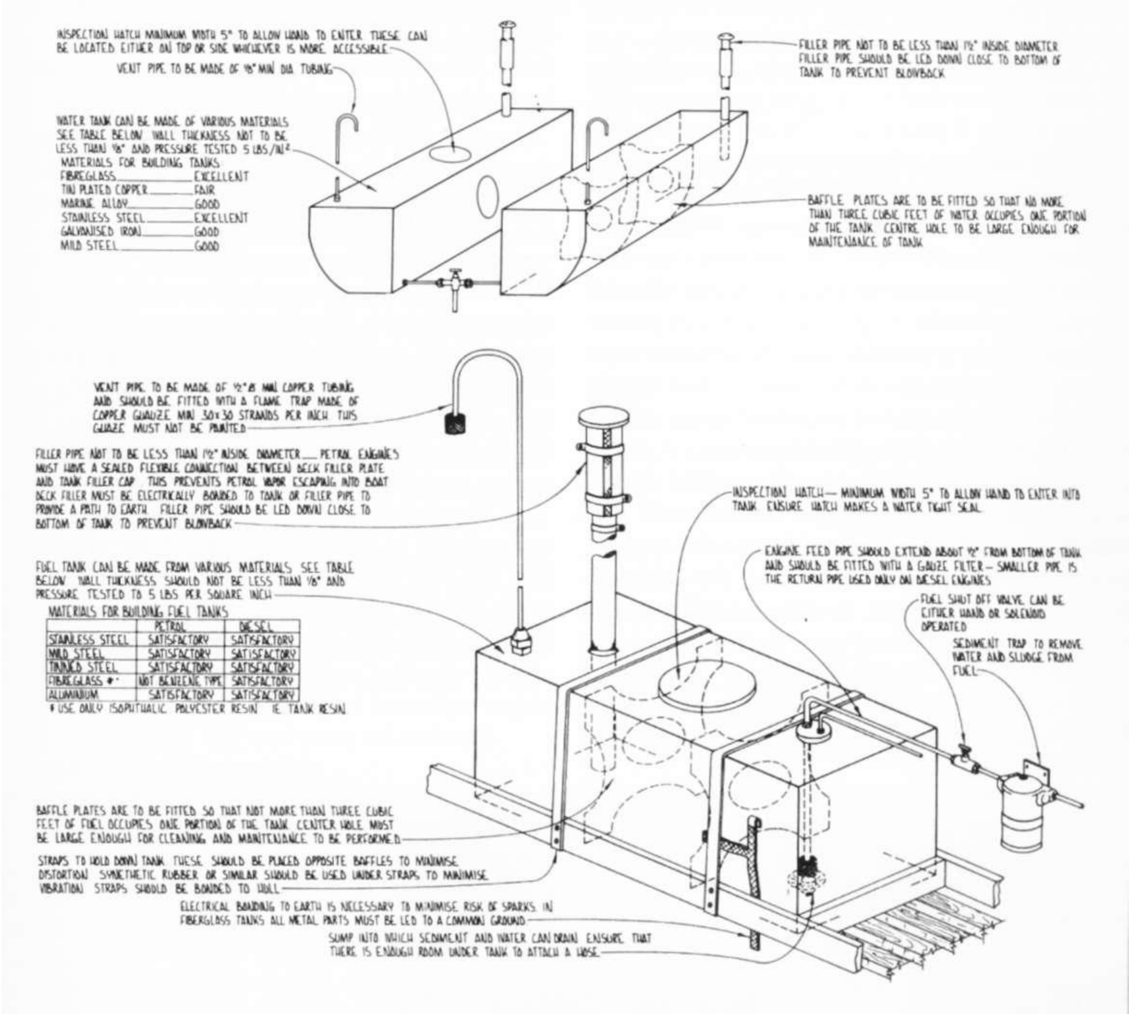
Tanks can be neatly arranged under the sole. Note the inspection and cleaning hatches in the tank tops.

FUEL TANKS

Aluminum is often used for fuel tanks, but there have been many problems. Aluminum tanks are susceptible to vibration and can fracture along the weld lines where baffles are attached inside. If you do use aluminum for tanks, make sure they are made from a high-magnesium alloy such as 5083 or 5086 specification. It may be better to consider tanks made of, or molded from, polypropylene.

Aluminum and steel tanks are sometimes built with the hull acting as one side of the tank. It's preferable to have the tanks built as a separate unit and tested before installation in the boat, because this will ensure that there are no leaks. Air pressure of about 3 pounds per square inch (psi) can be used to test the tanks. *On no account simply connect the tanks to a high-pressure air hose.* You may cause the tank to explode. Because of the risk of explosion, some experts recommend hydrostatic testing rather than the air test mentioned above.

Diesel fuel tanks may be built from a variety of materials, including high-density polyethylene, stainless steel, aluminum, or mild steel. Most builders choose regular mild steel. This material has the advantage of low cost, ease of fabrication, and low maintenance. The diesel fuel inside the tank prevents interior corrosion, and provided you keep the outside well painted, your steel fuel tanks should give you long service.



Your tanks should embody all of the features in these sketches. See the text.

Tank capacity is a contentious subject. Most designers specify small, easy-to-remove tanks. The builder wants large tanks so he can offer a cruising range greater than the competition. The owner often requests an *enormous* cruising range under power. Keep your tanks to a reasonable size; remember that diesel fuel gets stale; and it is subject to attack by various bugs when not changed on a regular basis.

All tanks should be fitted with inspection hatches and be capable of being cleaned through these openings. Fuel is drawn off by way of a pipe that enters the tank from the top and extends to within 1 inch (25 mm) of the bottom. Arrange the tank and fuel line so that any sludge will collect below the drawing-off line. A drain cock from the bottom of the tanks will allow you to flush out the tank. In the United States, these drains are not legal. Outside the United States, check local regulations before fitting the bottom drain. All tanks will need breather pipes—see the illustration above for these and other details. If you are purchasing a used or new production boat, your tanks may not meet all the criteria outlined in this chapter, and they may need attention in one or more areas that we have already mentioned.

If you're installing new tanks, or replacing old ones, choose tanks that give you a sensible cruising range. If you plan to have a diesel-powered generating set, a diesel cooking stove, and/or a diesel-powered heating system, take the usage of these items into your calculations. Remember that to avoid condensation and to minimize the chance of bugs infecting your fuel, you should keep your fuel tanks topped up whenever possible. In any case, it doesn't make sense to be carrying excessive weight in the form of too much diesel fuel. So the size of your fuel tanks is important. Large is not always the answer.

Sailboat owners should make careful calculations of their requirements. Armed with the knowledge that you will need to use the engine for a percentage of the time, allow for this and then add the other uses, such as diesel heating. Now decide on the size of your fuel tanks.

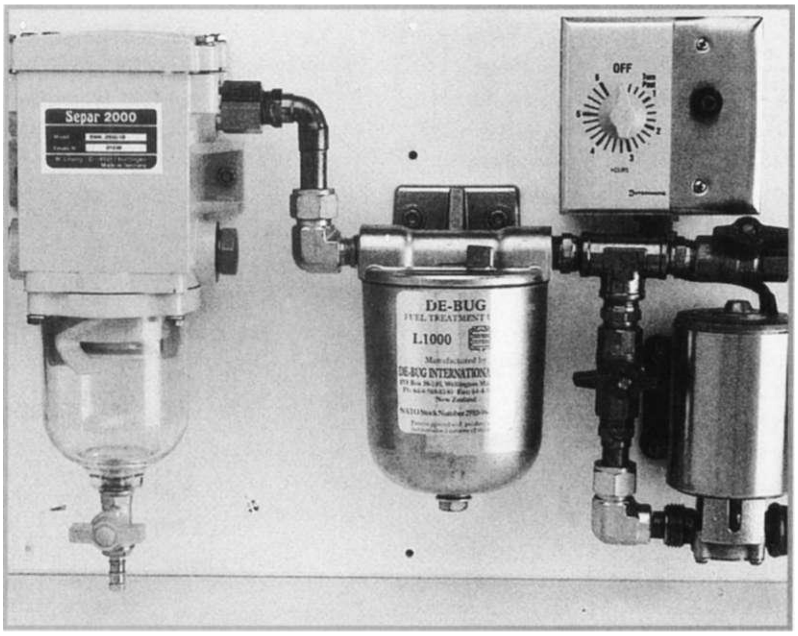
No matter what type of material you choose for the fuel tanks (or any other tanks), make sure they're firmly anchored in place. The thought of a loose tank, full or otherwise, charging about the boat in a rough seaway, should be enough to make you check all tank supports and containment arrangements very carefully.

MICROORGANISM CONTAMINATION

All diesel fuel systems can be contaminated by microorganisms. Neglected or unprepared fuel systems will continue to provide life support to these pests once they are introduced into the system. Problems show up in shortened fuel life, clogged fuel lines, and increasingly corroded fuel system components, including the tanks.

The degree to which microorganisms grow and prosper in the fuel system is relative to how fast the fuel is used up. Boats with small fuel tanks or with high-horsepower engines are less likely to have this problem. For several reasons already covered, cruising sailboats tend to have larger tanks and keep the fuel longer.

If you leave your boat for extended periods without making sure that the fuel tanks are totally full, then you run the risk of allowing microorganisms, or "fuel bugs," to breed in the tank. Partially empty tanks allow water to condense there, and the least effect of this is that your water trap and fuel filter will be working overtime. These bugs—in the form of algae, bacteria, yeast, mold, and fungi—all thrive when water is present. All owners and operators of diesel engines face this problem, no matter where the engines are located or what type of transport the engines are installed in. Boats used and laid up in warmer climates are most susceptible to the bug but



A fuel recirculation system is an effective solution to maintaining onboard fuel The unit pictured is the ESI Clean Fuel System.

many cases have occurred in the UK and colder parts of the United States, so this problem is not confined to tropical areas.

To eliminate bugs from your fuel, you need to understand how they breed. The various microorganisms need water to survive, since they live at the interface between the water and the diesel fuel, and they use the fuel as a food source. Diesel contains carbon, hydrogen, and dissolved oxygen, so it's a good source of nutrition for the bugs.

Once you've removed water from the system, you still need to take preventive measures against microbial growth. In a marine environment moisture is always present, and diesel bugs can grow quite rapidly. They can be present in the air, or in fuel taken aboard after you thought you had cured the problem. Some bacteria can grow into a mass many times their original size in just 24 hours. Other types can corrode fuel systems without being so obvious. They may show up as black grit, resembling coffee grounds, either in the filter, or, if you still have one, in the water-separator sight bowl.

Biocides

If you purchase a boat that hasn't been used for some time, you'd be wise to remove all the existing fuel from the tanks and have them flushed out and filled with fresh fuel. If you're in doubt about the cleanliness of the existing fuel, or if you're refilling after flushing out the tanks, you should add a biocide to your fuel. This will ensure that any remaining bugs are destroyed before they multiply and clog your fuel system at some inappropriate moment.

There are many brands of biocides available and they have one major factor in common. They are all expensive, usually costing around $25 (£15) for an amount sufficient to treat a 150-gallon (680 L) fuel tank. Another shared feature is that they are all composed of highly toxic chemicals; so highly concentrated, in fact, that they need to be handled with utmost care. It's as well to keep in mind that over time biocides lose their effectiveness and have to be replenished. If you have a bad case of the bug, don't be afraid to give your fuel tank a double dose of biocides. Select a safe storage method and wear disposable rubber gloves when handling biocides. Needless to say, keep these chemicals well away from children.

Water Dispersants

These additives are only successful when you use them as a preventive, rather than as a cure. The biocides should be used if your tank is already infected with the bug. Water dispersants are designed to absorb water into the fuel and in this way remove it before the fuel reaches the filters. Before using these additives, you must first drain as much water as possible. There are other benefits claimed for these products, including the fact that they inhibit separation of the waxes and gums that are present in diesel fuels. Only use dispersants if you have minor water problems or as a preventive method.

Enzyme Treatments

Having tried several methods to cure the chronic attack of "diesel bug" that attacked the diesel fuel in one of my own steel boats, I finally tried an additive called Soltron. This product was developed in Japan, but my supplies came from the UK. After three treatments, my diesel fuel system was finally free of the bug that had clogged my filters on several occasions. Soltron is a clear, enzyme-based liquid, and about half a pint treats 660 gallons. An Internet search should locate a source near you (www.soltron.co.uk in the UK and www.solpower.com in the United States).

Microorganism Fuel Filters

The system as described here is best used as part of your overall fuel-scrubbing system. Since not all diesel fuel sold at the various waterside filling-stations is equal, it's possible to introduce unwanted additives to your fuel tanks just by filling up at an unknown fuel dock. This can be especially troublesome overseas. The best solution to this problem is to have a system in which all the fuel is cleaned before it reaches the main engine filters.

The De-Bug filter is part of an overall fuel-filtering and scrubbing system marketed by the manufacturer. The De-Bug filter doesn't only kill the diesel bug, it also gets rid of the bodies. Those of you who plan to operate your boats under conditions where the fuel bug is likely to be an ongoing problem may want to consider a more positive solution to microorganism growth. Developed over 10 years ago in New Zealand, the De-Bug Fuel Decontamination unit uses patented and unique "multi magnet" technology to kill microorganisms. When it's correctly sized to the fuel flow of the particular engine installation, this unit kills 97 percent of the bugs in a single pass.

The De-Bug filter produces magnetic fields from ceramic-coated magnets. They destroy the microorganisms as they flow through the filter. This unit is a one-time installation; it has no moving parts and no electrical power is required. Replacement filters are not necessary and the only maintenance required is an occasional cleaning. Unlike the chemical biocides, the dead bacteria cells are destroyed in a way that does not result in a messy residue that will clog filters.

The De-Bug filter comes in various sizes and has been used in all types of diesel-powered applications, both ashore and afloat. The smaller unit is capable of handling up to 35 gallons (160 L) per hour. Larger sizes of this unit can handle amounts ranging from 265 gallons (1 kL) to 5,000 gallons (18.925 kL) per hour, and remembering that a 97 percent bug kill is claimed, this is one of the most efficient pieces of equipment you could add to your boat. Do you need it? We do, after the experience of losing engine power in a rather embarrassing situation—and all due to "the bug." Our boat is now fitted with this device.

SPARE PARTS, TOOLS, AND MATERIALS

The field of spares alone covers a multitude of possible items. Add some tools and construction materials, and you can see that a large number of items could be assembled under this heading. Perhaps this is a good time to review those items that you have already decided to install, and to decide if you really need them. Now consider how likely they are to need spare parts in order to remain in service.

You'll need to carry an adequate number of spares for your engine, of course. For instance, you must have at least two replacement sets for each filter installed on your boat. If you have more than one type of filter, then you need two spare filters for each one. Filters clog up at the most inopportune moments. Usually, one set of spares is just not enough. Don't forget the spare oil filters. While they're not needed as often as fuel filters are, they're required at regular intervals.

Hoses, cooling fan belts, alternator belts, impellers; the list goes on. Ask your engine supplier to suggest a complete list covering your expected requirements. Most manufacturers have recommended lists for local, coastal, and offshore cruising. Look over these lists and choose the one most appropriate for your needs.

On the subject of marine engine manufacturers, the word "manufacturer" is misleading. Most marine engines are assembled or "marinized" from another manufacturers' basic engines. Many of the filters, fan belts, and other consumable spare parts are available at less cost when some other manufacturer supplies them. The engine manufacturers naturally discourage you from obtaining these outside-sourced spares. You'll need to decide for yourself whether to buy and use these less expensive, unofficial spare parts.