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HOWARD I. CHAPELLE

Boatbuilding

A Complete Handbook of Wooden Boat Construction

Foreword by Jon Wilson

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FOREWORD

IT WAS my good fortune to grow up in a house in which the first edition of Howard I. Chapelle's *Boatbuilding* stood easily at hand on a bookshelf. It belonged to my grandfather, who turned seventy the year that first edition appeared, and I can well imagine how he thrilled to its every page. He had been around boats since boyhood; among his forebears were shipwrights and sea captains, and he was very familiar with the construction of yachts and boats. Yet, although he and other determined students or enthusiasts could find an occasional small book on the subject of building specific types of craft, there was nothing of substance which explored and revealed so many of the intricacies of this mysterious art and science. Thus, *Boatbuilding* became the first broad examination of traditional methods, and in this alone it probably would have found good success. But it had greater strengths and virtues, and they lay in the breadth of the author's scholarship, and in his ability to convey, through his numerous sketches and plans, a sense of the romance which is so much a part of designing, building, and sailing wooden boats. And *Boatbuilding*, like his *Yacht Designing and Planning*, *American Small Sailing Craft*, and others, finds much of its enduring value in its ability to inspire on both a visual and cerebral level in every chapter.

Although Howard Irving Chapelle (1901–1975) was completely at home at his typewriter, his drafting table, and in museum curatorial offices, his career and reputation sprang from the years he spent working in the field—around, on, and under the many vessels and small craft which were fast disappearing from the waterfront. He grew up around the harbor of New Haven, Connecticut, and sailed a traditional New Haven Sharpie, a local boat for oyster fishing. Although as a young man in 1918 he had been heads, and the fittings that require room to install easily. When he is satisfied that enough of such work is done, he lays the deck, fits the bitts, and makes up the hatch frames and cabin trunk. Then he puts in the cabin roof beams and lays the roof. If both or either the deck and cabin roof are canvas covered, he does this before securing any of the hatch frames in place. Then, when the deck is completed, he builds the rails; after this he may complete the deck fittings and install the hardware outboard. The interior is next completed, the plumbing installed, and all cabin fittings placed. When the engine piping and wiring are finished, the cockpit is completed.

Now the hull may be finished; any deck fittings or hardware not installed are secured and all outside smoothing is done. When the planing and sanding are completed, the boat is painted inside and out. While this is drying the builder can get out the spars, fit the rigging hardware and prepare to step the masts, put over the rigging, and get the sails ready to bend. When all is ready, the launching takes place, the spars are stepped, and the rigging set up. Then sails are bent, the motor tested, and a trial takes place. After this adjustments or small changes are necessary, as a rule, so these are done by the builder before he considers the job complete.

This, of course, is nothing more than a bare outline of the operations necessary to build a boat, and the sequence may vary a little in certain types of construction.

The most important requirements in a builder are accuracy and patience. The beginner should have no feeling of haste. He must plan each operation well in advance and try to see not only that particular job but the one following it; by this means he will avoid having to undo some work already completed in order to get at a fastening, or to fit some member later on.

In every amateur boatbuilder's shop there should be a "moaning chair"; this should be a comfortable seat from which the boat can be easily seen and in which the builder can sit, smoke, chew, drink, or swear as the moment demands. Here he should rest often and think about his next job. The plans should be at hand and here he can lay out his work. By so doing he will often be able to see mistakes before they are serious and avoid the curse of all amateur boatbuilders: starting a job before figuring out what has to be done to get it right.

Boatbuilding

CHAPTER ONE

PLANS

THE obvious first step in building a boat is, of course, to obtain plans. When these are once chosen, the size, type, rig, and accommodation of the finished boat are established. The cost and the amount of labor necessary to build the boat are also decided. Even the number and kind of tools and the equipment required will depend upon the plans chosen. It is hardly necessary to stress the fact that, aside from these matters, the behavior of the boat under sail and motor, her appearance, and, last but not least, the comfort to be had in her, are all decided upon when the plans are selected. Obviously, then, the plans are of the utmost importance and a great deal of thought must be given to the selection of them. The builder must decide for himself which model of boat and design he wishes to build; what pleases his eye, what fits his particular requirements as to wind and water, use and cost. Nevertheless, the following information will serve as a guide to the beginner.

Time

Most amateur builders do not care to spend more than a year in constructing a boat. The exact number of hours required to build a boat is an important consideration, particularly as the amateur builder usually works after business hours and on holidays and week ends. If a man is building a boat alone, he would not work over 936 hours a year if he spent two hours every weekday and eight hours every week end on the job. Of course, very few men with this amount of time to spend in building would actually be able to do so; in practice they would probably have trouble in reaching a total of much over 700 hours. Even with the uncertain help of friends it is doubtful if a total of 900 hours would be reached. Furthermore, the effectiveness of the hours spent on the job depends upon the skill of the builder in handling tools. Most amateur builders are unable, for this reason, to make the most of the time they allot to the work. Often mistakes are made and a task must be done over, with a resulting loss in time. In the case of the outright beginner this becomes particularly important as a cause of discouragement, since progress may become very slow. It seems apparent, on this assumption, that there are certain limitations on boats suitable for amateur construction.

Size

The chief of these limitations is size. This does not mean length alone; rather it is best represented by weight, or "displacement." The three dimensions—length, breadth, and draft of water—give a working idea of the actual size of a boat. It must be remembered that the greater the cabin space required, the greater the space inside the hull must be and therefore the greater the displacement; or, in other words, the greater the size actually becomes.

To make the matter clearer, a boat 40 feet long on deck, 11 feet beam, and 6 feet draft is usually a good deal heavier than one 40 feet by 9 feet by 4 feet. The first boat, weighing more, has greater cabin space and therefore takes more material to build, which in turn represents more hours of labor and more cost than would be required to build the second and lighter boat.

Suppose these boats are both of the common round-bottom class and that they have very meager cabin furniture, simply arranged; the number of effective working hours required to build the hull, cabin, deck furniture, and spars, and to paint and finish, would be about 980; add to this the hours necessary to install engine, tanks, wiring, plumbing, rigging, and ironwork, and the total is well over 1,400 working hours for the heavier boat. The total for the second and lighter boat, on this basis, would be about 1,100 hours. Of course, this comparison is based on specific examples that are reasonably alike in all but displacement. Differences in model, finish, and detail would have qualifying effects on such a comparison. Lest it be assumed that the differences in weight, or displacement, could be accounted for in ballast and not in work and material, it must be made plain that

the heavier a boat is in displacement, the stronger and heavier must be her construction, if she is to be a soundly built job.

The question of how large a boat an amateur builder should undertake depends wholly upon the following factors: his skill, time allotted for building, help available, and the model and finish of the boat shown in the design to be followed. As a general guide, however, it is possible to set up certain standards of maximum size that should not be exceeded. For a man who has never built a boat before, and whose skill in the use of tools is not great, a boat weighing between 2 and 3 tons is about as large a craft as he should attempt to build alone. In length, such a boat might fall between 24 and 30 feet, perhaps, depending upon model and type. If he has no allotted time for building then the size might be increased slightly, but this is not recommended; slow progress, which would naturally result, would be very likely to discourage him. Two such amateurs could build a boat up to 4 or 5 tons displacement, say, of lengths between 28 and 35 feet. Even the most skilled amateur would do well to take 14 tons displacement and 40 to 45 feet length on deck as the largest boat he can build at home, with occasional help. Such a boat would require about a year and a half to build under the best conditions that a beginner can expect; probably two years would be required. Since it is extremely important that the beginner not hurry his work, it is really a mistake to attempt to set an exact building period; on the other hand, few men wish to spend as long as two years building one boat. For that reason, regardless of model, a boat exceeding 45 feet in length on deck and 14 tons displacement is too large for home construction. As a general rule, the larger the boat chosen by an amateur builder, the simpler she must be in construction, model, and arrangement. Fancy finish is usually out of the question in a large, "home-built" boat.

Model

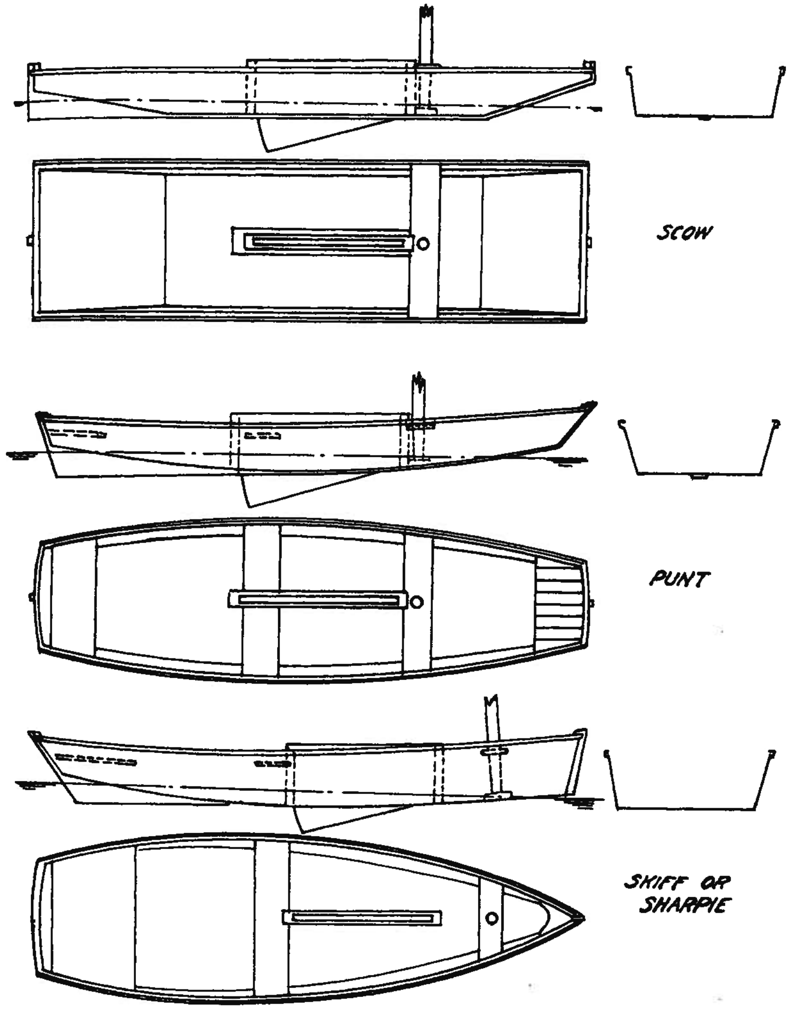
The model of the boat chosen for amateur construction must be subject to certain qualifications as to suitability. For this reason it may well be classed as another important limitation—as important as size and closely related to that consideration.

Model is taken to mean basic design. For practical purposes there are assumed to be three basic hull forms, graded according to the shape of their midsection, or largest transverse section: flat-bottom, V-bottom, and round-bottom. Each basic model is subdivided into a number of "types" which represent variations in the basic model, the result of the application of a model to some given condition or requirement.

Flat-Bottom Model

The first to be considered is the flat-bottom model of boat. Of all models this form of boat is the easiest to build; it requires the fewest tools and the least hours of work to complete in any given length. In type it is usually classed as follows: scow, punt, skiff, or sharpie. The scow is nothing more than a rectangular box with the two narrow ends sloping outward from the bottom, usually with shoal upright transoms or end timbers finishing off these sloping ends on top. The punt is an improved and developed scow, having the bottom well rockered fore and aft, flaring sides and raking transoms at bow and stern. The skiff is marked by a sharp bow and has less rocker to the bottom in profile forward; aft she is like a punt. These three types are usually built for rowing in lakes and rivers, but occasionally they are used as sailing craft. In the latter case they commonly have centerboards. In some localities the punt and skiff types are fitted with power and are used for fishing. The sharpie is really an enlarged skiff; sometimes, however, it has either a sharp stern like a canoe or a rounded stern something like that seen on the towboats used along the coast.

Examples. The flat-bottom model is suited for protected waters, but is occasionally used along the coast when built to sufficient size. Large-powered scows are seen in harbors and rivers; formerly such boats were commonly fitted with sail, either sloop or schooner rigged. Others of this class were punt shaped. The New Jersey oyster garvey, the Maine scow sloop, and the San Francisco scow schooner represent examples of the practical use of such hull forms. The skiff is also used under power and sail by fishermen or watermen along the coast. The sharpie, ranging from 18 to 60 feet in length, is usually a sailboat, but sometimes it is fitted with a motor. Boats of this class are in favor for shoal water work of all types; formerly they were very popular with oystermen on Long Island Sound, the Carolinas, and Florida

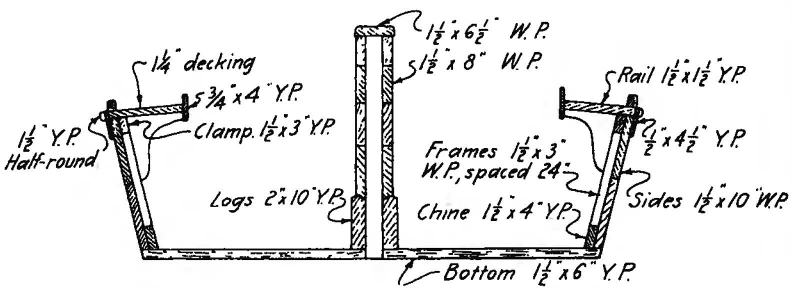


1. Flat-Bottom Types

waters. Many of the Chesapeake Bay crabbing boats are of this same general type. The use of flat-bottom hulls for pleasure craft was largely a development of the designs evolved in commercial boats, where shoal draft and cheapness were important.

The flat-bottom hull is commonly seen in the very small sailing classes, as dinghies and prams, and occasionally as small cruisers. Whether rowing, sailing, or power hulls, the designs are marked by light displacement, slight or moderate rocker to the bottom fore and aft, and simple construction.

Design. Observation indicates that for sailing, or power, the flat-bottom hull should be relatively narrow in proportion to length and that the rocker of the bottom fore and aft should be moderate. In sharp-bowed craft, the line of the bottom, viewed in profile, should conform to a general rule. The heel of the stem should either touch the water or be just clear of it. From this point the line of bottom, or chine, should run straight and sloping downward for about one third the water-line length of the boat; from there it should go into a reasonably gentle curve through the middle third, and then should again become straight, or very

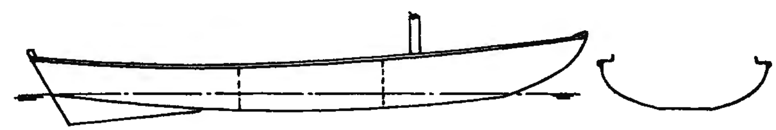


2. Typical Flat-Bottom Hull Construction

nearly so, and run upward to the stern. Even in rowing skiffs this general form is quite important. Much of the prejudice against flat-bottom dinghies can be traced to the neglect of this matter on the part of their designers and builders; if there is curvature in the forward third of the chine, in profile, the boat will row heavily. Flare is also important, for it not only aids in seaworthiness and stability under sail but also gives increased power to carry loads. The Gloucester Fishing Dory is a good example of a flat-bottom hull designed for rough water work and load carrying; it is also a good example of the effect of flare on sea-keeping ability in flat-bottom hulls.

Construction. The usual construction of a flat-bottom hull is to make up the sides of one or more strakes; the bottom is cross planked. Longitudinal stringers are placed at chine and sheer and secured to stem and transom or post. The planking of the sides is fastened to these and the bottom is fastened to the chine stringers. Along the sides cleats are worked in, vertically between chine and sheer, to serve as frames. Except in the large sharpies there is rarely any keel structure. A plank worked in along the center line, either inside or outside of hull, serves the purpose. A skeg or outside keel is sometimes used; this is merely spiked to the fore-and-aft plank on the center line and to the bottom planking. In a small boat only one or two molds are used, in addition to the transom.

Bottom Laid Fore and Aft. A few flat-bottom boats are planked fore and aft on the bottom. There are no advantages to this, and some disadvantages; a boat planked this way needs regular sawn frames and so is usually heavier than a cross-planked hull. Also there is often weakness in a sailing boat so built, unless she



3. "Curved Sides and Flat-Bottom" Sailing Dory

is well braced. The dory is the only well-known example of a working flat-bottom boat being planked fore and aft on the bottom. Due to their narrow bottom this can be done with two or three wide plank, so there is some saving of time in building. The necessity for making it possible for these boats to nest inside one another makes fixed thwarts or cross bracing out of the question and sawn frames are therefore required to keep the sides in shape. Since these frames must be used anyway, the fore-and-aft bottom plank naturally follows.

Curved Side. In an attempt to improve on the appearance of flat-bottom craft, designers sometimes employ curved sides in cross section; a common example is the stock sailing dory. There is no real advantage, other than appearance, in this idea and it makes the flat-bottom boat quite a bit more difficult to build. The chief advantage of a flat-bottom hull being her ease of construction, there can be no common-sense excuse for adding anything to complicate the building. A well-designed flat-bottom hull can be made very attractive in appearance by proper sheer and flare, combined with simple, straight-line stem and stern, if her freeboard and beam are both small in proportion to length. High freeboard or very high deck structures, such as cabin trunks, are not possible in a well-proportioned flat-bottom boat in lengths up to 45 feet overall. It is evident, then, that full headroom (6 feet 1 inch by rule of practice) is not practical in this class of boat.

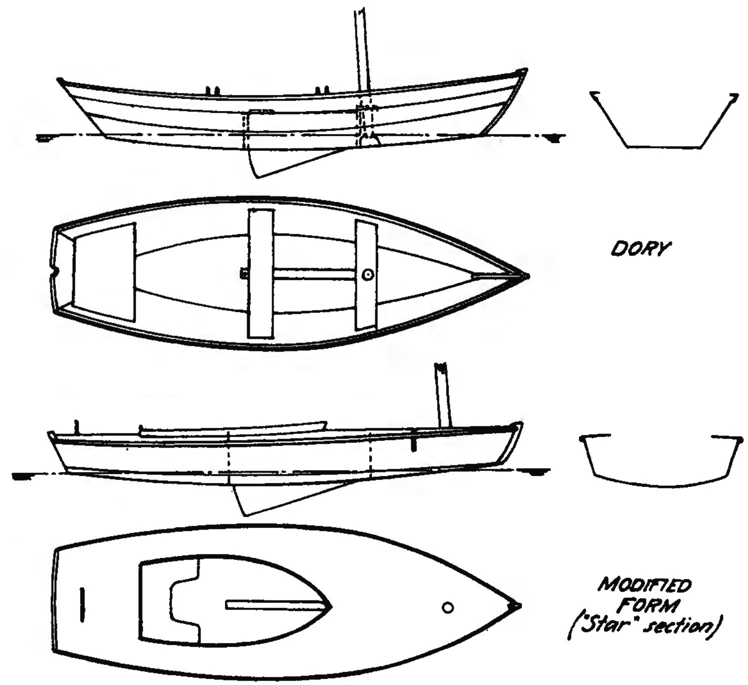
Seaworthiness. While it is true that flat-bottom craft are used in rough water (the Gloucester Dory, or "Bank Dory," for example), the model is not suited for this purpose, generally speaking. The sharpie type, in lengths between 28 and 60 feet, has gone to sea and, in proper hands, will stand a good deal of punishment; but her crew will receive as much as the boat. The large sharpies pound heavily under bad weather conditions; so severe is this pounding that there is danger that the calking may be knocked out of the seams in the bottom. Large flat-bottom craft are inclined to be unmanageable in a heavy-breaking sea. The model is suited to small craft or those used alongshore and in protected waters, not for deep-water cruising.

There is one further modification in the flat-bottom model. In this the bottom has some curve athwartships, but the sides are flat. This is seen in small racing classes, such as the well-known "Star Class" boat. This has the advantage in that it gives greater speed in light weather than is usually possible with a boat having the conventional flat bottom. Frames are usually required and the bottom is planked fore and aft.

Sailing Qualities. A general idea of the sailing qualities of flat-bottom models of good design can be given as an aid in forming an opinion on the suitability of the class for a given condition. The boats will run very fast in strong winds and smooth water. The long, narrow boats are fast reaching and running under such conditions. Most flat-bottom boats are a little slow in drifting weather. They will go to windward but will not point as high as a good round-bottom boat should do. Their worst sailing is done to windward, in light airs and in a choppy sea. Under such conditions they pound and lose headway. In strong winds they usually carry a strong weather helm. They sail best when the weather chine is just clear of the water and in rough water work when given some heel. They require much larger centerboards than do most round-bottom boats; this, incidentally, is one of their objectionable features when planning a cabin layout

for cruising, as the case invariably divides the cabin in two parts. Windage is a very important matter in the sailing of most flat-bottom types and should be kept to a minimum. High freeboard, large or high cabin trunks, and excess rigging should be avoided.

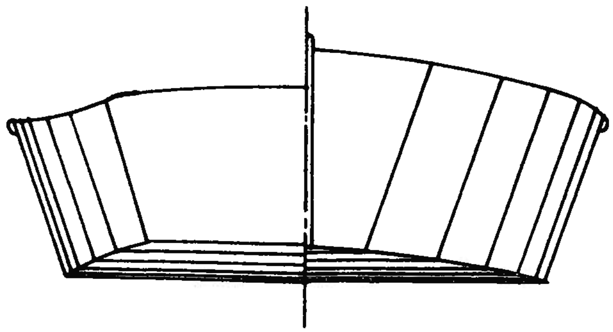
For Power. As a motorboat, the flat-bottom model is suited only for protected waters. It will carry heavy weights on a small



4. Flat-Bottom Types

draft of water and is fairly efficient with engines of low power. It is a mistake to attempt to drive a hull of this model at high speed. The punt type of hull is widely used as a commercial powerboat; it is a very efficient carrier and cheap to build. Sharpie-type power cruisers are sometimes seen; usually they are very small and are powered with outboard engines. It is a mistake to attempt to build a wide boat for this purpose, if power is to be used efficiently.

Judging for Building. There is one way of telling whether a design of a flat-bottom model is going to be difficult to build; in the part of the "lines" showing the cross sections look at the sides. If the lines of these as shown in the various sections are parallel, or nearly so, the side will bend into place without having to be twisted. If not parallel to a marked degree, the sides will have to be rolled in or out—and this is not easy if the plank is not very thin. To bring a flat side into a curved rabbet line at the stem



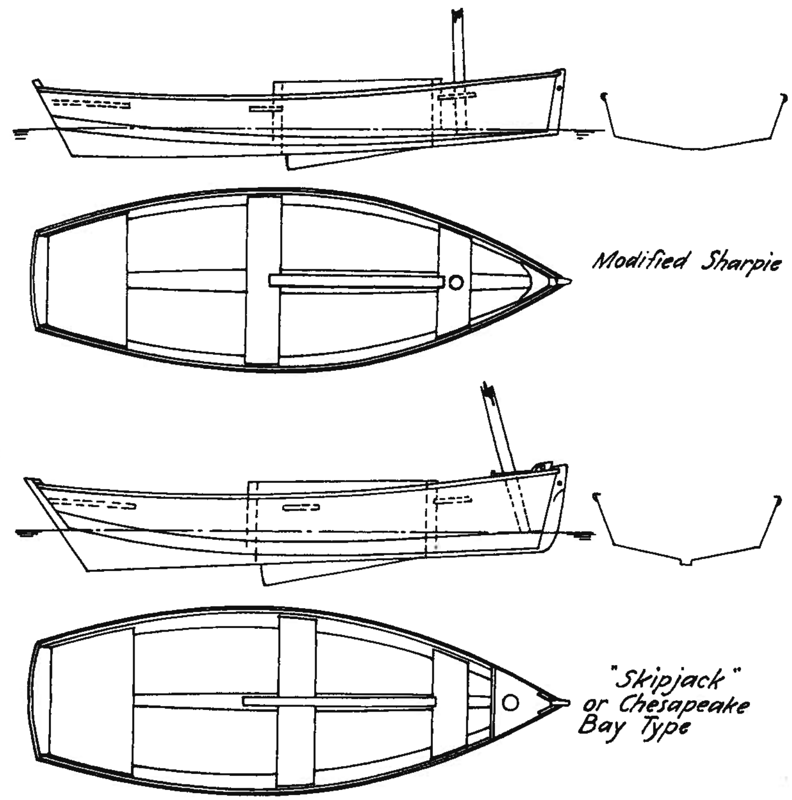
5. Body plan of straight-sided skiff with parallel sections indicating an easily planked hull. Transom side is not parallel to sections as it is raking in profile. This does not affect planking, however.

is likely to cause trouble too. If the stem is to be curved, this should be only in the profile of the stempiece, not in the rabbet.

CONCLUSION. A properly designed flat-bottom boat is undoubtedly the best subject for an amateur's first attempt. It offers a wide range of choice of types which fulfill the needs of at least the majority of beginners. Even if the amateur intends to build a different model, the flat-bottom dinghy will serve to practice on and to experiment with; the labor is not lost, since a useful boat will result.

V-Bottom Model

The V-bottom model has become very popular with amateur builders during the last thirty years. It is a more seaworthy model than the flat-bottom and is usually somewhat roomier since it is possible to employ greater displacement and beam. The V-bottom

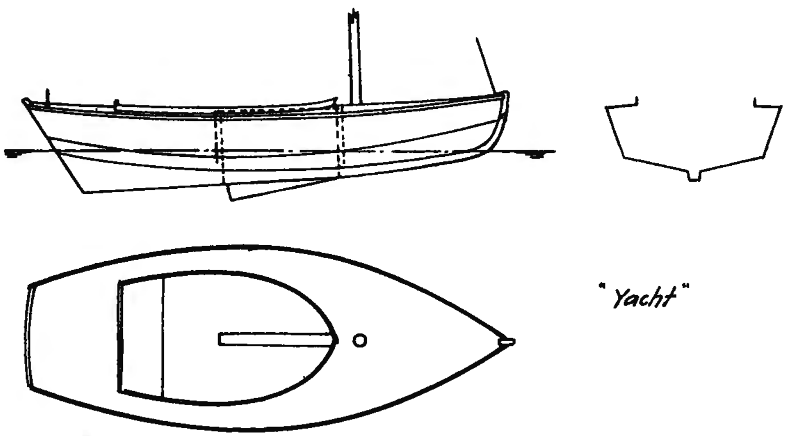


6. V-Bottom Types

is the outgrowth of the flat-bottom and was developed through the necessity of getting greater displacement in a given length than was desirable in the latter model. Because of the straight-line sections usually employed, the V-bottom is looked upon as a very suitable type for beginners. As will be explained, this may or may not be true, depending upon the exact shape and construction methods shown in a design.

TYPES. As in the case of the flat-bottom model, the V-bottom may be divided into types or classifications. The first is the "modified" sharpie, having either dead rise at the stern, or stern and bow, or a slight amount all along the bottom. A great many small racers and some cruisers might be said to fall in this classification.

The well-known Chesapeake Bay Skipjacks may be taken to represent the next type, having a good deal of beam and more dead rise than the modified sharpies. The third type is that seen so often in yachts, characterized by much lift to the chine fore and aft, a great deal of dead rise, and a rockered keel with centerboard or fin. The fourth type is usually employed in motorboat hulls designed for high speed. In this both the sides and bottom are curved in section; sometimes only the sides are curved. This form

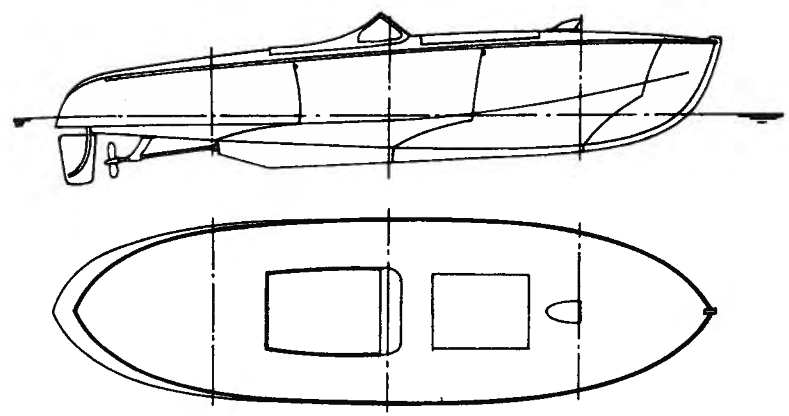


7. V-Bottom Types

is best represented by the stock high-speed runabout. There have been a large number of variations in the V-bottom model, employing two chines on each side, variously curved sections, or scow- and punt-type hull plan and profile. The outboard racing boats, hydroplanes, and certain classes of highly specialized and restricted racing craft, both sail and power, may be said to illustrate these variations in the V-bottom model.

Seaworthiness. The V-bottom model's seaworthiness is less easy to rule upon than that of flat-bottom types. Much depends upon the exact design rather than type classification, except, of course, where racing craft (either power or sail) are concerned. The modified sharpie and the yacht-type dead-rise model (dead rise is another name for a V-shaped bottom, though the term is also used in reference to the rising bottom or "floors" of round-bottom boats) have often been used in deep-water cruising. These

two types and the Chesapeake Bay type are used for commercial craft, both power and sail. The Bay Skipjack is not as seaworthy as the other two models because of her proportionately greater beam. Power dead-rise boats are used all along the Atlantic coast of the United States for both work and pleasure. Dead-rise working craft have been built as long as 90 feet and the common dead-rise power yacht is often over 50 feet in length. Stock-boat builders have developed many V-bottom power and sailing cruisers.



8. V-Bottom High-Speed Motorboat

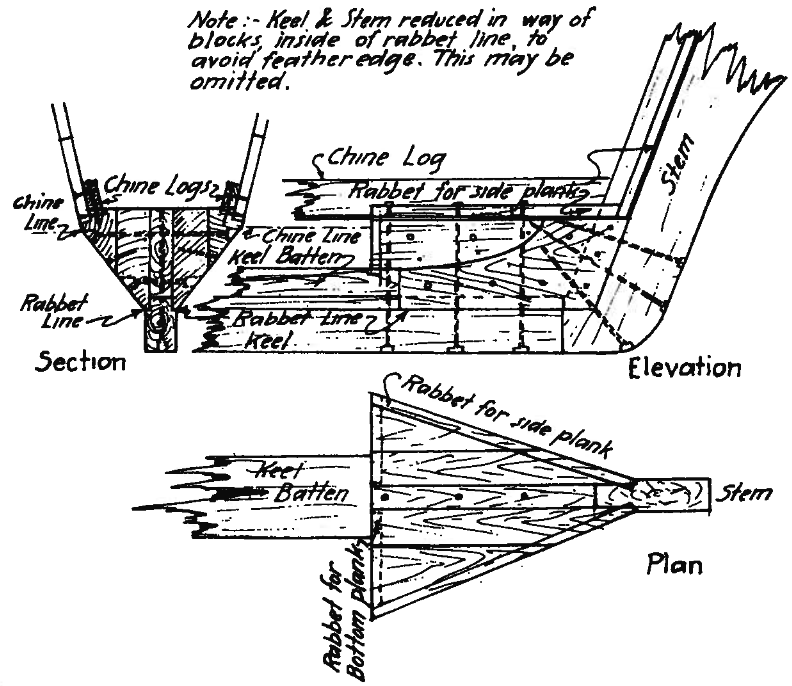
The majority of types having a V-bottom are designed for use in protected waters. In almost all hulls having this form there is some pounding in rough water. In power craft this takes place when driven fast, even in a moderate sea. In sailing hulls it takes place when the hull is heeled at certain angles, which vary with the individual design. In sailing V-bottom craft the pounding is rarely as severe as it would be in an upright, flat-bottom boat. A dead-rise hull does not have the power to carry sail, that a flat-bottom boat of the same length and breadth would have, without the addition of ballast. This is not necessarily an objectionable feature.

Sailing Qualities and Design. The sailing qualities of the V-bottom hull are somewhat like those of the flat-bottom types, but with improved windward qualities if well designed. They will rarely point as high as a well-designed round-bottom boat, though this is not the case with exceptional designs. It seems probable, from observation, that some designs are adversely affected by excess beam and windage. The effect of the chine may also be the cause of poor sailing. Too much rocker in the chine (in profile) is damaging to speed, as tank tests have indicated. In many designs the chine is carried very high, forward and aft, in an effort to overcome pounding. Apparently this is very harmful to speed. The chine ought not to be too deeply immersed amidships but, on the other hand, should not be out of water when at rest or a very uneasy boat is likely to result. All chine hulls having the sharp, conventional bow seem to benefit by greater sharpness than would be common in round-bottom boats. The exception to this is in long, low, narrow, very light sailing hulls of the racing type, where a full bow is often effective. Designers sometimes attempt to produce a deep keel hull, having a good deal of headroom, by employing great dead rise. Such designs are usually complete failures in speed and sail-carrying power. While it is possible to use a keel in place of a centerboard in the V-bottom, this ought to be in the form of a fin, rather than a part of the hull form, to avoid the undesirable effects of excessive rise of bottom. The angle of the bottom at amidships ought not exceed 18 degrees from the horizontal in V-bottom craft. The most common faults found in V-bottom yacht designs are too much rocker to chine, or to both chine and rabbet, too much dead rise, or too much beam or freeboard.

Power Design. Power hulls differ in characteristics of design according to the type and required speed. Low-speed hulls are usually long, sharp, and narrow; in profile their chines have little curve. The chine is usually at, or a few inches above, the water line at the bow, runs straight and sloping downward to a few inches below the water line at about one third the water-line length from the bow, then curves gently and comes out of the water at the stern in a long, flat curve or straight line. The chines are not deeply immersed and there is usually a rather deep forefoot. The transom is either clear of the water or immersed very little. In high-speed hulls the chine is usually rather high at the bow and has a good deal of curve in profile forward. The chine enters the water well amidships and then runs downward in an almost straight line so that the greatest depth the chine is immersed is abaft amidships or at the transom. In very fast hulls, having sufficient power, there are one or more steps in the bottom

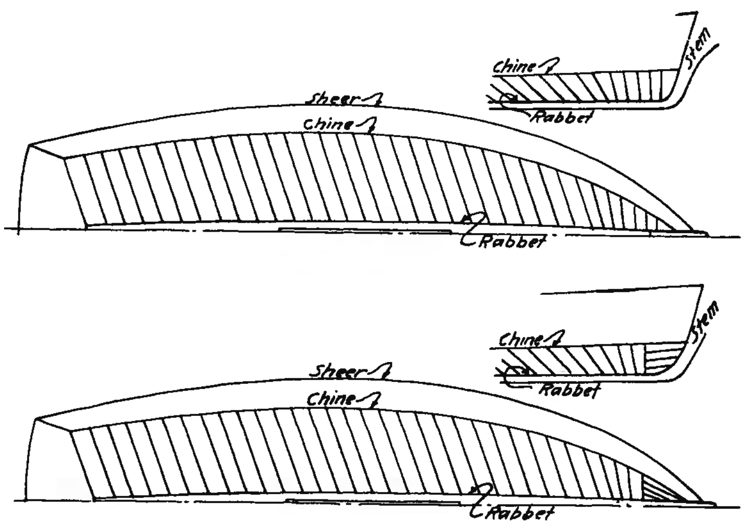
running from chine to chine; these are hydroplanes. In all high-powered craft the transom is well immersed when boat is at rest. The forefoot is very shallow in these boats; the stem is well curved, in profile, and the bow is full on deck.

Construction. The methods of constructing V-bottom types are many. Some are easily followed by the amateur builder but



9. Block Forefoot of Five Pieces, Chesapeake Bay Fashion

others drive even the skilled professional to the moaning chair in despair. The easiest type of V-bottom hull to build is the modified sharpie. This type has no forefoot as a rule; the chine and rabbet line of the keel meet at the heel of the stem. The sections are usually straight sided; the rabbet of the stem is straight, or nearly so. The stern may be sharp or have a transom, set raking or upright. Usually the keel has no rabbet cut into it; there is an inner member, the "keel batten," which backs up the bottom planking along the keel. The chine timbers are like those of most flat-bottom types; so is the side framing. The bottom is cross planked, but at an angle to the center line of the hull with the outboard ends of each plank further aft than at the keel. This is usually done so that the planks at the transom will be nearly parallel sided; the boats having plumb transoms or sharp sterns do not require this method of planking the bottom, though it is sometimes done. The forefoot is made most easily of a block secured to heel of stem and to keel and hewn to fair off with the bottom, when planked. In such construction the keel need not



10. Cross-Planked V-Bottom with Staving at Forefoot

be carried to the stem unless there is an outside shoe or "gripe." If the rabbet line of the keel is lower than the chine at the stem, the bottom planking becomes a little more difficult. Usually the easiest way is to plank the bow, between keel and chine, with narrow, thick staving for a few feet abaft the stem; this is then planed off to the thickness of the rest of the bottom planking, when that is laid. Sometimes it is better to lay the plank fore and aft, using thick staving, for a few feet, then cross plank the bottom. If the height between chine and keel rabbet at the stem is not great, then it is possible to form the fore part of the bottom by securing blocks on either side of the keel batten with dowels;

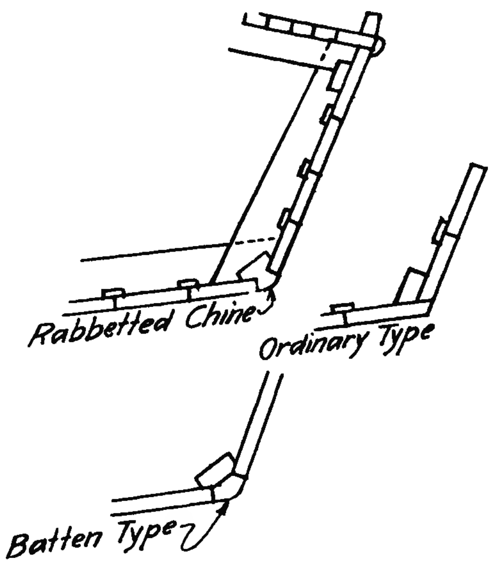
the blocks are deep enough to fill the height between rabbet of keel and chine, of course; then hew off the blocks fair to outside of bottom plank when laid. This is perhaps the best method when the forefoot is angular and the bow fairly full. Vertical staving, however, is often used in place of blocking.

In this class of work no sawn frames are required in the bottom, but if the boat is wide there are often two fore-and-aft battens inside, one on each side of the keel, parallel to it, and about halfway between chine and keel amidships. It is easiest to fit the outside keel or shoe before the bottom is laid. Boats having these features of construction ought to have strong deck framing, with a number of hanging knees, braces, or solid bulkheads to give them strength enough to stand strains set up by waves or, if a sailing boat, by the spars.

Bottom Laid Fore and Aft. In yacht designs it is common to require the bottom to be planked fore and aft. This occasionally causes a good deal of trouble to the inexperienced builder. With this method of planking the bottom, sawn frames are required. It is also necessary to fit the garboard in the same manner as in round-bottom hulls. Usually all bottom plank run to the rabbet of the stem, which requires spacing and fitting like the garboard. Should there be much twist in these planks they may have to be steamed, particularly if the bow is full. Steamed planking is one of the reasons why professional builders often claim the V-bottom is as hard to build as a round-bottom hull; fitting the bottom plank to some designs will cause the amateur to wear the moaning chair to footstool height.

When the bottom plank, laid fore and aft, does not run to the stem but ends on the chine, the long, narrow points formed by the acute angle at which the chine crosses each plank will usually cause trouble when the calking is being done.

Batten Seam Construction. Some plans call for the seams of the topsides, and of the fore-and-aft bottom plank, to be backed up inside by a batten, to which each plank is to be fastened as well as to the frames. This is known as "batten seam construction." Excellent for hulls subject to vibration, such as lightly built, high-speed power hulls, it is not wholly suited for amateur construction, unless the hull form is one that is easily planked. The battens cannot be placed until the planking has been laid off on the hull in accordance with the *width of plank available*, *after it has been shaped and fitted.* If this is not done, the builder is likely to find he cannot get out a plank the width required by an arbitrary spacing of the battens. Since the battens must be let into the sawn frames, or molds, before the plank is fastened, the



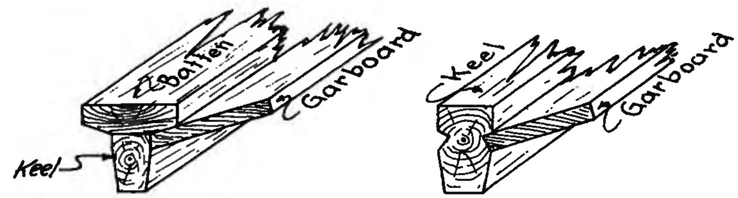
11. Batten Seam Construction and Chines

construction makes slow progress. With this type of construction, it is common in fast powerboats to use closely spaced steam-bent frames between the wide-spaced sawn frames, to give greater strength to the hull.

Rabbeted Keel and Chine. Sometimes a design will require a rabbeted keel; this will add to the labor required of the builder, but is not beyond the skill of a reasonably good carpenter. On the other hand, rabbeted chines are to be avoided as they require a great deal of mold loft and carpenter skill to make and fit. Such chines are sometimes employed in high-speed motorboat designs intended to be built by highly skilled professional builders. It must be remembered that the V-bottom is particularly suited to high-speed motorboat design and is used for this reason alone, not because it is necessarily easy to build. Because of this, complicated construction methods are often shown in a design of a

fast-power V-bottom in order to give strength with a minimum of weight. As a general rule, light, strong construction requires great skill on the part of the builder since every member must fit exactly and be well fastened.

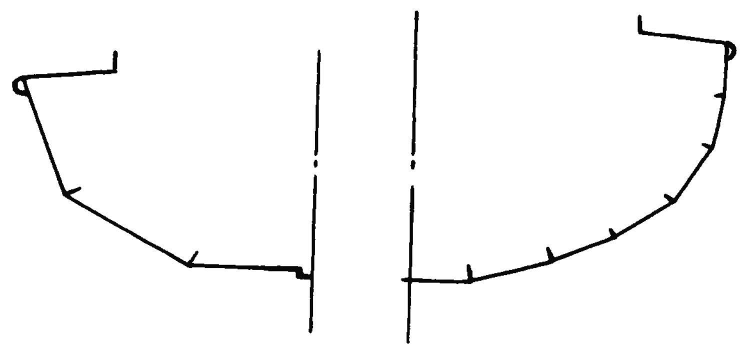
Plywood Construction. In recent years plywood has been used for planking both flat- and V-bottom small craft. The material used for this is made with a waterproof binder between the veneers; no other will serve. While plywood is not affected by water in contact with its faces, it may be harmed by water in contact with its edges. To prevent this, seams and raw edges



12. Batten Keel and Rabbeted Keel

are protected with a waterproof tape or cement. The lasting qualities of plywood hulls seem good if properly built and the construction is suited to small dinghies and similar craft. It is expensive in large boats. As it is very flexible, a number of closely spaced battens are employed between the frames to stiffen the skin of the hull; this increases the labor, so there is little saving, except in weight, over a planked hull. The source of most trouble in plywood, particularly the thinner sheets, is due to faulty manufacture; the inner plys (or core) are not closely butted and the sheet will fracture if bent in the vicinity of the open butt. In most sheets of plywood the inner ply (or core) is of fir, which is subject to quick rot. Therefore, the plywood should be well protected with paint, or canvas covered, to get the greatest life. In small cruisers that must be light, canvas-covered plywood makes an excellent deck or cabin roof if the required curvature is not too great. Plywood cannot be bent in more than one direction; the bending qualities of a sheet are best represented by a square of paper. Pressed fiberboards of certain classes may be used in the same manner and for the same purposes as plywood. These materials, plywood and fiberboards, are much used for cabin bulkheads if their binder is waterproof.

Multi-Chine Types. Hulls having more than one chine on each side are sometimes designed for amateur construction. These boats most commonly have two chine lines on each side and are planked fore and aft. It is doubtful if there is any particular ad-



13. Sections Showing Multi-Chine Hull Forms

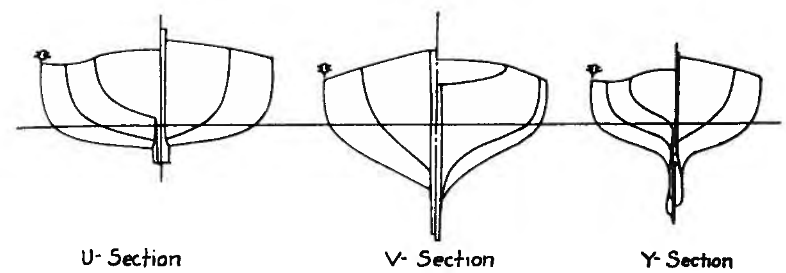
vantage to such hull shape, but some designers and builders prefer it to the orthodox single chine. The planking has to be spaced and fitted as in a round-bottom boat, though it is a little easier to get the plank in place. The chines are generally backed with a batten, beveled to fit the angles of the frames and plank. A better construction, though harder to do, is to lap the edges of the planks at these chines and omit the chine battens. This is the sailing dory construction; by multiplying the number of chines, a round-bottom hull results.

Round-Bottom Model

The round-bottom model is considered by most amateur builders too difficult to construct. This is not wholly correct; while it is true that some designs are beyond amateur means, both in skill and equipment, there are designs that are really no more difficult to build than a V-bottom model having the bottom fore and aft planked. The means of classification of the round-bottom model must vary from the rather simple method used in the other models. The clearest way, most suited to establishing the relation of a design to suitability for amateur construction, is to divide the

model's types according to midsection and then subdivide according to use and methods of construction.

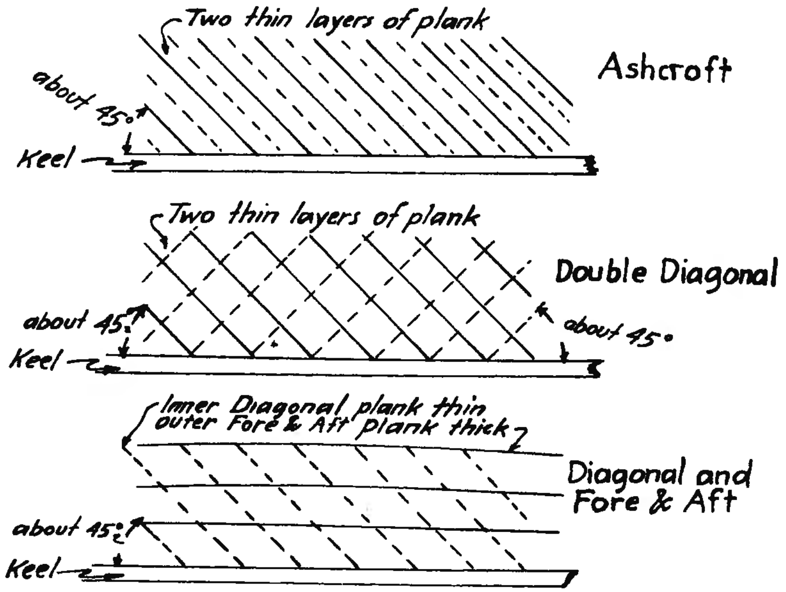
U-Section. The first midsection form is that which might best be called the "dinghy section"—almost U-shaped. This midsection is used not only for dinghies, but also for powerboats and even larger sailing yachts than dinghies. It is probably the easiest form to frame as there are commonly no reverse curves in the sections. There are a number of ways of planking this hull form,



14. Classification of Round-Bottom Types by Midsection, Showing Effect of Midsection on Other Sections in the Hull

clench or lap-strake, carvel, strip and diagonal. With the latter two methods of planking, the usual bent framing may be largely or entirely omitted. The clench or lap-strake and the diagonal methods are the lightest and strongest; they are excellent for dinghies. Clench planking is sometimes used in the bottoms of high-speed powerboats. It requires a good deal of skill to build a lap-strake hull, but it is not beyond the capabilities of a good amateur carpenter. The diagonal method, highly developed in England under the name "Ashcroft System," is particularly designed for amateur building. It is not to be confused with the regular, double-skin type of planking which is very difficult for the ordinary amateur. Carvel or smooth-skin planking is the orthodox method; it is suitable for boats having planking not less than ⅝ of an inch thick. It is not quite as difficult to do as lap-strake, but more difficult than the Ashcroft method.

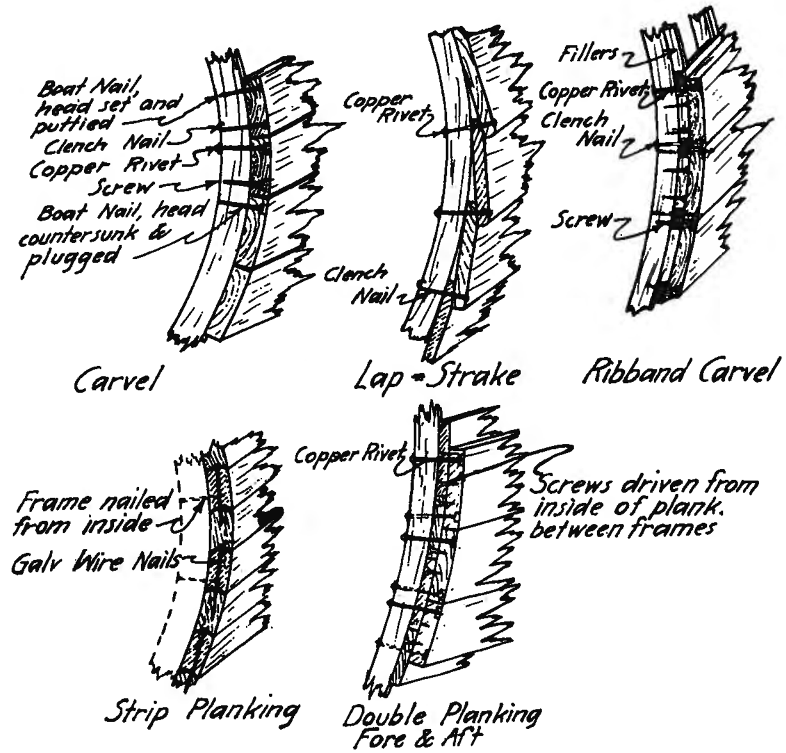
In some designs having carvel planking the seams are backed up with battens; this is known as "ribband carvel" or batten seam construction. It is subject to the same objections as the batten seam construction described for V-bottom craft (batten seam construction, page 41), with the additional drawback of having to pad the steam-bent frames between the battens. These make it unsuitable for amateur construction in most cases. Its advantages and uses are those of the same method applied to V-bottoms, already mentioned. Strip planking is made up of narrow strips,



15. Types of Diagonal Planking

edge nailed. It is relatively easy to do, as far as fitting is concerned, but is somewhat laborious in fastening. A strong but heavy method of planking, it is well suited to amateur building. Small craft having the dinghy section are sometimes carvel planked and then canvas covered; this method is also suited to amateur building, but is limited to canoes and the smaller class of dinghies. All of these planking methods will be explained in a later chapter. The dinghy-section round-bottom hull is easiest to build when it is not wide in proportion to its length. It is a pretty general rule that all wide hulls are much more difficult to build than narrow ones.

Sailing Qualities of U-Section. The sailing qualities of this section are usually excellent and so it is commonly used for small racing craft, either centerboard or fin keel. In Europe it has been used successfully in small auxiliary cruisers. With proper design, it has been used in large sailing craft having centerboards.



16. Common Types of Planking and Methods of Fastening Used for Each

U-Section for Powerboats. For power craft, the section is also a very good one. It is used in most round-bottom powerboats, either launches or cruisers. Generally the hull has a skeg or fin keel aft to protect the propeller and rudder, and to help in steering. It is suited to low- and medium-speed motorboats. When long and rather narrow, this hull form will drive easily with low power. In recent years boats have been built with the dinghy form forward and chines aft for high-speed work in rough water. This form is not easy to build and, like most high-speed hull forms, is unsuited to amateur building.

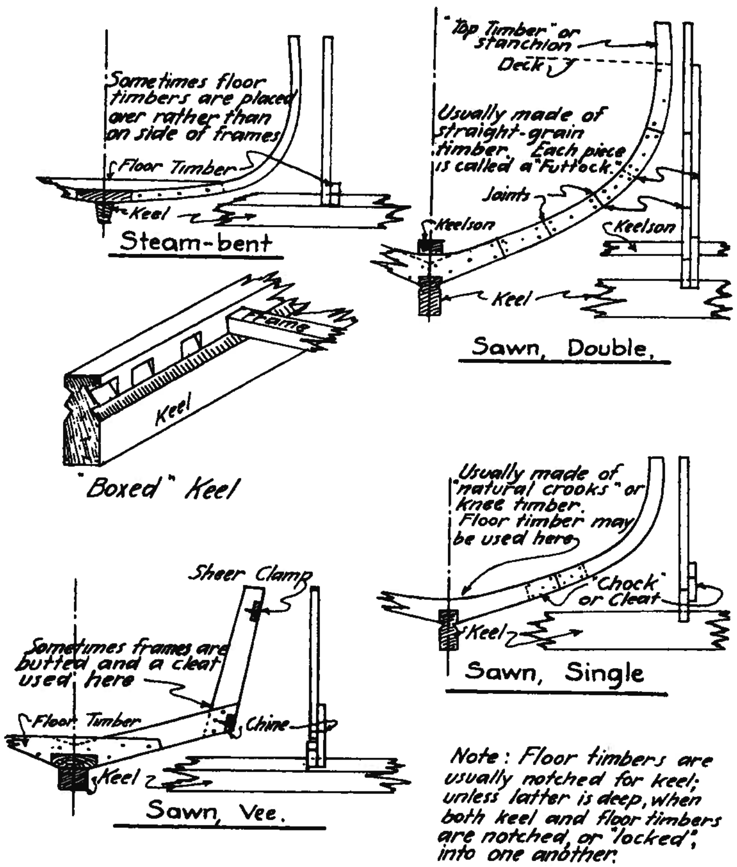
V-Section. The next form of hull, the V-section, partakes of the V-bottom; it is really a V-bottom with round bilges. It usually has reverse curves in the aftersections. Primarily it is a sailing hull, but it is so used in a modified form in seagoing powerboats and in tugs. In the small sizes it is usually seen in sailing cruisers, keel or centerboard, having all or most of their ballast inside. For this reason, it is generally more heavily built than the dinghy-section hull. In sailing craft this form of hull requires ballast, the amount usually depending upon the relation of depth to beam. It is usually easy to frame, only a little more difficult than the dinghy form. It is also rather easily planked, though if full ended or wide this is not true. The greatest trouble is usually aft, in the run, where there is often a good deal of twist in the bottom planking. It may be planked lap-strake, carvel, or strip. Neither batten seam construction nor diagonal planking is suited to the usual design for this form of hull. Diagonal planking can be used, however, if there are no reverse curves in the aftersections. It makes an excellent sailing hull for rough water and was much used, therefore, in small fishing craft having sail, with or without centerboard. It is suited to low-speed power craft only.

Y-Section. The third form of hull belonging to the round-bottom model may be described as having a Y-section, shaped something like a wineglass. This is the popular form for the more expensive sailing cruisers and racers having all, or practically all, of their ballast outside. The keel is usually very wide and heavy. It may be safely said that most designs having this midsection are unsuited to amateur construction, not necessarily because the hull form is difficult to frame or plank but because of the massive keel and ballast casting. Some designs are easily framed and planked, but as a rule boats having this section are harder to frame and plank than those having the dinghy or V-section. Hulls having the Y-section are usually carvel planked, though in some cases strip planking could be used. Expensive racers are often double planked, but this requires greater accuracy in planking than most amateurs are likely to possess. The hulls having the Y-section are not suited to much speed under power, so this hull form is not used in motorboats.

Hard to Build Features. The foregoing classification of the round-bottom model is somewhat arbitrary, for there are designs that do not fall into such clear-cut divisions of hull form. In order to help the amateur choose a design for a round-bottom model, the portions of a design that are hard to build, and which therefore decide its suitability for home building, will be outlined. As has been mentioned, the dinghy section, when given great beam, is difficult to plank. This is generally true of the V- and Y-sections also. If the boat is full on deck forward and fine on the water line, having great flare outward to the sides forward, she will be difficult to plank. If there is a sharp reverse curve aft, she will require careful spacing of the strakes. Fullness in the forefoot or in the stern near the lower part of the sternpost will make a trying job of planking. Very sharp curves in the sections, such as those at the bilge, often give trouble too. The oval stern, or elliptical transom, is much more difficult to shape and finish than the transom having angular corners at the deck or sheer line, in plan view. The transom having curves across its face is more difficult to frame and plank than one that is flat. When the rabbets of the stem and sternposts are well curved, the ends of the planking resting in them (called "hood ends" by builders) are long and sharply pointed; they are usually very difficult to fit.

Framing. Framing the round-bottom model is an important factor in ease of building. Some types that are planked diagonally or with strips require no frames, or at least very few. Framing is done, with other types of planking, in two ways: steam-bent or sawn to shape. The former is used in nearly all small craft of the round-bottom model. In light boats the steam-bent frames are small and closely spaced. In larger craft the frames become wide and thick, the spacing greater. Sawn frames are usually made up of two layers, with the butts staggered to obtain strength. They are heavier, but stiffer, than steam-bent frames. If made of natural crooks or knees, the sawn frame is very strong; in such cases it is not necessary to double the frames except where the joints, or butts, come.

Bent Frames. Steam-bent framing requires molds to be set up and ribbanded off before framing. Boats having sharp curves in the sections, reverse curves, curves near to the keel rabbet, or rounded-in sheers (streamlining), are difficult to frame. If the frames are of large section or are bent on edge they will be



17. Types of Framing

difficult to bend. If the frames must be of large section, then they ought to be wide and rather thin, instead of square, and bent on the flat (wide face to the planking and ribbands), to be suitable for amateur builders. In some localities it is either very difficult or impossible to get timber that can be steam bent.

Sawn Frames. Sawn frames must be all laid down in the mold loft and patterns made; the bevels must be taken from the mold loft drawing. It takes much longer to frame with sawn timbers than with bent ones. However, it is not necessary to set up molds when building with sawn frames and it is much easier for the

builder to check his work against the "lines" plan. The builder is more likely to have a boat exactly like the "lines" with sawn frames than with steam-bent frames. Hard curves in the sections are less troublesome to the builder with this mode of framing. If the frames are of thick timber, a power band saw with tilting frame or table is almost a necessity. In fact, to saw frames out by hand, even for a small boat, is a laborious task, added to which the bevels have to be cut on the face of the frames. Therefore, unless the frames required are few in number, sawn frames are not suited for most amateur-built round-bottom boats.

Heavy Keels and Outside Ballast

Heavy timbers cannot be easily worked by hand. Much of the shaping of the wide, deep keels, required in most outside ballasted hulls, must be done with power tools or with the adz, a highly dangerous instrument in unskilled hands. Then, too, the ballast casting is a difficult problem. If the ballast is of iron, and if the casting has curved sections (as is so often the case in modern yachts), an accurate pattern must be made, allowing for shrinkage. Arrangements for fastening the ballast casting to the keel must also be properly made on the pattern. This is beyond the skill and knowledge of most amateur builders. If the work is hired out, it is quite expensive. If the ballast casting is of lead and not too massive, the amateur builder may be able to cast it in his shop. Shrinkage is a matter of small importance in lead castings of the size an amateur is likely to undertake, so no allowance need be made on that score. It is also possible to make the pattern and mold without having great skill. Lead can be drilled and planed with hand tools, so the fastenings can be bored when the casting is completed. This is a decided advantage in building. Two men can cast a lead keel of 1,500 pounds without great difficulty if they make proper preparations. Smaller lead keels can be cast more easily, of course. The design having the ballast keel angular in section (straight sided and flat on top and bottom) is most suited to amateur construction. In spite of the greater cost of lead, compared to iron, the builder will usually find that the saving in pattern cost, foundry work, and transportation made possible by casting the lead ballast keel himself will more than make up the difference. If the keel casting is too heavy to be handled by two men, it should be cast alongside the stocks and secured to the keel before the latter is placed on the stocks. Inside ballast is no problem, of course, but cannot be used in all designs of round-bottom hulls.

Expensive Materials

In selecting a design from which to build, the beginner should avoid those requiring expensive materials. Mistakes in workmanship are hard to avoid and the loss in spoiled material may run to a large amount of money. Racing craft, except the few classes that were designed primarily for amateur building, should never be attempted by the beginner. He would be wise to try a simple design, flat- or V-bottom, for his first attempt.

Source of Plans and Cost

The model having been chosen and the size, rig, type, and accommodation decided, plans must be obtained. It will be very helpful to have the advice of some other builder in this matter. Plans may be obtained by ordering them from the professional designers whose advertisements may be found in yachting magazines. Or, if the proper plan can be found, it may be possible to use the "how-to-build" articles in yachting and mechanics' magazines, hobby magazines, or books. Those in the yachting papers and books are usually the better designed since the editors know they will be criticized by experienced yachtsmen as well as by professional designers. Unfortunately, many plans used in mechanical and hobby magazine articles are not the work of experienced or professional boat designers. For this reason, advice is very helpful when choosing from such sources. If plans are chosen from a published source, magazine or book, the cost is very low. If a designer is required, the cost will be a good deal greater. There is no fixed scale of fees for boat designing. This is particularly true where very cheap or small boats are concerned. Large yachts are designed on a percentage basis, just as houses are. This percentage is usually from 6 per cent to 10 per cent of the estimated building cost taken for an average building yard. In most offices having a staff of draftsmen a minimum fee is established, usually between fifty and one hundred dollars. This is applied to all designs in which the percentage would run under the established minimum. When the design is of a boat estimated to cost over the minimum, the exact percentage will vary with the type, size, and accommodation. In other words, if a small boat is designed, having a complicated arrangement, the design fee may be higher than for a larger boat having a simple arrangement. If inspection, or inspection and supervision, is desired, the fee usually reaches 10 per cent, or even more.

Stock Plans

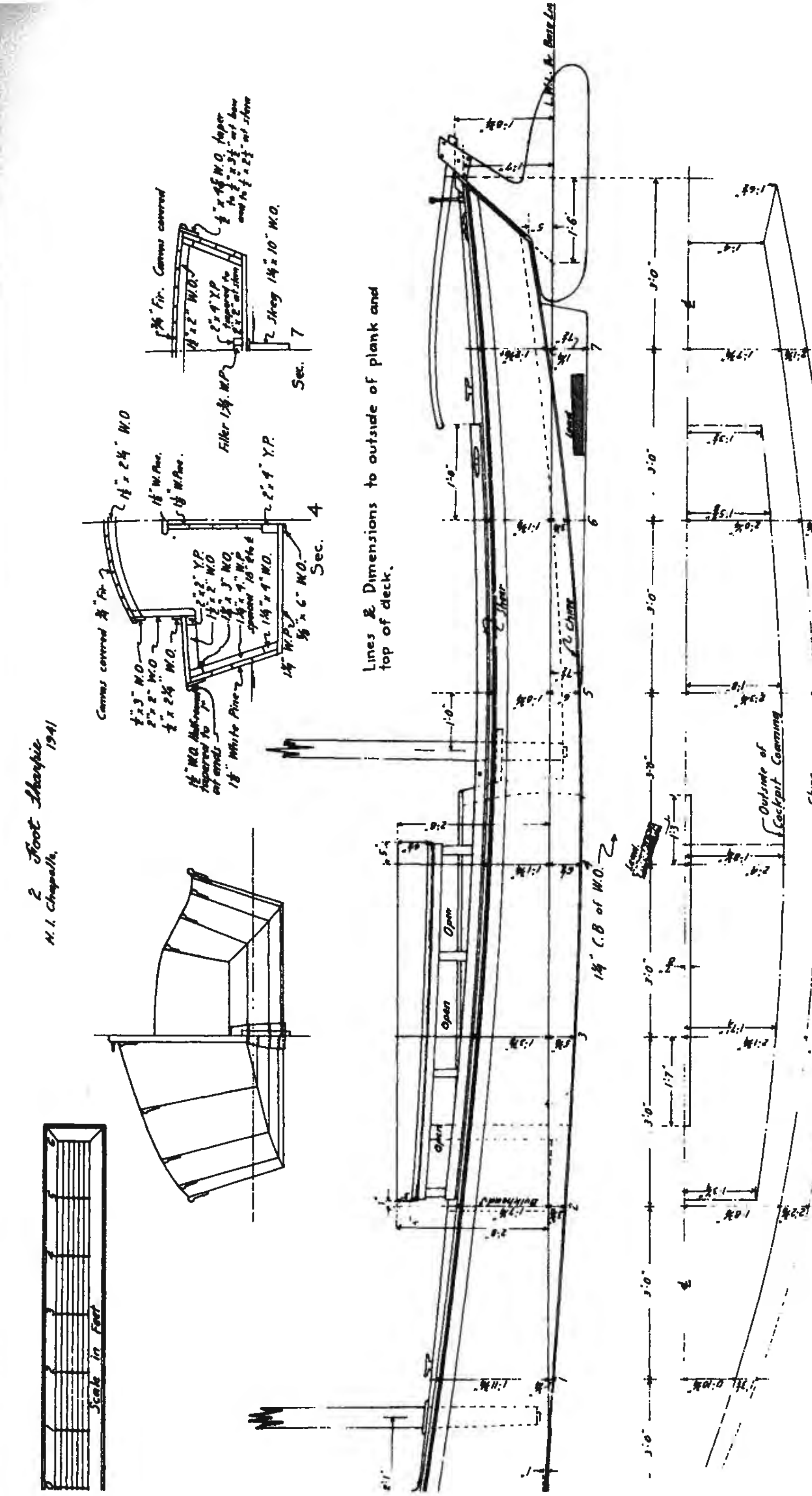
Some designers have "stock" plans; these are plans on hand that they will sell for a low price. These have usually been made to fill a demand for a special type and size, or are old designs that have become more or less obsolete. Very often these plans are excellent and tested designs. However, there is one disadvantage in their use: they cannot be altered in any respect except at an additional cost. If changes are wanted it is wise to have a special design made rather than to ask a designer to make changes in a stock plan. Since the prices of stock plans are usually low, the designer cannot give much time to advice and assistance. If an amateur wishes to build a boat which will require professional advice from the designer, he would do well to have a special design drawn for his particular needs. Some designers do not have stock plans —very few, indeed, have catalogues of available designs—so it is very necessary that inquiries from amateur builders be very complete as to requirements.

Choice of Designer

Choosing the designer is an important matter. It is not difficult for the amateur builder to find examples of the work of the designers listed in the advertising sections of yachting magazines. He may be able to see finished boats in his vicinity, or at least can find examples of designs in the "Design" section of the magazine or in articles. Then, too, there are a number of books showing plans of various types of boats and yachts by specialists in each type. Some designers specialize in small craft, some in large, or in racing boats, or cruisers, or powerboats—wherever their personal interest is greatest. Not all designers are interested in the types of craft suitable for amateur construction. The choice of designer is best made by finding one who specializes in the desired type and who has some interest in amateur problems. An experienced designer may refuse to design a boat of a given type or appearance because he is not interested in it or has objections to it; in that case he will state his reasons or refer the inquirer to a specialist in the type desired.

Ordering Plans

When the designers specializing in a given type are discovered, the amateur builder can write them for quotations on the design of the boat to be built. It is highly important that the designers be given all the pertinent information possible: general dimensions, type, rig, engine, accommodations, and the fact that the boat is to be amateur built. Also a sketch should be given of the cabin arrangement or of the general appearance desired. It is a good idea to give some information on the timber available in the district in which she will be built. Do not ask for just "plans of a 30-foot yawl"; tell exactly what you require. It is sometimes helpful to send the designers photos, or clippings of a plan published in some magazine, showing a boat approximately like the one wanted. Sometimes it may be desirable to have the designers submit sketches of their ideas; for sketches there is usually a small charge, but they are only necessary when large boats are being discussed or when there is doubt as to the proper arrangement of accommodations. Ordinarily sketches are not required if the inquirer is specific in his request for a quotation. Some of the designers approached may refuse to design the boat according to the exact requests of the amateur and will state reasons. These should be carefully considered as designers can make a more accurate study of a proposed boat than is possible by an amateur builder. While it is possible that there is a misunderstanding of requirements or prejudice on the part of the designer, it is likely that any objections he may raise are founded on practical considerations. When the quotations are received and the correspondence compared, a choice of designer can be made and the plans ordered. If the design is to be a new one, remember that the designer will require time to make the drawings; also it may be necessary to have some correspondence in regard to possible



Lines' Plan of flat-bottom hull showing typical fairing lines and method of giving offsets by dimensions on plan, and construction sections

PLATE 1. Lines of a 24-foot sharpie. Sail plan shown on Plate 7.

changes as the plans progress. It is very important that the plans be final, that no changes in shape, dimensions, rig, or accommodations be considered after the plans are once finished.

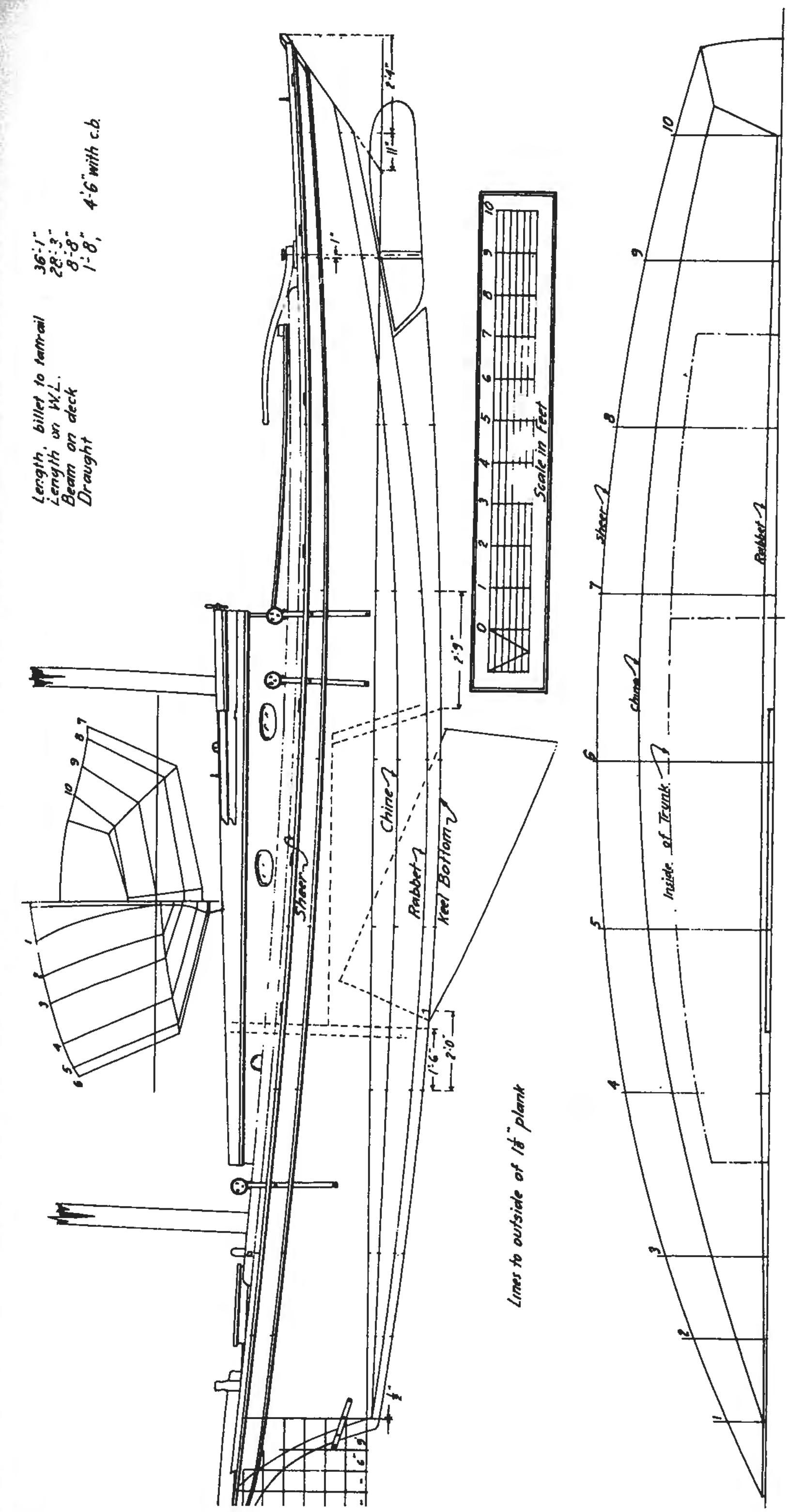
The Lines

When the blueprints of the design arrive, it will be found that they are made up of a number of sheets or plans, unless the boat is a very small and simple one. One of the plans will be the "lines." This shows the shape of the boat. In it are three elevations or views: the profile or sheer plan (or view), showing the appearance of the hull seen broadside on; the half-breadth plan, showing one half the hull seen from above; and the body plan, showing the transverse or cross sections of one half the hull. Only half of the hull is shown because both sides are alike in shape and dimensions.

FLAT-BOTTOM LINES. If the boat is a flat-bottom model, the lines show the profile of the top of the hull or "sheer" line, the profile of the bottom or "chine" line, and the profile shape of both bow and stern in the sheer plan. The half-breadth plan shows the same, viewed from above, giving the outline of the deck or sheer line and of the bottom or chine line as seen from this point of vantage. The half-breadth plan will also show the half-thickness of the stem (and sternpost if sharp sterned) and the half-width of the transom at top and bottom. If there is a keel or skeg, its outline is shown in the sheer plan and its half-breadth in the half-breadth plan. The body plan shows sections taken at selected points indicated in the other two views, and the end-on shape of bow and stern; usually the half-breadth of the skeg or fin is again shown. The positions of the masts and deck structures are usually drawn in the lines and there are dimensions given for placing sections, and for profile of stem and stern, that will be required to make the full-sized drawings necessary for building. (Plate 1.)

V-BOTTOM LINES. If the hull is V-bottom, the lines will show the same things as in the case of the flat-bottom boat, with the addition of the profile and half-breadths of the keel, at its bottom and where it meets the bottom plank (rabbet line). The sections in the body plan will show the amount of vee or dead rise in the bottom, of course. (Plate 2.)

ROUND-BOTTOM LINES. If the hull is round-bottom, there are a number of additional lines, or longitudinal sections, required. In



"Lines" Plan of "modified sharpie" showing typical fairing lines used in the V-bottom hull form and method of using squares to enable drawing stem full-size.

PLATE 2. *Lines of a 36-Foot Modified Sharpie*

the sheer plan the profile not only shows the sheer line, rabbet line, and profile of bow and stern, but also a number of straight lines parallel to the load water line, or to an arbitrary base line; these are the location or heights at which the longitudinal sections, called "water lines," will be taken. On the profile will be seen long curves marked "buttocks"; these are the outlines of a number of equally spaced longitudinal sections, taken through the hull vertically and parallel to the center line of the hull. The half-breadth plan shows the outline of the water lines, shown as straight lines in the sheer plan; while the buttocks are shown as straight lines in the half-breadth plan, parallel to the center line, they are shown as curved lines in the sheer plan. The half-breadth plan will show the half-width of the rabbet along the keel and stem and sternpost; sometimes the half-width of the bottom of the keel and the face of the stem and sternposts are also shown. The body plan shows the cross sections located by vertical straight lines on the other two views. These are crossed by horizontal straight lines, representing the straight lines called water lines in the sheer plan and the curved water lines in the half-breadth plan. There are also vertical straight lines crossing the body plan sections; these are the buttocks, shown as curves in the sheer plan and as straight lines in the half-breadth plan. The end-on elevation of the rabbet line, along the keel and up both stem and sternpost, will also be shown, and the same view of the bottom of the keel and the face of the stem and sternpost may be shown. Across the sections in the body plan are some sloping straight lines, meeting and crossing in the center line of the plan. It will be noted that each pair has its outer ends at the same height from the nearest water line or from the base line and out the same distance from the center line. These are the "diagonals"; their projection through the hull longitudinally is represented by a number of long sweeps or curves superimposed on the half-breadth plan, or opposite to its center line. The projection of all of these sections is required to fair the shape of the boat; fairing means to develop curves around which a batten, plank, or steam-bent frame can be bent without breaking or having humps and waves. The whole of the lines for a round-bottom hull should be drawn full size and checked before building, as will be described later. (Plate 3.)

What Lines Represent. It is important that the builder be able to visualize the lines in the plan as the completed boat. To do

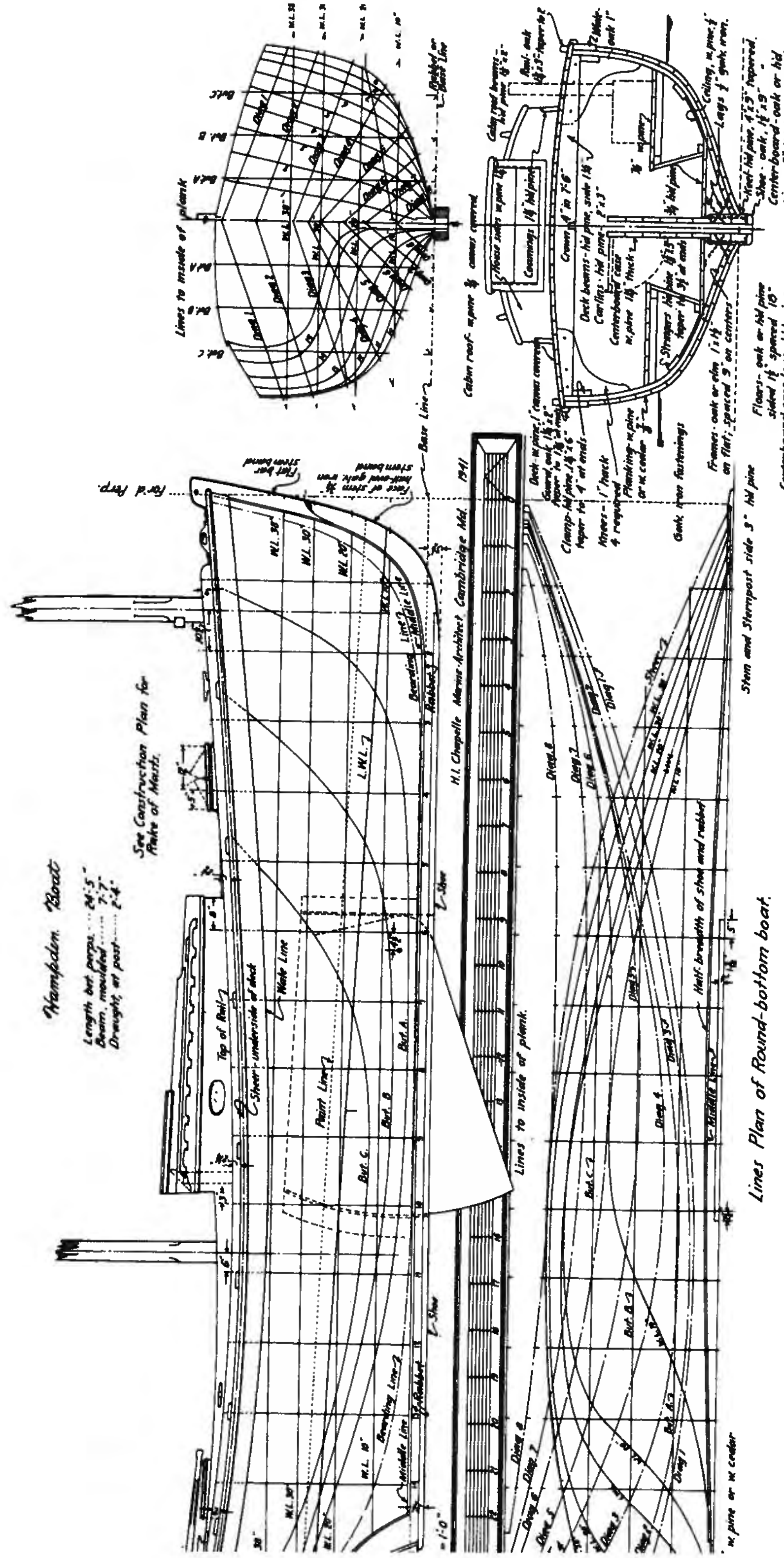
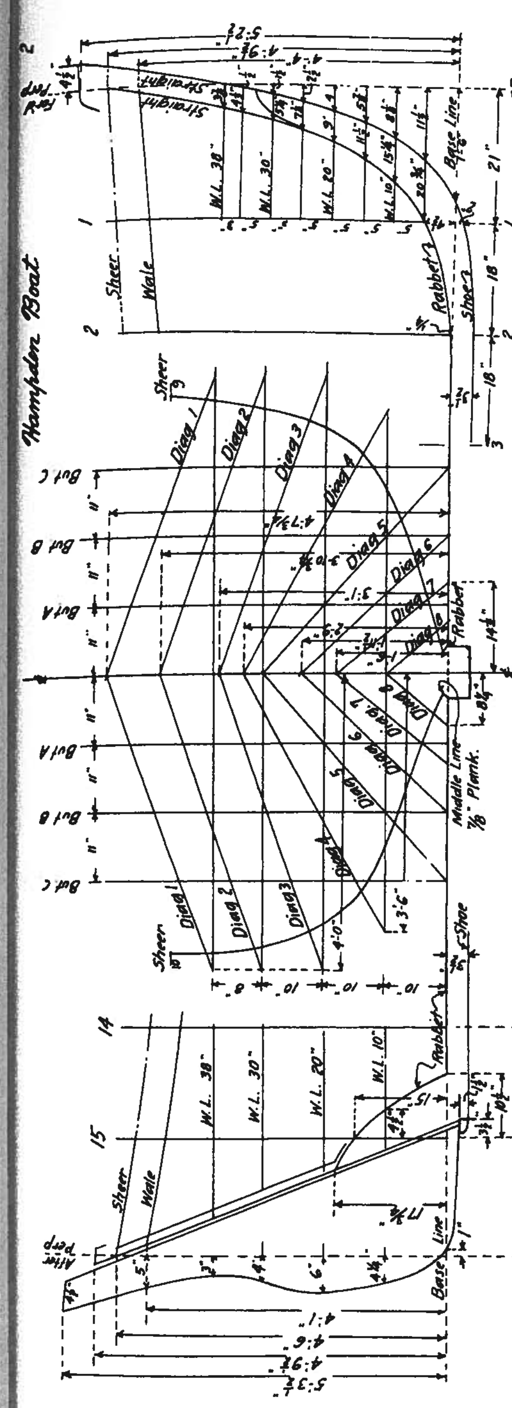


PLATE 3. *Lines of a 24-Foot Hampden Boat*

this, it is necessary to know what water lines, buttocks, diagonals, and sections really indicate as to the shape of the boat. Suppose a solid wax model of the boat is at hand, made to the same scale as the drawing of the lines. If this model is split lengthwise, two half-models result. Take one of these, whose bow and stern will coincide with those drawn when laid on the lines. This is the half-model that the lines must show in such a manner that any section can be projected and enlarged to full size. When the half-model is laid on the lines so that its flat back coincides with the sheer plan, it will be obvious that the sheer line and the rest of the profile of the model will coincide with the drawing. Now cut the model in parallel slices coinciding with the straight water lines in the sheer plan and perpendicular to the flat back. The outlines of these slices will coincide with their respective water lines when laid on the half-breadth plan. If cut transversely in the same manner, coinciding with the vertical section lines in the sheer plan, each section in the body plan will be duplicated. If cut longitudinally to coincide with the buttock lines shown on body and half-breadth plans, the sections obtained are those shown in the sheer plan. In the same manner the shape of the diagonals can be verified. It can be seen that there is a definite relation between each section cut and the shape of the hull. The use of the various sections obtained in the lines will be explained when the making of full-sized drawings is discussed.

Offsets

Attached to the lines, or on a separate sheet, will be found a Table of Offsets. (Plate 4.) These are the necessary dimensions to make the full-sized drawing and to reproduce each section or line shown in the "lines" plan. It will be noticed that the height and breadth of each water line and buttock, the sheer line, rabbet, and every other curved line are given with the dimension taken from base and center line opposite the proper line name and under the number of each station, or section, number. The dimensions are given in feet, inches, and eighths; thus: 7–6–3, meaning 7 feet 6⅜ inches. Sometimes the signs + and — are placed after the dimensions; this merely means the dimension is either full or scant by ¹⁄₁₆ or ¹⁄₃₂ of an inch. Some designers show all the dimensions required to lay the boat down full size on the offset table;



Stations 18" apart, waterlines as marked.

Lines to inside of 7/8" planking.

		Transom	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Bow
Heights above Base	Sheer	4-6-0	4-3-4	4-0-2	3-10-4	3-9-3	3-8-7	3-8-7	3-9-3	3-10-1	3-11-0	4-0-1	4-1-3	4-2-6	4-4-2	4-5-7	4-7-4	4-9-4
	Wale	4-1-0	3-9-4	3-7-0	3-5-0	3-3-5	3-2-7	3-2-5	3-2-7	3-3-3	3-4-1	3-5-2	3-6-4	3-8-1	3-10-0	3-11-7	4-1-6	4-4-0
	But C	*	2-9-3	1-2-2	1-9-1	1-5-0	1-2-2	1-0-6	1-0-2	1-1-7	1-5-6	2-4-4	3-7-7	*	*	*	*	*
	But B	2-6-6	2-4-0	1-10-6	1-5-6	1-1-2	0-10-1	0-8-0	0-6-5	0-6-5	0-7-0	0-8-4	1-1-0	2-0-5	3-7-3	*	*	*
	But A	2-4-0	2-1-2	1-7-2	1-1-3	0-8-6	0-5-7	0-4-2	0-3-0	0-2-5	0-2-6	0-2-7	0-3-3	0-4-7	0-9-1	1-9-6	*	*
	Rabbet	1-5-6	1-3-0	0-0-0	Same as Base.											0-0-4	0-4-4	*
Half-breadths	Sheer	2-7-0	3-0-0	3-4-0	3-6-7	3-8-5	3-9-2	3-9-2	3-8-5	3-7-2	3-5-1	3-2-3	2-10-5	2-6-0	2-0-2	1-5-7	0-10-4	0-0-6 ±
	W.L. 38"	2-7-2	2-11-5	3-4-0	3-7-0	3-8-5	3-9-0	3-9-0	3-7-7	3-6-0	3-3-5	2-11-6	2-7-3	2-2-1	1-8-5	1-2-2	0-7-5	*
	W.L. 30"	1-6-3	1-3-7	3-1-3	3-5-5	3-7-5	3-8-2	3-8-2	3-6-4	3-4-2	3-1-4	2-9-3	2-4-7	1-11-6	1-6-3	1-0-4	0-6-2	*
	W.L. 20"	0-1-3	0-2-4	1-0-5	2-5-6	3-2-2	3-4-2	3-4-6	3-3-4	3-0-6	2-10-0	2-5-5	2-1-3	1-8-3	1-3-4	0-10-3	0-4-4	*
	W.L. 10"	*	*	0-2-4	0-6-5	1-1-1	1-9-4	2-3-5	2-5-3	2-4-5	1-2-6	1-11-3	1-8-0	1-3-4	0-11-2	0-6-6	0-2-1	*
	Rabbet & Shoe	0-1-4	0-1-4	0-1-6	0-2-4	0-3-0	0-3-5	0-4-0	0-4-1	0-4-3	0-4-1	0-3-7	0-3-4	0-2-7	0-2-3	0-1-5	0-1-4	0-1-4
Diagonals	Diag 1	2-10-4	3-2-6	3-6-6	3-9-7	3-11-5	4-0-1	4-0-1	3-11-1	3-9-2	3-7-0	3-3-2	2-11-1	2-6-1	2-0-4	1-5-7	0-10-4	*
	" 2	2-7-7	3-0-2	3-5-0	3-8-6	3-10-4	3-11-0	3-11-0	3-9-4	3-7-3	3-4-7	3-0-7	2-8-5	2-3-5	1-10-2	1-4-0	0-9-1	*
	" 3	1-8-4	2-1-3	2-9-6	3-3-7	3-7-2	3-8-1	3-8-2	3-7-0	3-4-5	3-2-0	2-10-1	2-5-6	2-0-7	1-7-7	1-1-7	0-7-4	*
	" 4	0-11-3	1-3-0	1-10-6	2-5-3	2-11-2	3-2-2	3-3-6	3-4-0	3-2-3	3-0-2	2-8-5	2-4-6	2-0-0	1-7-3	1-1-4	0-7-1	*
	" 5	0-6-5	0-9-1	1-3-4	1-9-2	2-2-1	2-5-5	2-8-0	2-8-7	2-9-1	2-8-2	2-6-5	2-4-0	2-0-0	1-7-4	1-2-2	0-7-4	*
	" 6	0-2-7	0-4-2	0-9-6	1-2-7	1-6-6	1-10-0	2-0-1	2-1-2	2-1-4	2-1-4	2-1-0	1-11-4	1-9-0	1-5-3	1-0-6	0-6-4	*
	" 7	*	0-2-0	0-6-0	0-10-4	1-4-6	1-4-1	1-5-5	1-6-5	1-7-0	1-6-7	1-6-6	1-6-2	1-5-1	1-2-5	0-10-6	0-5-1	*
	" 8	*	*	0-3-1	0-5-6	0-7-5	0-9-2	0-9-7	0-10-4	0-10-6	0-10-6	0-10-6	0-10-5	0-10-0	0-8-6	0-6-3	0-2-4	*

Plate 4. *Offsets for a 24-Foot Hampden Boat*

others put dimensions on both the lines and offsets, so that both are required in making the full-sized drawings. There are many methods of showing the dimensions of the bow and stern. If simple in detail, dimensions are commonly used, but if there is decoration or other complications the stem and stern may be shown in the offset plan, superimposed over a series of squares for which dimensions are given. By this means enlarging to full size can be easily and accurately done (see Plate 2).

Construction Plan

There will be a "construction plan" in the set of blueprints (Plates 5 and 6); this usually shows an inboard profile made as though the hull were split lengthwise. By this means a true projection can be made of the appearance of the hull frame. Here you will see the shape of the pieces of timber making up the keel, deadwood, and stem and sternpost. The location of the bilge stringers and other longitudinal members is shown. The position of the deck framing can be seen. It is usual to show the mast positions, shape of the steps, height of cabin trunk, cabin and cockpit floor, propeller shaft position and dimensions, engine beds, and the other structural members required by the designer. On the same plan will be a midsection, showing a cross section or "typical construction section." Here will usually be given the timber sizes and other building specifications not given elsewhere. The third elevation is a plan view of half the deck framing where dimensions and timber sizes required are given so that an accurate deck arrangement can be laid out. It is general practice to omit some dimensions on the construction plan; therefore the builder will have to scale the size of many members (particularly in the deadwood and ends of the hull) from the blueprint. On this plan the keel, stem and stern, and all deadwood members, the profile of cabin trunk and the roof framing, and the whole of the deck framing shown in the plan view, must later be drawn full size.

Joiner, or Cabin, Plans

If the boat has a cabin there will be a plan similar to the construction plan which shows two or three views of the cabin arrangement. This plan has an inboard elevation showing one side

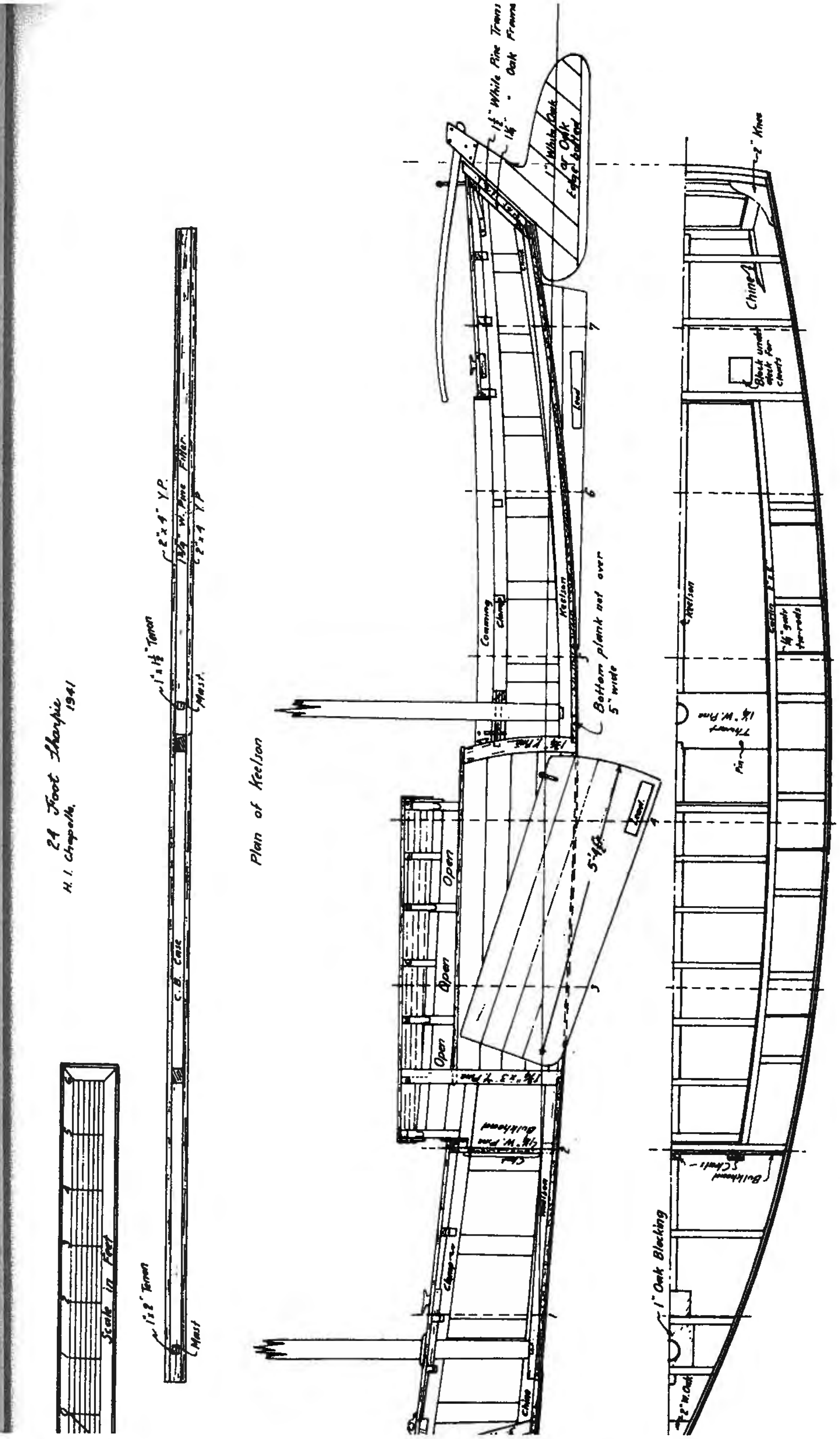


PLATE 5. *Construction plan for a 24-foot Sharpie. Lines shown in Plate 1.*

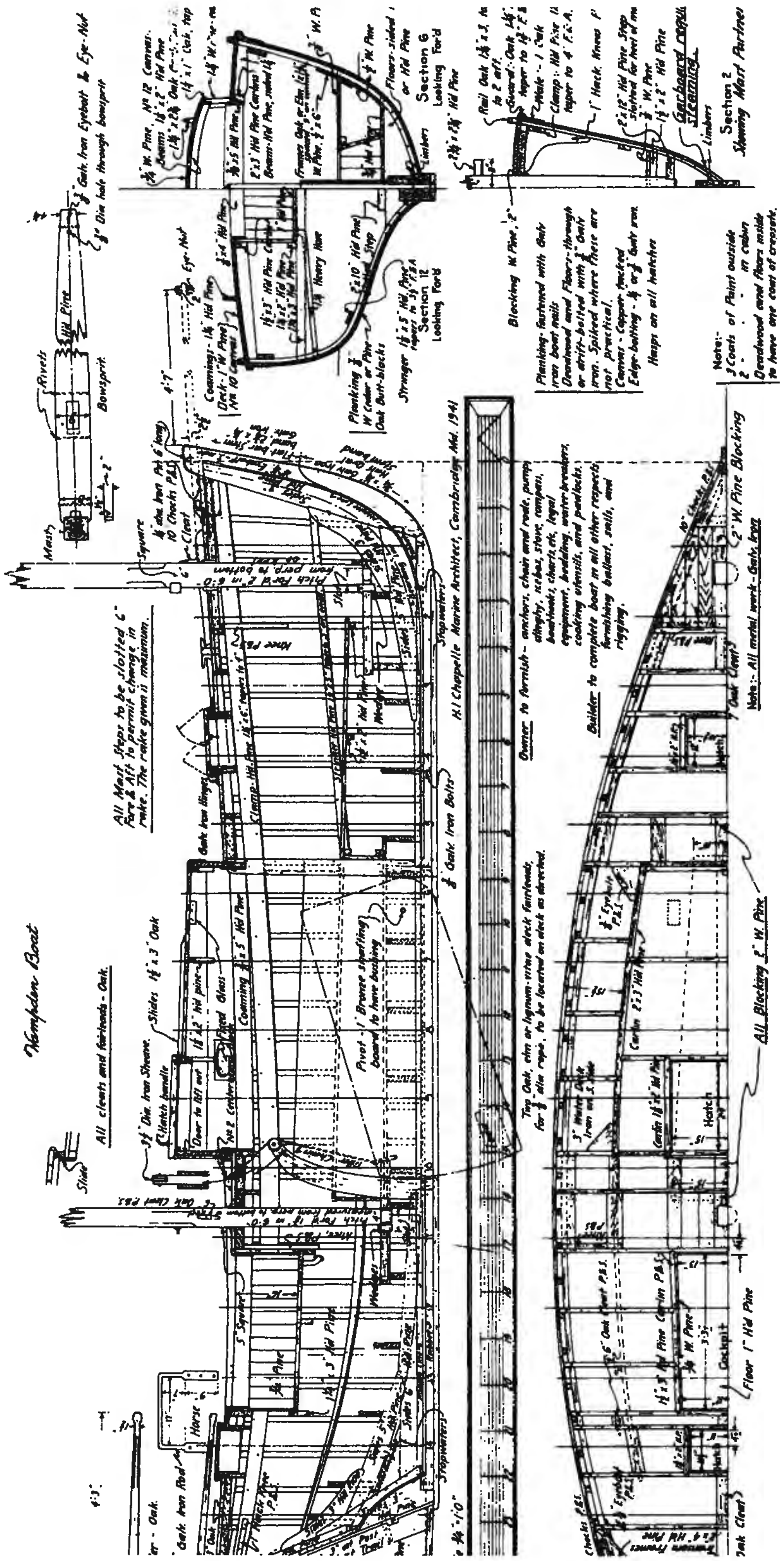


PLATE 6. Construction plan for a 24-foot Hampden Boat. Lines shown in Plate 3.

of the cabin furniture, with some important dimensions. The plan view shows the whole cabin arrangement when viewed from above; it is usual to show both sides of the boat in this since the two sides of a boat's cabin may not be alike. Additional dimensions are usually shown here. There may also be a section or two showing the important details in the cross sections of the cabin. If the boat is large, or has a good deal of cabin furniture, there may be a separate plan showing a number of sections. These one or two drawings are usually referred to as "joiner plans." Both the construction and joiner plans are, to some extent, merely pictures with only the important dimensions given; the less important must be scaled from the blueprints.

Sail Plan or Outboard Profile

If the boat has spars and sails, there will be a "sail plan" (Plates 7 and 8), showing shape and dimensions of the sails, spar dimensions, and details of the rigging. This plan also gives a picture of the outboard appearance of the hull. If the design is for a motorboat, there is an outboard profile instead of a sail plan, serving the same purpose. Occasionally there may be separate detail drawings, or some may be included in the construction, joiner, and sail plans. Equipment (such as deck and cabin fittings) and all important hardware are listed on the construction and joiner plans. Common practice is to give some maker's or dealer's name and his catalogue number; it should be understood that this is generally for guidance to type and size in purchasing and that similar equipment and hardware from other catalogues will serve.

Specifications

In small craft there are usually no specifications, as these are made a part of the plans. In large boats and most cabin craft additional information to the plans may be needed. The designer may therefore furnish a number of typewritten or blueprinted pages, usually in pamphlet form. These contain all the necessary information to supplement the plans. The kind and size of timber to be used in each part of the boat, fastenings, method of building, hardware, fittings, plumbing, engine installation, painting, and other information are found in the specifications.

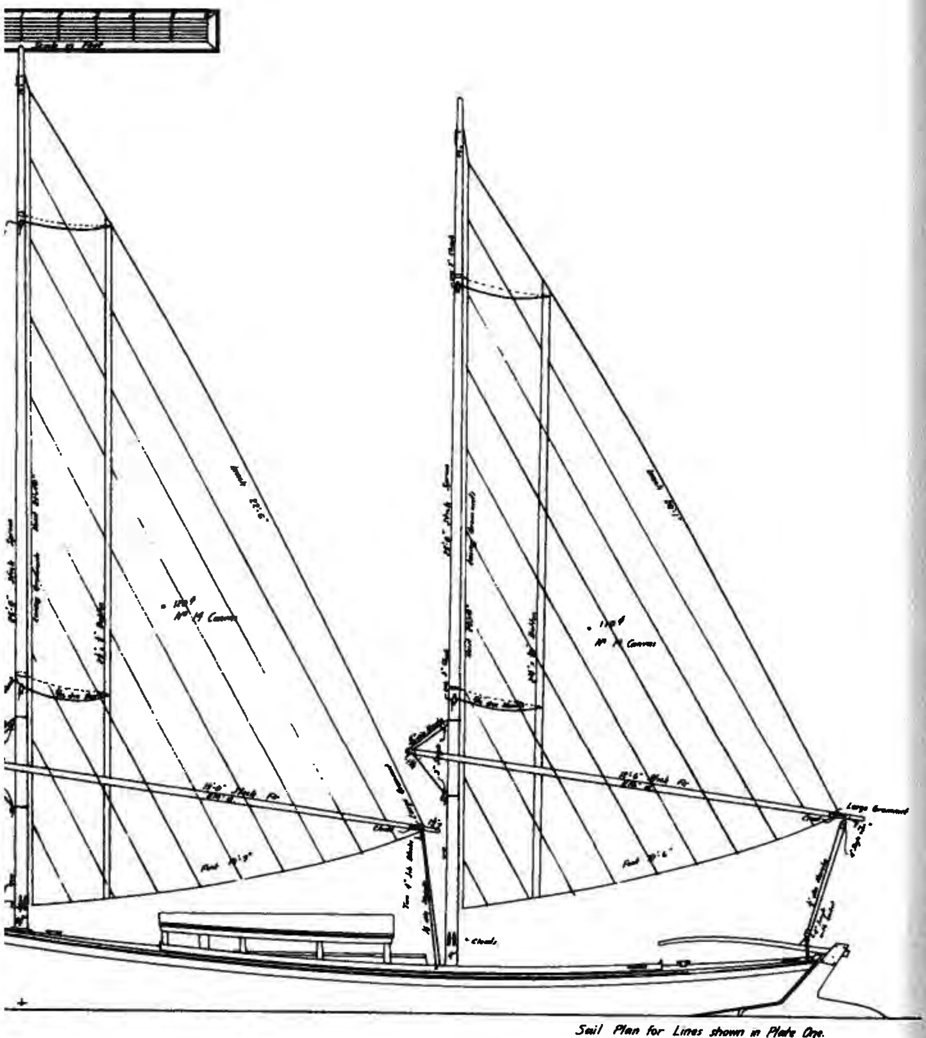


PLATE 7. *Sail Plan for a 24-Foot Sharpie*

Details

When the plans are studied, some details may appear to be missing. In this case read all the notes on the plans carefully and then turn to the specifications. The missing details may be referred to there. If not found, the builder can write to the designer for instructions. The amount of detail shown on plans varies with the designers. Very often the detail of construction not shown on a plan is a matter of common building practice and the designer feels he need not bother to show it. If he is asked to furnish detail drawings there will be a charge for them. In most boats a completely detailed set of plans would be unnecessarily expensive. Perhaps the best attitude the builder can take in regard to the plans is that what is shown is important and should be followed; what is not shown is not important and the builder can therefore do it as he thinks best. Timber sizes noted on the plans are usually dimensions of the lumber before being finished, unless marked "f" (finished size).

Lumber List

Few designers will attempt to furnish a list of lumber required; this must be taken from the blueprints by the builder. The way to do this is to pick out each piece in the deadwood, for example, and scale its dimensions. Then note its greatest thickness. Allow a little margin for shaping all around. When all the pieces are listed, go over them and rearrange them so that all pieces of the same width and thickness are together. Do this for all timber required. For planking and framing it is usual to add from 10 per cent to 20 per cent for loss through breakage or waste. Now the list should be converted to commercial sizes of timber. All timber is sold by the board foot, 1″ x 12″ x 12″; in most sections of the country there are standard sizes of commercial stock. The common lengths are 10–12–14–16–18–20–22–24 feet. The standard widths and thicknesses are 1″ x 2″, 1″ x 4″, 1″ x 6″, 1″ x 8″, 1″ x 10″, 1″ x 12″, 2″ x 4″, 2″ x 6″, 2″ x 8″, 2″ x 10″, 2″ x 12″, 2″ x 14″, 2″ x 16″, 3″ x 6″, 3″ x 8″, 3″ x 10″, 3″ x 12″, 3″ x 14″, 3″ x 16″, 4″ x 4″, 4″ x 6″, 4″ x 8″, 6″ x 6″, 6″ x 8″, 6″ x 10″, 6″ x 12″, 8″ x 8″, 10″ x 10″, 10″ x 12″, 12″ x 12″, 12″ x 14″. Some lumber dealers will furnish out-sizes, such as 2″ x 2″, 3″ x 3″, 2″ x 3″, and others, at no additional cost; but in most cases an order for a lot of 2″ x 2″ 's will require sawing from 2″ x 6″ 's. The reason 2″ x 2″ 's cannot be made by ripping 2″ x 4″ 's is that the actual dimensions of commercial standard stock is under the sizes given; take a 2″ x 8″, 14 feet long, as an example; it would actually be about 1⅞″ x 7⅞″ and about 13′–11″ long. Due to checks in the ends of timber it is well to consider a 14′–0″ piece as actually being 13′–6″. If greater lengths are required than 24′ a premium will usually be paid.

The cost of sawing and the waste will be figured in when the dealer makes up timber not of standard sizes. Occasionally the "standard" sizes vary somewhat from those given, but this is unusual. Now, by going over the list of timber sizes required for the boat and adding those of the same width and thickness, it is possible to find out how many lengths of commercial stock will be required. By comparing thickness and widths of the required lumber with the stock sizes it is possible to select the properly dimensioned commercial stock. The cost of lumber is usually given "per thousand board feet." When the unit price is known, it is possible to estimate the cost of the lumber to be ordered from the completed list. If it is desired to have any of the stock reduced to some odd thickness or width, the cost of such work will have to be added to the cost of the lumber. Most dealers have mills for this purpose and will give an estimate. Order timber by commercial standard size, whenever possible, and be sure to state the kind of timber required. Excepting pine, spruce, and cypress, it is usually cheaper to order random widths, whenever possible, than specified widths.

Grading of lumber varies a good deal with the timber and location; the highest grade ("clear of knots on one side and free of rot, shakes, or checks, and other faults on the other side") should be ordered for all hardwood material such as oak, maple, and mahogany. This grade is called "Firsts" in the lumber trade, and the next grade "Seconds." Stock for steam-bent frames should be specially listed and the dealers informed of the purpose for which it is to be used. It should be "Firsts" and should be of young timber, not dried. Old, large oak trees will not do for bent timbers. All softwood timber should be "Select." This is subdivided into A, B, C, and D. Select A and B are suited for "bright" or natural

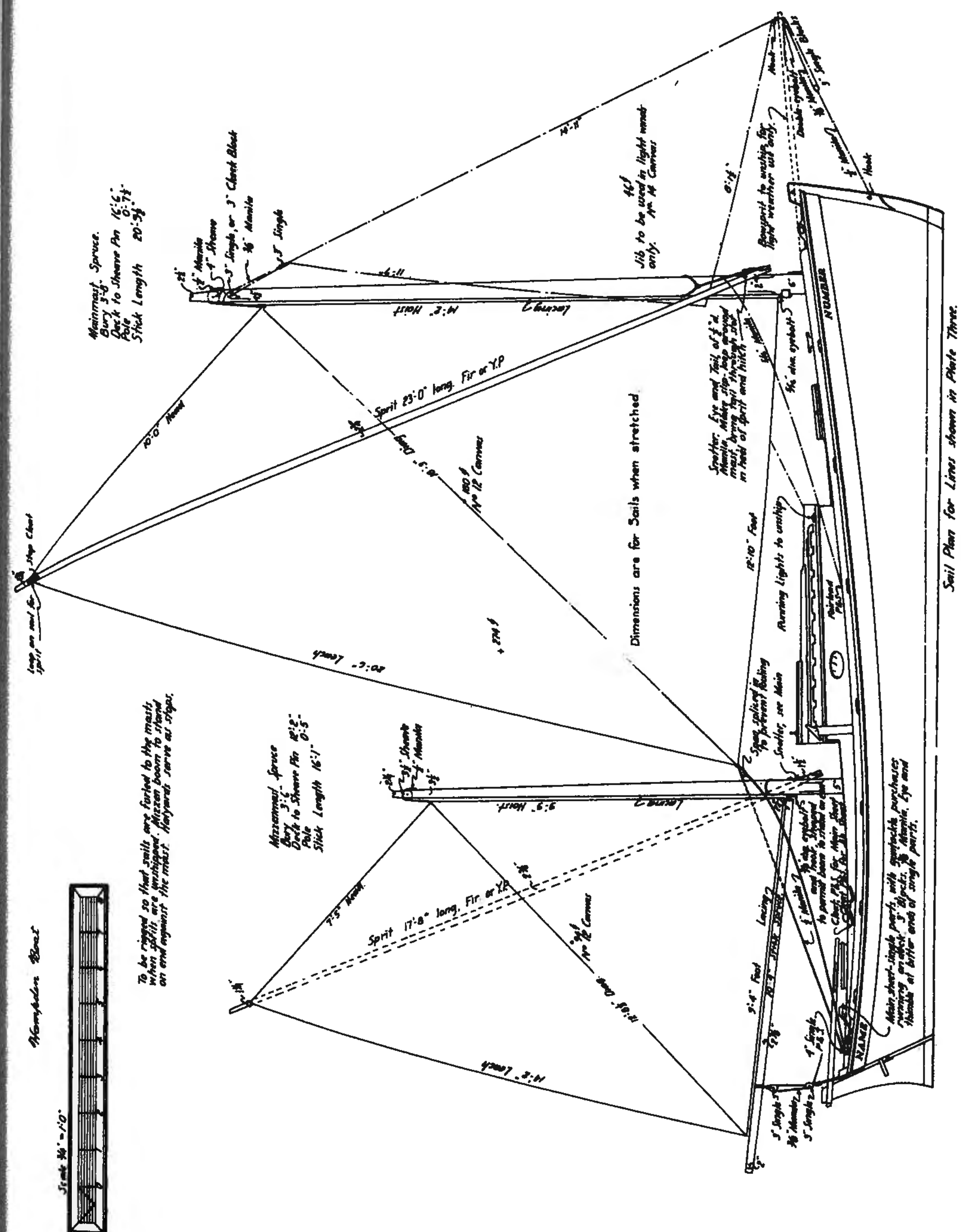


PLATE 8. *Sail Plan for a 24-Foot Hampden Boat*

finish while C and D are suited for paint finish. The Select grade, when bought in plank, is called "Number One" grade.

Planking for hulls may be bought in some varieties of lumber "flitch sawn," which means that each plank has bark on its edges so that the builder may get the greatest benefit from the shape of the tree. Cedar is commonly sold this way. If possible, the builder should see the lumber stock of the dealer before ordering. Decking, when painted or finished bright, should be ordered "quarter-sawn." If the dealer specializes in boatbuilding timber the decking should be ordered to finish size. Steam-bent frames should likewise be ordered to finish size and at least 2 feet longer than the maximum length required in the hull. Air-dried stock is the best for boatbuilding timber, but is almost impossible to obtain in most sections of the country. For this reason kiln-dried stock must be accepted. Some woods, such as teak, should not be too dry when used for planking. White cedar, white pine, and longleaf yellow pine are considered the best planking from among our native timbers; loblolly (Virginia or North Carolina) pine is also used to some extent. Cedar and white pine are the easiest to work. Longleaf yellow pine may be used for keels, deadwood, stem and sternposts, stringers, and clamps, in place of white oak. Steam-bent frames can be made of rock elm instead of white oak. Fir and spruce are sometimes used in hull construction, for plank and framing (not steam bent), but are short lived compared to the others mentioned; they are suited, however, to spar building.

Hardware List

When the lumber has been ordered, the hardware and fittings must be listed, checked against marine hardware dealers' catalogues, and ordered. The fastenings should be roughly estimated and ordered. There is no ready rule for estimating quantities of fastenings, but an estimate can usually be made from the blueprints, allowing at least three fastenings per plank per frame. Keel fastenings average about two per frame, frame fastenings (to keel, floors, and to longitudinal members) about twelve per frame. Materials and fastenings will be dealt with in later chapters. When ordering deck and cabin fittings be sure to order the required number, size, and type of fastening for each item. Sails,

rigging, and motor can also be ordered prior to building if desired.

Before starting to work on the boat, the builder should take time to study the plans carefully. It would be well to try to find out what steps will be required to build the boat in the easiest way, to decide what the best sequence of jobs seems to be, and to see that the plans are fully understood.

Selecting Place in Which to Build

While this study is being made, a place in which to build must be found. To the average city man this is a great problem. Garages are often used, or sometimes space may be rented in an old warehouse or loft. If a building is to be used, it is very important that definite plans and measurements be made so that it is certain that the finished boat can be removed without tearing apart the building. This has been a standing joke among amateur builders for years, but is often overlooked in spite of that. If the boat is to be built in the winter, then heating must be considered. No man can work well, or be accurate, when he is physically uncomfortable. If no building is available and the boat is to be constructed in the open, then she must be built in warm weather. Obviously, the space in which the boat is to be built must be suitable for the size of hull chosen. No guide can be given that covers all eventualities, but if possible the building space should be 1½ times the over-all length of the hull, 4 times the beam, and 1½ the height, keel bottom to cabin roof top. The boat should not be built close to any wall or obstruction that will prevent the builder from handling timber easily or from being able to stand back and look at his work. There must be space for tool and material storage, room for a workbench and for the usual visitors. A floor or bench suitable for the full-sized drawings must be provided for. *In any case, the full-sized plan should be in existence the whole time the boat is building* so that the drawing can be referred to.

Making the full-sized plans is the next step.

CHAPTER TWO

LOFTING

Reason for Lofting

LOFTING the plans, that is, drawing them full size, is the foundation of good workmanship in building a boat. Because this is usually a tedious task and because the builder is impatient to see the hull take shape, lofting is often scamped, even by professional builders who know better. Making the full-sized drawings avoids much "trying and fitting," which represents a great saving in time and labor. In the lofting of the plans the builder has an opportunity to preview the details of building before setting up the hull and this aids greatly in planning the required sequence of operations. Too often only the lines of the boat are "laid down" full size; this enables the molds and backbone to be shaped according to the design, it is true, but leaves much timber to be shaped by trial and error when actual construction starts. By lofting part of the construction and joiner plans as well as the lines, this can be avoided. Mistakes made in the full-sized plan can be easily corrected, which is not true of the full-sized hull; very often what appeared to be a serious problem when studying the plans becomes self-explanatory when drawn full size. Sometimes errors are found in the plans, designers being human, and lofting will expose and correct them. While making the full-sized plans, the builder should build the boat mentally, to get the full advantage of the operation. Plenty of time must be allowed for the task and it should be borne in mind that there was never a boat built in which too much lofting had been done.

Lofting Space

In order to make the full-sized plans, a mold loft must be provided. For a small boat, a large piece of paper or cheap plywood

will serve. If there is no room for the loft drawing in the workshop, it is possible to lay down the plans of a boat up to 45 feet long on paper and so preserve the plan for reference. Under such conditions, paper may be joined in order to get sufficient size. Usually it is possible to make such a plan in some attic or other place where it is possible to lay down the whole roll or sheet. Sometimes, when space is lacking, the plan must be made in two or even three sections; but this is not recommended for a beginner. In a well-equipped boatyard there is a "mold loft," a shed or floor giving enough space for making full-sized plans. Here it is customary to make the drawing on the floor, in pencil and colored crayons; the floor is sanded smooth, or sanded and painted flat gray, or white. This is the most satisfactory method. Therefore, if there is space, the amateur builder should build a temporary loft, even if it must be outside the shop. Such a floor may be constructed by joining sheets of plywood or by laying a cheap but smooth floor on bearers or sawhorses. The floor should not only be smooth, but should also be flat, without humps or ridges. In picking up patterns it is desirable to be able to drive nails into the drawing on the floor. If paper must be used, heavy, rosin-sized building paper will serve, though it will be difficult to avoid tearing it. Do not use cheap wrapping paper, since it stretches with dampness, is easily torn, and is not a good working surface. The thick paper will give enough strength to permit drawing of lines while the paper lies on a rather irregular surface, such as most attic floors. It is possible to make the loft drawing on paper using an apartment floor, but this makes picking up patterns somewhat troublesome (unless you wish to break a lease).

The amount of space to lay down a boat properly, in one section, is easily decided. There should be sufficient length to permit the battens, used to fair in the profile and half-breadth plans, to extend from 3 to 6 feet beyond the bow and stern. In other words, a boat 24 feet long would require a lofting space about 30 feet long. As to width, the space required is about one and a half times the depth from base to highest point on the cabin roof or sheer, or one and a half times the beam, whichever is the greatest. To lay down a boat in two sections requires a loft length equal to half the length of the hull plus the spacing of two sections shown on the lines drawing plus 4 to 6 feet. Thus, a 24-foot

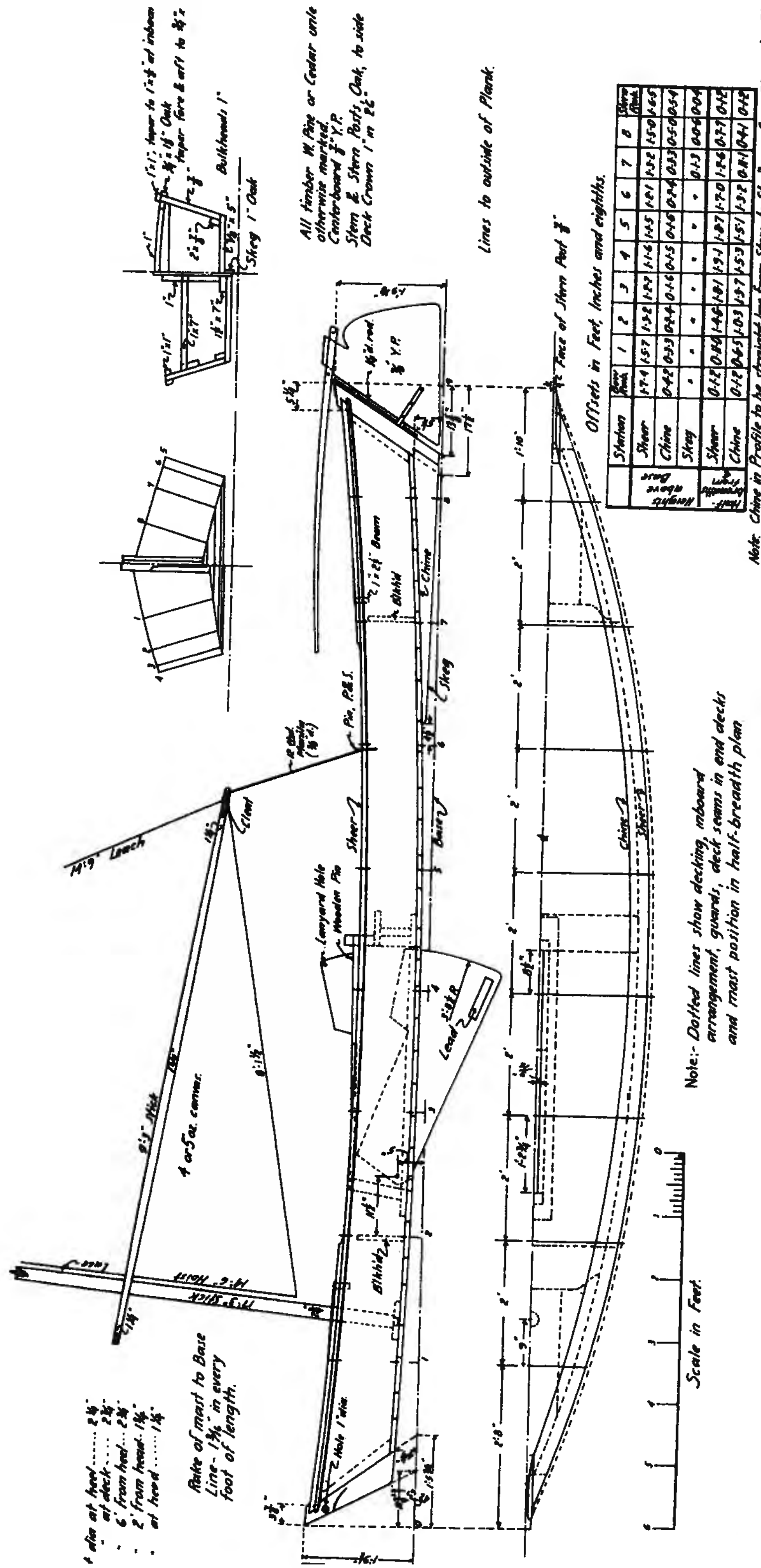


PLATE 9. *Plans for an 18½-Foot Sailing Skiff*

hull having stations or sections spaced 2 feet would require a loft length of 12 plus 4 plus 4, or 20 feet. The extra length, in each case, is desirable so that the curves formed by the battens can be continued beyond the ends of the hull in order that they may be fair and without flat or straight "spots." The width of the loft space is fixed by the room required for profile or half-breadth, whichever is largest, because these views are superimposed. Enough additional space for the battens, used in the body plan (also superimposed on the profile), to lay fair is required. Of course there must also be enough room to work around the plan on the floor. If paper is used for lofting it need only be large enough to contain the actual drawing, but the same amount of working space is required as for lofting on a floor.

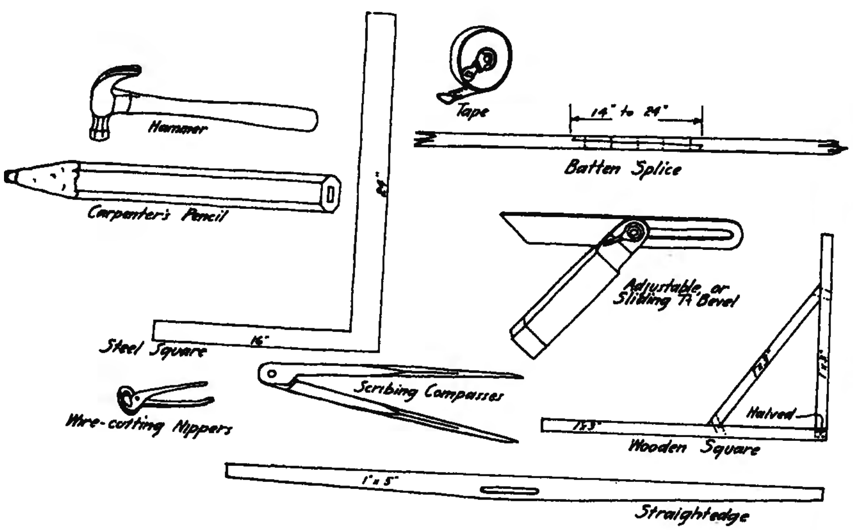
Battens

Battens must now be prepared. These are long, narrow strips of wood used to guide the drawing of curved lines on the floor or paper. They should be made of clear white pine if possible, though any flexible wood will do. The edges of the batten must be straight and smooth. A number of battens are required—say, three long and three short ones. One, to be used for the sheer line and other long, gentle curves, should be quite stiff, about ½ inch or ¾ inch by 1½ inches or 2 inches, to be bent with the wide side on the floor, and 3 or 4 feet longer than the boat. Another batten of the same length, about ½ inch by 1 or 1½ inches at the middle, tapered to ½ inch by ¾ or 1 inch at the ends (with all the taper taken on one edge), can be used for water lines, buttocks, and diagonals. A third long batten is useful; this should be about ¾ inch square, ⅜ inch for a small boat (under 16 feet in length). These battens may have to be spliced and this should be done near the middle of the length. A scarf must be used, fastened with glue, rivets, or screws; it should be between 14 and 24 inches long, well secured.

Short battens will be required for drawing the body plan of a round-bottom hull; these should be a couple of feet longer than the girth of any half-section shown in the body plans. They should be between ¼ and ½ inch square. One should be tapered at each end, by ⅛ inch, and another should be reduced toward its middle. The third should be parallel sided. For dinghies and canoes, drafting battens can be used for the body plan; these are of hard rubber, or of Celluloid, obtainable from stores selling drafting supplies. To hold battens in place, nails can be used. For the larger battens use 1½- or 2-inch wire nails (sixpenny common or finishing brads); for the small battens 1 inch (two-penny finishing brads). If more than one boat is going to be built, then get two-dozen common scratch awls; these have tempered steel points held in a wooden handle and may be forced into the floor without hammering. If paper is being used, on a floor that must not be marred, battens may be held in place fairly well by using a number of old-fashioned flatirons, obtainable from any mail-order house. The battens may be painted if desired; black is the best color as a rule.

Tools

For marking the floor or paper, the ordinary carpenter's pencil, hard lead, sharpened to a chisel point, is best. Colored pencils or crayons (hard) can be used to advantage, as the colors will serve to identify certain lines on the loft plan. The only other tools required are a steel square 16 by 24 inches (or a large



18. Lofting Tools

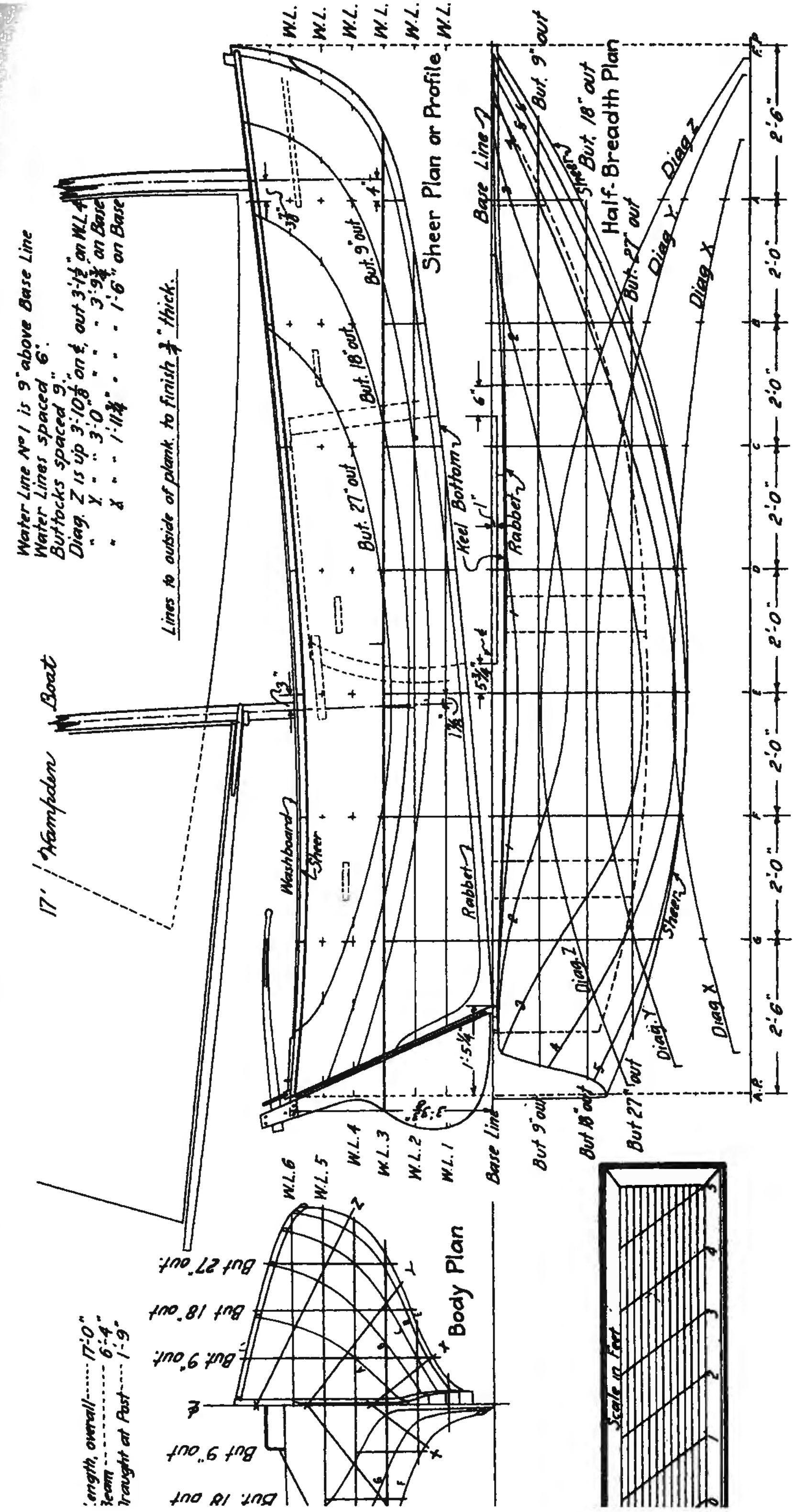
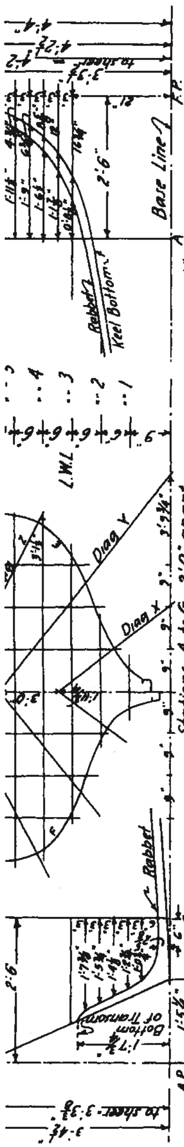


Plate 10. *Lines of a 17-Foot Hampden Boat*



Post sides 2¼" at bottom of transom, 1½" at heel.

Stations A to G, 2'0" apart

Stem sides 2½" at head, 2½" at L.W.L. 3" at heel. (sta. A). Face of stem side 2" at head, ¾" at L.W.L. 1" at sta. A.

Offsets, in Feet, inches and eighths, to outside of plank.

	Station	Stern	G	F	E	D	C	B	A	Bow	Station	
Heights from Base	Sheer	3-3-3	3-1-4	3-1-2	3-1-7	3-3-2	3-5-1	3-7-4	3-10-2	4-2-0	Sheer	Heights from Base
	Buttock 27" out	*	2-4-1+	1-9-3	1-7-6	1-9-6	2-3-0	*	*	*	Buttock 27" out	
	" 18" "	2-7-6	1-11-1	1-5-7	1-4-1	1-5-1	1-8-0	2-2-5	*	*	" 18" "	
	" 9" "	2-2-1	1-7-2	1-2-1	1-0-0	1-0-7-	1-3-0	1-7-0	2-3-0	*	" 9" "	
	Rabbet	1-7-6	0-2-5	0-4-2	0-6-1	0-8-3	0-11-0	1-2-1	1-6-4	*	Rabbet	
	Keel Bottom	0-0-0	0-0-5	0-2-1	0-4-2	0-6-6	0-9-4	1-0-5	1-4-5	*	Keel Bottom	
Half-breadths	Sheer	1-9-7	2-8-3	3-0-3	3-1-5	3-0-6	2-9-4	2-2-7	1-5-0	0-1-2	Sheer	Half-breadths
	Water line 6	*	*	*	*	*	2-8-6+	2-1-6	1-3-1	0-1-2	Water line 6	
	" " 5	1-7-2	2-6-7	2-11-7	3-1-2	2-11-2	2-6-5	1-11-1	1-0-6	0-1-2	" 5	
	" " 4	0-10-3+	2-1-2	2-9-6	2-11-2	2-8-3	2-3-0	1-6-2+	0-9-0	0-1-2	" 4	
	" " 3	0-1-6	1-0-6	2-2-1	2-4-7	2-1-6	2-1-5	0-11-6	0-3-4-	0-1-2	" 3	
	" " 2	*	0-3-2	0-10-2	1-3-2±	1-0-7	0-9-0	0-3-2	*	0-1-2	" 2	
	" " 1	*	0-1-6	0-3-6	0-4-5	0-3-2	*	*	*	*	" 1	
	Rabbet	0-1-2	0-1-3	0-2-0+	0-2-5	0-2-5	0-2-5	0-2-3	0-1-3	*	Rabbet	
	Keel Bottom	0-0-6	0-1-3	0-2-0	0-2-3	0-2-3	0-2-3	0-1-4	0-0-4	*	Keel Bottom	
Diagonals	Diagonal Z	1-11-6	2-9-3	3-2-6	3-4-1	3-1-6	2-9-3	2-2-4	1-4-6	0-1-3±	Diagonal Z	Diagonals
	" Y	1-2-3	1-9-6	2-3-4	2-5-3	2-3-6+	2-0-5+	1-7-5-	1-0-6	0-1-3+	" Y	
	" X	0-3-2	0-8-5	1-1-0	1-2-7±	1-1-7	1-0-2	0-9-2	0-4-5	0-1-6±	" X	

PLATE 11. *Offsets for a 17-Foot Hampden Boat*

wooden square may be made), a 6-foot rule, a compass or scribe, chalk line and chalk, hammer, steel tape, wooden straightedge (3 to 6 feet long), wire-cutting nippers or pliers, erasers, jackknife, and a sliding T bevel. A wooden mallet is useful in picking up patterns. Have plenty of pencils and crayons at hand. If laying down the loft plan on paper, adhesive is necessary to join the sheets together and to repair tears.

Plans

The plan to be laid down first is the lines. To do this, the offsets must be at hand, of course. As mentioned on page 60, the offsets give the measurements of the lines in feet, inches, and eighths; thus: 6–8–4, or 6 feet, 8 inches and ⅘ inch.

Base Line and Stations

To start, strike a base line near one side of the floor or paper. This is to be the base line shown in the profile (in the lines) or may be the load water line, from whichever the heights in the offsets are measured. It will also be used as the center line of the half-breadth plan; so allow the necessary room. The line should be struck with a chalk line if the boat is longer than any straightedge at hand. If there is any doubt about the use of the chalk line, try this. Stretch a thin fish line between nails just clear of the floor or paper. Draw taut; make pencil marks *directly under* the line, about 30 inches apart. Then draw a line with pencil and straightedge from mark to mark. All lines should be sighted on the floor as the eye will seek any irregularity in a line. Always sight lines from both ends. The base line should be a couple of feet longer than the hull to be laid down. A base line batten can be used to advantage in setting off the offsets. This is a straight strip of wood, about ½ inch by 2 inches, nailed to the floor below the base line with the top edge coinciding with the base line. This batten serves as a stop against which the end of the rule may be jambed, with no danger of overrunning the base line with the rule and so getting a short dimension. On the base line measure and set off the stations given in the lines and offsets; number them according to the lines. With the square erect perpendiculars at each station, taking care to be accurate. With the straightedge extend the perpendiculars far enough to exceed the greatest measurement on the stations, either in the profile or half-breadth.

Water Lines in Profile

The water lines shown in the profile view of the lines must now be drawn. Measure up the distance each is above the base line (or above and below the load water line if that is used as the base) on the end stations. These end stations are usually referred to as the fore and after perpendiculars. When the heights of the water lines are set off accurately, the lines are drawn in the same manner as the base line.

Profile, Outline of Sheer

The next step is to lay down the profile view. Begin by setting off the sheer line, bow to the same hand as in the lines plan; measure up the height on each station, as given in the offsets, from the base line. At the proper dimension make a pencil mark and if possible drive in a nail. Take the long sheer batten and lay it on the floor against the nail, or mark, on the fore perpendicular, with the ends of the batten extending beyond the fore perpendicular a little less than at the after perpendicular. When the batten is tight against the nail, or mark, on the fore perpendicular, drive a nail through the batten or against the back of it opposite the nail in the fore perpendicular. This new nail is to hold the batten in place. If nails cannot be used, put one of the holding weights in its place. Now bend the batten along the line of nails, or marks, representing the sheer heights, securing it with nails or weights as it touches each station mark in turn. When the stern is reached, it is probable that the batten will bend so stiffly that it will not meet the station marks in one or two stations ahead of the stern. Spring up the extending and free end of the batten until it does meet the marks, and secure. Do the same at the bow. It is very important that the free ends of the batten always be sprung and secured so that it is possible to remove the holding weight or nail at any one of the forward or after stations without the batten's moving. With the batten secured, look along its length from each end; if there are waves, humps, or dips, remove the nail or weight at the place they occur and correct by allowing the batten to spring a little.

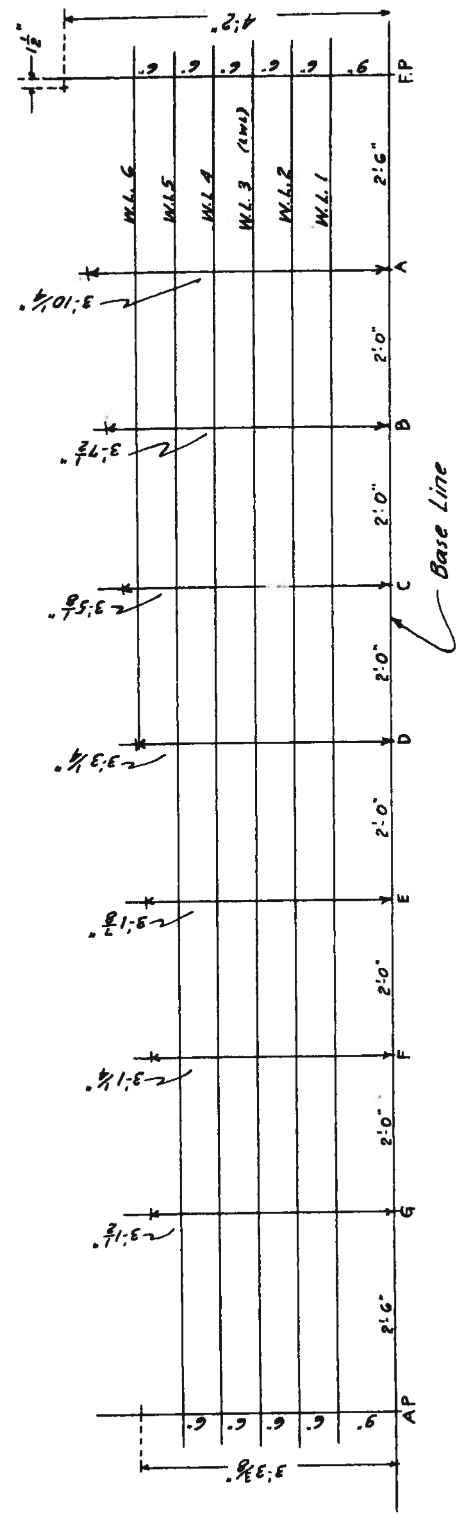


PLATE 12. *Lofting a 17-foot Hampden Boat. First stage—setting off sheer in profile.*

Sometimes a mistake in the offsets will be found and it will then be necessary to make a correction. If it is apparent that one offset is wrong, let the batten pass through the points on all the other stations fairly; the spot where it crosses the station, whose offset is out, is the corrected height. If it is found that the batten is too stiff to stay in place while being bent, remove it and try another, or cut down the size of the one used. The batten can be too limber, however, so care must be taken in choosing the right one. If the batten is too limber, it will not lay fair between the stations; if too stiff, it will jump out of position, or break, when being forced to the required curve. When the batten is fair, all offsets corrected, and you are certain that it is in accordance with the lines plan, draw in the line and remove the batten. Mark the line by its name and note whether it is the top or underside of rail or deck.

Profile of Keel, Stem, and Stern

Now the profile of the keel can be laid off. Measure up on each station from the base line the given offset and make a mark or drive a nail. If the keel bottom is curved, lay off in the same manner as the sheer, but do not attempt to force the batten around the sharp curves at the stem. Then, from the lines or offsets, set off the dimensions for the profile of the stem; fair in with a light batten (one of those prepared for the body plan sections). In the same manner lay off the dimensions for the profile of the stern and draw in with straightedge or batten and pencil.

Fairing with Light Batten, Forefoot

In using the light battens, remember that the retaining nails or weights must be close together, as obviously so must the stations or dimension marks. Always be certain that the batten is a couple of feet longer than the line to be faired. If it is necessary to join two curves of different degree—as, for example, the forefoot and a curved keel—draw in the gentle curve with as stiff a batten as possible, handling it like the sheer curve, and then put in the sharper curve with a thin batten, part of which must follow exactly the line of the gentle curve for at least a couple of feet. Thus a portion of the sharp curve is superimposed on the gentle

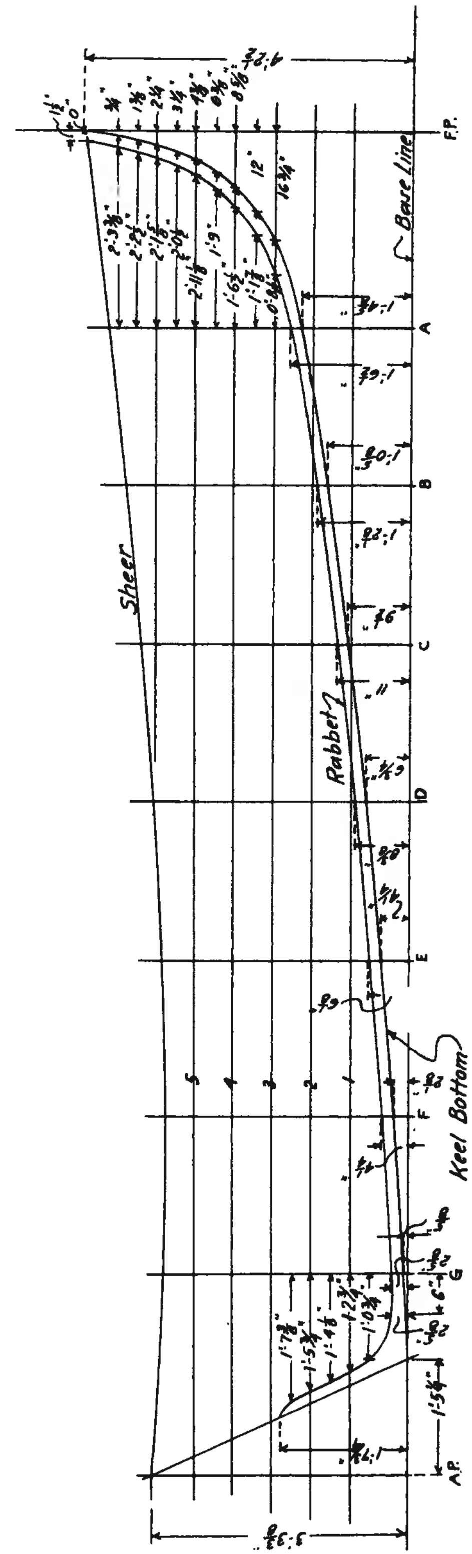


PLATE 13. *Lofting a 17-foot Hampden Boat. Second stage—setting off rabbet and keel bottom in profile.*

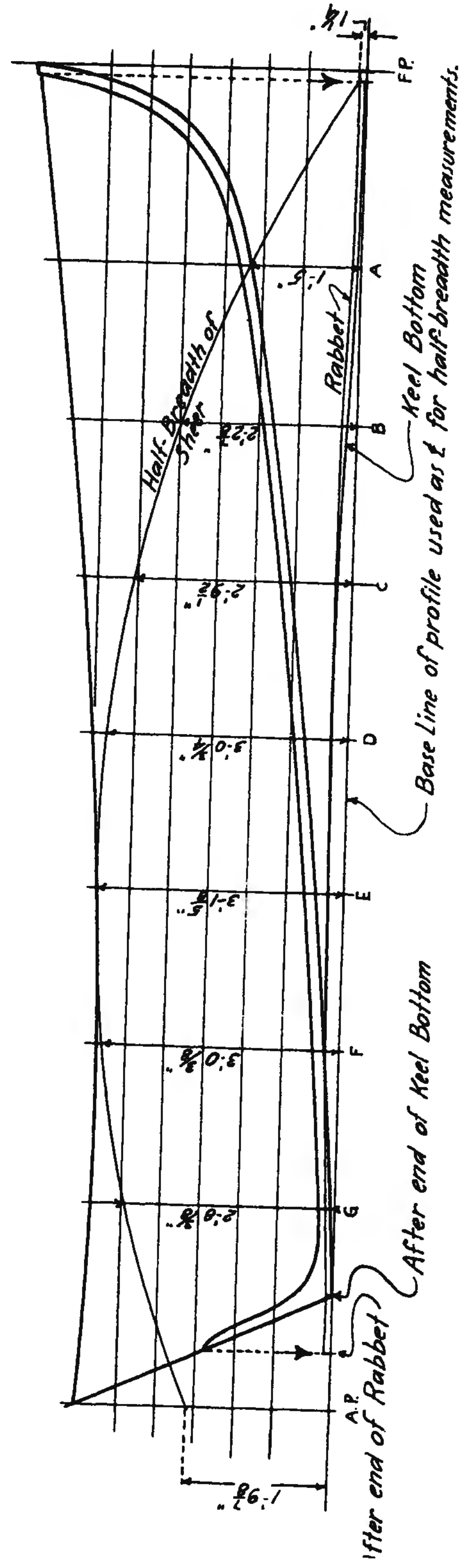


PLATE 14. *Lofting a 17-foot Hampden Boat. Third stage—setting off half-breadths of sheer, rabbet, and keel bottom.*

curve and their joining is fair. The same treatment must be applied to a sharp or gentle curve fairing into a straight line.

Profile of Keel, Rabbet

If the keel is straight, it is usual to give only the offset heights at the two stations marking the limits of the straight portion of the line. When the keel bottom, stem and stern profile, and sheer are drawn in, the rabbet line should be set off and faired in. This is done in the same manner as the keel bottom and stem and stern profiles. However, it is time to take notice of whether the lines were drawn to the outside of the plank, as is commonly the case, or to the inside of the planking. If the lines are to the outside of the planking, then the rabbet drawn on the mold loft drawing is the line of intersection of the outside face of the keel and plank. The rabbet eventually will have to be represented by three lines: the rabbet, inner or margin line, and upper or bearding line. For the moment, however, the other rabbet lines must wait. If the lines should be to the inside of the plank, as in Plate 3, then the line laid off on the loft plan is the innermost corner of the rabbet, the middle or margin line. If this is a straight line, the rabbet line will have a slight curve, as will be found when projected.

Marking Staffs

To save time, in most boats it is well to have marking staffs at hand. These are thin, narrow battens, straight and smooth, long enough to equal the greatest half-breadth and height given in the offsets. The staff used to record the heights should be separate from the one used for the half-breadths. Take the staff chosen for the heights and measure off each height to keel bottom, rabbet, and sheer, station by station, and mark each by its name and station number. To do this, lay the staff along each station with heel snug against the base line batten and tick off the proper heights. This will enable the corrections in fairing to be transferred later to the body plan without error or extra measuring.

Half-Breadth Plan, Sheer, Rabbet, Keel

Next set off the half-breadth of the sheer line. The base line for the profile will be used as the center line now. On each station set off the half-breadth offset given in the tables. Measure on the profile at the stem the point where the rabbet of the stem intersects the sheer, using the forward perpendicular for the base line. Transfer this distance to the center line. From the offset table take the half-breadth of the sheer at stem and set it off perpendicular to the center line at the point just obtained. This is the fore end of the sheer line. Obtain the end at the stern in the same manner. Sweep in the line with batten and pencil. Now lay off the half-breadths of the rabbet and keel bottom in the same manner. The end of the rabbet at the stern will be decided by the type of stern in the design; its fore-and-aft position is obtained in the same way as the fore end of the sheer. Mark the measuring staff for the lines faired in so far in the half-breadth plan.

Body Plan Position

Some builders proceed to fair in all the water lines next, but it is safest to fair in the body plan at this stage. Errors can be more readily checked if the loft plan is drawn in the same sequence as the design plan, in which the body plan is drawn when the lines described previously have been faired in. For the center line of the body plan it is customary to take the station at amidships (or the one giving the largest section area) and to draw the sections or mold forms on both sides of this. There is no particular importance to this location except that it puts the body plan in the center of the work and so is handy from all parts of the loft plan. Some builders draw the body plan on a separate drawing board, if the boat is small, in which case a base line, center line, and water lines have to be drawn with *exactly* the same spacing as on the large plan. We will assume that the body plan is on the floor, however, as the procedure is the same as far as fairing is concerned.

Body Plan Drawing Sections

Taking the midsection station on the profile as the center line of the body plan, space off the buttock lines shown in the design according to the measurements given in either the lines or offsets. The buttocks must be exactly parallel to the center line and spaced equally on each side. Next draw in the diagonals, dimen-

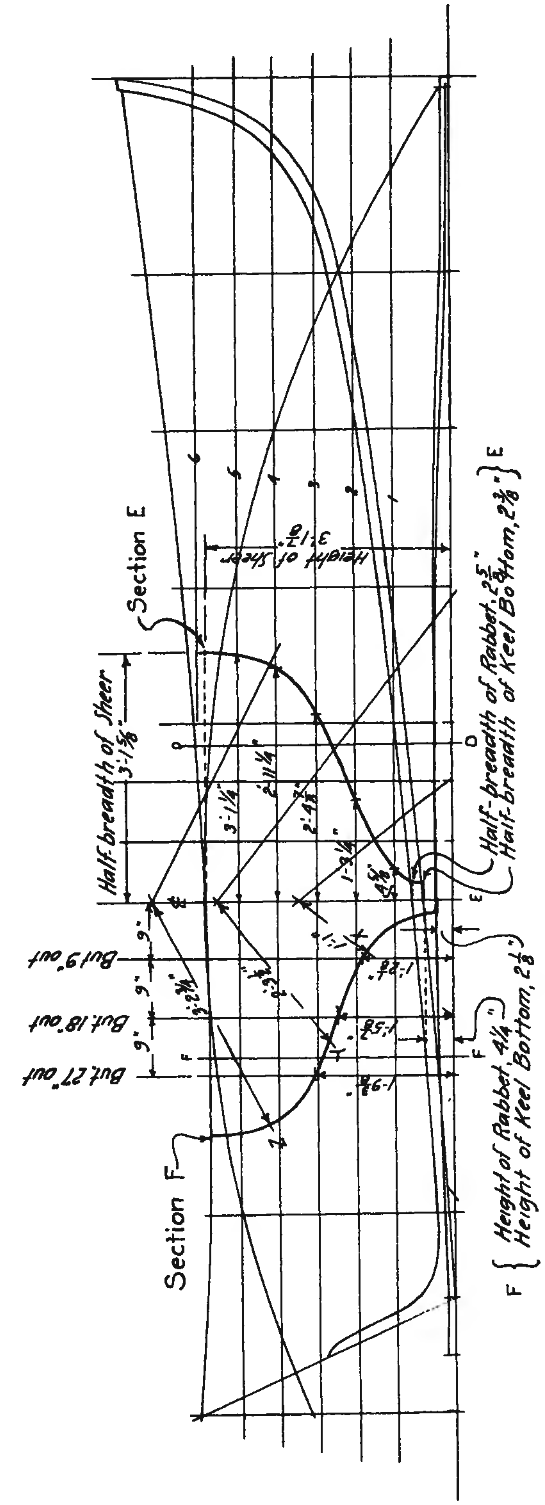


PLATE 15. *Lofting a 17-foot Hampden Boat. Fourth stage—drawing sections in the body plan.*

sions for the location of which may be obtained from the same plan and table. Note particularly the place each diagonal crosses the water lines and compare these with the lines plan; this will indicate any error, either in the loft plan or offsets. Now a base line batten may be tacked on either side of the center line, the side chosen depending upon which portion of the body plan is to be laid off first. Usually it is easiest to lay out the forward sections first. It is supposed that the profile of the hull on the loft plan heads the same way as in the lines. In this case the body plan may as well be made to follow the same arrangement as in the lines, for ease in comparison.

Suppose the bow sections are to be laid off first. Take the measuring staff made for the profile, or heights, and begin to lay off the sheer heights for the fore sections. Take two spots for each so that horizontal lines can be drawn from the center line outward, parallel to the base line. Do this for the rabbet and keel bottom, marking the station and identification for each. Then take the measuring staff for the half-breadths, lay it along each horizontal line, and tick off the half-breadths of sheer, rabbet, and keel bottom for the corresponding station. Turn to the offset table and select the foremost station. Begin by setting off each water-line half-breadth for this station on the loft body plan, taking care to be exact in reading and laying off dimensions. Be sure to get the water lines correctly numbered or identified on the loft plan so that mistakes in plotting can be avoided. Each offset must be measured from the center line out, with the rule laying along the horizontal line representing the water line or half-breadth. When the water-line offsets are marked, either by pencil or nails, pick out the heights of the buttocks in the offset table. These must be set off vertically from the base line on the buttock lines, on the loft body plan, corresponding with those in the lines plan, of course. This is emphasized as it is very easy to misread offsets, and thereby set them off on the wrong line, or to take the wrong station. Set off the buttock heights, then, in the same manner as was done with the water-line offsets, but measuring vertically from the base line.

Next find the diagonal offsets on the offset table. These must be set off on the corresponding diagonals on the loft body plan. Measure from the center line of the body plan, that is, from the point where this line intersects each diagonal. Again the rule must lay along the line in setting off measurements, sloping downward from the horizontal according to the slope of the diagonal. When these are completed, the section may be faired in with a batten. In the sections at bow and stern some offsets for water lines, buttocks, and diagonals may be found missing on the offset table. This is because the fairing lines omitted may fall outside the limits of the section or because they may coincide too closely in position with the sheer or rabbet lines. In fairing in the sections it is probable that the batten will show that humps will result if it is forced to meet every offset mark. Therefore, some corrections must be made, but never at sheer or rabbet, in order that the batten lay fair; it should pass through the majority of the offsets set off as explained in regard to the sheer line. Every station, or section, shown in the lines, including the stern elevation of the transom, must be drawn in the loft plan in the manner explained for the foremost station, the base line batten at center line being shifted when necessary.

Fairing Body Plan Sections

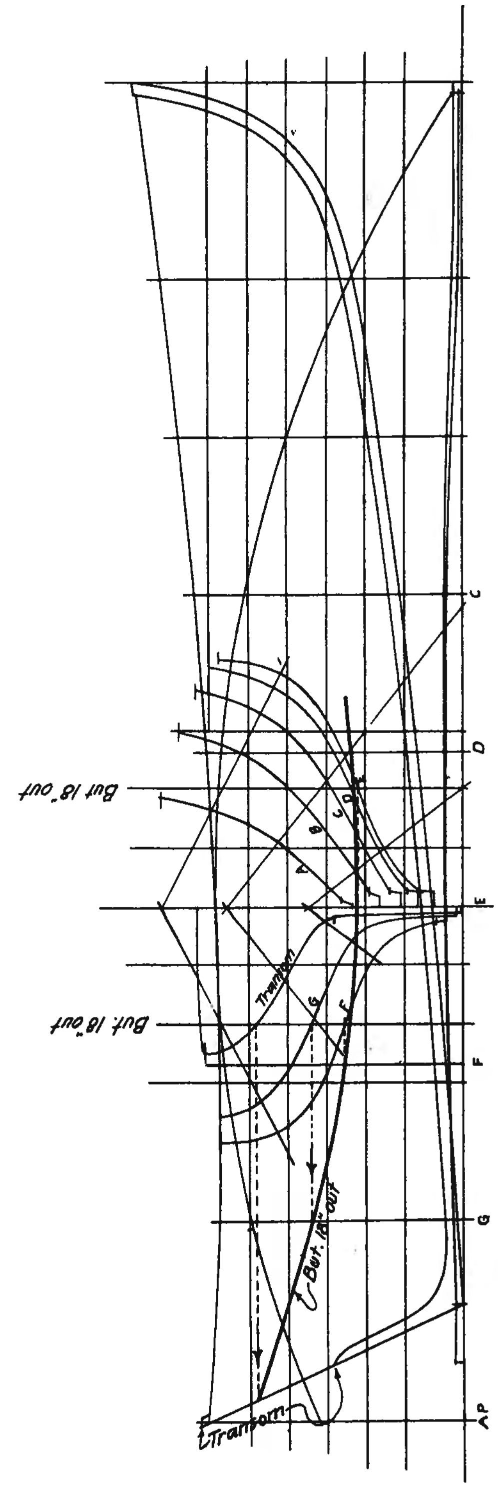
In fairing in the sections, certain general principles must be observed. If the hull form is of the dinghy or U-section model, the bottom will be straight in section for a short distance out from the keel. This is the "dead rise of the floors" and must be correctly drawn on the loft plan. If one does not take care, the batten will tend to make the dead rise of the floors curved instead of straight. When fairing such a section, the batten must be forced where it fairs into the bottom. The need for this can be judged very easily by studying the section as shown in the lines plan while fairing it in on the loft plan. This applies, of course, to round-bottom hulls of all types in which such section forms exist. In fairing reverse curves, in the sections or elsewhere, there must be a short portion that is dead straight between the reverses. If this is not done, a hump will form in the section at the point where the curve reverses. Again note the section form shown in the lines, in order to find out what is required. The whole idea of drawing the loft plan is to reproduce the designed lines as closely as possible. It must be emphasized, however, that fairing in the sections must under no circumstances require changes in the sheer and rabbet positions as transferred from the profile and half-breadth on the loft plan. If the design is well drawn, there ought to be no marked alterations required in the offsets to fair the lines. It is necessary that the batten be shifted about a bit if the offsets do not seem to fair, adding a little to one offset and subtracting a little from another. It pays to be careful in all loft work, to check and compare at every step.

Fairing Lines

Now the body plan is complete and the rest of the fairing may begin. The choice of which to fair in first—water lines, diagonals, or buttocks—depends wholly upon the form of the boat. Lines which cross the sections in the body plan at, or nearly at, right angles are the most useful fairing lines since it is possible to find their exact intersection. So in the afterbody (sections toward the stern) the bottom is best faired by the buttocks, the topsides by the water lines; in the forebody (sections toward the bow) the water lines will serve. The diagonals usually serve to fair in the middle third of the boat's length and the topsides to the best advantage.

Fairing Buttocks

Let us suppose it has been decided to fair in a buttock first. Take one about one quarter the beam of the boat, out from the center line, whichever buttock is nearest to this position in the body plan. The measuring staff for heights should be marked for the buttock, taking off the heights from base line to where the buttock intersects each section in the body plan, by laying it along the chosen buttock line and ticking the batten as previously explained. Lay the measuring staff on each station in turn, on the profile, and mark the height at which the buttocks crossed it in the body plan. Fair these points in with a batten, but do not attempt to run the whole line in. Only fair the sections from just forward of amidship to the stern. This should require no alteration in the heights marked on the stations; but, if it does, then the body plan must be changed so that the section there coincides with the changed offset height in the profile. The remaining buttocks in the afterbody may be faired in, in the same way; but if any of these run up the side of the hull aft, omit them for the



Buttock heights lifted from Body Plan.

PLATE 16. *Lofting a 17-foot Hampden Boat. Fifth stage—fairing first buttock.*

time being. Now the buttocks may be drawn on the half-breadth plan—in which they are straight lines parallel to the center line. Measure these off in the same manner that the water lines were in the profile. If, in the loft plan, they should coincide, so much the better. Perhaps the superimposed lines are becoming confusing; if so, they may be traced over with colored crayons—say, the water lines in blue, buttocks in green or yellow, and diagonals in black. Save red for the construction drawing which comes later.

Fairing Water Lines, Ends

Leaving the buttocks, turn to the water lines. Make a measuring staff for the half-breadths of the load water line in the body plan. Transfer these to the corresponding stations on the half-breadth plan. Now the ends of the load water line must be found. On the profile, measure in along this water line to the rabbet and face of the stem, using the forward perpendicular as a base. Transfer these measurements to the center line of the half-breadth plan and square up the half-breadths of the rabbet and face of stem; these points are the forward end of the load water line. If the stem sides are not faired to the side of the planking, but form an angle to it in the half-breadth plan, only the rabbet need be found as the end of the water line. The same operation may be performed at the stern. If a large enough wooden square can be made, these points may be obtained by placing the square on the center line (or base line batten of the profile) and squaring the intersection of water line and rabbet down to the proper place. On the profile, measure the points of intersection of the load water line with the buttocks already faired in. Square these down to the respective buttocks on the half-breadth plan. This gives additional fairing points. Through this sweep a curve with batten, pencil, or crayon. Again, if there is any variation from the offsets in the sections, the latter must be corrected. Where the water line crosses the buttocks on the half-breadth plan will be the hardest to check for position as the angles are so acute on the profile that they will be difficult to establish accurately. Even so, the projection of these to the half-breadth plan is highly desirable. All the water lines can now be faired in, following the method employed in the load water line.

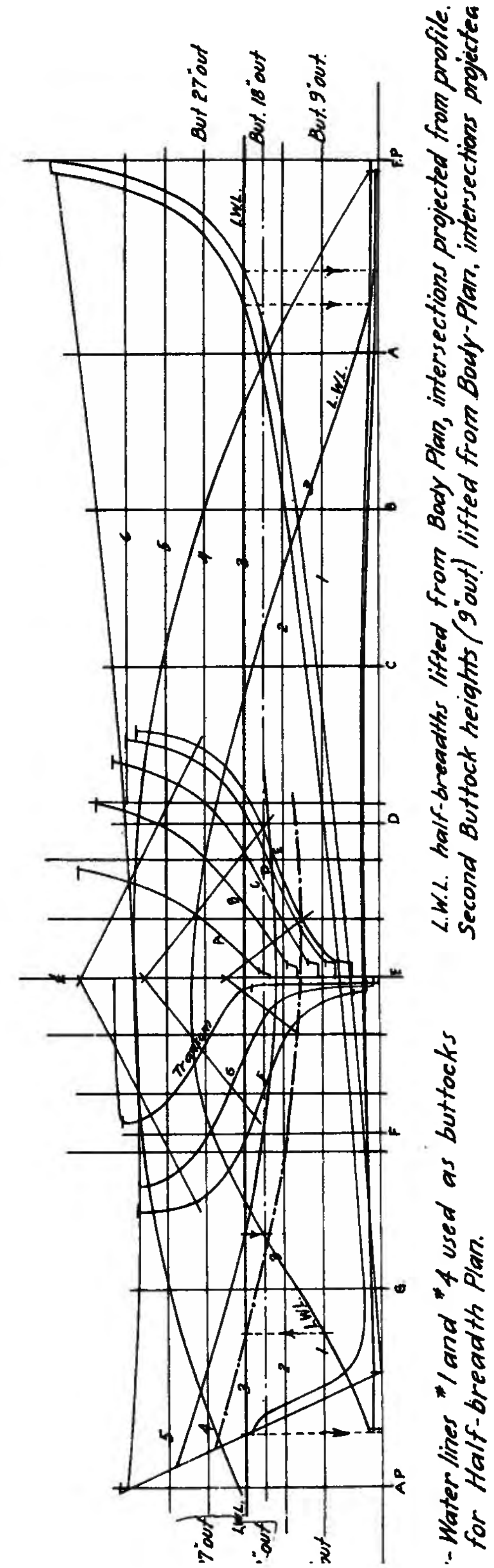
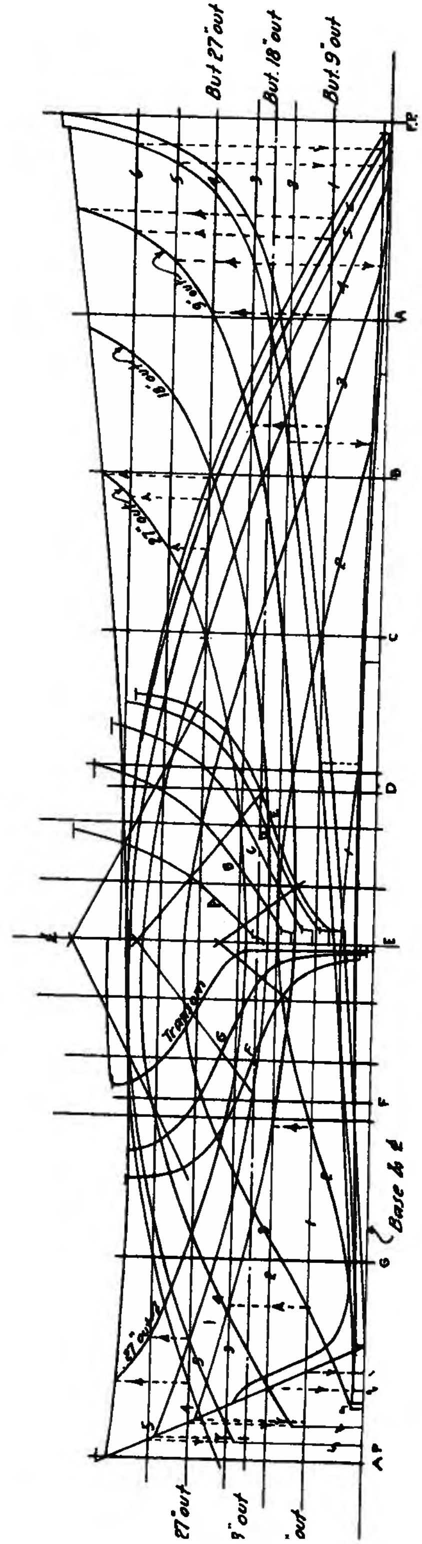


PLATE 17. Lofting a 17-foot Hampden Boat. Sixth stage—fairing first water line and second buttock.



All heights and half-breadths lifted from Body Plan.
The projection of intersections aids and checks fairing of water-lines and buttocks.

PLATE 18. *Lofting a 17-foot Hampden Boat. Seventh stage—fairing water lines and buttocks and projecting their ends and intersections.*

Finishing Buttocks, Bow and Stern Ending

The buttocks can now be finished on the profile. Square up the intersections of the straight-line buttocks with the water lines on the half-breadth plan to the profile, spotting each intersection on its respective water line. Do the same with the intersection of the buttocks with the sheer line. This gives additional points which enable the buttocks to be completed on the profile. If not fair, the water lines or sections, or both, may have to be altered. Due to the rake or curvature of the stern, it may not be possible to complete the buttocks and water lines close to the transom until its true shape has been projected in the profile. It has been assumed that the transom is flat in the design being lofted, but if this is not the case the transom outline must be drawn in the profile and half-breadth plans before the water lines and buttocks can be properly faired.

Sharp Stern

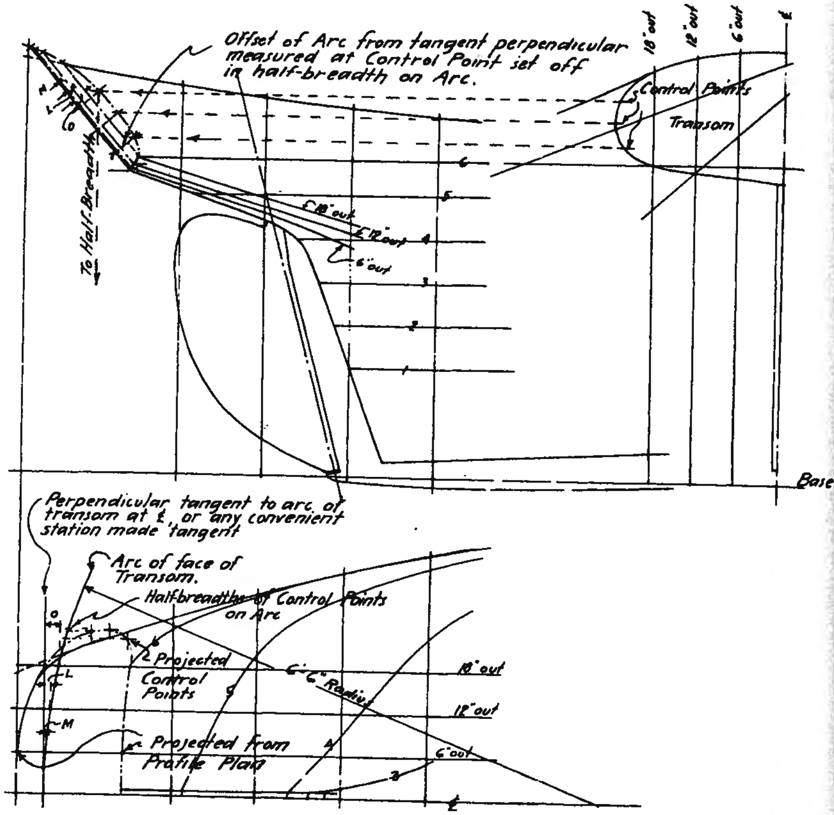
In a sharp stern, with either the usual straight sternpost or the overhanging "canoe stern," the fairing is the same as at the bow, and no further directions are required. Water line and buttock ends are projected as at bow.

Plumb Flat Transom

If the transom has no rake, that is, stands parallel to the section or station lines in the profile, and is flat across its face, its true shape is shown in the body plan and its outboard edge is represented by a straight line (coinciding with the transom center line) in the profile plan. Water line and buttock ends are taken from offset table.

Raking and Flat Transom

If the transom is raking in the profile but is flat across its face, the outboard edge in the profile coincides with the center line but the elevation in the body plan is not its true shape. To lay off the shape of this transom in the half-breadth plan, set off the distance its face is from the after perpendicular in each water line



19. Projection of outboard edge of transom in profile and half-breadth plans to end water lines and buttocks. See text.

in the profile, transfer these distances to the half-breadth center line, and erect perpendiculars. Now measure each water-line half-breadth in the transom on the body plan and set off on the corresponding water line in the half-breadth transom. Then measure the intersections of the buttocks with the transom, square to the after perpendicular in the profile, and set the distances off on the corresponding buttocks in the half-breadth plan. Set off the top of transom in the body plan if it can be done by offsets, transfer the heights this intersects the buttocks there to the profile, and square these points down to the buttock lines in the half-breadth plan. The position of the bottom of the transom

is found by squaring it down from the profile (where it has been established) to the half-breadth center line, where its half-breadth is set off perpendicularly, as measured from the body plan. By drawing a curve, or curves, through the points obtained, the shape of the transom as viewed from directly below is outlined on the half-breadth plan, and the end of each water line and buttock is marked for completing the fairing. Before leaving the transom, set off the thickness of the transom planking and of the stern frame in the profile plan, the lines of which are straight and parallel to the original transom line there.

Remarks

In the type of transom described so far the projection of the outboard edge in the profile and half-breadth loft plans are really of small importance, since the points on the transom may be readily obtained directly from the offsets as previously explained. Nonetheless, the projection of the transom of the sloping or raking type is good practice, since it will aid in understanding the principles of projection that are employed in the more difficult shapes.

Plumb and Curved Transom

If the transom is perpendicular in profile but is curved across its face, the center line of the transom in the profile is a vertical straight line, probably the after perpendicular. The apparent shape of the transom, as seen from dead aft, is shown in the body plan. The amount of curvature is shown in the half-breadth plan. Due to the fact that the outboard edge of the transom does not coincide with the center line in the profile, it is impossible to end the water lines and buttocks (or chine line) until it is projected in the profile and established on the half-breadth plan. The radius of the face of transom is given on the half-breadth plan in the designer's lines drawing. Make a trammel by boring a hole for a pencil in a batten somewhat longer than the required radius. Measure off this radius dimension along the batten from the pencil point, and at the required distance drive a nail through the batten as a pivot point. Lay the trammel on the half-breadth plan with the pivot on the center line and the pencil point on the same line where the transom center line is established by squaring it down from the profile. Sweep in an arc a little longer than from center line to sheer-line half-breadth. On a measuring staff, tick off the half-breadths of each water line at the transom on the body plan. Set these off square to the center line on the arc in the half-breadth plan; this will require shifting the batten for each half-breadth in order to keep it square and yet have the tick-mark for half-breadth fall on the arc. Identify each mark as the end of a water line; these may now be completely faired in on the half-breadth plan. To obtain the ends of the buttocks in the profile, square up their intersections with the arc in the half-breadth plan to the profile; then carry over the heights from the body plan, square to the base line, of course. This will establish the ends of the buttocks in the profile so that they may be faired completely.

The chine and sheer lines are projected in the same manner as water lines. It will be wise, for the sake of clarity, to project the ends of the water lines on the half-breadth to the corresponding water lines on the profile, doing the same with sheer and chine, if one exists, so as to draw in the side elevation of the outboard edge of the transom. This line passes through the buttock ends, of course, and the buttocks on the face of the transom are vertical lines parallel to the center line, squared up from these ends. If the top of the transom can be established from the plans, it is drawn on the body plan and the heights of the buttocks, intersections (and center line) are carried over to the profile transom buttocks and center line, where the top may be drawn in profile. If the top of the transom is at deck level, however, the deck crown will have to be drawn before the top can be shown in the body plan. The transom just described is most common in motorboats. The inside of the transom plank and frame should be set off on the profile as parallel lines to the transom center lines. These should be drawn on the half-breadth plan by reducing the radius by the required amount so that the arcs are all parallel. This stern is now completely drawn, for the time being; but later it will be necessary to project its shape when laid out flat.

Raking and Curved Transom

The third type of transom is the most difficult to build and is rather tedious to project, though it is one of the handsomest

sterns used today. This transom rakes in profile and is curved across its face. Not only must its shape be projected on the profile and half-breadth plans, but later it is necessary to expand its shape when laid flat. The first step is to establish the shape of its outboard edge in the profile and half-breadth so that the ends of the water lines and buttocks may be established, as well as the ends of such diagonals as cross it in the body plan. Inspection of the lines plan will show that the designer has given the radius of the face of the transom by a dimension line and measurement; the former is drawn perpendicular to the center line of the transom in the profile. This dimension line is usually drawn so that it passes through the outboard edge of the transom, where it is farthest from the center line in the profile; this represents the widest part of the transom. It will also be found that the apparent shape of the transom is established in the body plan by offsets on sheer, water lines, rabbet, buttocks, and diagonals, so that it can be drawn in the loft body plan. It is usual to establish the top of the transom in the body plan also. The rake of the center line of the transom is given by dimensions on the lines plan. It is also usual to give dimensions that will enable the sheer half-breadth to be carried to the transom edge in cases where it does not intersect the edge of the transom, but curves in and up to pass over the top. When this is done, the resulting transom is elliptically shaped in the body plan, well and unfavorably known as "the loftsman's curse" for reasons that will become plain when it is lofted.

The first step in projecting this class of transom is to draw it in the body plan and to set off the rake of the center line in the profile, to find the outline of the stern overhang. Then a trammel is made to the required radius (as described on page 97). Place the trammel on the half-breadth plan so that the pivot is on the center line and the pencil is on the intersection of the after perpendicular (or aftermost station) and the center line. Sweep in an arc from center line to a little outside of the sheer line. Then erect two short perpendiculars inboard on the transom center line in the profile, say, one at or close to the bottom and the other close to the top (or sheer line) of the transom. Next, with a measuring staff, tick off the distances on each buttock from the after perpendicular to the intersection of the arc, on the half-breadth plan. Transfer these distances to the profile and set them off on the two perpendiculars to the transom center line, measuring from the latter. Draw lines through the points thus set off. These lines are inboard of the transom center line and parallel to it. They are the buttocks, as viewed from the side, on the face of the transom. Then transfer the heights of the buttocks at the bottom and top of the transom, in the body plan, to the profile and set them off on the sloping buttocks previously drawn, measuring square to the base line. This step enables the buttocks to be completed on the profile since the after ends are now established.

Next make a mark or series of marks on the outboard edge of the transom in the body plan. One of these should be at the point of greatest beam in the apparent transom shape. Measure the height of these on the body plan and transfer them to the profile, measuring square to the base line. Set off the heights of the points on the profile of the transom, making short, horizontal lines a few inches ahead of the center line of the transom. With the measuring staff, pick off the half-breadths of the marks on the transom in the body plan, taking care that the offset is taken square to the center line. Transfer these offsets to the arc in the half-breadth plan, keeping the measuring staff square to the center line as the distances are ticked off for each half-breadth on the arc; this will necessitate shifting the staff to keep it square and to bring the half-breadth tick-mark to the arc. Identify these marks plainly in the body plan, half-breadth, and profile. With a measuring staff, set off the distances between the after perpendicular and these half-breadth offsets on the arc in the half-breadth plan, keeping the staff square to the after perpendicular. Next transfer these to the profile, setting off with the staff square with the center line of the transom in profile and shifting it so as to have each tick-mark intersect its corresponding horizontal line. This will give enough points on the profile to enable the loftsman to sweep in the outboard edge of the profile when the sheer line, or point approximating it, has also been projected in the manner just described. It is impossible to utilize the water lines in this projection because they do not intersect the transom face at right angles and are not true radii for the plane to be projected.

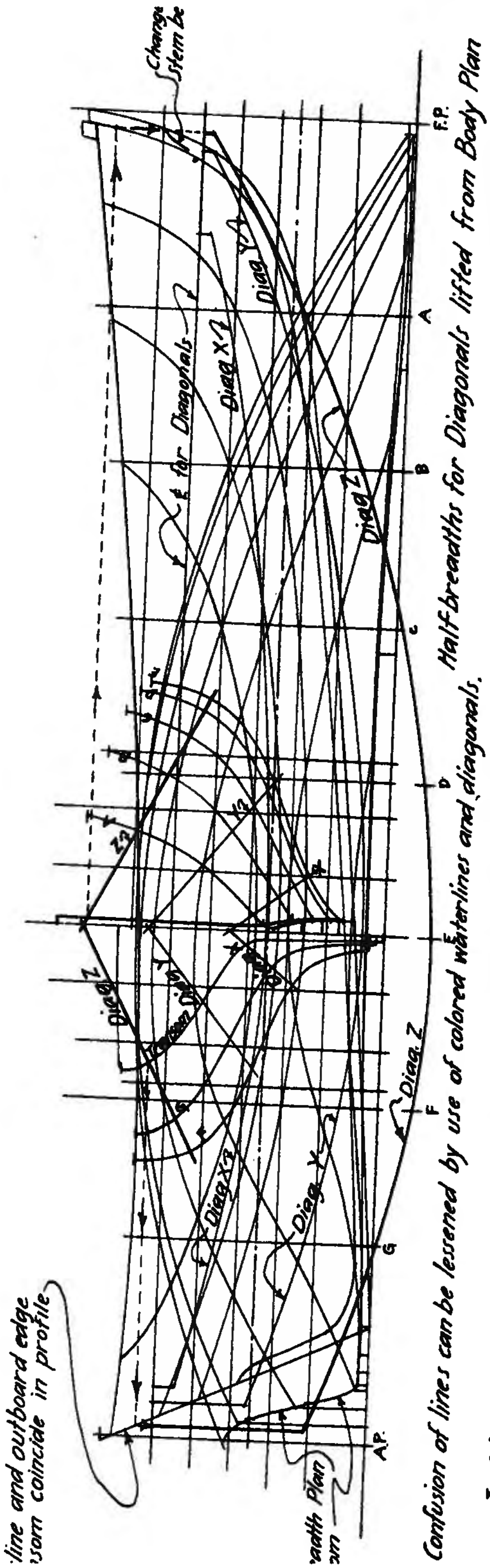
It may be desirable to add more buttocks or marks on the body plan in order to obtain enough points on the profile to fair in the correct shape of the outboard edge in that elevation. When the outboard edge of the transom has been drawn in the profile, it can be drawn in the half-breadth plan to obtain the ends of the water lines and, later, to check the ends of the diagonals aft. Square down the ends of all water lines intersecting the outboard edge of the transom in profile to the half-breadth plan, as lines square to the center line of the latter. Take the half-breadths of these from the body plan and set them off on the corresponding lines in the half-breadth plan. Square down the ends of the buttocks and the transom bottom at rabbet. It is an excellent plan to set off all the other points used to find the outboard edge of the transom in profile to the half-breadth, taking them as water lines have been. This will give a large number of points on the half-breadth plan through which the outline of the transom can be drawn, as seen from directly below. Do not hesitate to add a number of control points in laying off the three views of this type of transom. It is due to shirking this that builders find the transom pattern wrong when they come to set it up.

Accuracy

It is worth while to take pains to be extremely accurate in making the projections necessary in the lofting of the lines. This becomes of tremendous importance when such transoms as the last described are to be developed. Due to the number and tediousness of the projections required, even professional builders are inclined to try "short cuts," with the result that both builder and designer wonder why the stern does not look right on the finished hull.

Fairing and Ending Diagonals

The diagonals should now be faired in. They will be superimposed over the half-breadth plan in the loft. To avoid confusion, it is best to use the uppermost buttock in this plan as the center line for setting off the diagonal offsets, with the curves downward, or opposite to those of the water lines. Having chosen the center line for the diagonals, the first step is to establish the ends of the diagonals on this line. On the body plan measure the height at which the uppermost diagonal crosses the outboard edge of the transom and transfer this to the outboard edge of



19. *Lofting a 17-foot Hampden Boat. Eighth stage—fairing diagonals and projection of their ends. Lines faired, ready fo expansion of transom and other detailing.*

the transom in the profile. Measure the distance this new-found point is before the after perpendicular and square this down to the center line for the diagonals. Measure the width of the transom in the body plan, along the diagonal, transfer this to the center line of the diagonal at the point previously found, and set it off perpendicular to the center line. This is the end of the upper diagonal at the stern. To find the forward end, draw the half-breadth of the stem rabbet, on the body plan, as shown in the lines plan. This may be taken from the profile and half-breadth plan instead of from offsets, if desired. Measure the height the uppermost diagonal crosses the rabbet in the body plan, square this to the rabbet on the stem profile, measure this point from the forward perpendicular, and square this distance down to the diagonal center line.

Next measure the distance from center line to rabbet, along the diagonal, on the body plan and set this dimension off square to the diagonal center line at the point just projected. This is the forward end of the uppermost diagonal. The half-breadths of the uppermost diagonal will now be measured in the body plan. The measuring staff is laid along the diagonal and the distances at which the diagonal crosses each station, measured from the center line, are ticked off. The staff is then transferred to the diagonal center line and from this the half-breadth of the diagonal at each station is set off. When all the stations are marked, a line is faired through the points obtained, running from end to end. If it is found that this curve, when fair, misses some of the station marks, it is well to check the measuring staff before changing the station on the body plan as it is very easy to make an error in setting off the diagonals. This is particularly true in the sections in the stern, where a diagonal passes through the portion below the bottom of the transom. Fair in all other diagonals in the same way that the uppermost has been worked out. The ends of diagonals under the transom or on the sternpost are obtained as at the bow.

Correcting Body Plan

It may be found that, in making changes in the body plan to agree with the faired diagonals, it will be necessary to refair some of the water lines or buttocks. This may seem a tedious job, but it must be done if trouble is to be avoided later. When the lines are faired to the builder's satisfaction, he can draw in the location of the masts on the profile and lay off the cabin trunk or cockpit outlines on both profile and half-breadth plan. These are sometimes given on the lines drawing but, if not, will be found on the construction drawing.

Deducting Plank Thickness in Body Plan Sections

If the original lines plan was drawn to the outside of the planking, as is the usual custom, the thickness of the plank must be deducted from each section in the loft body plan. Turn to the construction or lines plan, whichever shows the "construction midsection," or consult the specifications, to find the thickness of the planking. As has been mentioned, the thickness given for the planking is usually the rough size, when finished on the boat; the thickness will be a little less than this. This matter is not important on a cruising boat, but on a racer the deduction for planking must be very accurate or the boat may be narrower than the plans call for. In thin planking, under ¾ inch thick, use a thickness $\frac{1}{16}$ inch less than given in the plans; in planking under 1¼ inches deduct ⅛ inch from the given size. Set the compass to the thickness decided upon and, beginning with the foremost section on the loft body plan, sweep a series of small arcs along the curve of its outline. The compass pivot point must be on the curve and the arcs should be inboard, of course.

These arcs should be close together where the curve of the section is sharp, and further apart where the curve is gentle. They may be taken 2 or 3 inches apart on sharp curves and 4 to 6 inches apart on gentle curves. Through the arcs sweep in a curve with a batten in order to set off the inside of the planking. Care must be taken that the batten is tangent to each arc, so that it is parallel to the original section curve. This new line may be drawn in red. At the point where the rabbet is set off on the section curve, the new line must be ended. Set a square on the original section, one blade along the original section curve as far as it will go outboard from the rabbet with apex at the rabbet. Mark the place where the other arm crosses the new curve; this is the lower end of the new curve and is the position of the inner line of the rabbet on this section. The top of the new curve must be found. Find out from the lines if the sheer was drawn as the top or underside of the deck. If the latter, the upper end of the new curve is on the same horizontal line as the original section curve's sheer mark. If the sheer line is the top of the deck, subtract the finished thickness of the deck from the horizontal sheer mark, for the original section curve, and make another short horizontal line on the new curve. This is the sheer to the inside of plank. Perform the same operation on all the sections in the body plan, including the transom. We now have the correct shape for each mold form which will control the shape of the boat when set up and framed.

Keel Structure in Profile and Scaling Blueprints

The next step is to lay off the keel construction in profile. It will be necessary to scale the blueprint of the construction plan to do this. Always scale from the nearest station for fore-and-aft position, and from the nearest water line for height (if the base is not closer than a water line). This is done to avoid accumulating the error in scaling which would result in taking long measurements on a blueprint. All blueprints stretch and shrink, stretching in the direction the paper runs through the blueprint machine and shrinking at right angles to this direction. It is quite important that the loft work on the keel profile be carefully worked out. Every piece of timber making up the keel, deadwood, stem and sternposts, centerboard case, skeg and rudder should be accurately shown in profile. The center line of the propeller shaft should be laid off and the location of bearings or stuffing boxes shown. All jogs in timbers, to lock them together, must be correctly drawn. It is necessary that the heels of the frames be drawn in, accurately spaced, so that the floor timbers may be located and later drawn in. If the keel is jogged for the floor timbers, it is well to show the floors in section (as though cut in two along the center line of the boat) in the profile so as to be able to fix the depth of the jogs. If there is a ballast keel, the bolt positions must be worked out. Sometimes the construction plans show the position of the important bolts in the keel structure; transfer these to the loft profile. It will save time and trouble to show the mast steps, engine beds, and bearers in the loft profile.

Changes in Deadwood and Keel from Plans

It is often said that it is very important that the builder make no changes from the plans when drawing the loft plan. This is certainly true; yet in working out the keel structure it may be possible to save a great deal of time and money by altering the arrangement of timber in the keel structure. In all fairness, it must be admitted that some designers are pretty careless when laying off the sizes of timber for the keel structure of a design. It is not wholly uncommon to find excessively wide timber called for, or knees that are practically impossible to obtain, due to size or shape. Sometimes this apparent thoughtlessness is due to the conditions existing in the location the design was made. Thus, in New England large knees of hackmatack are available; in some other parts of the country it is almost impossible to get large knees of any timber. In some parts of the West it is not particularly difficult to obtain very wide timber of certain species, but in other sections such timber is simply unavailable. As a result, it may be highly important to make some alteration in the keel structure design in order to use local timber or available stock.

Rules for Changes

It is quite impossible to give complete and accurate instructions that would meet all conditions that might exist in making alterations from the plans. However, there are some general rules that should be followed. Study the construction plan before making any change whatever in the keel. The fewer the number of seams crossing the rabbet, the less the liability of leakage. All fastenings into the end grain of a timber are weak. All butts in the external keel must be backed by an inside timber in the ends of the hull. If two timbers, say, the keel and stempost, are joined by a knee (in the original construction drawing) which is not available, straight-grained timber may be used in its place; but the ends must extend beyond the arms of the original knee for at least enough space for an additional fastening in each end. Such a change will increase the weight, so great care must be taken in planning any alteration in the keel structure. If the plans call for a keel in a single length and this cannot be obtained, it is permissible to scarf the keel. The location of this should be

chosen with care so that the scarf bolts will not interfere with the bolts in the floor timbers or those for the ballast keel.

The length of the scarf should be five to eight times the depth of the timber, or not less than three frame spaces in any case. Before making any marked changes in the keel structure it is wise to submit the proposed alterations to the designer. The builder should remember that too many small pieces worked into the deadwood or keel structure increase the opportunity for rot to start in one of the numerous seams that result. Also it is well to avoid laying out the keel structure so that end grain is exposed in any piece, either inside or out of the hull. Such exposure can be avoided by notching pieces into one another; in the ends of the hull, pieces can be worked in at angles that will further reduce exposure. Of course, it will not be possible to avoid entirely the exposure of some end grain, but the danger can be reduced by rounding off the ends of the members approaching the vertical—arms of knees, for example. No pockets that will hold moisture should be permitted in the top of the keel structure profile.

Projection for Rabbet Lines

When the keel structure is laid out on the loft profile, the inner line of the rabbet and the bearding line will have to be drawn so that it will be possible to rough out the whole rabbet before setting up the keel on the stocks. If this is allowed to wait until the boat is set up, the work is measurably increased. The first step is to draw the half-breadth of the keel on the loft body plan. It has already been drawn outside the rabbet line. Take the heights of the top of the keel structure from the profile at each station and transfer to the body plan; there outline the half-section of the keel structure at each mold section. By so doing, the position of the bearding line at each mold station is found. The bearding line is formed by the intersection of the *inside* of the planking with the face or side of the keel, just as the rabbet was formed by the intersection of the *outside* of the planking with the side of the keel. The inner line of the rabbet was established on each section by finding the keel end of the line representing the inside of the planking of each section. The heights of the inner line of the rabbet should be transferred to the profile for each station. Do the same for the bearding line. Enough points will be obtained from

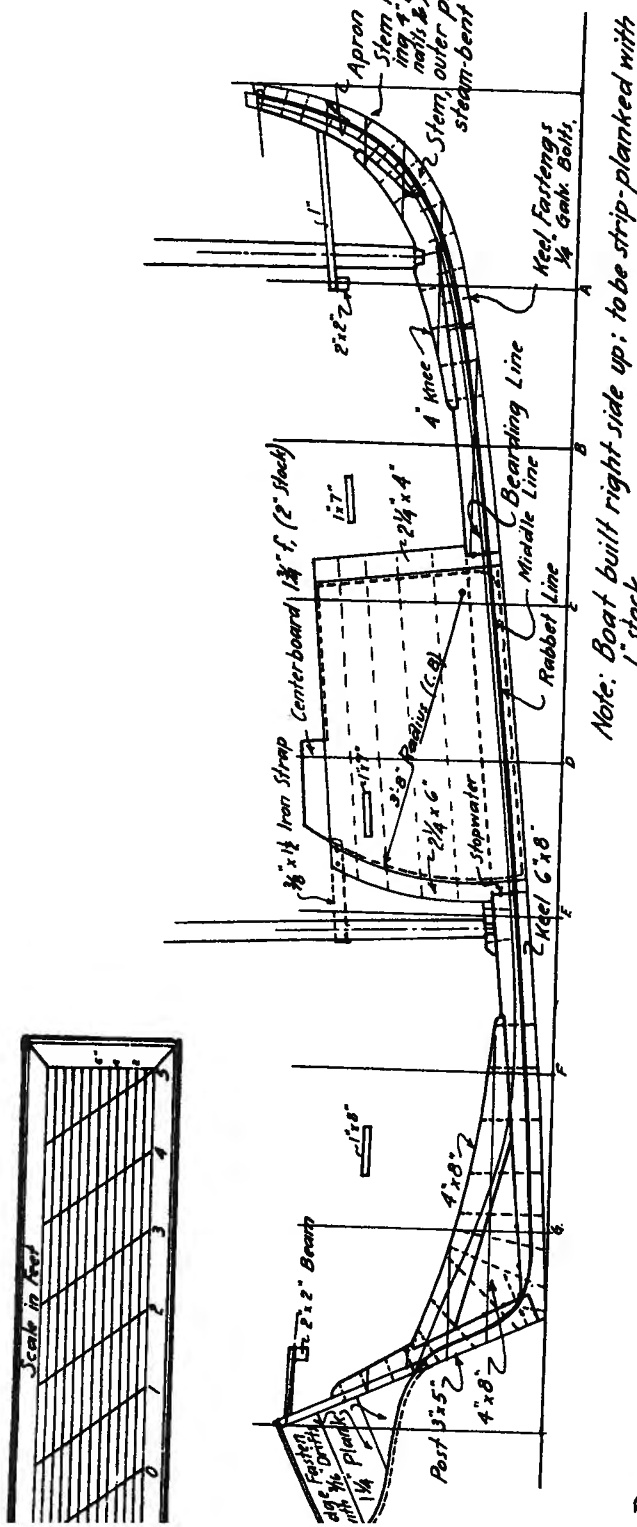
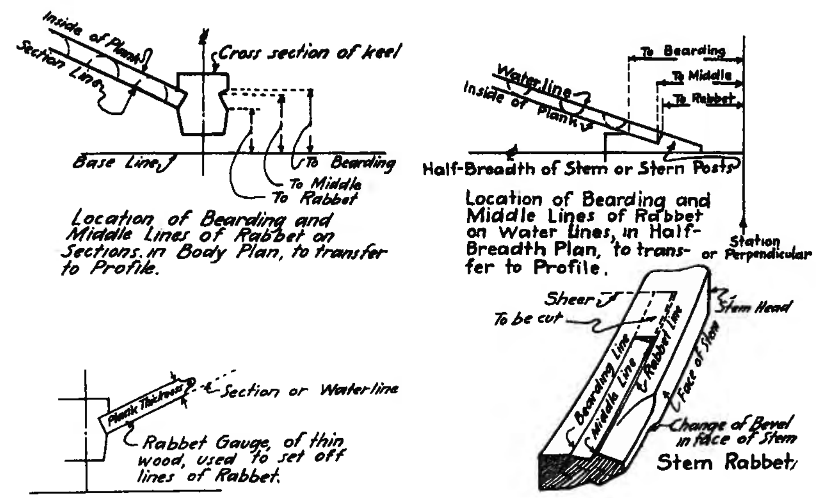


PLATE 20. *Lofting a 17-foot Hampden Boat. Ninth stage—deadwood and keel lay-down, rabbet lines, and transom.*
(Rough timber sizes marked.)

the body plan to establish the curve of these lines on the profile through the mid-body of the hull, but more will be required before the two lines can be drawn on stem and sternposts.

To get these, we go to the half-breadth plan. With the compass, set off the *inside* of the planking on each water line at the stem and sternposts, running from the rabbet of each a couple of feet inboard, and sweep in the curve of the inside of plank of each water line, establishing the inner line of the rabbet as done in the body plan sections. Next draw in the half-breadth line of the keel in the half-breadth plan. Where this crosses the line of the



20. The Rabbet

inside of plank for each water line is the position of the bearding line for each water line. Square these points (for inner line of rabbet and for bearding line) up to the profile to the corresponding water lines there. Perform the same operation on the sheer line. By doing this at bow and stern enough points should be obtained to complete the fairing in of the inner rabbet and bearding lines on the profile. If not enough are found, then it is necessary to run in a few more water lines or sections, drawing them in only close to the keel or to stem and sternposts, to fill in the gaps caused by too wide a spacing of sections and water lines in the original design plans.

If the lines were designed to the inside of the planking (as in Plate 3), and as in most designs for lap-strake (clench, clinch or clincher-built) hulls, the operation of finding the inside of the planking is reversed so as to establish the outside of the planking at the keel, in order to project the rabbet line. In this class of design the rabbet is replaced on the lines by the inner line, or margin line, of the rabbet and both the rabbet line itself and the bearding line have to be developed by projection in lofting the lines. The process of obtaining the position of these lines on the profile is the same as described previously.

Additional Fairing Lines

No special explanation should be required in regard to adding water lines and buttocks to the loft plan. Such lines are set off on the profile body plan and half-breadth, regardless of position, in the same manner as laid off for the lines shown in the designer's plans. Diagonals may be added also, if desired. They are first drawn on the body plan. In laying off diagonals the joining of each pair must be at the same place on the center line and must also be at exactly the same angle; their outer ends must pass through a given water line equidistant from the center line of the body plan.

Adding Sections

Additional sections may be added at will, in order to project the shape of a bulkhead or to locate properly some particular point on the hull. To draw a new section, erect a perpendicular to the base line on the profile and then project this down, square to the center line of the half-breadth. The location of this line can be established anywhere in the length of the hull without regard to its position in reference to any other section line. Using a measuring staff, mark on it the half-breadths of the water lines on the new section and transfer to the corresponding water lines on the body plan. Do the same with the diagonals. Then measure the height of the buttock lines, sheer, rabbet, and keel bottom on the new section line in the profile and transpose these to the proper place in the body plan. Then project the half-breadth of sheer, rabbet, and keel bottom to the body plan as previously explained

in the setting off of the design sections. A curve through the points thus obtained on the body plan gives the shape of section at the chosen location. The thickness of the planking and the half-section of the keel, position of inner rabbet, and bearding line are found as described for laying down the sections shown in the lines plan.

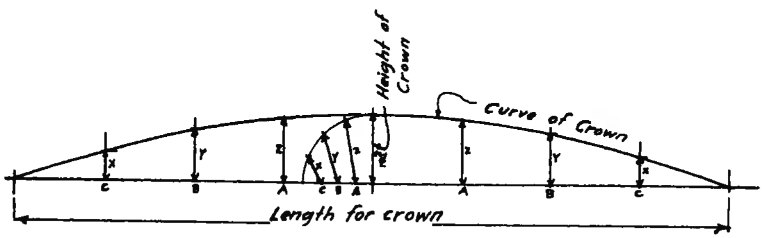
Lofting Sawn Frame Hull

The lofting of a sawn frame hull is no different from the method outlined, which is intended for a steam-bent frame hull. In the sawn frame design there are more sections in the body plan. Since most designers give offsets for every other sawn frame, the intermediate frames must be projected on the loft plan. It is common practice to fair up the sections given in the offsets first; when these are complete the intermediates are projected as though they were new sections. Loftsmen do not bother to correct water lines, buttocks, and diagonals for the intermediates unless the shape of the section indicates great errors, or some irregularity in offsets causes doubt as to which should be followed.

Deck Crown and Pattern

The crown of the deck is laid out as a pattern, as a rule. To make this the crown must be known. This is given in the plans, either in the lines or construction plan. Usually it appears as Crown of Deck 6″ in 10′, the actual figures varying with the beam of the boat and the amount of crown in the deck the designer requires. It will be noticed that the length specified for a given crown is equal to or very slightly greater than the greatest width of the hull on deck. The amount of crown or bow-up of the deck is measured at the middle of this width; if the length for crown is 10 feet and the height of crown 6 inches, the latter is at the middle of a straight line 10 feet long, represented by a perpendicular 6 inches high. A curve passing through the ends of the 10-foot line and the top of the 6-inch perpendicular is the crown of the deck. This is commonly laid off as a parabolic curve.

First, to prepare to set off the crown, take a piece of thin board (plywood or cardboard will do in small boats) longer than the length given for crown and a few inches wider than height for crown. Near one edge of this strike a straight line and set off the length for crown. Find the middle of this length and erect a perpendicular on which set off height for crown, measuring from the length line. Set the compass to the height of crown and, with the pivot at the intersection of the length and height line, sweep an arc from the length to the height line. Divide the length of the arc within these limits into four equal parts. Divide the portion of the length line between the arc and the height line into



21. Making Deck Crown Pattern

four equal parts. Connect each mark on the arc with each mark on the length line by a straight line, beginning with the marks closest to the perpendicular height line.

Next divide the length line, on each side of the perpendicular height line, into quarters—eight parts in all. Erect perpendiculars at each mark, except at the extreme ends. Measure the heights of the sloping lines inside the arc, from length line to arc, and transfer these to each pair of perpendiculars (one on either side of the height line), beginning with the two nearest to the height line. The two ends of the length line will have no height measurement. Run a line through the tops of the heights set off on the quarter perpendiculars, beginning at the extreme ends of the length line and curving up and over the height of crown as set off at the middle of the length line. This is the shape of the deck crown. Cut the board to serve as a pattern, the top of which will be the curve of the crown. The lower edge should be a few inches away from the length line, parallel to it, and perfectly straight.

To use, lay the pattern on the body plan with the height line on the pattern coinciding with the center line of the body plan, and the curved edge of the pattern against the sheer or deck mark of the section. The bottom of the pattern must be at right angles

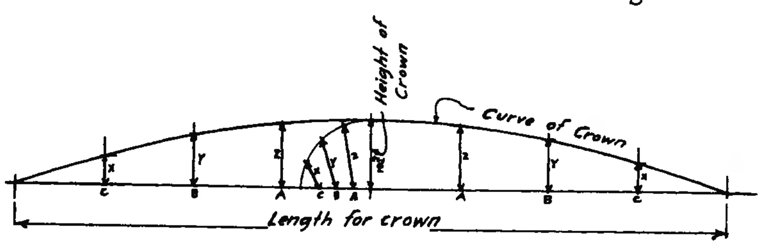
with the center line of the body plan. Sweep in the curve of the top of the pattern from sheer or deck height to center line and the deck crown at the station is found. The pattern can be used to lay off the top of the deck, the underside of the deck, or the underside of any deck beam. It will be noticed that the amount of crown in any section is controlled by the amount of beam of the section. The top of the transom may be drawn on the body plan with this pattern, if not already established (if the top is fixed by the deck crown).

Transom Expansion

The expansion of the transom, when it rakes or has a curved face, has been mentioned. The usual procedure is to expand the transom to the outside of the planking and deduct the plank thickness. If the transom is very curved, or if the sides of the boat come into it with a very full curve, there is actually a slight error resulting from this; but it is so small that it may be overlooked. The outside face of the transom, when expanded in the usual way, is used to set off the bevels—or angles at which the sides join it—to obtain the sawing shape, or "molded face," of the frame. This is not difficult to do if care is taken. First the various methods used to expand transom forms must be understood.

Suggestion for Expansion

In small craft, where there is no transom frame and the sides and bottom are therefore fastened to the ends and bottom of the transom plank, the most satisfactory way is to expand the transom at its forward face, or inside of the transom plank line in the profile. This is particularly true when no tilting band saw is available. The usual procedure of getting out the finished transom, in this case, is to saw to the pattern obtained with a handsaw and then to work in the bevels with drawknife and plane after the transom is set up. As will be explained, it is possible to get out the correct bevels of the transom beforehand with a little more work on the loft drawing. Projecting the transom to the inside of its plank is a little more laborious when lofting the lines, but is less productive of error in setting off the bevels. In boats having a transom frame, it is possible to project the transom to length given for crown and a few inches wider than height for crown. Near one edge of this strike a straight line and set off the length for crown. Find the middle of this length and erect a perpendicular on which set off height for crown, measuring from the length line. Set the compass to the height of crown and, with the pivot at the intersection of the length and height line, sweep an arc from the length to the height line. Divide the length of the arc within these limits into four equal parts. Divide the portion of the length line between the arc and the height line into



21. Making Deck Crown Pattern

four equal parts. Connect each mark on the arc with each mark on the length line by a straight line, beginning with the marks closest to the perpendicular height line.

Next divide the length line, on each side of the perpendicular height line, into quarters—eight parts in all. Erect perpendiculars at each mark, except at the extreme ends. Measure the heights of the sloping lines inside the arc, from length line to arc, and transfer these to each pair of perpendiculars (one on either side of the height line), beginning with the two nearest to the height line. The two ends of the length line will have no height measurement. Run a line through the tops of the heights set off on the quarter perpendiculars, beginning at the extreme ends of the length line and curving up and over the height of crown as set off at the middle of the length line. This is the shape of the deck crown. Cut the board to serve as a pattern, the top of which will be the curve of the crown. The lower edge should be a few inches away from the length line, parallel to it, and perfectly straight.

To use, lay the pattern on the body plan with the height line on the pattern coinciding with the center line of the body plan, and the curved edge of the pattern against the sheer or deck mark of the section. The bottom of the pattern must be at right angles

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Transom Expansion

The expansion of the transom, when it rakes or has a curved face, has been mentioned. The usual procedure is to expand the transom to the outside of the planking and deduct the plank thickness. If the transom is very curved, or if the sides of the boat come into it with a very full curve, there is actually a slight error resulting from this; but it is so small that it may be overlooked. The outside face of the transom, when expanded in the usual way, is used to set off the bevels—or angles at which the sides join it—to obtain the sawing shape, or "molded face," of the frame. This is not difficult to do if care is taken. First the various methods used to expand transom forms must be understood.

Suggestion for Expansion

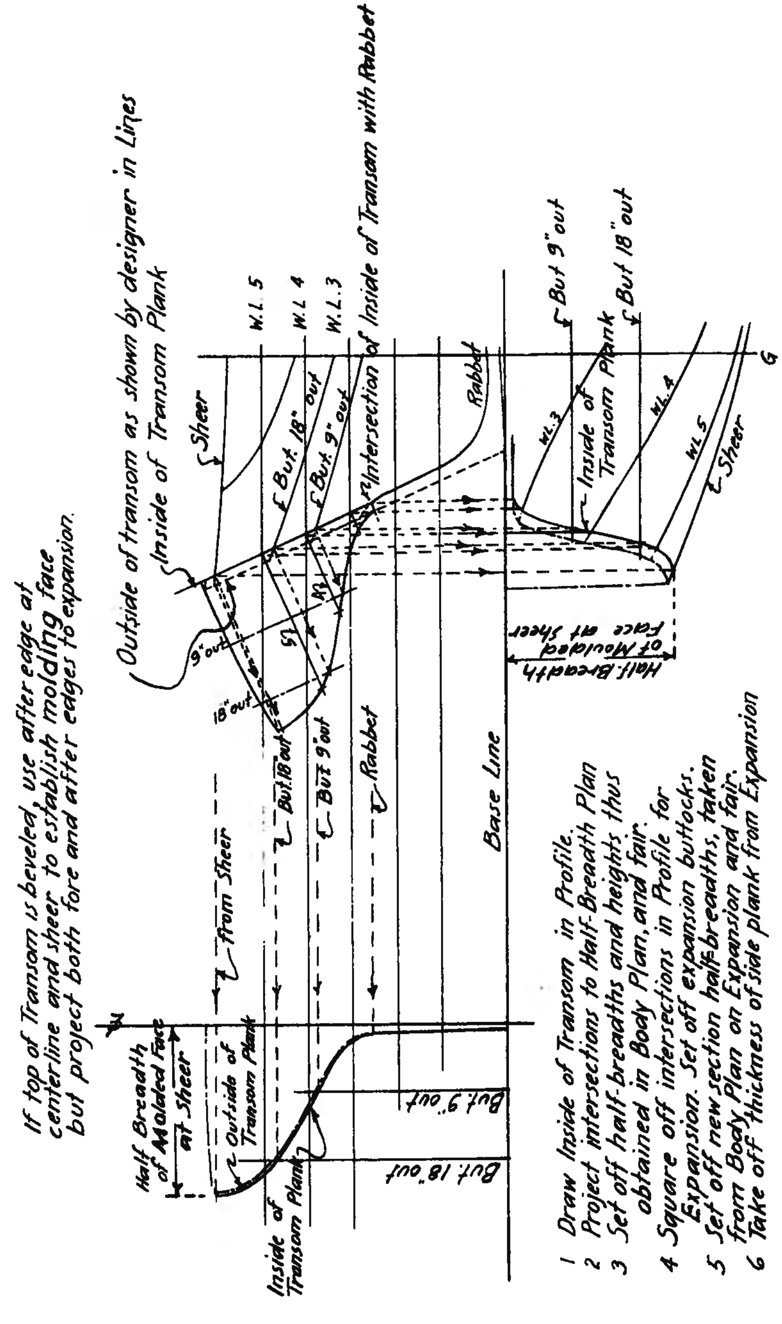
In small craft, where there is no transom frame and the sides and bottom are therefore fastened to the ends and bottom of the transom plank, the most satisfactory way is to expand the transom at its forward face, or inside of the transom plank line in the profile. This is particularly true when no tilting band saw is available. The usual procedure of getting out the finished transom, in this case, is to saw to the pattern obtained with a handsaw and then to work in the bevels with drawknife and plane after the transom is set up. As will be explained, it is possible to get out the correct bevels of the transom beforehand with a little more work on the loft drawing. Projecting the transom to the inside of its plank is a little more laborious when lofting the lines, but is less productive of error in setting off the bevels. In boats having a transom frame, it is possible to project the transom to the inside of the frame line, if desired, by the method suggested. This should be clear, however; the methods of projection used to expand the transom can be used to obtain the shape of the transom at its after face, forward face, or the forward face of its frame, by changing the position from which to start the projection. In the descriptions that follow the projection is taken at the inside of the transom plank, with one exception.

Plumb and Flat Transom

In a flat transom, standing plumb, the body plan transom gives the true shape to its outboard face. To obtain the inboard face, draw in an extra section line on the profile and half-breadth plans at the distance forward of the transom face required by the thickness of the transom plank, or plank and frame. Project this to the body plan as explained in the development of extra sections on page 110 and set off the line of the inside of the side planking on the resulting body plan section; this is the required molding face.

Expansion of Raking Flat Transom

If the transom is flat athwartships and raking in profile, the body plan shows the apparent shape of the after face of the transom. The inner face of the transom plank has been marked on the profile. A section representing this must be projected to the body plan first. Square down the intersections of the line on inside of transom plank with sheer, water lines, buttocks, and rabbet in the profile to the corresponding lines in the half-breadth plan. Draw in the outline of the section there as was done with the outboard face of the transom. Take the half-breadths of water lines, sheer, and rabbet of the new section on the half-breadth plan and transfer them to the body plan in the usual way. Take the heights of buttocks, sheer, and rabbet at inside of transom plank from the profile and set them off on the body plan. Draw in the section on the body plan. The diagonals may be checked as though the new section were the after face of the transom. Now a section is projected that is the forward face of the transom. To make the expansion, the raking line of the inside of the transom plank in the profile is taken as the center line for the expansion drawing, which will stand off from it abaft the



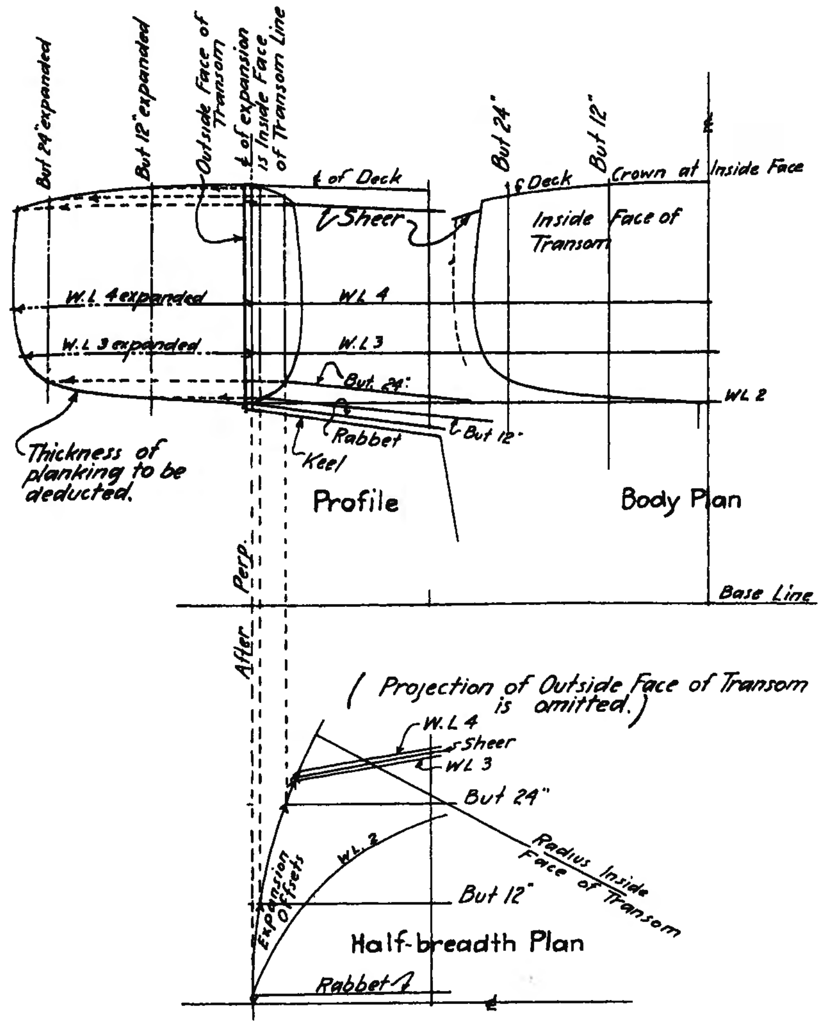
22. Expansion of Flat and Raked Transom, 17-Foot Hampden Boat

stern. The height of the rabbet has been established on the raking line of the inside of the transom plank in the transom profile by its intersection with the profile rabbet line. At the rabbet height, square out its half-breadth, taken from half-breadth plan to the expansion-drawing center line.

The sheer is squared out on the expansion center line and its half-breadth set off in the same way. At the points where the water lines intersect the line of inside of transom plank on the profile, square out water lines (from the expansion center line). Take their half-breadths from the projected section of the inside of transom plank in the body plan. Draw buttocks on the expansion plan; these are parallel to the center line of the expansion drawing. Their spacing from it is the same as in the body and half-breadth plans. The heights of the buttocks at top and bottom on the expansion are found by squaring out from the expansion center line the intersections of the buttock lines with the line of the inside of transom plank in the profile as projected from the body plan. Draw in the outline of the expanded transom, through the points obtained. This is the true shape of the section of the hull at the position of the forward face of the transom plank. The shape to inside of plank is obtained by setting it off in the expansion drawing in the same way as in the sections in the body plan. If the top of the transom is beveled, project both fore and after edges at sheer and center line to expansion drawing.

Expansion of Plumb and Curved Transom

If the transom is perpendicular in profile but curved athwartships, the center line of the inside face of the transom has been drawn in the profile and the arc of this face in the half-breadth (page 98). The section at the inside of transom plank, or frame if desired, is to be projected on the body plan. The heights of the sheer, rabbet, buttocks, and chine, if one exists, are established for this section by obtaining the outline of the outboard edge of the inside of transom plank line, in the profile. This is done in the same manner as in the outboard face of the transom. The points of intersection of each water line, sheer, rabbet, chine, if one exists, and of each buttock line, with the arc of the inside of transom plank is squared up to the corresponding lines in the profile from the half-breadth plan. When the outboard edge is



23. Expansion of upright, curved transom. See text.

drawn, the heights of sheer, rabbet, buttocks, and chine are transferred to the body plan at their proper places. The half-breadths of the water lines, sheer, rabbet, and chine are then lifted from the half-breadth plan, square to its center line, and carried to their respective lines in the body plan. The outline of the section in the body plan can then be drawn and the diagonals checked by projecting them as if the new-found station were the transom.

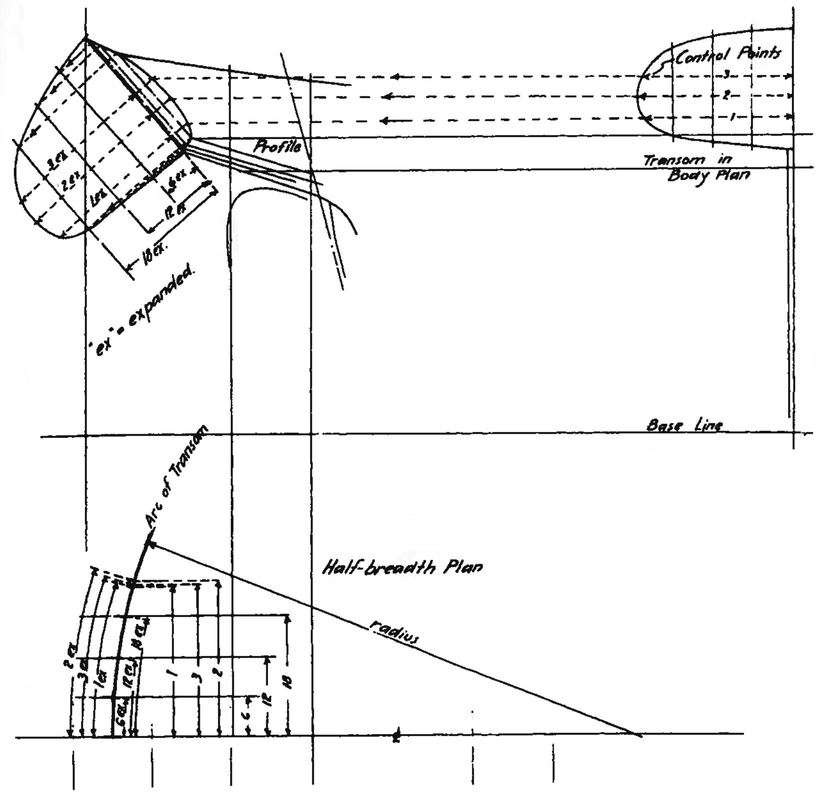
It is now possible to make the expansion drawing. The inside face of the transom plank at center line in the profile is taken as the center line for the expansion. The heights of sheer, rabbet, buttocks, chine, and water lines are squared out from this center line at the heights they were established in the profile at the outboard edge of the inside of transom plank. A batten is now bent around the arc of the line of the inside of the transom plank on the half-breadth plan and the spacing of the buttocks, from the center line, is ticked on the edge of the batten. Also the half-breadths of the water lines, sheer, rabbet, and chine, if one exists, are set off on the batten. When the batten is straight these dimensions are expanded. The expanded offsets are set off on the expansion drawing for water lines, sheer, rabbet, and chine. The expanded spacing of the buttocks is also laid off and these lines are drawn in parallel to the expansion center line. The heights of the buttocks are taken from the profile or body plan section, at the inside of transom plank, and squared off to the expansion buttocks. The top of the transom may be set off from the body plan in the same way. The outline of the expansion is then drawn in, the thickness of the side planking set off, and the true shape of the molded face of the transom plank is the result.

Expansion of Raking and Curved Transom

The transom set raking, with its face curved athwartships, cannot be easily expanded in the manner applied to other forms of transom. To attempt to set off the molded shape of such a transom is a very involved procedure and it is easier to work from the expanded shape of the transom plank at its outboard face, unless the original lines have been drawn to the inside of the plank. Should it be desired to attempt the projection to the inside of the transom plank or frame, it is necessary to add a large number of water lines and buttocks that will pass through the transom, and these must be faired through the after stations on the profile, half-breadth, and body plans. With these, the projection can be made by following the methods outlined, with a little ingenuity in adaptation. However, this is one of the reasons that the raking and curved transom is not suited for the nonprofessional builder

and that even the better professionals have trouble obtaining the proper shape.

The method to be explained will give a reasonably simple method of preparing the transom pattern. The expansion will be made with the line of the outside of transom plank at center line



24. Expansion of raking, curved transom. See text.

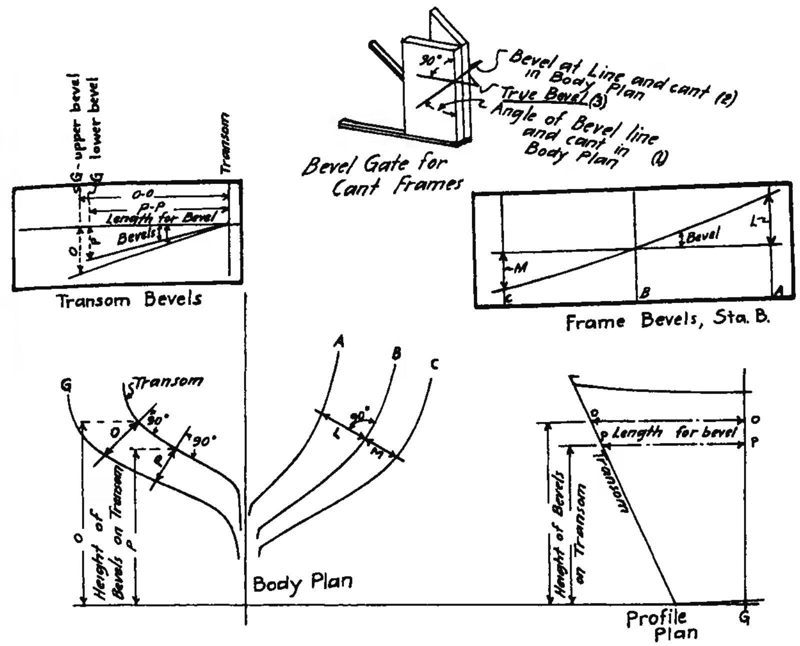
in the profile as the center line for the expansion. Bend a batten around the arc of the face of the transom in the half-breadth plan to get the expanded spacing of the buttocks from the center line. Having marked these on the batten, transfer to the profile and set off at right angles to the expansion center line. Draw in the expansion buttocks parallel to the expansion center line. Square out the intersections of the buttocks, at top and bottom of transom, with the outboard edge in the profile to the corresponding buttocks in the expansion, using the expansion center line as a base. Square out in the same manner, from their position in the profile, all the control points marked for establishing the outboard edge of transom originally. Do the same with sheer, rabbet, and top of transom at center line, identifying each. The expanded half-breadth of each control point, and of the sheer and the rabbet, are obtained by setting off the half-breadth of these in the body plan on a measuring batten, transferring these to the arc of the face of the transom square to the center line in the half-breadth plan and marking there. Then a batten is bent around the arc and the expanded half-breadths set off on it. These are transferred to the expansion and set off on the corresponding heights or lines there. The outline of the transom can now be drawn in the expansion and the thickness of the planking set off. The expanded shape of the transom to the inside of the side planking and to the outside of the transom plank is now formed. To obtain the molded face of the plank or frame, the bevels must be lifted and applied to the expanded shape.

To Find Bevels

The method of finding the bevels for the transom is the same as for finding the bevels of sawn frames, or for the floor timbers when bent frames are used. Among professional builders methods vary, but that to be explained is perhaps the most common. First, however, it is important that the builder know the reasons for using the method suggested. It might be supposed that the bevels of the frames, transom, and floors might be obtained by the apparently simple method of setting them off from the half-breadth plan with an adjustable bevel, using the intersections of a section line with water lines, buttocks, and diagonals. This would only work at the places where these fairing lines pass through the section, as outlined in the body plan, at right angles. As this is the case in only a few instances, a method giving more control points is necessary. The reason that the bevel must be taken at right angles to the section line, as shown in the body plan, is that it is in this position that the bevel must be used in sawing. First, the method of lifting a bevel for a frame will be explained.

Take a piece of plank or plywood (or heavy cardboard) two

frame spaces long and about 12 inches wide. Down the center of this strike a base line, the length of the board. Then erect perpendiculars to this at three points, measured off to equal the spacing of three frames, edge to edge or center line to center line of the frames—it makes no difference. Extend these perpendiculars across the board. Mark the middle perpendicular with the frame



25. Bevel Boards—Measuring Bevels

number (or floor number) whose bevels are required. This will be a "bevel board." Turn to this particular section on the loft body plan and make marks, on its outline, which are spaced to give the desired number of bevel points on the frame or floor outline. Lay a 2-foot rule on one of these marks, laying the rule as nearly at right angles as possible to the section outline at the marked point and noting the exact measurements to the intersection of the rule with the stations on each side of the one chosen. Now take notice of the relative position of the chosen station to the side of the boat, that is, which way the bevel must slope. If the bevel formed is an acute angle it is an "under bevel"; if an obtuse angle it is a "standing bevel." Bevels are always taken from the side of the frame or floor that has been represented in the body plan. Now take the board and set off the distances measured on the body plan from the chosen station to the adjoining ones on either side of the middle perpendicular (which represents the chosen station); one dimension will be above the base line and the other below, according to which way the bevel stands. A line is now drawn with a batten from the measurement on one perpendicular to the measurement on the other, passing through the point of intersection of the base line with the perpendicular representing the chosen frame. This line is usually straight, but may be curved if necessary to pass through the three points required.

To illustrate the process, let us suppose that three frames or floor timbers are taken as examples—A, B, and C. These are in the forebody and C is the farthest forward; B is the frame on which the bevels are required. The bevel board has been laid out and the perpendiculars representing the frames drawn. The bevel points on B are marked in the body plan and the measurements to the stations adjoining (A and C) have been made there, for one bevel mark. It is found that B in the body plan is the after face of a frame (or floor) which will make the bevels "under," since the forward face must be smaller due to the run of the sides of the hull toward the bow. Therefore, the measurement on C on the bevel board will be taken above the base line and that on A will be below. Since B is the face from which the bevels are set off, strike in the forward line of the frame on the bevel board to represent the forward face. Now the bevel line may be drawn from the measurement on C through the intersection of base and perpendicular at B and then to the measurement on A. This line cuts the forward and after lines of the frame B on the bevel board at the bevels required for the mark on the body plan that was chosen. From this board the amount of wood to be cut off frame B on its forward edge, to get the proper bevel, is measured. When all the bevels for a frame have been marked from the body plan to the bevel board it is a simple matter to set off the other side of the frame when one side is already drawn. Had the line B been the forward side, the bevels would obviously be the opposite and would be "standing" in order that the after face be the larger, by the amounts of bevel required at the different marks on the body plan section. The spacing of the marks on the body plan

station may be any desired amount to give enough points to control the bevel in the band saw or to draw the opposite side of a frame to guide beveling with hand tools.

Transom Bevels

The bevels of the transom may be taken in the same way, but the spacing of the perpendiculars on the bevel board must vary with each mark plotted when the transom rakes or curves. The reason for this is the variation in distance between the after frame and the outside edge of the transom. To lay out a bevel board for a transom, draw the base and erect a perpendicular near one end and extend across board. Make the marks on the transom for bevel points. Pick off the distance between the transom and the section adjoining, as was done with frames and floors in the body plan. Carry the mark on the transom edge in the body plan to the transom edge in the profile plan and measure the distance to the adjoining station, parallel to the base line of this view or square to the adjoining station. We now have the amount of bevel and the distance between transom edge and next frame or station.

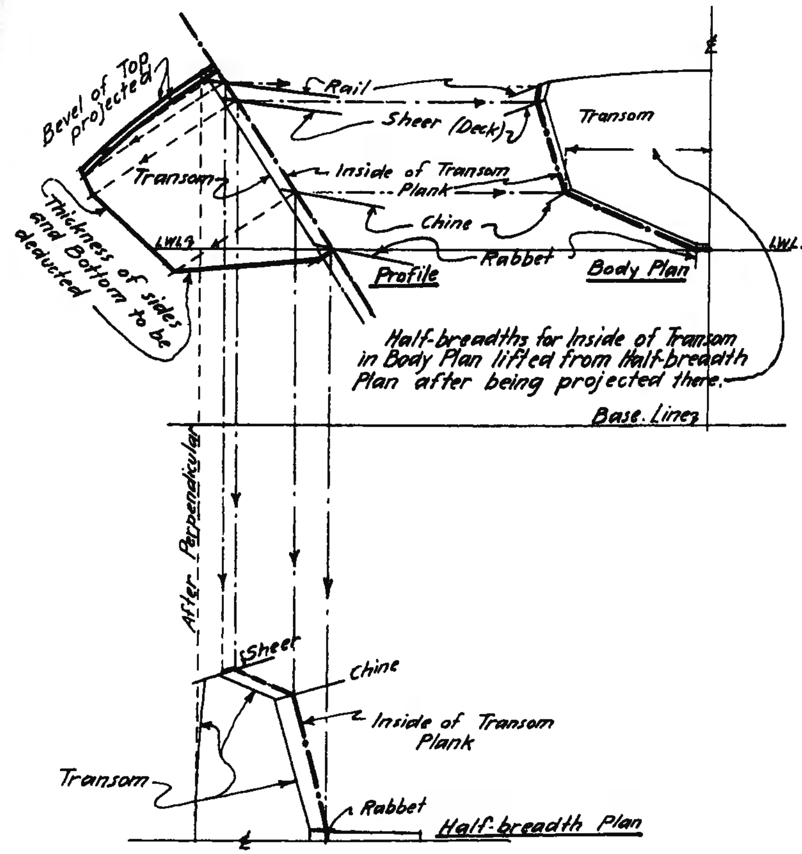
Set off the frame distance on the base line on the bevel board, measuring from the transom perpendicular. Erect a perpendicular and extend across the bevel board. Now set off the bevel measurement below the base on the perpendicular representing the adjoining frame. Draw a line from this to the intersection of base and transom perpendicular. If the transom perpendicular represents the after face of the transom, then the line representing its forward face must be between it and the frame on the bevel board. If the transom perpendicular represents the forward face, then the after face line must be drawn outside of the transom perpendicular on the bevel board and the bevel line projected across it. By so measuring the bevel and distance to adjoining frame for each bevel mark, a tolerably accurate transom will result. If the transom is plumb and flat, it is treated as a body plan section in lifting bevels, of course. Transom bevels are sometimes taken from the half-breadth loft plan, taking the bevels on the sides at the water lines and on the bottom at the buttock line in the loft profile.

Bevels Required for Cant Frames

In a steam-bent frame hull, the bevels are required at the transom and on the ends of the floor timbers that bind the frames together at the keel. All other bevels may usually be lifted from the loft plan without a bevel board. In sawn frames it is customary to lift three bevels for every buttock or timber that makes up a frame, on each side of the hull. If a sawn frame is canted, the bevels are hard to pick up as the spacing between frames varies with the height above the base line. One method is to make a "gate." This is a pair of short boards hinged along one edge. To these are nailed strips along an edge square to the hinged one, to act as handles and bases on which to stand the gate. The device is used to transfer the apparent bevels to the real bevels; the angle at which a water line or diagonal crosses the line of a section in the body plan is picked off with an adjustable bevel. This is transferred to the gate and marked on the blades, using the hinged edge to represent the line of section. Then the bevel of the chosen line with the section is picked up from the half-breadth plan and, with the bevel set to this and tipped to the angle marked on the gate, the latter is then opened until the sides of the gate are snug to the bevel's arms. The gate blades are now held in place by a weight and the bevel removed. The true bevel may now be found by placing the adjustable bevel against the gate square to the hinged edge. This method is somewhat tedious but easily understood. Cants are rarely used in framing today. The methods of beveling to be used, when such frames are numerous, are best found in old shipbuilding books. The cant frame is one that is not set square to the center line of the hull. It was once used to frame the ends of the hull when very full, to avoid the excessive bevels that would be required if the frames were square to center line.

Lofting of Flat- and V-Bottom Hulls

The lofting of a flat- or V-bottom hull having straight dead rise and side in section is, of course, very simple compared to the lofting of a round-bottom hull. All fairing is usually done with sheer and chine in a flat-bottom hull; sheer, chine, and rabbet in



26. Expansion of Transom V-Bottom Hull without Water Lines or Buttocks

a V-bottom. In a V-bottom only four bevels, two on the side and two on the bottom, need be measured for sawn frames. The bevels of the chine can be lifted from the sections. Four transom bevels, located as on sawn frames, are required for the transom of both V- and flat-bottom hulls. The method of drawing the keel structure, getting the mold shapes, and drawing the rabbet, middle line, and bearding line in a chine hull is the same as that described for round-bottom hulls.

Rabbet Projection for Faired Posts

Sometimes the lines are faired to the face of the stem and the offsets for the rabbet on stern and stemposts are not given. The rabbet is established in the half-breadth plan, however. This is usually a curved line with the rabbet widest amidships. The profile of the rabbet is also established on the profile for the sections. Transfer the heights of the rabbet to the body plan after it has been faired and set off the half-breadths. These should come on the section outline. The width of stem and sternposts is now set off on the body plan and faired into the rabbet as marked on the sections. Pick up on a measuring batten the half-breadths of the rabbet as indicated by the stem and sternpost half-breadths in the body plan for each water line. Set these half-breadths off on the water lines faired in, in the half-breadth plan, keeping the batten square with the center line and sliding it fore or aft until the offset mark intersects the water-line curve. Mark this and then square the point up to the corresponding water line on the sheer at stem or stern, as the case may be. When all the water lines and the sheer are so treated, it is possible to establish the rabbet on the profile and to be sure that the outside of the planking is fair with the side of the stem, to the forward face of the cutwater.

Stem Bevels and Finish

Some designers and builders do not fair the lines to the face of stem all the way up to the sheer, but allow the stem to widen out on its face, very suddenly, near the sheer. This should always be done, as it gives strength to the stem and enables it to withstand blows. If there is a bowsprit, the squaring of the stemhead in this manner makes the fitting of the gammon iron much easier and neater. The change in section of the stem, from square to taper, should be located on the profile just below and clear of the gammoning, if not shown in the plans. Another matter having to do with the finish of the stem is the head. In many boats having no bowsprit or stemhead fair-lead (such as is often seen in motorboats) the stem is sawn off flush with the deck. This practice usually spoils the appearance of the whole bow. Whenever possible, the stemhead should come above the deck and finish in a form having its greatest height above the deck at its forward end in profile. The very recent practice of streamlining the bow is an exception to this rule, however.

Lofting Barrel Bow

The so-called "barrel bow" has been developed by streamlining. It really serves no useful purpose in a small boat designed for sailing, or for ordinary speed under power. Nevertheless, it is often attractive and so may be called for in a design. The methods of building vary; the most common practice is to form the stem of wide plank, doweled and glued together in the fashion used for building model boats called "bread and butter" construction. When the structure is formed, it is shaped with templates in the same manner as a model boat is shaped; then it is hollowed and the after edges of the stem are rabbeted to take the plank of the sides and bottom. The laminations may be vertical or horizontal. The shape of each lamination must be drawn in the loft plan. If the laminations are vertical, then buttocks are drawn in, of the spacing required by the thickness of the laminations or "lifts." If the laminations are horizontal, they are drawn as water lines, of course. These must be faired back from the bow far enough to make certain that the stem structure will fair into the hull when complete. The keel and other longitudinal members notch into the inside of the barrel-bow structure. With certain forms of diagonal planking the barrel bow can be planked up, but this is not true of the conventional methods of planking. Care should be taken, in lofting a barrel bow, to set off both inside and outside of each lift or lamination so that, in making up the stem, fastenings can be worked in that are clear of the outside and inside lines and that will not be disturbed in shaping. By this means, it is possible to use nails or screws to back up the glue used in forming the stem as well as to preserve wooden dowels when shaping.

Lofting Deck Frame

Let us return to the lofting that was being described. The fairing of the lines had been completed, the projections for mold forms had been made, and the profile of the keel structure had been drawn. Before beginning to lift the templates or patterns, it is a good plan to draw the deck framing on the loft half-breadth plan. This can be done in red crayon. The location of all hatches, their inside dimensions, the shape and position of all deck knees and blocking, and the exact position of every deck beam can be copied from the designer's construction plan. The top of the cabin trunk can be worked out. Sometimes it is possible to use a beam mold, such as was made for the deck crown, that can be used to shape every cabin roof beam. However, it will be found that in many designs the position of the top of the sides and center line of the cabin trunk roof are given by offsets; in this case a mold must be made for every individual beam. This can be done by designing individual beam molds for every width and height of cabin roof beam required. In rare cases it is necessary to fair in the deck with buttocks as though it were the bottom, upside down. This is sometimes necessary in streamlined hulls. It is also possible to lay out and project the cabin trunk sides. To do this, it is necessary to draw the deck and construction section at each station that passes through the trunk. Such projections should also be made at the ends of the trunk. The half-breadth plan will give the length of the trunk sides, which may be expanded with a batten. The height of the trunk sides and cockpit coamings can often be roughed out after such a drawing has been completed.

Lofting Joinerwork

Usually it is well to wait until the boat is under construction before lofting any of the cabin plan, but for the sake of brevity it will be discussed here. The important bulkheads can be easily lofted and patterns made by which the bulkhead can be completed before the hull is ready to receive it. Anyone who has any knowledge of drafting can work out the shape of any piece of cabin furniture in the loft plan. The importance of this is, perhaps, not so great in amateur building as in professional work, since the amateur rarely has any problem in doing the work inside the hull. The professional builder, however, may have a number of men at work in the hull at one time, and so all the structure completed outside reduces the chances of hindrance through men being in one another's way.

Cross-Sectioning Timber

It is usually very helpful, in shaping timbers, to have the cross sections at each station drawn out. Cross sections through the keel, showing the exact bevels and cross-sectional shape, are particularly useful in checking the work. Such members as chine logs, keelsons, keel battens, and the sheer clamp, or clamp and shelf, may be cross-sectioned in each body plan section to advantage. This detailing will often show where study must be given the construction prior to the actual building, in order to carry out the designer's intentions correctly.

Short Cuts in Lofting

The methods of lofting that have been described are not exactly those that are generally followed by professional builders; rather they are those most easily understood. As a builder gains experience, he will work out short cuts and variations desirable in the type of boat he commonly builds. It will be found that the work of some designers requires less lofting than that of others. Some hull forms need relatively little fairing; others a great deal. It is well to remember, however, that work in lofting is work saved in construction.

Templates and Material

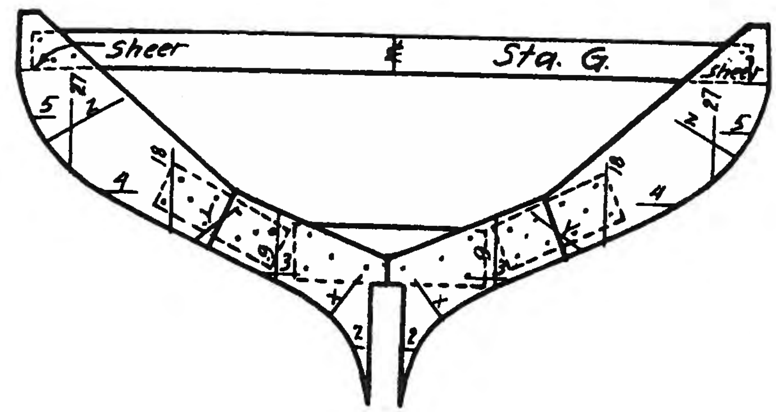
The next step is to make the templates or patterns. These may be made of cardboard if the boat is very small, or of plywood or any thin plank ¼ to ⅜ inch thick if the boat is large. The extent to which the templates are made should depend upon the number of boats to be built on one design. If only one is to be built, no patterns are required for the molds, as their shapes may be transferred directly from the floor or loft drawing to the wood to be used in making the molds used to form the hull.

Molds and Picking Up

Suppose it is desired to make the molds first. Rough lumber will do for these. The plank used should be wide enough so that not more than four or six pieces will be required to get out the shape of the mold, not including the tiepiece across the top, called the "cross-spall." The thickness of the plank used for the molds should be ample to give strength. In small craft, up to 20 feet in length, ¾- to 1-inch stock will do. For hulls 20 to 30 feet, use 1¼-inch stock; larger boats require molds from 1½ to 27 inches thick. The plank for the molds can be in short lengths and waste timber can be used. The first step is to prepare the loft drawing for picking up. There are many methods of picking up, but for the moment it will be assumed that it is possible to drive nails into the lofting floor. Small wire brads, about ⅜ inch long, will do. The heads should be cut off snug. Drive these along the line of the inside of planking of the foremost section in the loft body plan. The nails should be spaced about 1½ inches apart, 2 inches in large boats. Drive nails along the curve of the section at the inside of planking line, taking care that each nail is directly on the line, with top of nail about ¼ inch above floor. Outline the cross section of the keel, inside the rabbet bearding line, and the center line there, with nails. Lay a plank on the nails in such a way that it covers the maximum part of the section outlined in nails. When this has been found, hit the plank a few raps with a mallet so as to make an impression in the underside of the plank of each nail driven in the body plan section. Turn over the plank and run a line through the nail impressions with a batten and a straightedge so that the exact section, to inside of planking, is outlined on the plank, and so that the outline of half the keel cross section, inside of the bearding line, is drawn.

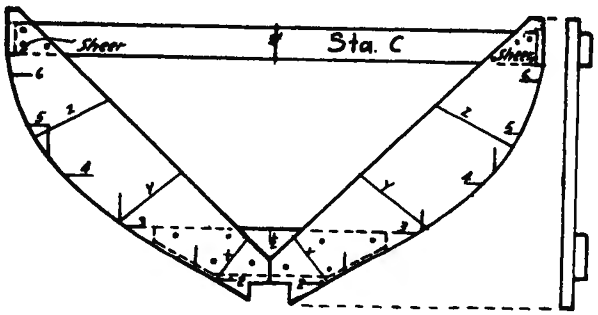
In the foremost section it should be possible to make a half-mold out of one plank. The plank should be long enough to extend 3 inches or more above the sheer or deck. At the center-line marks in the plank draw the center line to form the lower limits of the mold. Saw out the mold plank along the lines just drawn and plane fair and smooth to the exact line of the section. The notch for the top of keel is sawn out as marked and then the center line is used as a guide to saw for the butt to be formed there. Here there ought to be about 3 inches of width to the plank along the butt—more, if possible—so as to give room for fastening the cleat at the butt. Repeat this operation with another plank to form the duplicate for the other side. Now pull out the nails (with pliers) that were driven into the loft body plan. Lay the first mold plank back on the section, making sure that it coincides exactly with the inside of planking line and with the center

line and top of keel. Mark plainly on the plank the lines crossing the section in the body plan (water lines, buttocks, and diagonals), drawing them across the width and edges at the angles formed by the drawing. Also mark plainly the sheer. In some cases it may be desirable to pick up the cross section of such members as the chine log and stringers, or clamps, on the mold plank. When the plank has been marked, turn it over and place the duplicate on top of it. Then mark this plank with the same lines, so that the markings will be on the same face in both halves of the mold when assembled.



27. Four-Piece Mold, 17-Foot Hampden Boat, Station G

Get out the plank used for the cross-spall. Lay it across the section in the body plan so that its underside is at the sheer or deck line and square to the body plan center line; mark both center line and sheer half-breadth on it. Reverse and mark off the other side for sheer half-breadth. Cut spall to proper length. Now lay the two halves of the mold together in the proper position, one half on the body plan section but with markings on plank down, and secure the cross-spall in place to both halves. The cross-spall must be square to the center line and its underside exactly on the sheer or deck marks so that it will be level when the mold is set in place. The cleat holding the two halves together over the keel is next made and fastened. If necessary, this will be notched to fit the top of keel. The width of plank used for cross-spall and cleat should be 3 to 6 inches, depending on the size of boat. The thickness should be the same as the mold stock. Perhaps this is obvious, but it is mentioned in order to emphasize the importance of strength in the molds. These members may be fastened with large screws or with common nails. After the mold is fastened together, it should be turned over with markings up and checked with try square and straightedge to make sure that it is properly lined up and put together. The other molds are made in the same manner, but each side of the mold will have to be made of two or three pieces and then cleated together. The corrugated fasteners used for fastening crates, packing boxes, and window screens are very useful in fastening the parts of the mold together before



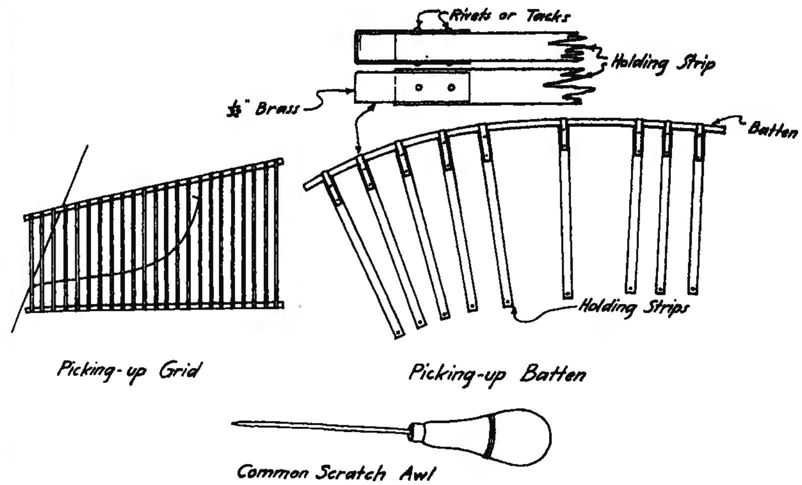
28. Mold Station C, 17-Foot Hampden Boat

fitting cleats. The butts formed on the pieces of the mold need come in no special position; their location can be decided by the stock on hand. No mold need be made for the transom. Molds in way of centerboard case can be made in two sections, deducting case thickness if it is intended to set up case with keel. Molds are cleated to case side in setting up, if this is done.

Other Methods of Picking Up Molds and Patterns

If the loft drawing cannot have nails driven into it, tacks may be set on the drawing with points up and heads on the line. If the drawing is on paper, the wood for the molds may be slid under and the lines transferred by punching through the drawing with a common scratch awl. Various types of toothed wheels are made for this purpose. These are called "tracing wheels" and are used by dressmakers to transfer paper patterns; they may be obtained

from mail-order houses. Special battens can be made for picking up. The most common consists of a limber batten, square in section; to this are attached short wooden strips at right angles. The method of attachment is a brass sleeve, shaped like the letter "U," over the end of each short strip. The long batten is then passed through the U. This enables it to be shifted in the attachment. In the ends of the short strips are small holes. The long batten is

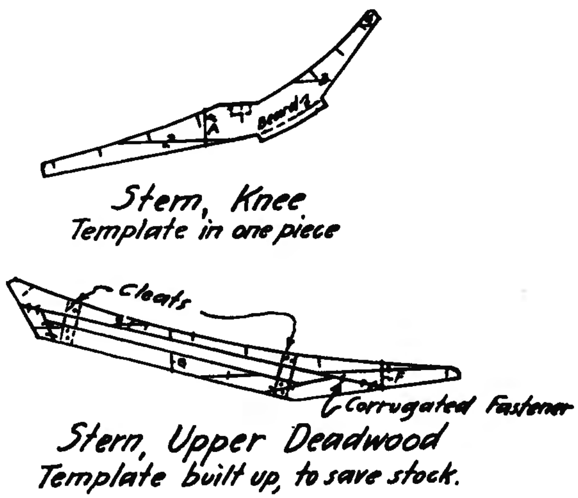


29. Picking-Up Tools

bent around the section on the loft body plan and held to the curve by awls driven through the holes in the short strips. These, by their attachment to the large batten, hold the section curve and the batten can then be lifted far enough from the floor to slide under a plank, on which the shape of the curve is then traced. The fairing of the batten on the section curve can be controlled by shifting the holding strips as required. Another idea, sometimes employed, is to build a grid of thin battens, consisting of ¼- by ½-inch pine strips, about 3 feet long, spaced about 1 inch apart on two 1-inch by ⅜-inch battens. This grid is laid over the body plan and where the chosen section crosses each batten a tick-mark is made on the grid. This is then transferred to the mold plank and the process reversed. Such a device as this is suitable for lofting small craft such as dinghies and canoes.

Patterns

Patterns are picked up from the loft plan in the same manner as molds. The patterns for the wide timbers in the keel may be outlined in skeleton form with narrow battens held together by corrugated fasteners and braces or cleats. The pattern, or template, outline should be the exact shape of the timber for which it is made. The lines on the timber, such as bearding, middle, and rabbet lines, are picked up from the loft plan on the pattern as



30. Keel patterns, 17-Foot Hampden Boat. Note station and water-line marks. Mark for bolts also.

was done in picking up the shape of the molds. These lines are drawn on the pattern in their correct place and shape. When it is necessary to transfer them, nails are driven through the pattern, along the lines, into the timber to be shaped; the outline is traced around the edge of the pattern and all control points are then transferred to the timber. As in the molds, it is very important that all section lines, water lines, and the sheer, when possible, be transferred to the pattern and from there to the timber. The reason for this is that these marks will be necessary to properly fit the timbers together and to set the molds. Patterns should be picked up for every timber in the keel structure, for stem and

sternposts and their knees, and for all deck framing. If there is a centerboard, or fin keel, the timbers for this must have patterns. The rudder should be drawn in the loft plan and a pattern made for each individual plank in its structure, if large. When the patterns or templates for the keel are completed, put them together on the mold loft plan to check them against the drawing and to be sure that the lines marked on the various templates coincide as they should. This is a very important check. It will show any errors in outlining the scarfs or laps in the timber patterns. As each pattern is made, make some identifying marks on it and upon the timber in the loft plan, so that its place is known. Patterns should be made for deck knees and blocking if there are many pieces to be cut. With the deck crown pattern and the loft plan it should be possible to get out the deck beams without individual templates.

Transom Pattern

A light wooden pattern should be made of the expanded transom and the bevel spots marked. The transom template should be complete, like the molds. The amount of bevel to the transom edge is on the bevel board, and if it is desired to make the inside and outside lines of the transom plank or frame this can be done on one pattern. The transom pattern must have the center line, all the water lines, and the buttocks that cross it plainly drawn. It is usually well to mark on the diagonals also; very often these lines are useful in taking measurements necessary to properly set the transom.

Floor Timbers, Patterns, and Bevels

When the molds and the patterns, or templates, for the keel structure, stem and sternposts, deadwood timber and deck framing are completed, the floor timbers should be projected on the mold loft drawing and patterns made. From the designer's plans the position of the floor timbers can be transferred to the loft profile. From here their shape can be projected to the body plan by the methods used for additional sections (page 110). There is one point that should be made here: it will save time if the *molded face* of the floors be chosen for the body plan section to give under bevels. This means that the after sides of the floor timbers, in the profile, are taken as section lines in the forebody; the forward sides in the afterbody. The bevels for the floor timbers can be measured as for frames (page 120).

Sawn Frames, Templates For

If the boat has sawn frames, templates are made for every timber, or futtock, that makes up each. The bevel spots, as well as all other identifying lines, must be marked on the pattern. The templates for each frame are put together in a pile, with the bevel board, so that they will not become mixed and hard to pick out when getting out stock. After the individual timbers of a frame are shaped, the whole frame template should be assembled and cleated together to aid in putting the frame together prior to setting up. This will give a handy check for frame shape. No mold forms are necessary, of course. Otherwise the patterns are the same as required for a bent-frame boat.

Joinerwork Patterns

Now the molds and patterns are complete for the hull frame. If desired, patterns may be made for the cabin joinerwork or for bulkheads. Then the patterns should be stored in the order in which the timber is to be worked.

Planning Setup

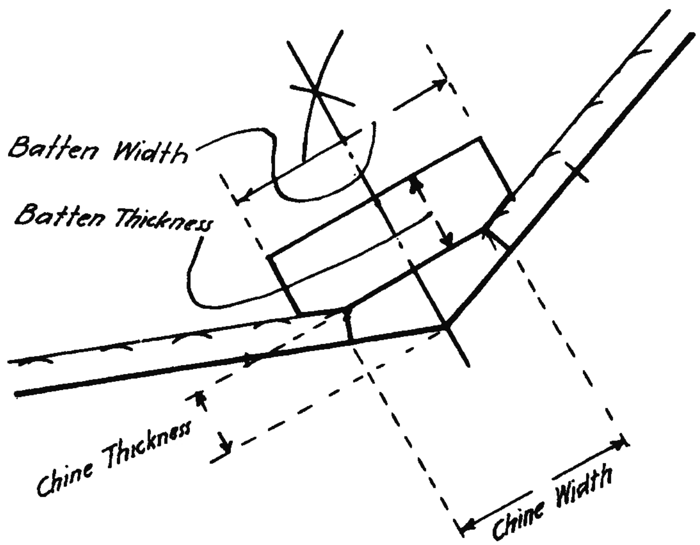
At this stage it is well to begin planning how the hull is to be set up for building. If the boat is small and rather light, it is usually built upside down. On the other hand, a heavy boat, or a large one, is built standing on her keel. If the boat laid down is to be built upside down, it is well to strike a base line on the loft plan representing the floor or building base line. Then the setting-up heights for each mold from this to base line and to the sheer (which is the underside of the cross-spall, remember) can be measured full size and marked on each mold spall. Some builders plan the molds so that the ends above the sheer will reach the floor, when upside down, at the required height. The base line position in relation to the sheer should be carefully chosen to keep clear of the spalls, the stem and sternposts, and the transom top. If the base line is to be the floor, the height of the boat when set up should be considered. There must be plenty of room for the builder to crawl under the hull and there ought to be comfortable sitting headroom between the floor and underside of keel. If the boat is to be built right side up, it is often a trouble saver to establish the building base line in a different position from that in the designer's lines. In this case the corrected heights should be measured from base to rabbet line on each station (or from base to sheer, if desired) and marked on the corresponding molds. The height at which the boat is set up will probably be governed by the headroom in the shop. It is well to set the boat as high as possible, as a rule, to give ample room to work on the bottom, under the bilges. It will be found useful to establish two base lines, one below the keel and one above the sheer, in boats over 30 feet long overall, in some designs.

Special Cases

If the boat is strip or diagonal planked, the position in which she is set up is particularly important. Usually it is best to set the strip-planked boat right side up. The diagonal-planked hull is easiest built upside down. If such a boat is fairly large, it would be well to start planning the method to be used to turn her over when the planking is done. The gear can be easily rigged, but room is required. Flat-bottom hulls are usually built upside down; so are V-bottom hulls, unless they are large. When boats of these models are large and built right side up, there should be more room between the floor and chines than would be required between floor and keel in a round-bottom model. If the boat has a motor and it is desired to put it in before the hull is moved out of the shop, it is wise to check the headroom to see if it can be hoisted clear of the gunwale or sheer when the boat is complete. If not, it may be necessary to put in the motor before ribbands are fastened to the molds; this will require putting in some floor timbers before setting up the molds. These are possible details that should be considered now and planned ahead.

Suggestions: Batten Chines and Batten Keel

There remain a few suggestions and remarks concerning lofting. The best method of finding the shape of the notch to be cut in the molds for a chine timber that is carried through the planking (in the same manner as a keel and keel batten) is as follows. Bisect the angle formed by bottom and side in a section in the body plan and draw a line to represent the division. This line should pass through the point of the chine and inboard a few inches. The thickness of the plank on sides and bottom is drawn. From the specifications get the size of the outer chine member. Set off its width square to the bisecting line, with half



31. Layout for Batten Chine

of the width on each side. Project this until it intersects the outside of plank on both side and bottom; this marks the position of the seams along the outside of the plank at chine. Square in, to the face of the plank of bottom and sides, their thicknesses. Connect these two points and the cross section of the outer member of the chine is drawn. The inner member is laid off with its thickness along the bisecting line, measured from the inside of the outer member. The width is laid off square to the bisecting line with half on either side. Square the edges from the back or inboard face of this member to the inside of plank and the cross section is completed. This not only shows the shape of the notch to be

cut in the molds, but also the bevels of each member at the given station. By this means it is possible to lay out the chine members with their proper bevel before fastening into the hull; but it is advised that the bevels be only roughed out so as to leave a little wood for fitting, since the sections may be rather widely spaced. In getting out the batten keel the same methods can be followed. Sawn frames for either flat-sided hulls or the round-bottom model are usually beveled on the inside with the same bevels established for the outside.

Curved Transom

If the transom is raking in profile and curved very slightly athwartships, it may save time to treat it as a flat-raking transom, picking up the transom expansion pattern to the inside of a thick transom plank, or to the inside of both it and the frame, and then cutting the amount of curvature (to the after face of the transom) out of the thick transom plank. This will work when the amount of curvature across the face of the transom does not exceed ¾ inch, measured in the hull profile at the widest place. If light weight is important, however, this practice is frowned upon.

Stopwaters

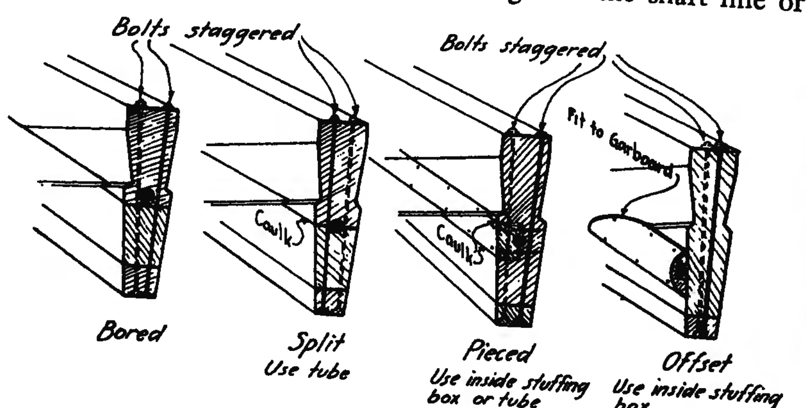
It is a good plan to mark the stopwaters in the keel structure in the loft plan and to indicate them on the templates so that they won't be overlooked. These should be placed so that one goes through a keel scarf at the middle line of the rabbet and another just inside of the bearding line, that is, between middle and bearding line. The rake of the scarf and the distance between middle and bearding line will fix the spacing of the stopwaters. These should be of white pine or cedar and should range from ¼-inch diameter in a small boat to ½ inch in a large one. Common sense is the best guide for exact size; too large a stopwater will cut away the space inside the rabbet lines excessively. There should be two stopwaters in every seam passing through the rabbet in the keel, stem and sternposts, or deadwood structure, whenever space permits. If the space between middle and bearding lines is scant, the outermost stopwater may be located between rabbet and middle lines. If the seam is vertical to the rabbet, one stopwater will have to serve.

Ballast Pattern

If there is an outside ballast keel of lead that is rounded or shaped in cross section, a full-sized replica will have to be made of softwood, for a pattern. This can be built by gluing together plank and shaping, as was done in directions for the barrel bow, following a plan used for building model boat hulls. If the ballast keel is rectangular in cross section, no pattern will be required; it can be cast in a wooden mold as will be described later. When there is a ballast keel, be careful to draw in the ballast bolts in the loft profile to make certain that they do not foul the bolts required for floor timbers or scarfs; the patterns should show all bolt locations so that these can be laid off on the timbers when shaping them.

Shaft Log

Take particular care in laying off the shaft log. It is well to draw a number of sections to see how the through-fastenings are going to work out. This will save untold trouble later. Too often it is found that the shaft (or shaft and its tube) is so large that it is difficult, if not impossible, to bore for the through-fastenings or drift bolts without danger of running into the shaft line or



32. *Common Shaft Log Construction*

running too close to the rabbet when the latter is cut. The greatest danger usually exists when the deadwood is thin. If boring looks too difficult, or tools are not available, the use of split or pieced shaft logs may solve the problem. If the deadwood is very thin, it is usually better to offset the shaft and put a faired strip over the shaft. In this case the shaft runs along one face of the deadwood and may or may not be covered by a slotted plank, rounded on its outer face. Sometimes the designer has shown a "feather" or strip run in along the seam on both sides of the split shaft log. If it appears that this is going to be cut by bolts it might as well be omitted and the hole for the shaft protected against leakage, through these seams on the sides, by a lead or brass tube running the full length of the shaft hole, even though not called for in the plans or specifications. Perhaps the greatest difficulty in making a shaft log by boring is to avoid fouling keel drifts or bolts. The longer the shaft hole, the greater the difficulty in boring. For most amateurs the split, pieced, or offset shaft holes are the most satisfactory. This subject will be discussed in greater detail in the next chapter.

This completes the mold loft work. Remember, an eraser will correct an error in the loft drawing but more than that is required to correct the same error when actual building begins.

The next step is to shape the backbone and set up.

CHAPTER THREE

THE BACKBONE—SETTING UP

Importance of Lumber Storage

WHILE the lofting has been going on, the timber necessary for building should have been delivered. If it is possible to use the lumber at once, it will suffice to put it under cover and pile in such a way that the sticks desired first will be on top. Few home builders can plan on full-time construction, however, and a good deal of time may intervene between the starting and finish of the boat. During this time it is possible for some of the timber to be harmed by heat and moisture unless it is properly stored. This is particularly true of oak, spruce, elm, and pine. Of course, the space available will govern the storage of lumber but, if possible, certain precautions should be taken.

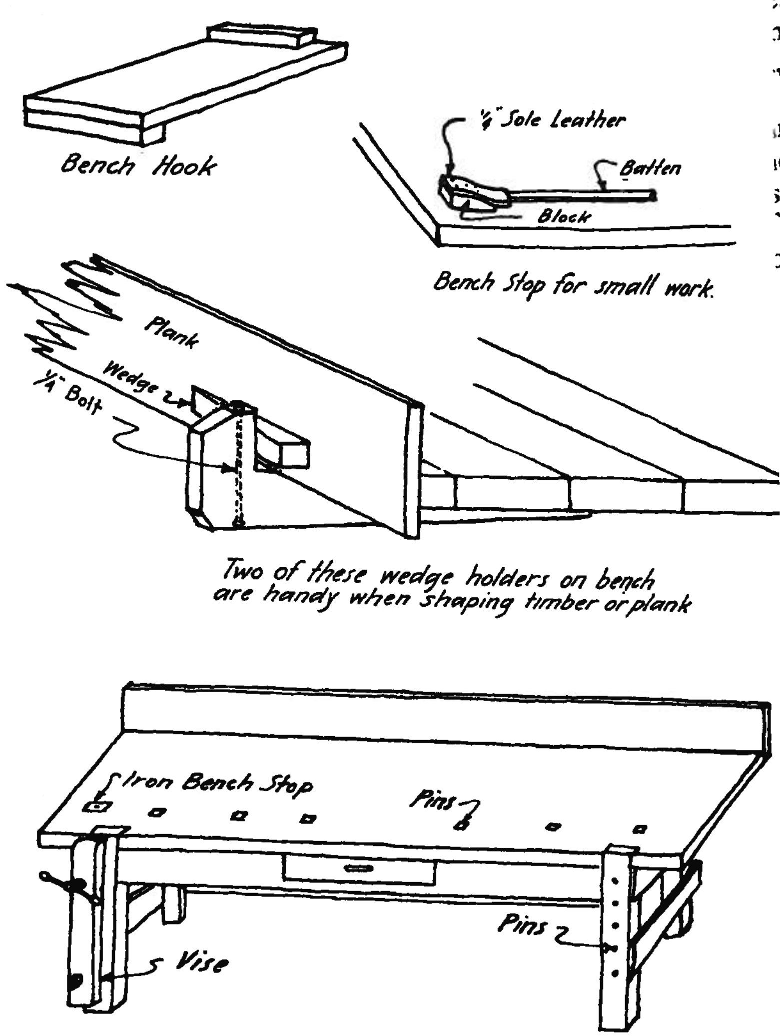
Methods of Storage and Protection

The best way is to pile plank on a level, dry floor, one plank on top of another. The pile should not be so high as to be easily knocked over; if there are too many planks for one pile, make another against the first. On top of these planks put the heavy timbers, spreading them out so that their weight is evenly distributed over the length and breadth of the pile of plank. The weight of the large timbers will keep the plank from warping, springing, or twisting. Do not put stones or other heavy, but small, objects on the lumber pile in place of heavy timbers. Concentrated weights will do more harm than good. If there is no floor available, put a couple of thick, rough plank on sleepers, level, and then stack the lumber on the platform so formed. If the lumber

is very green and it is hoped to dry it out while building, insert battens under each plank as it is added to the pile. These battens should be about 1 by 2 inches, laid on the flat, spaced about 4 feet apart. Take care that the battens, as they are placed, line up with those below. The bottom plank of the stack should be well off the ground. If the stack is in the open, one end should be lower than the other so that rain water will run off. It may be well to remind the reader that it takes from two to three years to air season timber. If there is a quantity of heavy timber to be seasoned, it may be stacked on end, against a building or fence, leaving air spaces between the timbers. If timbers are to be stored under cover for any great length of time, pack them in a pile as was done with plank, on a level floor, and over them lay some wide planks; erect posts along the sides of the stack and then cleat across the stack. The posts may be toenailed to the floor and the cross cleats nailed to the posts; these will prevent the sticks from twisting. This is a good way to store oak and elm. When oak or elm timber, or plank, is on hand, it is a good plan to paint the butts with orange shellac, red lead, or old paint that is rather thick. This will usually prevent the ends from checking. Piles of lumber should be covered with paper or old sacks to keep dirt and grit from accumulating on the surfaces of the plank; oak may be protected from checking by covering with damp sawdust and salt. If the pile must be in the open, it may be covered with tar paper or tarpaulin. It is not desirable to store lumber overhead in a shop as the heat is usually too great. Also, dust and dirt will accumulate on the upper surface of any timber so stored.

Tools

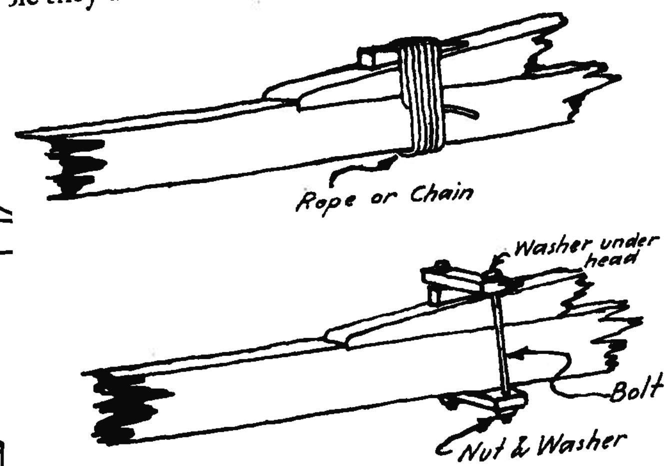
The tools required for getting out the backbone depend upon the size and design of the boat to be built. In any case there must be a workbench. This should be fitted with a woodworker's vise, not the iron- or steel-jawed machinist's or metalworking vise. A metal bench stop should also be fitted. For smoothing thin battens, a wooden stop topped with sole leather may be used. This is shown in the accompanying cut. A bench hook can be made of a hardwood plank, as also shown. This is useful in sawing short pieces of wood on the bench, or in working with chisels; it will steady the work and save the top of the bench from becoming



33. Workbench for Planking

cut up. A separate planking bench is useful if there is room. This may be made against a convenient wall. It does not need to be wide; 20 inches is ample. On this can be fitted the plank holders shown in the cut; these and wedges will hold a plank better

a vise when smoothing up the edges or working with a draw-
:. Tools for getting out the timbers are a cross-cut handsaw,
ıd ripsaw, compass saw, broad hatchet, brace and bits, ball
., hammer, a light sledge hammer, mallet, drawknife, chisels,
plane, rabbet plane, smooth plane, bullnose plane, and try
ıre. For a small boat, iron C-clamps capable of opening to 8
ıes can be obtained at low cost; large C-clamps are very ex-
ɜive, however.
'here are various types of adjustable bar clamps, but on the
ɔle they are not strong enough for holding deadwood timbers.



34. Makeshift Deadwood Clamps

Makeshift clamps can be fashioned that are better suited to the job. One way of clamping is to take a few turns of rope around the timbers, draw up snug, and tuck under the ends. Then drive a large wedge between rope and timbers. If the rope is well stretched before using, the results are satisfactory. In handling knees by this method, a cleat nailed to each side of the timber will keep the rope from slipping down the slope of the top of the knee. If rope is too light for the work, small chain can be used. Similar results can be had by using a wedge clamp, made of two pieces of oak and two carriage bolts, shown in the cut. This can be taken apart to get it over the ends of timbers, if necessary. Large keels require a broad ax and an adz to shape by hand. If there is a mill handy, it is best to mark the timbers and carry them to the mill to be rough-shaped rather than attempt to work them down with hand tools. Where power tools are available, a band saw will serve for shaping deadwood and keel timbers.

In shaping the rabbet, a carpenter's slick (a large chisel with a blade over 2 inches wide) is very useful. All chisels should be heavy-duty tools. The "framing chisel" is most commonly used, as the "firmer" is too light for work on the keel. The brace should be of the ratchet type. The auger bits should vary according to the work: for hardwood use bits having a single cutter; for planking and joinerwork use the double cutter. Also a selection of ship augers is required. For long holes use the barefoot ship auger (which is started by first boring a shallow hole with an ordinary bit). The ship auger with screw is used in counterboring for plugs in planking and for heavy work, but is not used for long, straight holes, such as the shaft logs require. The ship auger bit is between 13 and 20 inches long; it can be used in an ordinary brace, but when used for long holes an iron stock is welded on to serve as a brace. The stock can be made and welding can be done by any blacksmith. The diameter of the stock should be about the same as the shank of the auger, above the twist.

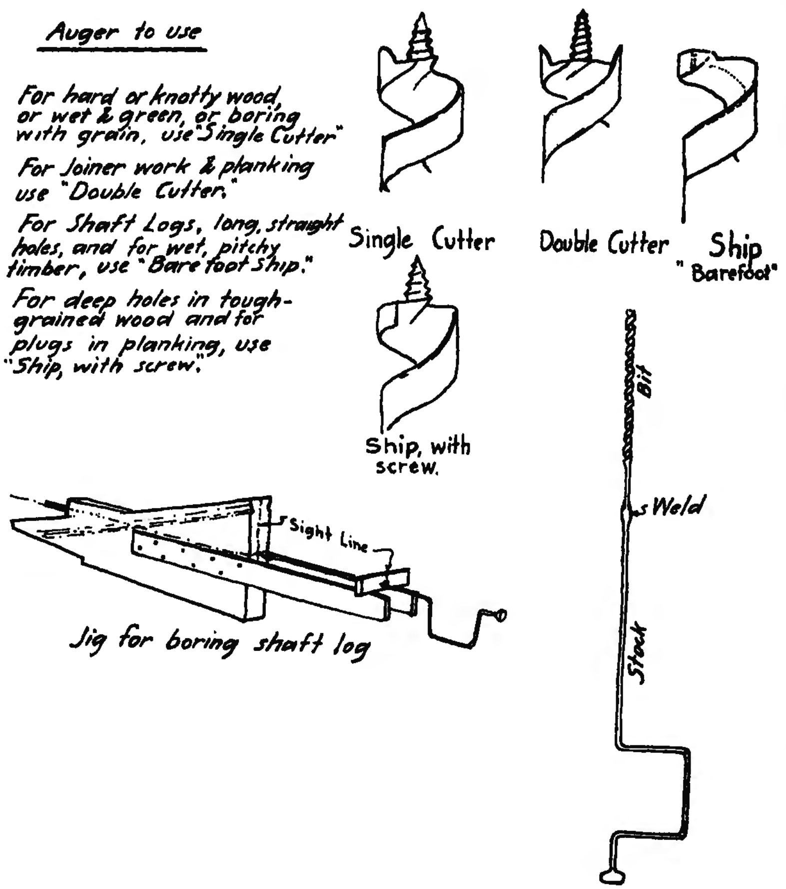
The saws should be chosen with care; for hardwood and smooth cuts, use saws having 10 or 11 points to the inch; for softwood and rough, quick cuts, use saws having 8 or 9 points to the inch for cross-cut, 5½ points to the inch for rip. The large, one- or two-man cross-cut saws, used in cutting cordwood, are suitable for cutting ends off keel timber. If some fastenings are countersunk, the Foerstner auger bit should be used to counterbore. It is much better than the common bit on sloping surfaces; the expansion bit is useless in this situation. The adz should have a lipped blade, since most cutting will be done across the grain of the wood. A good grindstone is a necessity; high-speed abrasive wheels or grinders are not satisfactory for heavy tools. Hacksaw, or boltcutter, sledge, and spikeset (heavy punch with point cut off) are required for fastening.

Marking and Cutting Timber

Now the marking of the timbers may be started. Select the pieces for the keel from the lumber pile. Consult your lumber list to be certain you choose the right pieces. With the templates mark the outline of the first piece and cut to the line. After the outline has been cut, lay off the center line and the taper, if the keel is not parallel sided; with adz and broad ax, or with band saw, cut the taper in the sides of timber, to the marks. Finish with a plane. Now lay template or pattern back on the timber and mark the position of stations and water lines, as shown on the template, on the face of the timber. Square these across the top and bottom and mark the opposite side. Drive nails through the template to hold it in position on the timber while marking. The location of the rabbet can be transferred to the timber by driving nails through the template along the rabbet, middle, and bearding lines shown there. If the template is transferred to the opposite side of the timber, the nail holes will guide to spotting and fairing the rabbet lines on that side. When the lines of the rabbet are marked, fair in the lines with a batten, tacked to the timber. Mark the location of bolts, or fastenings, shown on the template. It may appear unnecessary to mark all these lines on the timber, but they will become very important when the keel is being put together and when the molds are being set. If joinerwork is required in the boat being built, these lines and marks on the deadwood will be of great assistance in getting all measurements correct. One of the greatest causes of trouble and error in setting up the deadwood and molds can be traced to neglect in properly marking the timbers.

After the timber is shaped and marked, the rabbet may be roughly cut, if desired. Mark and cut each timber for keel, deadwood, stem and sternposts, and knees in the same manner. If there is much change of width in any timber, due to taper, the stations should be marked on with the outline and squared across top and bottom after shaping these surfaces, renewed on the sides from these lines after the sides are cut off to make the taper, and then the rabbet set off by measurements on these stations.

The scarfs should be planed smooth, exactly to the line. Notched timbers may be worked smooth with a bullnosed plane. When cutting the rabbet use a plank gauge and check the bevel at each station on the timber with each station on the loft body plan. Cut the stem and sternposts long at the top, for nailing stays when setting up; the stemhead can be marked, but the shaping may be done after the deck is laid. Take care to bevel the



35. Augers

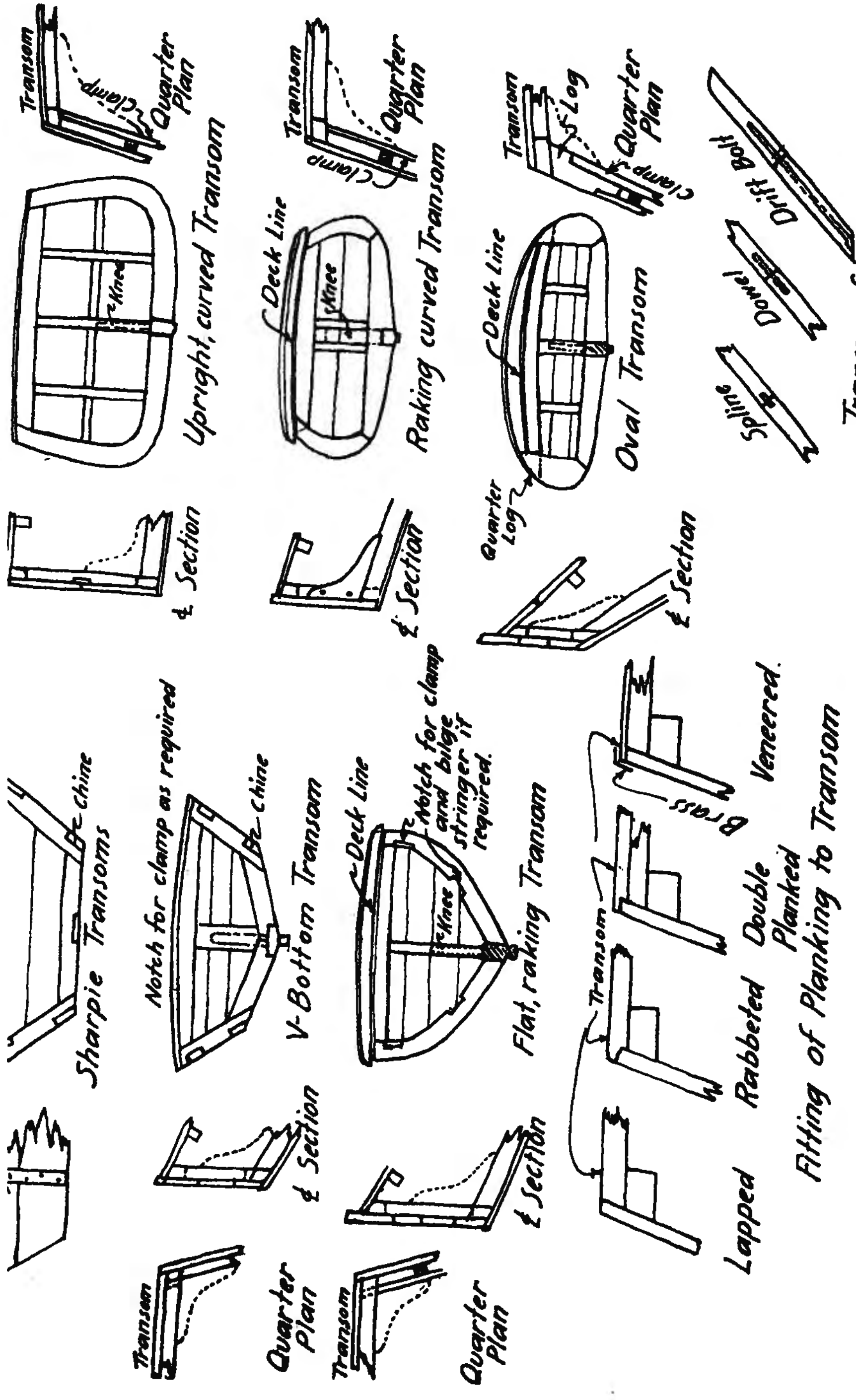
stem properly so that the width of its face, or forward edge, will run fairly into the width of the keel bottom. If there is a centerboard, cut the slot in the keel allowing for the tenon of the "ledges," or endpieces as shown in the proper keelpiece template. It is very important that the slot be straight and in line with the center line of the keelpiece. The slot is cut by first boring holes along the slot and then opening up with saw, chisel, and slick.

Constructing the Transom

The transom is next to be built. If the transom is of a single plank, it is made up from the pattern and the cleats or side frames attached. If the template was made to the molding face of the transom frame, the frame is first marked and shaped, then planked; the whole is then beveled, or left square to be beveled when set up. If the transom is curved, the frame is sawn to the arc of inside of transom plank shown in the half-breadth plan in the loft, then shaped by bending the transom template to the face of the frame. The transom planking is then steamed and bent over a form having a little less radius than the arc of the frame. The steaming of timber will be described when framing is discussed.

The sharper bend in the transom planking is to allow for straightening out, which will take place when the planking is removed from the form. Usually the radius of the form for bending the planking is around one twenty-fourth less than the radius of the transom frame. Little need be said about framing the transom. Flat-bottom craft usually have transoms of either a single plank, or two or three cleated together. Sometimes two-plank transoms are doweled or drifted together instead of cleated. In large flat-bottom boats a transom frame is required; it may be notched for keel, clamps, and chines. If the frame is not notched, the ends of the clamps butt against the frame and are secured by knees, called "quarter knees." Sometimes a center batten is also used, on which the stern knee at center line of hull will bear. The chines do not require knees at transom as the bottom planking, when nailed on, acts as a bracket or knee. V-bottom transoms are framed in a similar manner to flat-bottom transoms.

In large boats the transom frame is halved at chine and sheer; in small craft this is not necessary. Flat-raking transoms for round-bottom hulls have frames differing little from V-bottom transoms. Vertical-curved transoms usually have two or more stiffeners on each side of the center batten; all are halved or notched into the transom frame at bottom and at deck. The clamps are butted against the frame and secured with quarter knees. The keel is notched into the frame. Raking-curved transoms are framed about like raking-flat transoms. The keel is notched into the frame and there may be one or two center battens for the transom knee,



36. Common Transom Frames and Construction

or a heavy center batten and knee with stiffeners outboard on either side. If the transom is large, the frame is halved at the butts; cleats are used occasionally instead of halving. If the transom planking is reasonably heavy, the transom frame need have no great strength at the butts and joints, since the planking will serve as cleats when secured to the frame.

In the oval transom it will be necessary to fit logs at the sheer, running fore and aft, in order to have means of shaping the tumble-home of the quarters. This log is sometimes secured to the transom by quarter knees let into the top of the log and resting on the transom frame under the deck. In other cases the knee is secured to the inside of the log; the position depends upon where the deck actually is in relation to the sheer. When a few wide planks are used to make up the transom, the seams should be backed with a seam batten or a spline. The frame of curved transoms must be sawn to the proper curve at top and bottom. The sidepieces can usually be shaped out of plank.

The method of fastening the side and bottom planking to the transom is usually specified in the plans; if not, common sense is the best guide. It is common practice to bring the planking past the transom and saw it off flush with the transom face; this is the "lapped" method of fitting. The sides and bottom are nailed, riveted, or screwed to the transom frame, with two fastenings into the ends of the transom planking, in each strake. The "rabbeted" method of fitting is used on highly finished hulls; the planking rabbet in the transom is cut as the side and bottom planking is laid on. Usually there are two small fastenings, driven through the transom planking and into the ends of each side and bottom strake to keep the rabbet closed; the main plank fastenings are driven into the transom frame. Double-planked transoms are usually rabbeted; only the inside transom planking is put up with the frame. The outside transom plank is not put on until the side and bottom planking is in place and trimmed off, projecting a little, along the transom edge. The outer planking of the transom may be easily marked when clamped or shored into place, then removed and accurately rabbeted.

When finally fitted and placed, the two layers of transom planking are secured together by marine glue and screws. The same result is obtained by means of a veneered transom. In this construction the inside planking is put onto the frame and the beveling completed; then the veneer is glued in place with a liberal margin beyond the transom edge all around. This is not cut off until the hull is planked. Sometimes the veneer is put on after the side and bottom planking is completed. The final step is to put a brass binding all around the transom to cover the edge of the veneer. This binding is made of brass or bronze angles, usually formed to shape by brazing. The veneer used is marine plywood, 3-ply, about $\frac{3}{16}$-inch total thickness. This method gives a seamless transom suitable for varnish finish. The veneered transom is used in powerboat construction and is rarely seen in sailing craft. Rabbeted and veneered transom construction requires a good deal of skill and great care in fitting; it is probable that few amateur builders would attempt to build these types of transoms unaided. As far as practical considerations are concerned, the lapped method is as good as any, since it is strong and lasting. In very large vessels, over 60 feet long, with planking 2 or more inches thick, it is customary to miter the ends of the transom planking into the side and bottom planking; but this never should be done on a small boat. Occasionally the side planking is rabbeted into the transom plank—in small boats, when there is no transom frame; but the practice is not good unless the transom is unusually thick. Screws, nails, or spikes are used for fastening the transom frame together, bolts being required only in the knees. Large vessels have their transom frame bolted and drifted.

Centerboard Construction

The centerboard construction is usually well detailed in the plans furnished by the designer. The following remarks are intended to give the builder an idea of common construction details that will serve if the designed method cannot be followed for some valid reason. There is no good reason for complicated centerboard trunk construction. Except in large craft, the strains set up on the case, when sailing, are not very great. The centerboard is usually rectangular in shape and is pivoted at its lower forward corner. The lanyard is attached to the after part of the top of the board. This type of board is undoubtedly the best when strength and durability are important. It is sometimes built of a single plank when the boat is small. If this is called for in the plans, put a drift bolt through from top to bottom, edgewise, at the

fore and after ends. This will prevent the board from warping. If the board is large, it is best constructed when the planks that form it are narrow. These may be edge-bolted as each piece is set in place, then through-edge bolts driven at each end of the board, top to bottom. The drift bolts can be quite small in diameter; a board $1\frac{1}{2}$ inches thick should be fastened with $\frac{3}{8}$-inch diameter, wrought-iron rod, galvanized. The hole for leading these drifts should be about $\frac{5}{16}$ or $\frac{11}{32}$ inch in diameter. The diameter of any edge bolt should not be greater than one third the siding of the smallest timber fastened. This is a rule that applies in all deadwood and keel fastenings. Other proportions will be given later.

The lead ballast for the board should be near the lower after corner; a square or rectangular hole is cut through the board to receive it. The lead can be held in place by nails or spikes driven around the inside of the hole before the lead is poured. A better finish is to chamfer the sides of the hole on both sides of the board, to form a V-section all around the edges of the hole. The lead is poured into the hole with the board laid on its side and level, after the bottom or underside of the hole has had a plank tacked over it. If the ballast casting is large, paint the board and edges of the hole with water glass (such as used for preserving eggs, etc.) to prevent burning. Pour the ballast in one operation; this requires the whole amount of lead to be melted at one time.

The pivot bolt must be bored so that the board will swing in its case properly. The plans should show where the bolt is placed. A heavy board should have a bushing for the pivot bolt, secured to the board. A very fair iron bushing can be made of two pipe flanges, having the flanges let into the board on each side. Bronze bolt and bushing are the highest specification. Wrought-iron bolt and pipe flanges, galvanized, are the next best. The bolt should be fitted with washers, one on each side of the board and one on each side of the case. A lock washer may be used under the nut as the bolt may have a tendency to turn. This is sometimes overcome by using a carriage bolt; the head is covered by a wooden cleat set in white lead or wicking and secured to the case with screws. The nut may be covered in the same manner.

The lanyard is secured to the board by an eyebolt, or screw-eye, when the board is small and light. When the board is heavy, two straps, one on either side of the board, and through-fastened, are required. The straps may be made of flat-bar, galvanized wrought iron or bronze. If no drill press is available, a breast drill and high-speed, round-stock twist drills will serve to bore holes in metal. The straps should be let into the sides of the board so that they are nearly flush. The length of the straps should be sufficient to permit the lower through-fastening to pass through the plank next below the top one of the board, at least. The top of the straps should stand high enough above the board to give room for a bolt and shackle, or bolt and splice.

If the board is very heavy, the lanyard should be of chain. If extremely heavy, the board should be fitted with an iron rod in place of a lanyard; this is split and welded to form an eye for the bolt in the straps at the top of the board. The rod may be jointed by use of an eye-in-an-eye, if necessary. In some small craft the board is not ballasted, so the rod is not only used to raise the board but is also used to force the board down. Some arrangement is made to hook or lock the handle of the rod when the board is down. One very common way of doing this is to form the handle of the rod in a narrow V shape that will jamb in the case but which will be knocked loose and out if the board touches bottom. When a heavy board is built, it is a good idea to put in a lifting eye on top, at the forward end; this will give something to secure a tackle to, in hoisting out for inspection or repairs. Sometimes the ends of the board are cleated to cover the end grain. The lower and after edges of the board are tapered and faired to ease the flow of water. The lower edge is made full and round, the after edge fined off to about half the thickness of the board. In a large, heavy board the fairing of the after edge is said to increase its life and durability.

Dagger Boards and Other Types

Small craft are sometimes fitted with "dagger boards." These are blade-shaped boards without pivots, to be lifted out of the case when not in use. They are usually made of one or two planks; in either case edge bolts are driven fore and aft. The top of the board is fitted with stops which rest on top of the case when the board is in position, and so support it. A handle is usually cut in the top of the board for convenience in lifting it out. This type of board should be heavily ballasted. The board should have a

marked slope or "drag" to its bottom profile, deep aft and shallow forward, so it will rise if it touches bottom. If the bottom of the board is not rounded, it is common practice to finish it off with a fore-and-aft cleat. The forward, or "leading," edge below the keel should be slightly tapered and rounded; the after, or "trailing," edge should be fined down and faired thin in the well-known streamline form.

In recent years designs have appeared with centerboards shaped somewhat like the letter L, or inverted T. The upright arm of these boards is used to form a lever by which the board is raised and lowered; the lanyard is attached to it. In L-shaped boards, the arm may be fore or aft in the case. The blade of the board in these types is under the cabin floor. The obvious advantage of such designs is that only a short case is required for the arm of an L or inverted T board and so cabin floor space can be utilized to the best advantage as far as joiner arrangement is concerned.

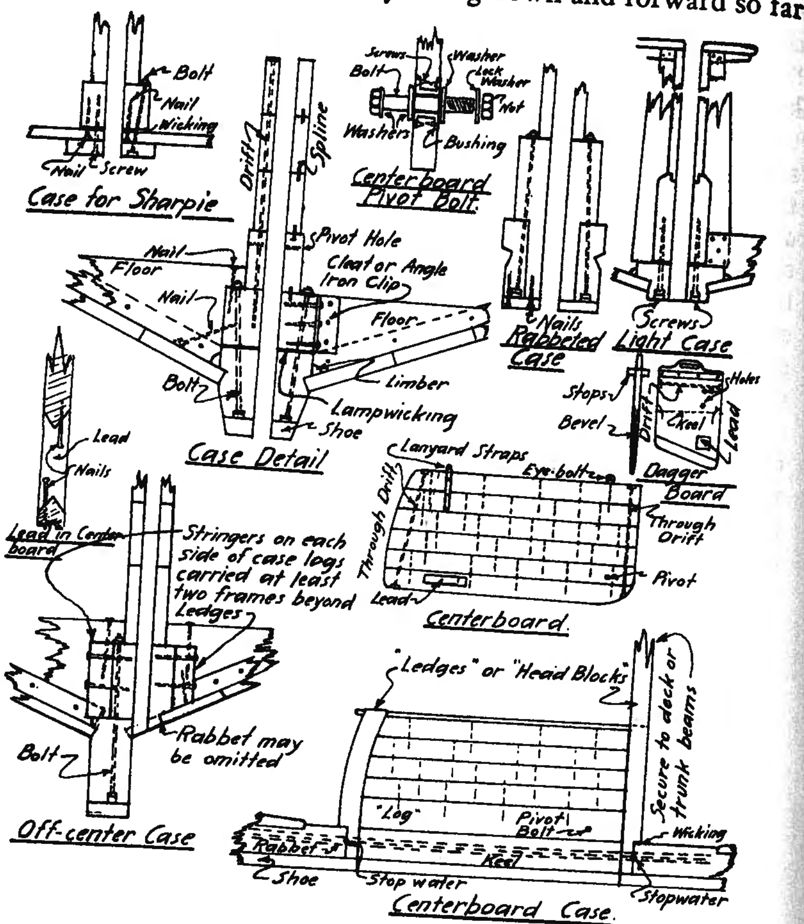
There is one serious disadvantage to these boards, however; their cases are hard to keep tight and form excellent nests for worms and a breeding place for marine growth. Since the greater part of the case must be closed, inspection is practically impossible except by hauling out the boat and dropping the board. These boards seem more likely to wring and twist than the rectangular shape. Metal boards are sometimes employed; they are satisfactory in small craft but much less so in large boats. This is because the metal board is easily bent when touching bottom, particularly when the boat is large enough so that the jammed board will not lift the hull.

Size of Fastenings

The fastenings used in the board may be worked out by rule if no specification is given in the plans. The through-edge bolts used in the ends of the board, and the drifts, should not be less than one eighth or more than one third the thickness of the board; the diameter of the pivot bolt is one half the thickness of the board.

Pivot Bolt

The location of the pivot bolt should be governed by the plans, of course. However, one observation must be made. The pivot should be high enough in the board and case so that the board will not be able to swing out of the case, and slot, if the lanyard should break. If the pivot is low—say, in the keel outside of the rabbet—the board will not only swing down and forward so far



37. Centerboards and Cases

that it will be entirely out of the slot, except for a small triangle at the forward end, but will also swing slightly across the slot and jam. In this condition the boat will neither steer nor handle and the captain-owner has an exciting but unpleasant time. The old rule of thumb for placing the pivot was one sixth the length of

the board from the fore end and from the bottom of the centerboard.

Centerboard Case Construction

The case is undoubtedly well detailed in the plans, but the cut (page 156) shows the most common methods of fitting. Light cases, such as used in sailing canoes and dinghies, are made of two thick planks fitted to the top of the keel; these are the "case logs." They are secured to the keel by long screws, lampwicking or flannel, well soaked in paint, having been put between the keel and the logs. The endpieces, or "ledges," or "head blocks," are run through the slot to the bottom of the keel; usually the tenon so formed is about half the fore-and-aft width of each ledge timber. This stiffens the case and protects the open grain of the keel at each end of the slot. The tenon may be carried flush to the bottom face of the keel, but if there is a shoe or rubbing strip the bottom of the tenon should be covered by this member. The case sides can be made of thin plank or waterproof plywood, rabbeted into the top of the logs. At the ledges the sides of the case run by, or lap, and are generally through-fastened. The sides may be stiffened by vertical cleats or braces; these are screwed to the outside of logs and case sides. The floor timbers lap over the top of the keel and butt against the case logs. They should be secured to the case cleats; the latter's location can be decided by this. The top of the case can be stiffened by a fore-and-aft seat which can be nailed to the top of the case sides and supported by the top of the case-side cleats. If there is no seat the top can be stiffened with fore-and-aft battens, if necessary.

Rabbeted Case

If the board is large and the keel is wide enough, the "rabbeted case" is very sound construction. In this the logs are rabbeted deeply enough so that the inside half of each extends through the keel to the shoe. This requires a very wide slot, of course, and should never be used if the keel is going to be severely weakened by it. When the logs are rabbeted in this manner, the shoe is spiked to both keel and logs, where possible, and the logs are through-fastened to the keel with carriage bolts. Wicking is placed in the rabbet, at the top of the keel, where the fastenings pass through the log and keel.

Common Construction of Case

In flat-bottom craft the rabbeted logs can be used to advantage. It is common, however, to use fairly thick logs resting on top of the cross planks of the bottom, with wicking or flannel soaked in paint between. The bottom planks are nailed to the log, and the shoe through-bolted through bottom planks and log, or screw-fastened in the same manner. The head blocks or ledges usually tenon into the slot the depth of the bottom plank. The same general plan is used for building a case on a batten keel, substituting the batten for the bottom plank in the description. This is the construction generally used in all cheap boats, flat-, V-, or round-bottom. The bolts in the logs are carried through the logs, so that the nuts are exposed on top. When the case springs a leak under the log, a few heaves on the nuts with a wrench will tighten the seam. The through-bolts should have heavy washers under head and nut and should be spaced reasonably close together—say, not over a foot in a 30-to-40-foot hull. In a small boat they may be spaced as closely as 6 inches.

Securing Floor Timbers to Case or Keel

In the usual centerboard hull, the case logs not only are secured to the keel but also are used to secure the floor timbers to the keel. This is done by notching the floors over the top of the log and spiking, or cleating (or clipping), the end of each floor to the outside face of the logs. It is apparently not necessary to make such fastenings extremely strong, probably because the planking, when in place, tends to force the floors inward against the logs. Screws, spikes, or nails are therefore considered adequate for securing the floor timbers to the case logs.

Head Blocks, Luting

The head blocks need not be rabbeted or splined for the sides of the case. There is sufficient surface to ensure a tight joint by putting the case together with wet paint or other material in all joints and seams. This is called "luting" and many things may be

substituted for wet paint: hot tar, marine glue, or the standard luting mixture. This last is made by using the following formula (the quantities are by volume): to one part of putty add one-half part white lead. Mix until streaks disappear. Add a few drops of linseed oil and work, adding more oil if necessary, until the mixture has the consistency of heavy cream. Then add a very small amount of "turps"; better, merely sprinkle with enough red lead to turn the mixture a very faint pink when well mixed. This will not harden entirely when applied to the surfaces of a joint. Luting is applied to the inside of all joints in a boat; these surfaces are known as "faying surfaces" and, as a result, the act of luting is called "faying." Hot tar, or pitch, is sometimes used for the same purpose, but is annoying to handle.

Bracing the Case

The forward head block or ledge should be well secured at the top; if possible, it should be carried up to the deck or cabin roof beams. Should it happen to fall between two beams a locking block, formed with a socket to take the ledge end, is required. The after ledge does not need to be extended above the top of the case.

Cases for Large Boats

Large and heavy centerboard cases should have the sides made up of rather narrow stuff, which should be edge-bolted as set in place on the logs. The tenons at the bottom of the ledges are cross-bolted through the keel athwartships. If possible, stopwaters should be worked in. The ledges should be of white oak if possible. It is common to find the first strake of the case sides, above the logs, somewhat thicker than the next above. This need be done only when the logs are on the light side, due to the narrowness of the keel.

Off-Center Case Construction

If it is necessary to place the centerboard and case off center, along the side of the keel, the log is usually doubled on the side away from the keel; the doubling piece is carried well fore and aft of the case and is notched over each intervening frame; these are fastened to the doubling from below, prior to planking. The doubling is spiked or screwed to the case log, athwartships. The floors usually lap over the top of the doubling and log and are fastened through the lap. The inner log may be doubled to give a better fastening for the floor timbers along that side of the case. In any case the inner log is through-bolted to the keel. When the centerboard drops alongside the keel there is no rabbet cut along the slot, in the side of the keel toward the board. Sometimes a rabbet is cut in the bottom of the outer log (outboard of the keel) to take the planking instead of merely lapping with the plank. The head blocks are carried to the outside of the planking and their outboard ends are metaled to protect the open grain of the tenon formed. It is usual to back up the head blocks fore and aft of the case, with filler blocks fitted between the extensions of the log-doubling timbers, for the length of one frame; these should be well luted. Sometimes these blocks are really a padding between the notch of the heel tenon of the head blocks and the planking; they are then notched into the ends of the case logs inside of the doubling pieces.

Rudder Construction

The rudder should be made up of narrow stock if too large to be made of a single plank. The pieces making up the rudder are first shaped to the profile struck off in the loft plans and then edge-bolted together with drifts. The stock is first made, then the first plank drifted to it, then the next is added. If there is only one plank in the rudder, it is still desirable to drive a couple of edge bolts to prevent splitting and warping. Sometimes the planks making up a rudder are notched close to the edge of the blade to avoid feather edges. Many rudders having a more or less straight bottom are cleated there to cover the end grain. Outboard rudders usually have tillers; these either pass through the rudderhead by means of a hole formed by cheeks through-fastened on each side of the head, or the head passes through a slot in the tiller, which is riveted at each end of the slot to prevent splitting. Sometimes a metal sleeve is formed over the rudderhead to form a socket for the tiller. Outboard rudders are usually hung to an outside sternpost, or to the sternpost and transom, with pintles and gudgeons. A screw, or through-eyebolt, is used in place of a gudgeon

in the transom of some boats. The bolt on which the rudder pivots, if there is no pin on the pintles, is made in a number of ways. Individual bolts are sometimes used, but the best practice is to use a long pin going through all the pintles and gudgeons; this will allow the rudder to rise without destroying the blade or the pivoting arrangement. The top of this long pin, or rod, may be finished in an eye or bent and stapled into the top of the post or transom, after being bent in a hook. If there is a propeller close to the rudder a stop must be fitted to prevent the blade from fouling the wheel. This can be made of two oak blocks, beveled so that their after face is approximately 35–45 degrees to their base. One of these is placed on each side of the sternpost, with the blade of the rudder confined by their beveled faces. They should be located close to the water line, parallel to it, and well fastened. It is usually necessary to locate them below the water line.

Rudder Braces

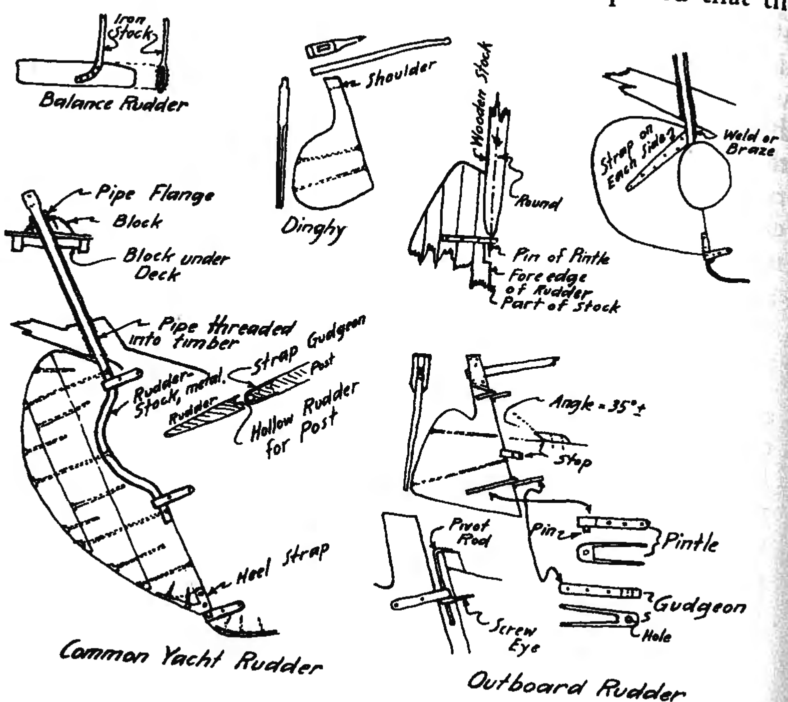
The pintles and gudgeons, sometimes called "rudder braces," are made of bronze, or wrought iron galvanized. The pintle, properly speaking, has a pin which enters the female gudgeon and forms the pivot. However, it is common to call a brace on the rudder the "pintle" and one on the sternpost the "gudgeon," even though they are actually made from the same pattern. Pintles and gudgeons are let in flush in rudder and post. They are through-bolted except when the end fastening of a gudgeon is in the planking; there a large screw is driven.

Rudderstock Types

Rudders are built with wooden or metal stocks when in the inboard position. In this case the stock passes through the counter or stern overhang by means of a built-up trunk of wood or a metal tube. Wooden-stocked rudders are usually built when the vessel is large. Metal-stocked rudders are used for sailing yachts and powerboats as a rule.

Wooden Stocks

The wooden-stocked rudder is made with the stock running the full length, in one piece, from rudderhead to the heel of the blade. Where the stock passes through the counter it is round; below the counter it tapers quickly to the upper pintle. Below the upper pintle the stock is shaped so as to be part of the blade. The center line of the stock in the counter is in line with a center line passing through the pins of the rudder pintles. This makes the round portion of the stock offset ahead slightly, in relation to the forward edge of the blade. The pintles are so placed that the



38. Rudder Details

center line of the pins of the pintles is either in line with the forward edge of the rudder blade or very close abaft it. As a result, it is necessary to notch the forward edge of the blade to receive the pintles and to permit them to be engaged with the gudgeons. This notch is made long enough, vertically, so that the rudder can be lifted the height required by the pins in the pintles to pass over the top of the gudgeons before the pintle pins drop into the holes in the latter.

To keep the rudder from being lifted out accidentally, after

being shipped, it is "locked" by means of a block inserted in one of the notches so as to fill the space between the bottom of the notch and the underside of the gudgeon. This block is held in place by a screw driven slantwise into either side of the blade, through the block. The lock is usually in the top notch if there are two sets of braces, in the middle notch if there are three and the boat is deep. It should be easily reached from the ground when the boat is on the railway. The forward edge of the rudder blade is beveled on each side to allow the rudder to swing without binding its edge against the sternpost. The latter is sometimes beveled slightly to match the rudder. The forward edge of the rudder blade at its center line (inside the bevels) should be close to the sternpost, not over ⅝ inch in a large vessel.

The building of this class of rudder proceeds as follows: the stock is made up as to shape, then the first plank of the blade is shaped and drifted to the stock, then the next. When the blade is completed, the rudder is fitted with the pintles and the necessary notches cut. Then the fairing of the trailing edge and the beveling of the forward edge are finished and the pintles fastened in place. It is important to regard the following points in building this type of rudder: the weakest place is just above the upper pintle where the rudderstock tapers from the round to the blade very quickly. There should be room for two drifts without cutting away the wood to a dangerous degree. In other words, the blade should run up on the after side of the stock so that its top is as close as possible to the bottom of the counter and yet permits the blade to be lifted out. Care must be taken in selection of the proper width for the stockpiece and in cutting the notches for the pintles. The latter must not cut through the stockpiece; in fact, it should not be deeper than half the fore-and-aft width of the stock in the blade section. The top of the sternpost must be hollowed to take the offset of the round portion of the rudderstock.

Metal Stocks

Power craft usually have a wooden or metal rudder blade fitted to a metal stock. In high-speed motor craft the blade and stock are usually in a unit, cast of bronze. In cheaper and slower boats the blade is made of a metal plate inserted in a slot cut in the bottom of the stock and secured with rivets or by welding. The stock may be of galvanized wrought iron or of steel, but the best is bronze, of course. Both types of plate rudders usually have a small amount of area forward of the center line of the stock; they are called balance rudders for this reason. In workboats and sailing craft the balance rudder is usually made with a plank blade and metal stock. The stock is bent aft on each side of the blade to form a lever. In sailing craft the blade for this type of rudder can usually be made of a single plank. The stock runs through a tube in the counter. The balance rudder can be fitted outboard; its construction and hanging follow the usual practice for outboard rudders.

Metal Stock Construction

The metal-stocked rudder is generally made with a Tobin bronze stock, though iron is used on rare occasions. This is bent to shape, if required to pass around a propeller aperture, and the head is squared to take a tiller or quadrant. It is then bored for rudder-blade bolts. The sternpost is hollowed on its after edge. The forward edge of the rudder blade is also hollowed for the length of the stock; if the latter does not run to the heel of the blade, the forward edge is rounded to fit the hollow of the sternpost below the stock. The planks forming the blade are then fashioned and edge-bolted, the piece nearest the stock being prepared first and the others fastened to it in the usual manner. The whole assembly is then bored to match the stock and through-riveted or through-bolted. The heel of this form of rudder may be fitted with some form of pintle casting, with a gudgeon to match on the post. The gudgeons are mere straps passed around the stock through small slots cut in the fore edge of the wooden blade, aft of the stock. These straps are passed and secured after the rudder is shipped. They are through-fastened in the sternpost. If castings are required, the designer may be able to furnish them or refer the builder to some foundry having patterns. If this is not possible, a pattern must be made; this is a job for a professional patternmaker. In shallow hulls the metal stock is sometimes short and the blade is steadied by a heavy strap passed around the stock, riveted, and brazed, or made as a casting and fitted to the bottom of the stock. If iron or steel stocks are used, the strap is usually welded and no casting made.

Fairing Rudder Blade

Deep rudders should be well faired along the trailing edge, as a rule, but apparently this is neither necessary nor desirable in shoal rudders, if the area is properly designed with this in view. The hollow sternpost should be carefully faired and shaped so that the rudder will not bind when turned. In fitting any rudder, great care must be taken that the pintles or straps are correctly lined up and the stock is straight so that it will revolve truly on its axis. The size of fastenings in the rudder blade follows the same rule that was given for centerboards.

Rudder Trunk

If the rudder is inboard, the tube or trunk for the stock must be prepared. The trunk used on large craft is made up somewhat like a centerboard case, in some boats. The forward head block is the sternpost hollowed for the stock, inside the counter, and an after head block is tenoned into the counter's keel (called the "horn-timber"). A hole is drilled for the rudderstock in the latter. This is carefully lined up with the post outside and is lined with a copper tube the depth of the horn-timber. The sides of the trunk are then planked fore and aft with splines or worked in with feathers. Another construction is made by fastening vertical planks on each side of the sternpost, extending a short distance aft of the after face of the latter. The sternpost is first hollowed for the rudderstock, of course. The after head block is rabbeted into the two sidepieces and all three are rabbeted into the horn-timber, at their heel. The after head block should be driven down the rabbets from above. Splines may be used instead of rabbets in the sides and after head block. There is no great difference in either form of construction, as far as any real advantage is concerned. Both may be made tight when properly fitted. The disadvantage of this form of construction is that worms and rot may destroy the trunk in time. To prevent this, some builders run a sheet-copper tube liner through the trunk; this is only necessary when the counter is so low that water is always in the trunk.

Rudder Tube

Metal-stocked rudders require tubes, as a rule, and the construction is very simple. The tube is cut to length, to extend from a little below the tiller or quadrant to the bottom of the keel or horn-timber. The lower portion is threaded the depth of the horn-timber. A hole a little smaller in diameter than the tube is then bored, taking care to line it through the horn-timber so that the rudderstock will hang correctly when in place. When the hole is bored, the pipe or tube is then screwed into the hole. It is an excellent plan first to paint the hole or to daub it with white lead before starting the pipe. The size of the pipe is usually specified; it should be from ⅛ to ¼ inch greater in inside diameter than the diameter of the rudderstock. It must be of the same metal as the stock. The head of the tube is held by deck blocks worked in between the deck beams and by a finish block shaped to the proper rake of stock and to the deck, above deck. In power craft, and those with tiller below deck, the head of the tube is held by a thwart, or plank run athwartships, at the required height. This should be notched into the frames on either side and supported by two fore-and-aft battens secured to the frames. This thwart must be well fitted and strongly secured. Sometimes a bearing or flange is placed at the head of the tube; if required, this is shown in the plans. Of course, much of this description of the fitting of the rudder and trunk or tube cannot be carried out until the boat is well under construction, but it is necessary to know how the rudder is hung and fitted now so that the work may be planned ahead.

Mast Steps

If there are masts, and steps are required, they should be shaped, patterns made from the loft drawing being used to shape and notch them correctly. The tenon socket for the heel of the mast can be cut and drain holes bored. These should be so arranged that the socket will drain completely, when in position.

Shaft Log

The shaft log should be shaped and bored before the keel is assembled. The following is usually the easiest method. The manner of constructing the log without boring a shaft hole has already been discussed in the lofting of this member (page 140) and requires no further reference here. If the shaft hole is to be bored, the log is first shaped and the center line of the shaft hole is carefully struck off on the timber from the template. The center line is then duplicated on the opposite side of the timber and squared across the inside and outside edges, where the shaft will enter and leave the log. Then a fore-and-aft center line is drawn on top of the log and brought to intersect the shaft line at either end, so that the exact points at which the shaft hole will enter and leave the timber are marked. A jig can then be made of two heavy battens; one of these is nailed on each side of the log, parallel to the shaft center line as drawn on the timber and a few inches below it. The hole for the shaft should be started with a single cutter auger bit in the after end of the log. Then a crosspiece is made with a notch which will support the long stock of the ship auger in correct line when boring. This should be secured to the battens as shown in the cut on page 148. If a hole is used in place of a notch, a sight line should be struck on the crosspiece. The hole for starting the boring should be a couple of inches deep. The barefoot ship auger bit, welded to a long stock or brace, can then be used to complete the boring. When boring a long hole the bit should be pulled out and the chips removed from the hole a number of times while the boring is being done. If the bit and its stock are correctly lined up there should be little trouble in getting a true hole. After boring, the hole can be reamed by using a piece of iron pipe of the right diameter and roughing its surface with saw cuts opened with a cold chisel. Another way is to heat the end of the pipe and to burn the hole out smooth. The longer the battens are extended abaft the shaft log, where boring starts, the more accurate the boring is likely to be but the longer the stock on the auger will have to be; and this, in practice, fixes the position of the crosspiece or guide.

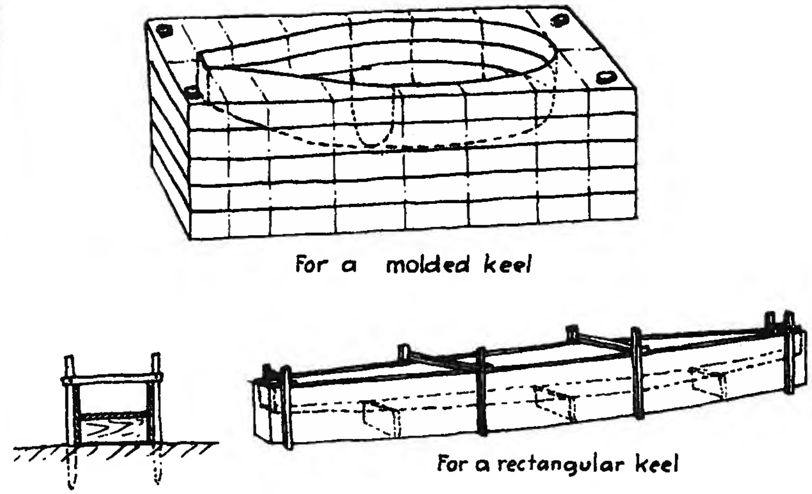
The size of the shaft hole is governed by the shaft diameter, of course; the hole diameter should be from one fourth to one third greater than the shaft diameter, the larger hole being required if a tube is used. The tube is usually standard lead tubing, with an inside diameter about 20 per cent greater than the shaft diameter. The hole must be slightly larger than the outside diameter of the tube so that it will enter without driving, which, of course, it will not stand. The tube may be cut to length when the hole is bored;

it should be from 6 to 8 inches longer than the shaft hole so as to leave material to make the flanges. The tube is marked and then removed. The sides are split at each end, almost to the marks; usually four to six splits are made in each end. The tube is coated with white or red lead and inserted; then the flanges are formed inboard and out by carefully bending down the flaps formed by the split ends. These are secured to the timber by brass or copper tacks. Use plenty of lead under the flaps and, after bending, tap flat with a hammer so that the flange is tight and smooth. If any irregularities appear inside the tube, as a result of flanging, be sure to ream them out; they usually can be reached with a file, round or triangular, or can be pounded out with a round piece of wood and a hammer.

Ballast Keel Casting

If there is a ballast keel to be cast, this should be done before setting up the keel. If it is necessary to have the work done in a foundry, the casting should be ordered while the loft work is being finished. The construction of a mold for a ballast keel that is rectangular in section is simple. The sides are made of two plank on edge, sprung to the taper of the keel. The bottom of the keel can be formed by a plank shaped and sprung between them, at the proper depth. The ends are completed with plank to form the end of the ballast casting. If the sides have flare, the top of the side planks will have to be trimmed straight when bent and flared to the correct shape. If the casting is large, the bottom should be supported by bearers inserted under the bottom and between the sides, of sufficient depth to reach the bottom of the sides. The top of the form can be stayed by crosspieces nailed to the top of the sides, their ends extending out 6 or 8 inches from the side planks. Sections taken from the loft floor can be used as temporary molds to check the shape. This mold should be made of green wood. If holding bolts are to be cast in place, they can be placed in the mold with heads wired to the bottom board and the shanks secured to crosspieces. The centerboard slot can be cast by putting a thick plank on edge in the mold. When ready to pour the casting, the mold is set on solid ground with top level, lengthwise and athwartships. Earth should be packed under the bottom plank, if possible.

Stakes are then driven along the sides to give additional support. A pair should be driven at each crosspiece; the latter can then be nailed to the stakes. After earth has been piled against the sides and tamped, the mold is ready for use. If the keel to be cast is under 1,000 pounds weight, the mold can be made of inch plank; if heavier, the plank should be from 1¼ to 2 inches thick. The mold can be protected against burning by painting with water glass or some of the so-called fire-resistant materials, such as whitewash or sodium silicate. Before pouring the metal be certain the inside of the mold is dry; no puddles or drops of water must be allowed to be in the mold. When the metal is poured the mold should be allowed to stand for a day or two, so as to cool; then the mold can be knocked apart. Care in handling the casting is necessary as it will bend easily if long and narrow.



39. Ballast Keel Molds

Casting a Molded Keel

If the keel is shaped and is small, it is possible to make a wooden mold and avoid the expense of a pattern, though the building of the mold is somewhat laborious. The mold to be described should not be attempted when the ballast casting has a length greater than 40 inches, a width of over 12 inches, and a depth of over 16 inches. To build a mold for a shaped ballast keel, the ballast casting is faired on the loft plan by water lines spaced 2 inches apart or a little less. The shapes of these water lines are then laid off on each side of a center line on a plank having sufficient width and length to give a few inches margin to the largest water line, and of the thickness required by the water-line spacing in the loft plan. The water-line shape is then sawn out, leaving a little clearance outside of the saw cut and inside the water-line shape. The planks are bolted together when all are prepared and the inside hollowed out carefully to give the proper shape to the casting. This is the reverse of the bread-and-butter method of building a model boat hull or a keel pattern. The mold should be treated as the one first described, when preparing to pour. It should be made of softwood for ease of working, white pine being the most generally used. This is one reason why the construction is unsuited to a large ballast casting. The mold must be staked and banked before pouring unless very small.

Foundry Work

The melting of the lead requires some preparation. First, the lead used is not pure, but is usually impure scrap. Some of this may come from telephone or electric cables, or pipe. This is much cheaper and very nearly as heavy per cubic foot as pure lead. It is important that a small margin in excess of the proposed weight of the ballast keel be allowed when ordering the pig lead. Lead keels usually run a little heavier than estimated; allow about 3 to 5 per cent excess. If a melting pot with a spigot can be borrowed, rented, or purchased, this should be set up on a temporary brick hearth high enough for the spigot to be fed into the mold. A trough can be made of iron or brick, mortared, to carry the hot lead from spigot to mold. If the mold is long, a metal trough is necessary as it will have to be moved from time to time. Fill the pot with pigs and get a hot fire going. When the metal is completely melted, start pouring and at the same time add the additional pigs that are required to keep the pot full and to fill the mold. The new pigs will melt rapidly in the molten metal. In this

way it is possible to cast a keel of large size with a rather small pot. The fire can be fed with shavings, waste lumber, or charcoal; it should be kept hot throughout the whole operation. The pouring should not stop for a period long enough for the surface of the metal in the mold to cool. As the metal runs into the mold one man can skim and puddle; most builders use a piece of green oak for puddling or stirring the metal. A skimming ladle should be used to prevent a scum from forming. The trough should be moved occasionally to be sure that the metal is going into the mold evenly and that no air pockets are being formed. If the keel is large, pouring is a four-man job.

Foundry Work, Small Craft

If the ballast keel is small and the spigot pot is not available, the melting can be done in a small pot such as is used in brass foundries; the pouring can be done by using the tongs with which these pots are handled; a temporary crane and a chainfall are required to lift the pot from the fire and to swing it over the mold in pouring position. It is advisable to plan and try this out before filling the pot.

Molding Sand

The use of a pattern and molding sand is usually beyond the facilities of the amateur builder. It can be done, however. The assistance of an experienced molder is the best way to learn how to handle the sand. The pattern is placed in a trough of sufficient size, with its top level with the top of the trough. Molding sand is rammed under and around it as the trough is gradually filled. When the trough is filled and the top of the sand leveled off, the pattern is lifted out and the mold formed is cleaned and patched. This requires a bit of patience and care. The ramming of the sand is perhaps the most important part of the operation. The manner of placing the pattern is the part that requires the most knowledge; a two-part mold is a foundry job. If the pattern is such a shape that it cannot be lifted out without breaking the mold, take it to the foundry. Very small ballast keels may be molded by using plaster of Paris instead of molding sand. These may be poured with a ladle.

Ballast Bolts

In most cases it is hardly desirable to cast the bolts in place, or to try to core for the bolt holes, in a lead keel. It is easier to place the ballast keel in position and to bore from above through holes established in the keel. The boring can be done with twist drills sold as "Electricians' Drills"; these fit a two-chuck brace of the type used by carpenters. The lead can be smoothed up with a hand plane set for a fine cut. The ballast keel bolts should be of bronze if the keel is of lead, of galvanized steel if the ballast keel is of iron. The bolts should be staggered if possible, not all placed on the fore-and-aft center line of the keel. If the keel is heavy a ballast keel bolt should pass through every other floor timber, but this is admittedly open to objections. In most cruiser designs the ballast bolts are set up on the inside of the keel. If the ballast casting is of lead and the bolts of bronze, then there should be lead grommets, or washers, under the head and nut of each ballast bolt. If the ballast casting is of iron and the bolts of steel, grommets of calking cotton well soaked in paint should be used in place of lead. When the ballast casting is ready to be fastened to the keel, the top of the casting can be coated with hot pitch or a sheet of tarred felt, or canvas laid in wet paint can be worked in instead. This will prevent rot in the keel, in the way of the ballast casting. It is a safe rule that all large areas of metal in contact with wood should be insulated in order to prevent the rot that is likely to take place. The "sweating" of metals is the cause of a great deal of rot in keels.

Ballast Bolts through Floor Timbers

If the design calls for bolts passed through ballast, keel, and floor timbers, there is likelihood of leakage between floor timbers and keel. This can be prevented, in most cases, by putting wicking, laid in wet paint, between keel and floor before fastening the latter in place. The keel should be well calked outside the rabbet. When the bolts pass through the floors great care is required in boring for them and they must be staggered so that they will clear the bolts that secure the floors to the keel. It is best to bore from the top of the floors downward.

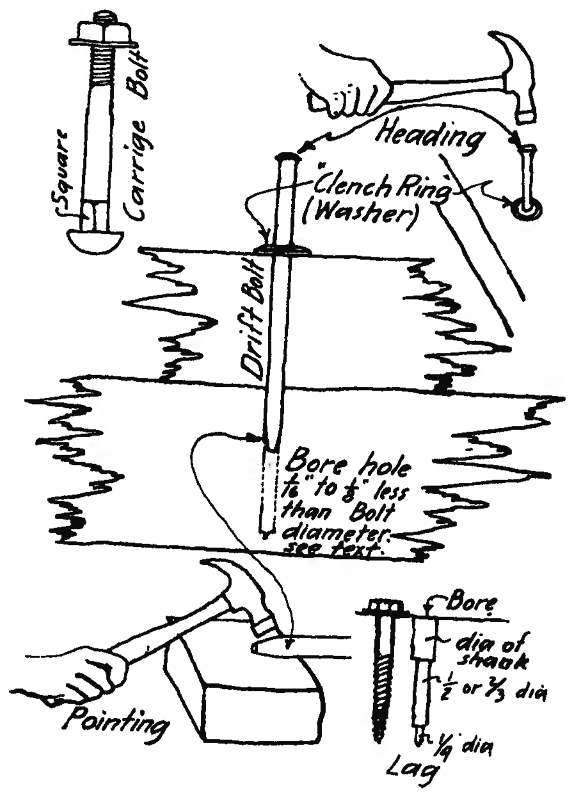
When all the keel, deadwood, and backbone timbers are shaped, it is a good plan to place them on the loft profile drawing, if size and weight permit, so as to get one last check. This will show any tendency of the assembled timbers to gain or lose length, due to faulty marking or shaping.

Assembling Keel

Assembling the backbone can usually be started before setting up the building stocks, unless the keel is very heavy or the boat large. Since most home-built craft are small, it will be assumed that the stocks will not be built until after the keel is wholly assembled. Obviously no directions are necessary as to how the timbers should go together, the loft plan and the patterns or templates having made the builder familiar with the proper setup. All scarfs and laps in the keel and deadwood must be payed with paint, white or red lead, or other luting material before being fastened. As each piece is set in place, its marks are brought to coincide with those on the adjoining timber and then securely clamped before boring for fastenings. If the fastenings are marked on the timbers from the loft plan, care must be taken to bore at the required position and angle.

Fastenings, Drift Bolts

The fastening most commonly used in the keel is the drift bolt. This is made of galvanized wrought iron or steel rod. It is cut to the required length with a hacksaw or boltcutter. The point is then tapered on an anvil (or block of steel), cold, by blows with a light hammer. It is not necessary to make a long taper, usually less than ½ inch being sufficient. This gives a rounded, blunt point. The boring for drifts must be done with care. The hole should be a little less in diameter than the rod. If the drift is less than 14 inches long, the hole should be bored about ⅛ or 1/16 inch less in diameter than the rod, depending on the hardness of the wood; if the hole is long, its diameter should be about 1/32 inch less than the rod. In very hard wood, or where there is danger of splitting, it is best to bore the hole 1/32 inch, or even 1/64 inch, less in diameter than the rod. When the hole has been bored, a clench ring is set over it and the rod driven. Clench rings should be of wrought iron, galvanized. The cast-iron clench rings are useless, since they break when the bolt is driven home. Test the clench rings by pounding them with a sledge hammer. Inspect a clench ring and you will see that it has a top and bottom. The latter is flat, like a washer. The top is crowned and countersunk for the drift-bolt head. Be sure to set the ring right side up. Drive the drift with a heavy hammer, using a few heavy blows in preference to many



40. *Bolts*

light ones. If the first bolt drives very hard, the next can be lubricated with soft soap. If the hole for the drift is not of sufficient diameter or not the length of the bolt, a split timber will result. When the drift is nearly home, shape a head with a light hammer, by tapping the edges of the top of the rod. The impact of the sledge used in driving will usually upset the top of the rod to such an extent that it will only require shaping. If the head mushrooms, or breaks up, either the bolt is driving too hard or the hammer

used to drive it is too light. When the head has been shaped, the bolt is driven home with its head in the countersink of the clench ring. In order to get a neat, strong job, the clench ring must be the proper size for the rod used.

Through-Fastening Drifts

The same method may be used in a through-fastening. This class of fastening should be used wherever possible. The drift is usually driven from the outside to the inside of the hull whenever practical. The bolt must be cut about two diameters longer than the hole, plus the two clench rings' thicknesses. This will allow for heading and riveting. The bolt is driven as previously described, headed, and driven home. Then a helper holds a heavy sledge against the head, if the fastening is short, while the point is riveted or headed over a clench ring with a light hammer or small sledge. The outboard end of a through-fastening should be countersunk and plugged.

Copper and Bronze Fastenings, Drifts

Copper and bronze drift bolts and bronze clench rings are sometimes used. These metals do not have great holding power and are, therefore, generally used for drifts as through-fastenings. The hole for bolts of these metals should be bored to the full diameter of the rod. The impact of driving will swell the bolt and it would hang if the hole were not bored to the same diameter as the rod. Otherwise the driving of bolts of these metals is in no way different from that used for iron or steel drifts. In selecting copper or bronze rod for drifts be sure that the metal is neither too soft nor too brittle; drive a test rod into some waste timber. Annealing the rod may reduce its tendency to break up at the head and in riveting the point.

If clench rings cannot be procured, use as thick a washer as can be obtained for the required diameter of bolt.

Carriage Bolts

Carriage bolts are also used in fastening keel timbers, particularly when the timbers are too small to drift or where there is great danger of splitting. They also are used to pull timbers together where clamps cannot be used. These bolts have crowned heads and a short portion of their shanks, under the head, is square to prevent turning when the nut is set up. They should be purchased in the proper diameter and length. The latter should be taken as the length of the hole plus about 1½ diameters, to allow for nut and washer. The hole is bored the same diameter as the shank of the bolt. It is a good plan to smear the shank of the bolt with red lead before driving it into its hole. Carriage bolts are made of galvanized steel and bronze.

Lag Bolts

Lag bolts are really screws with a square head. Made of galvanized steel, bronze, and alloys, they require proper boring to be strong enough for a hull fastening and are not highly regarded by experienced builders. The lag should be measured before boring—the hole for the depth of the shank should be the same diameter as the shank. Three quarters of the length of the screw or thread should then be bored for, using one half or two thirds the shank diameter. The remaining length of the thread should be bored for, using one fourth the shank diameter. This is a troublesome fastening to use because of its changes in boring diameters.

Spikes

Spikes are sometimes used in keel construction. The square-shanked boat spike is generally preferred. A measurement of a flat side of its shank is used to represent the diameter. Bore a hole for a spike about three quarters the diameter. If the wood is very hard or has a tendency to rend or split, bore a hole seven eighths the diameter of the spike. Round spikes are sometimes used and are often employed for through-fastenings. They are treated as drift bolts both in boring and riveting.

Hanger Bolts

A hanger bolt is a form of lag bolt which has a threaded shank and nut instead of a head. Used for securing machinery and engines to their beds, it is driven by temporarily adding another nut to the one already on the bolt; this prevents the first nut from jamming, which would happen if it were used alone for a driving

head. The hanger bolt must be bored for in the same manner as a lag. It is useful where it is necessary to remove a fitting without disturbing the bolt.

Screw Bolts

Machine bolts, called "screw bolts" in some sections of the country, are sometimes used in hull construction, but more generally in securing ironwork to the hull or for machinery foundation bolts. The head and nut can be obtained either square or hexagonal; the latter is the traditional form, in some shipbuilding towns, for fastening the gammon iron and bobstay plates to the hull. They are driven in the same manner as carriage bolts.

Rod Bolts

Another form of bolt sometimes used is made of rod, threaded at both ends. It is driven by screwing a nut on the end to be used as a head. The point is secured with a nut and washer after being driven. A variation of this is a rod threaded at one end with the head formed by upsetting the opposite end. The purpose of rod bolts is to fill a need for bolts whose required lengths cannot be obtained from standard sizes. These bolts are very good through-fastenings and are much cheaper than having carriage or machine bolts made to special lengths.

Boat Rivets

For small craft, boat rivets can be obtained in sizes ranging from 3/16 inch in diameter and 2½ inches long, to ⅜ inch in diameter and 12 inches long. These may be used as drifts or as through-fastenings, riveted. Boat rivets can be bought only of galvanized iron; their heads are crowned like a carriage bolt.

Stove Bolts

Stove bolts are rarely used in keel construction, but are sometimes required in securing deck hardware. They can be obtained in galvanized iron or in bronze, have a head like a screw, and are designed to countersink. The nuts are square.

Treenails

Hardwood dowels or treenails ("trunnels") are also used occasionally in keel construction, either as through-fastenings or as drifts. Locust or white oak, well air-seasoned, should be used for the treenail. The use of wooden fastenings of this type should be limited to keels in which the timber is reasonably well seasoned. The boring should be done with great care to ensure a drive fit, but not a loose one. After driving the head is cut off and then the exposed end is split with a chisel and a thin oak wedge is driven into the treenail end. As this leaves a flush head, no countersinking is necessary, of course. The point of a through-fastening is treated in the same manner. Treenail, or peg, fastening is very strong if properly done, but a careless piece of work is utterly useless. Treenails can be used in small sizes, ranging from about ⅜ inch in diameter up to 1½ inches; the smaller the diameter, the shorter the length should be, of course.

Boring, Drawing Bolts, Driving

In boring for a long fastening in hardwood, such as oak, the auger should be greased. It must be withdrawn from time to time, to clear the hole and bit of chips. If a drift bends, or if it is found that it must be withdrawn, use two jacks and an iron clamp. The clamp is set up at right angles to the drift just under the head and the two jacks placed between clamp and timber as close to the drift as possible. If there is no room for jacks it may be possible to withdraw the drift with a claw-end crowbar or "wrecking bar" worked over a block to raise the fulcrum. If the drift is of galvanized iron and the timbers are of oak, do not let a poor fastening stand for any length of time; withdraw it at once. Otherwise it will "set" and be very hard to withdraw. Curiously enough, this is not true of copper drifts; if allowed to stand a few days they will drive or withdraw more easily if they bind. When driving a drift into a countersink it may be driven flush with a sledge and then set into the countersink with a heavy punch or spike set. A spike set should be fitted with a handle so that the holder will not be injured if the driver should miss with the sledge. As was suggested previously, it is well to lubricate all drift bolts with soft soap. Grease may be used instead, but is said to have an ill effect upon

the holding power of the fastening, in some timber. Remember to stagger all fastenings; if this is not done, splitting will often occur.

Building Stocks

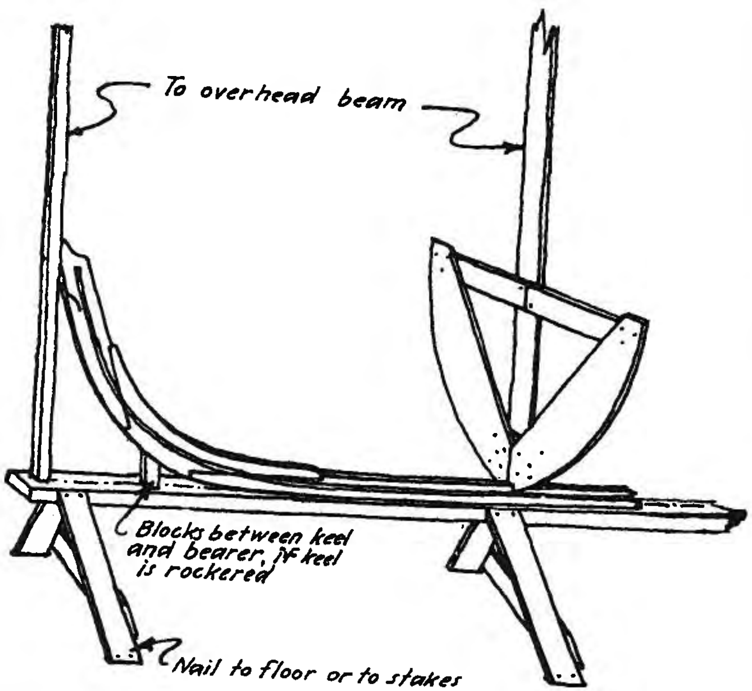
When the keel has been assembled, or as much of it as can be conveniently handled, the stocks can be built. On these the hull will rest while being built. Many amateurs make unnecessary trouble for themselves in planning the stocks because of their worry about a base line. If the deadwood is properly marked with water lines and stations there is no reason for extraordinary alarm about a base line. An outside base line, that is, outside the hull, must be used, of course, to set the stocks and keel in the proper position, as shown in the lines and loft plan. Here its usefulness usually ends and an inside base line becomes important. By stretching a line inside the deadwood, at any water-line level, an inside base line is easily obtained. As there are a number of water lines it is possible to run a number of base lines, if it is found that some structure interferes with one. The advantages of this are too obvious to require explanation. There is nothing more useless than an outside base line, once the hull is planked; it cannot be used for height measurements in any practical way. Furthermore, the outside base must usually be stretched offside from the actual center line, if the hull is built right side up, and therefore it is usually out of reach for athwartship measurements. If the hull is built upside down the base line is usually on center and can be utilized to somewhat greater advantage, but once the hull is planked and righted a new base line will be required to finish the deck and cabin. It is plain that the marking of the deadwood is the only practical way that this can be accomplished with any degree of accuracy.

Setup

The question of how a boat is to be set up—right side up or upside down—has already been discussed in the last chapter. No hard and fast rules can be laid down, but it is general practice to build a small boat upside down except when she is strip-planked. Most clench-built (lap-strake) hulls are also built right side up. The builder must follow the plan that seems best suited to the design and to the working space available. A carpenter's level is required to set up most stocks; a string level is also necessary.

Building Horse Right Side Up

If the boat is to be built right side up and she is small and light, it is possible to build her on a horse. This is made of timber a little longer and about as wide as the keel, of sufficient depth to be stiff; it is supported by legs, sawhorse fashion. The legs should be nailed to the shop floor or to stakes driven into the ground. The spacing



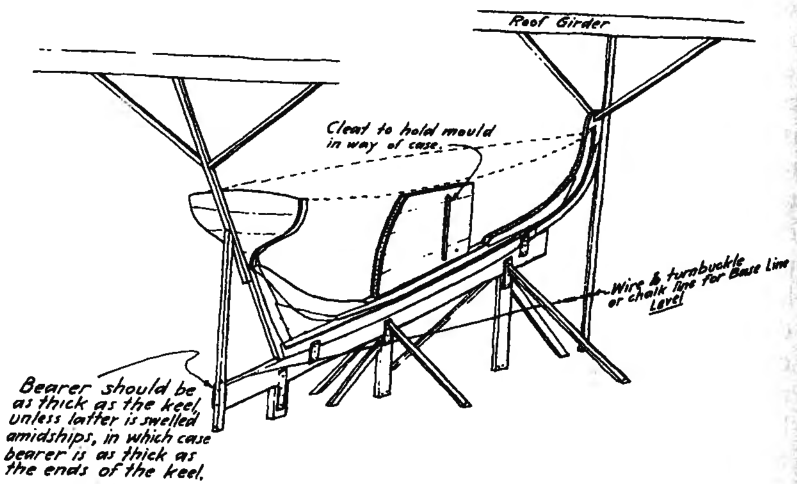
41. Setup of Small Boat, Built Right Side Up on Building Horse

of the legs should vary with the weight of the hull; it is usually sufficient to locate a pair of legs at each mold position. A center line is struck off on the top of the bearer and the keel set up. If the rocker of the keel is slight, blocks are set on the bearer to chock up the keel. If the keel is sprung to a long sweep, the blocks must be cut to the proper height and bevel and set at each mold station; in this case the top of the bearer must be level and straight as it will

serve as a base line. If the keel is straight the bearer may be leveled, if desired, but in any case should be straight. If the bearer is not levéled, the molds can be set with a steel square from the keel or bearer instead of being plumbed. If the keel is to have drag and so is set at an angle to the base, it is best to set the bearer level and to block up the keel with blocks set at each mold station. When the keel is set in place, it is nailed or cleated to the bearer. The center line of the stem and of the sternpost or transom is then plumbed and each is stayed. These stays are of plank or scantling lumber; they are best secured to a ridgepole supported by posts driven or set in the ground to give 8 or 10 feet headroom, or secured to the roof truss of the shop. Take care to get the top of the keel level athwartships and set at the proper angle to the bearer, or to the proper curve. After all the stays are in place it is a good plan to check the bearer for level and the stem and stern for plumb. The molds will be set on the keel, cleated to the top of the keel by a block nailed or screwed to one face of the mold, and stayed at the center line to the ridgepole. The setting of the molds will be discussed later.

Timber-bearer Stocks

If the boat has a great deal of rocker or drag, the bearer may be set to the required drag, or the top curved to fit the rocker for a portion of the length of the boat. In this case the bearer is shorter than the hull and is supported by legs, or well-braced posts, nailed to the shop floor or set into the ground. The bearer is commonly made of a piece of heavy scantling on edge, and the keel is secured to it at the ends with side cleats. The base line may be struck across the legs or posts with a chalk line, or a piece of fine wire set up with a turnbuckle may be used. The thickness of the bearer and posts is fixed by the thickness of the keel at each end of the bearer. If the boat is very heavy, posts or legs should be located at each station. The plumbing and staying of the keel are the same as described for the setup on the horse. Care must be taken to be certain that the base line is set level before measuring for cutting off the posts or legs to set the bearer at the proper angle. It is sometimes easiest to lay off the bearer and supports, as well as the base line to be used, on the profile in the loft drawing and to pick up the bearer shape from there, as well as the bevel and height of each



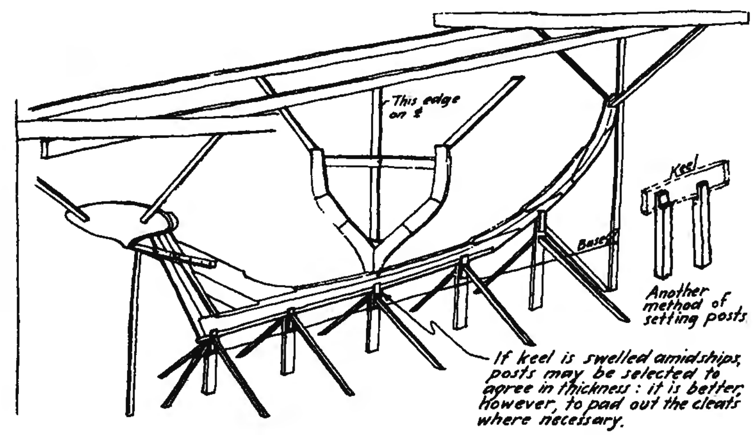
42. Setup for keel of a heavy boat built right side up in a shop. Top of bearer under keel usually shaped to profile of keel, but blocks on bearer will serve the same purpose.

leg or post. If the ballast keel is not ready, or if it is to be put in place after the boat is nearly completed, the bearer may be made to fit the part of the keel left for the ballast casting.

Post Stocks

Another variation of this setup is to set the keel on a series of heavy posts. This method is often used when there is no floor in a shop, or when the boat is built in the open. The posts are set in the ground in a very secure manner, with the earth well tamped around each. Care is taken to line them up carefully so that they stand in a straight line. A level base line is struck across them and then each may be cut off at the proper height and bevel. The spacing is usually at each mold station and at the extreme ends of the hull. When the tops are cut off, they may be notched to take the keel. The usual way of doing this is to use wide posts and notch the tops alternately right and left; the keel is then wedged against the standing side of the notch, or temporarily nailed to it. Since most boats have some swell to the keel, however, it is usually easi-

est to saw the posts to the height of the bottom of the keel and then to cleat the latter to each post with side cleats; these are padded out from the posts, where necessary, to give sufficient breadth for the swelling of the keel. Of course, the posts may be selected to give



43. Setup for a heavy boat built right side up, using posts. Common methods of bracing shown. Posts at every station used for a mold.

the proper width at each station, if desired. The treatment chosen for these setups would ordinarily be governed by the number of boats to be built on the individual stocks. For one boat there is little value in notching, or in using posts of varying widths.

Stocks for Large Craft

These methods of building stocks would not do for a very large and heavy vessel. In building a large wooden hull the stocks are built first and the keel is assembled on them. First, heavy oak sleepers, somewhat longer than the beam of the boat if possible, are laid on the ground. They are spaced about 6 feet apart and are laid at right angles to a center line representing the keel of the boat. Usually the ground is prepared for the sleepers by leveling and sloping at the angle required for launching. This slope is governed by the weight and size of the boat and the amount of "run" she can be allowed in launching. If there is little space or insufficient depth to permit her to run very far after launching, the slope is slight—about ⅝ inch per foot of length. Normally the declivity is about ¾ inch per foot or a little more, unless the boat is very small or light. One inch to the foot is about the maximum required under any ordinary condition. As the weight and size of a vessel increase, the declivity decreases; a 100-footer would normally be launched at a ¾-inch declivity, while a 400-footer requires only ½ inch. The sleepers are well tamped in place and occasionally staked to prevent their moving. If the ground is soft, piles may be driven to bear their weight. On these sleepers short blocks are laid in order to raise the keel a few feet above the top of the sleepers. The blocks may be cleated together, or iron staples made of ⅜-inch diameter rod, in a shallow U, about 12 inches between points and 5 inches from points to crown, are used. These are driven into the blocks with one point in each. When the blocks are all set and their tops checked to see that the keel will bear on each, the keel is placed on them and assembled. Sometimes the keel is given a little sag in the middle, if it is over 85 feet long, in order to allow for the drooping of the ends which may take place. The amount of sag is about 1 inch in a hundred feet of length. The keel is held in place by short shores nailed to its top and reaching to the sleepers. These keep the keel from capsizing while being fastened together.

The sternpost is then set up, fastened along with the after deadwood, and shored. Then the frames are usually raised as they are assembled on a temporary platform built over the keel and moved as the raised frames make necessary. The first frame to be raised is commonly the aftermost "square frame." This frame is the one farthest aft having a floor athwart the keel. Though they do not actually set at an angle to the keel, the frames which have no floors but have their heels spiked or bolted to the deadwood (even if they have a "strongback" to tie the two parts together in place of a floor timber) are still known as "cants" (see Plate 21). After the aftermost square frame is raised the others are assembled and raised one by one until all the frames are raised. Then the after cants are raised, when the square frames have been plumbed and ribbanded, and shored. The forward cants and the stem are raised last. The stem and stern are well shored after being plumbed. If there is a transom or stern frame this is generally raised with the after cants. When all the frames and cants are secured and faired

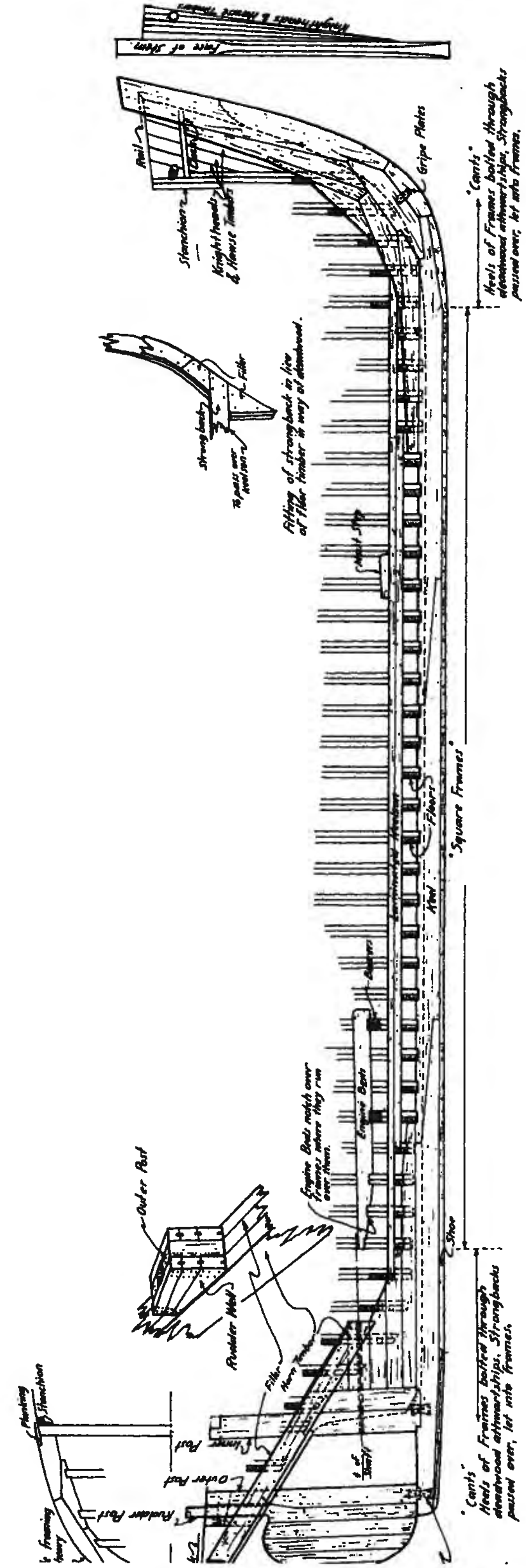
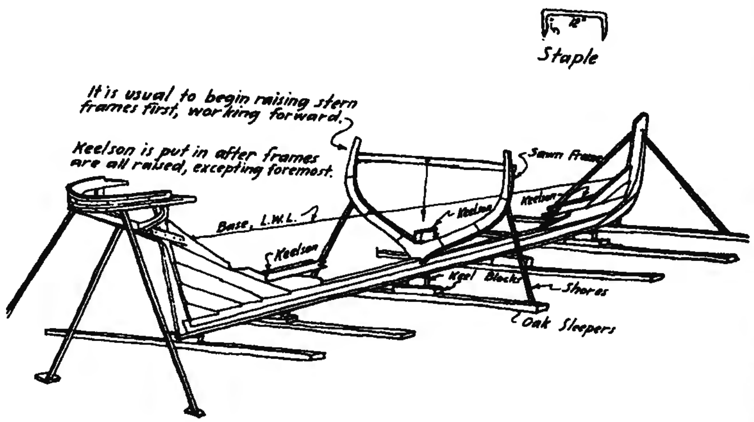


PLATE 21. *Deadwood Plan for a 75-Foot Dragger (Sawn Frames)*

with ribbands, the keelson is secured in place. This general description will be enlarged upon later. The accompanying cut is designed to show the method of setting up a large vessel and of shoring; it does not show all the frames in place nor the usual sequence of operations. As most large vessels nowadays have straight



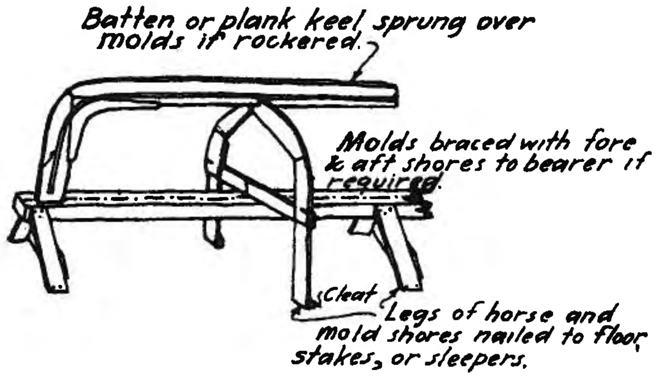
44. Setup for a large vessel built in the open, showing method of shoring, setting of keel blocks, etc. In practice, sleepers are about 4 feet apart. Keel is steadied by short shores to its sides (not shown).

keels, it is easiest to raise frames square to the top of the keel or rabbet if the design permits. Otherwise great care must be taken that the keel is set on the blocks at the angle that will allow the frames to be plumbed in position with a plumb bob or level. This sometimes causes difficulty in setting the launching ways. The appearance of the keel structure of a heavy vessel is shown in Plate 21.

Building Horse Upside Down

If the hull is to be built upside down and it is small and light, it may be built on a horse. The stem and stern are assembled on the keel and the whole structure is mounted on the horse with the stern blocked up so that the keel is set at the proper angle to the base line; usually the latter is the top of the horse. The molds are set on the horse, between it and the keel, as shown in the accom-

panying sketch. Usually the molds are made long enough at the tops, above the sheer, to reach the floor when turned upside down and set on the horse. These ends serve as shores and may be toe-nailed or cleated to the shop floor, or nailed to stakes. It will be found convenient to set the cross-spalls at the base line instead of the sheer; this must be laid off on the mold loft drawing, of course,

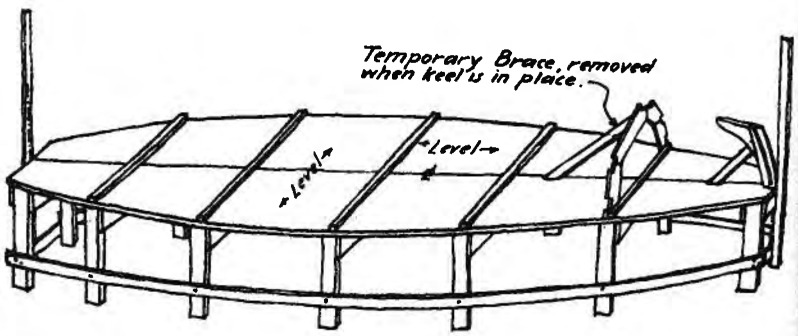


45. Setup for Small Boat, Built Upside Down on Building Horse

and the molds marked for sheer and base. When the molds are set in place they should be cleated to the keel and to the horse. If the keel is to be sprung to a curve the molds must be set in place, cleated to the horse, squared and plumbed, and then securely shored, after which the keel may be bent over them, shored to the ridgepole or roof—and the stem and stern secured. The horse should be built in the same manner as described for building right side up: the center line of the boat is struck off on the top of the bearer and the stations marked off.

Building Table

If the boat is very light, and particularly if frames are used for molds, a building table makes excellent stocks. The table is made of two or more planks shaped roughly to the form of the sheer of the two halves of the boat, one of which is shown in the half-breadth plan in the loft drawing. The center line of the boat is marked and the stations located and squared off to it. Cleats are then nailed or screwed to the table top at each station to which the frames or molds will be secured. The whole structure is placed on legs or posts and securely braced. The frames or molds are made so that their tops are at the base line, which is the table top, of course. The stem and stern are set in place on the table and fastened by shores or uprights to the shop roof or ridgepole. The molds or frames are then fastened to the table and temporarily screwed to the cleats; then they are plumbed, or squared, and



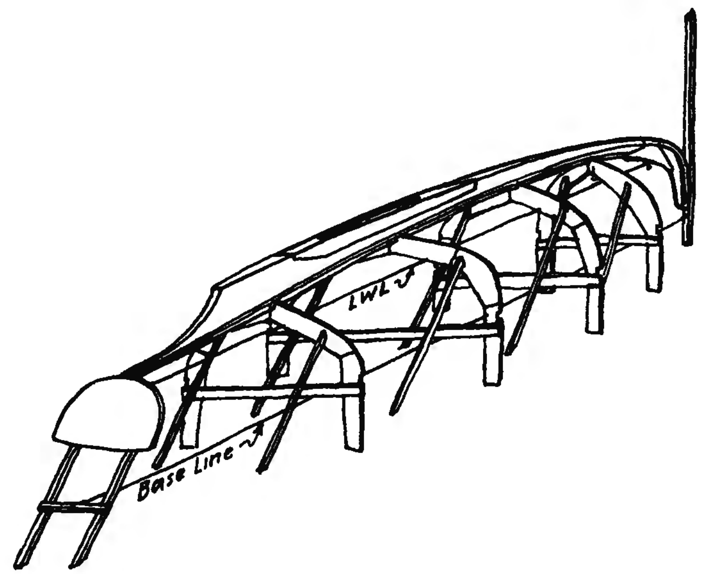
46. Building table, suitable for very light construction. Boat built upside down. Table-top level, used for base.

shored. Care should be taken to get the table top as straight as possible, and level in all directions along its surface, before cleating. Experience shows that it is very desirable to locate the table legs or supports at each mold station. This form of stock is very convenient when a number of boats are to be built off one design. The cut shows the appearance of a building-table setup. The molds must be prepared from the mold loft plan by setting off the base line in the building position there and building the molds accordingly.

Building Upside Down on a Floor

If the shop has a straight, level floor, the setup may be based on it. This is shown in the sketch; the tops of the molds are made to the building base line which is established in the loft drawing. A center line is struck off on the floor and the stations marked and squared to it. The molds are then set up on each station, squared, plumbed, and shored. The tops of the molds are cleated to the

floor. Some pains are necessary to get the center line of the molds plumb over the center line on the floor. This can be done by use of a plumb bob if the cross-spalls and molds are properly marked. By a little extra work in the loft drawings it is also possible to pick



47. Usual setup when building upside down. Molds carried to floor line; braces off center. Centerboard case not set up with keel.

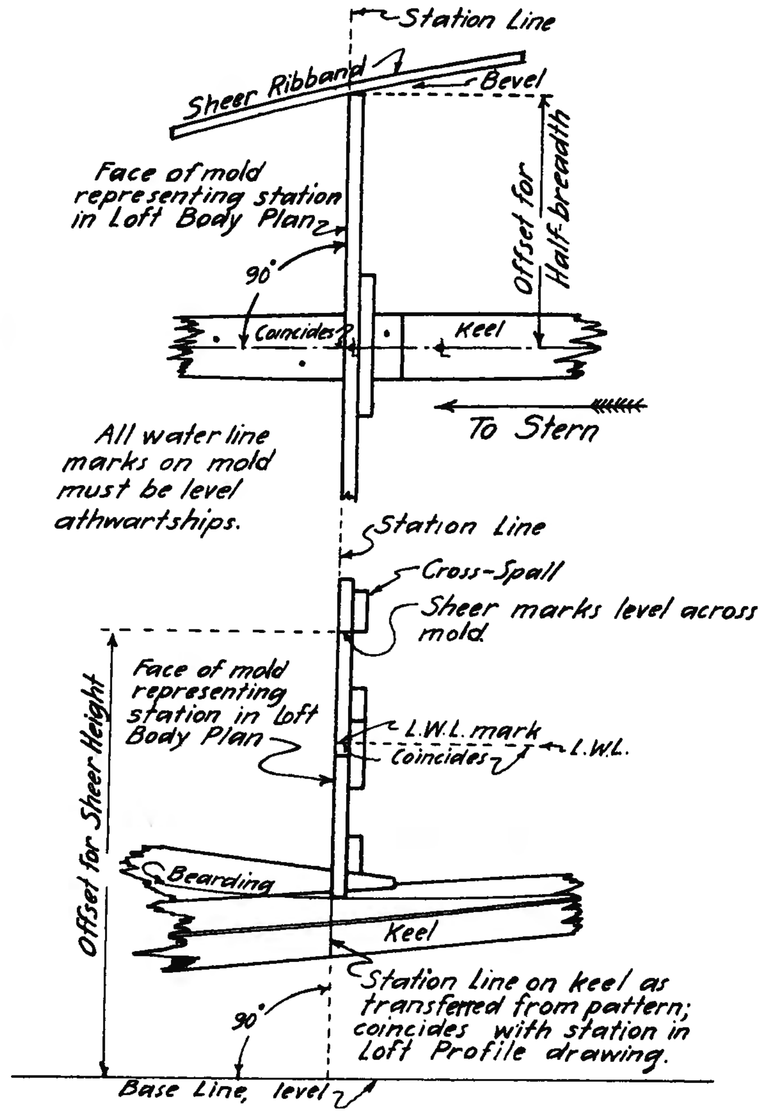
off the half-breadths of the tops of the molds at floor level (base line) and to set those off on the floor, by which the molds should automatically center correctly. Once the molds are in place, the keel is set on them and stem and stern plumbed and shored. The keel can be cleated or temporarily screwed to the molds.

Remarks

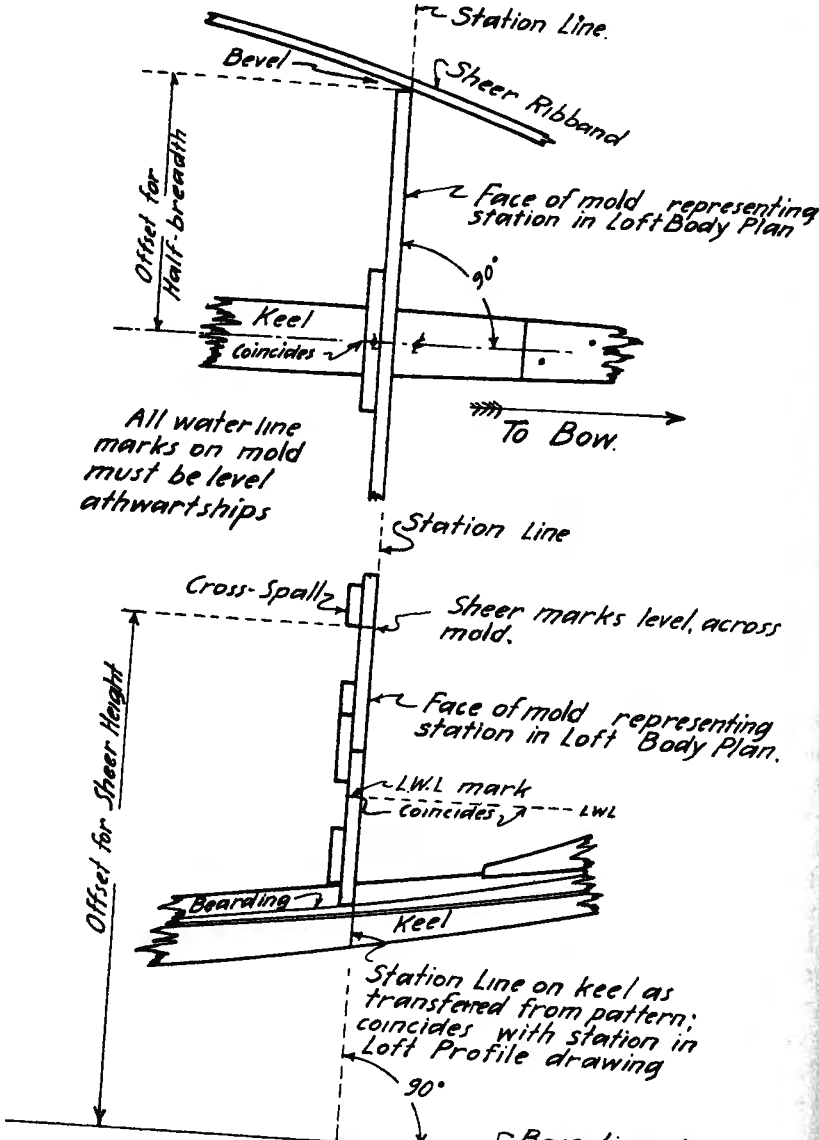
It is very important that any setup be firmly built. Not only is the weight of the keel and molds to be considered, but also the strains caused by bending frames, ribbands, clamps, stringers, and planks. These strains are relatively great and the molds and backbone must therefore be well shored and braced. Screws and lags are often used as fastenings in building stocks and setting molds, since they can be removed without destroying timber and can be driven without impact which might disturb the setup before it is wholly fastened in place. It is very important that the molds be set square to the center line and plumb to the base line; no amount of care is too great. It is also very important that the base line, if on the supporting timbers of the stocks, be marked and referenced, as it may be necessary to remove a stretched line or wire from time to time as construction progresses. Emphatically, the keel must be laid at exactly the right curve, or slope to the base line, and the stocks must be adjusted by accurate cutting, blocking, or shimming to permit this. It is utterly useless to be accurate in the mold loft drawing and then careless in setting up. Any mistake in lining up the molds and backbone not only makes the completed boat different from the lines drawing, but also makes trouble in building; nothing fairs properly and all fitting must be done by "try and fit." This always results in a botched job.

Setting the Molds

Setting the molds on the keel, when it is in place on the stocks, requires careful attention. Since the edges of the molds are not beveled, the molds must be set, in relation to the station lines shown in the loft plan and marked on keel and stocks, to compensate for this when the ribbands are bent into place. The sketches show how this should be done. The molds forward of the point of greatest beam in the hull should be set so that their forward face is on the station line. Those abaft the point of greatest beam should be set with their after face on the station line. These faces of the molds are now the planes used for the sections in the loft body plan. When the ribbands are bent into place around the molds they will touch only on the faces or edges representing the body plan sections in the loft drawing, as will be seen by inspection of the sketches. This is a very important matter and neglect of this precaution will cause unfairness in the hull, or a lot of trimming or "dubbing" of the molds; either will result in a hull whose lines are different from the design, not only in appearance but also in behavior when under power or sail, compared to a boat built correctly.



48. How Molds Must Be Set, Aft of Station Having Greatest Beam



49. *How Molds Must Be Set, Forward of Station Having Greatest Beam*

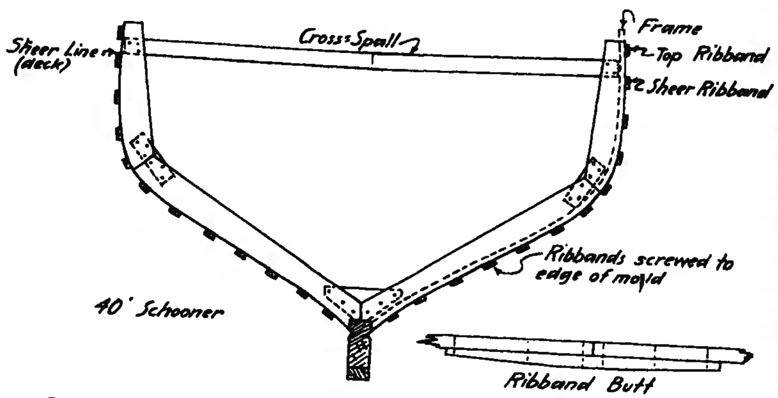
It is also very important, in setting the molds, to check heights of the sheer against those in the loft drawing. If there is variation it may be necessary to trim the notch for the keel in a mold, or to shim one up. Theoretically, the bottom of a mold should coincide with the bearding line on the keel; but as the bottom of a mold on each side of the keel may end in a long, thin point, which is easily broken or splintered in making or handling, it is not safe to use the bearding line of the rabbet as a reference line. The mold at the greatest beam in a hull is usually set with regard to the bevels formed at the lower water lines. In most cases either the forward or after face may be set to the station line at will, as there is practically no bevel required by the ribbands at this station. Occasionally, however, this is not the case because of what is known as a "raking midsection" in the design. This can be observed by noticing the relation between the points of greatest beam on each water line in the half-breadth plan in the loft drawing. It may be seen that there is no bevel required at the midship mold in the topsides, but below the load water line some bevel is required. Hence the mold should be set so that the face on the station will not require dubbing, when ribbanding. In most hulls having a raking midsection the mold at the point of greatest beam on deck is set with its forward face on the station line.

Stopwaters

Now that the molds are set in place, the next step is to drill and drive the stopwaters in the keel, if this has not already been done. Stopwaters should be made of white pine or cedar, from ¼ to ½ inch in diameter, and may be purchased as dowel stock from a woodworking mill. The dowels must be cut to length and should be long enough to pass through the keel or deadwood, with a little to spare. Holes are then drilled in the joints and scarfs in the deadwood and keel as described in the chapter on lofting. The stopwaters should be a drive fit in these holes, the ends cut off after driving. It may be well to repeat that a stopwater should be driven in every scarf and butt in keel, stem, and stern, the seam of which passes through the rabbet line. The stopwaters are all located in the rabbet, between the outer rabbet line and the bearding line. If possible, two stopwaters should be driven in every such butt and scarf.

Ribbands

Ribbanding may now be done. The first step is to cut some battens for these. Yellow pine, green spruce, or fir are generally used for ribbands. For small craft, with light frames and with molds spaced not over 36 inches apart, the ribbands should be from 1¼" x 1½" to 1½" x 2". In larger hulls, where the molds are spaced 4 feet or more apart, the ribbands should be from 1½ by 2 inches to 2 by 2½ inches. In boats over 40 feet long the ribbands are from 2 by 3 inches to 2 by 4 inches. It is a good plan to make many of the ribbands tapered toward one end and a few tapered toward both ends. There is no rule for spacing the ribbands on the molds. In a small boat the ribbands are usually spaced from 6 to 10



50. Common method of ribbanding molds. Frame bent to inside of ribbands.

inches apart; on a 40-foot hull the spacing ranges from 10 to 12 inches. However, much depends upon the shape of the hull. For the moment, the foregoing will serve to estimate the number of ribbands that will be required. If it is not possible to get ribbands in one length they may be scarfed, or butted and spliced. The scarf should be vertical when the ribband is on the hull. The splice is easier to make. The splicing strip is made of a ribband of the same size as the two being joined and is on the top or bottom of the ribband when it is in place. It is usual to begin ribbanding the hull at, or close to, the sheer. If possible, one ribband should be so

placed that its top is the sheer line if the hull is right side up, its bottom if the hull is upside down. In a small boat the ribband should be the same size as the rest, but in large hulls, 40 feet long and over, it will be found helpful to make the sheer ribband a little wider than the rest.

When a ribband is in place on one side, put up the one on the other side of the hull, as ribbanding one side of a hull will pull the molds out of line and plumb. When the two sheer ribbands are in place, put up the next two, which should be above the sheer, then the next below the sheer, and then on down. The spacing already suggested can be used as a guide, with these qualifications. Ribbands can be more widely spaced where the molds show that the hull sections have little curve. At the turn of the bilge, however, or wherever else a quick curve appears, the ribbands should be more closely spaced. If the ribbands run too close together at the ends of the hull they may be stopped on a mold short of the stem or stern, in places where there is little fore-and-aft curve. Splices or scarfs in the ribbands should be brought to sections where there is little fore-and-aft curvature also. At the top of the transom let the ribbands run a few feet abaft the transom and tie each pair together athwartships with a short length of rope outside the stern. This will require a little judgment, but it is desirable in order to produce fair curves in the ribbands, between the aftermost mold and the transom. It is necessary to spring the ends together a little before tying them; the amount of spring required can be found by not fastening the ribbands at the aftermost mold and transom. When sprung enough the ribbands will not only bear on the transom, but also on the aftermost mold, without being drawn up to it with fastenings. At the stem and sternposts the ribbands will serve to check the rabbet; if not completed the rabbets may be cut a little to permit the forward ends of the ribbands to end fair in the rabbet against the bearding. If there are quick curves in the hull, the tapered ribbands will permit bending to the required curve without breaking.

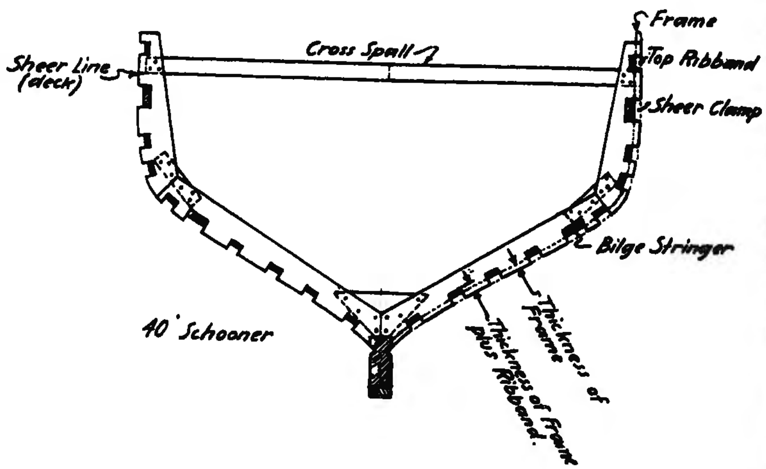
In rare cases it will be found necessary to use laminated ribbands to avoid breakage. The best way to fasten ribbands to the molds and to stem and stern is to use oval-headed screws, or lag screws if size permits, with washers under their heads—one fastening at each station. Usually it is best to fasten a ribband amidships and then to work toward the ends, fastening as the ribband bears on the mold (except near the top of the transom, where the ribband ends may be tied in pairs). It is usual to spring the ribbands a little up or down as they are bent into place to hold to a more or less regular spacing at the ends of the hull, but the ribbands should not be forced so much as to bring heavy strains on the molds, tending to lift them from the keel or stocks. The most common error in ribbanding is to space the ribbands too far apart in the hollows of the hull, near the counter and along the rabbet of the keel near the sternpost. This mistake will break frames that must bear on these ribbands, when forced to the sharp bend usually required there. A ribband should be located so that it runs through the sharp hollow that is formed at the junction of the bottom of the counter or stern with the sternpost. Ribbands against which frames will bear when being bent, such as in the "tuck" just mentioned, and along the keel when there is hollow in the sections, should be rounded on the inside to prevent their sharp corners from cramping the frame and breaking it by a cutting action. This is often neglected and is one of the causes of excessive frame breakage. The ribband above the sheer on each side is a desirable feature, when bending frames, as it gives support that will prevent the frame heads from flaring out while they are cooling after being bent in place. In some boats having rather straight sides they may sometimes be omitted. If the molds are of softwood—white pine, for instance—it may be noted that the ribbands are crushing the edge of the molds on which they bear. To prevent this, make some hardwood wedges and force them between ribbands and mold from the face of the mold that does not touch the ribband. This will give the ribband a better support and prevent the crushing of the sharp edge representing the section, by transferring some of the load to the whole edge of the mold. Be careful not to drive the wedges enough to force the ribband away from the mold, however.

If a ribband or other timber requiring great bend has a tendency to break, it is sometimes better to bend it from amidships to the ends at once, and clamp into place, before driving any fastenings, rather than to bend and fasten simultaneously. Lags can be driven with a socket wrench fitted to a brace. The ends of ribbands in the rabbet of stem and sternposts should be secured with screws. If the bow is full on deck, the ends of the ribbands in the rabbet of the stem may be held by cleats nailed or screwed to the sides of

the stem outside of the rabbet, to permit some movement in the ribbands when filling out the deck line, by inserting a staff between the upper ribbands. If it is not possible to fair out the bow between the stem and foremost mold in this way, an additional mold will have to be laid off in the loft plan and made to fill the hull form out at this place. It may be necessary to make an additional mold between the transom and the aftermost mold, given in the offsets, for the same reason. The curves formed by the ribbands must be fair and they must rest on every mold that they cross. If they do not, a mistake has been made in either the loft plan or in the setup. If the spacing of the ribbands at one end of the hull becomes too great at any one place, and if it is undesirable to spring the ribbands toward one another, then put in a short ribband at least three mold spaces long. Ribbands made too small will produce an unfair hull when the framing is in; ribbands too large will force molds out of line.

Ribbands Inside of Frames

The most common method of applying ribbands is to place them on the edges of the molds as just described. In building upside down, however, it is sometimes easier to use a different plan. With the ribbands put on as previously described, the frames will be bent on the inside of the ribbands and this requires working from inside the hull. The other plan is to bend the frames outside the ribbands and thus be able to work from outside the hull. To do this, the molds are notched to the depth of the ribband plus the thickness of the frame, as shown in the cut. The molds are also notched for sheer and bilge clamps or stringers in the same manner. The sheer clamp is located from the loft drawing and its notch cut, but the bilge stringer and ribband notches are cut by bending these members in place and holding them with nails or clamps, marking where they cross each mold, removing stringer or ribband, and cutting notches. It is possible to clamp a ribband to a mold when the clamp will not reach to the inside of the mold timber by screwing blocks to either the fore or after faces of the molds. Care must be taken in notching molds to allow the depth of the ribband plus frame thickness, so that the outside of the frames (when bent) will be in the correct position in relation to the edges of the molds. The notches are not beveled and the molds are set on station lines as previously described, to allow for the omission of the bevels. The advantages of notching the molds are greatest when the hull is built upside down, but occasionally it is desirable to apply this system to a hull built right side up. The only serious disadvantage is that the molds must be completely pulled



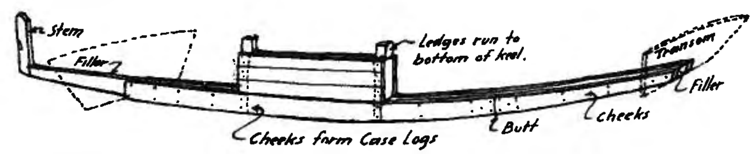
51. Mold Notched for Clamps, Stringers, and Ribbands; Frames Bent from Outside of All

apart and the ribbands sawn in two in order to remove them. If a heavy sheer clamp or bilge stringer is required, however, this system works very well and the setup is very strong when the ribbands are in place. It is claimed that building in this way is excellent when the frames must be given very hard bends at garboard or bilge.

Keel Types, Flat-Bottom Hulls

The general methods for setting up and ribbanding a hull have been discussed. The various classes of keel construction now require attention, as there are certain problems inherent in each type which have some bearing on the methods of assembling or of setting up. The keel structure of most large flat-bottom hulls is made of plank on edge. If there is a centerboard the keel is made of two members running the full length of the structure, with a filler be-

tween that is cut in the way of the centerboard slot. The two side members thus form the centerboard case logs. Very often these timbers do not run all the way to the bow, or to both bow and stern, but stop short. This is done to save weight. The side members of the keel and the timber between—the filler—may be butted if necessary. It is important that the butts be well staggered, however. This form of keel is very easy to build and is very strong. In the way of the case some care is required in fitting. This



52. Common Flat-Bottom Hull Keel; See Plate 5

is particularly true of the case ledges. These run through the keel and to the outside of the bottom planking where their ends are covered by a rub-shoe, or plank, run fore and aft along the bottom. In a few cases the ledges are cut off at the inside of the bottom planking. Some builders drive a stopwater through the keel at the seams formed by the ledges and the filler timber, but perhaps the best way to prevent leaks is to pay the timbers of the keel and the parts of the centerboard case with luting as it is assembled. If the hull is planked fore and aft on the bottom, or is built of plywood, the keel is notched to receive the frames. Plywood hulls are sometimes designed with a temporary plank keel, built somewhat like the one just described, to serve as a template on the building stocks to hold the molds, or frames, in the correct position. This keel is really a bearer and is removed before the hull is decked.

Keel Types, V-Bottom Hulls

Keels for V-bottom hulls vary in design. Heavy craft may have as complicated a structure as round-bottom types usually have. Plate 22 shows a batten keel for a heavy hull, cross-planked on the bottom. The skeg is merely an appendage built up of narrow stock, bolted, spiked, or drifted to the keel batten. Mast steps are made of blocks screwed or bolted to the top of the keel batten.

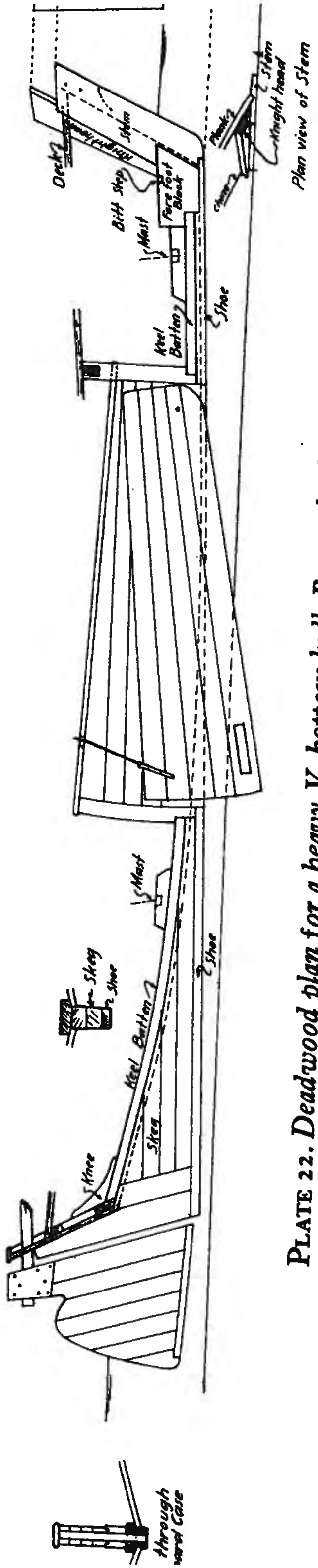


PLATE 22. *Deadwood plan for a heavy V-bottom hull, Batten keel and Skeg*

The construction is simple and cheap. Stopwaters are sometimes placed at the seams of the headledges of the centerboard case.

The methods of forming the forefoot have been discussed in the first chapter, page 40. The block method shown in Plate 22 is one of the many possible variations in construction. Since the forefoot block should be set up with the keel, the variations will be described now. The construction of the forefoot block is decided by the design of the bow and the size of the timber available. The keel batten may be notched into a single block, on which the stem is stepped in a notch or tenon in a very small boat. In a larger boat, where it is not practical to make the block of a single piece, two or more blocks may be doweled together to form the unit. In some craft having a heavy-shaped timber in lieu of a keel batten, this timber is carried to the rabbet of the stem by notching its end to receive the stem timber or by notching the latter to receive the keel. The two side blocks are doweled to the sides of the keel with oak pins and the whole is hewn to shape. The side blocks are then given additional fastenings, usually nails. This is the most common forefoot-block construction, seen in Chesapeake Bay V-bottom craft. The height of the block in these craft is fixed by the height of the bottom of the chine log. The latter is edge-fastened to the blocks. In some craft, however, the block is carried to the top of the chine logs and is notched along the sides to receive them. The disadvantage of the block forefoot is the exposure of end grain in the blocks, which eventually leads to rot.

Knightheads and Hawse Timbers

Plate 22 shows the "knightheads." These timbers are rarely seen in small craft. They are used in large craft for two purposes: to give additional backing to the planking just abaft the stem and to add strength to the bowsprit. In most craft they may be made of thick plank, shaped in more or less of a triangle and edge-fastened to each side of the stem with spikes or drifts. Their length is decided by the shape of the bow and by the sections of the hull immediately abaft it; knightheads should be carried as low into the hull as the timber and these limitations permit. The top of the knightheads is the underside of the rail cap or the top of the bowsprit in most craft, but occasionally the knightheads are carried higher and their tops exposed. This is the old-fashioned way and has no particular advantage except tradition and perhaps appearance. Knightheads of this description are still to be seen in some Bugeyes and Skipjacks on the Chesapeake. They are inclined to rot at the top, due to the exposed end grain, unless capped with wooden blocks or sheet metal. In small craft the knightheads are usually wide enough fore and aft to take the hawseholes, or the hawsechocks. In large craft, however, additional knightheads are necessary; these are called "hawse timbers" because they back up and support the hawsehole castings or chocks. They are made of timber the same thickness as the knightheads and, like them, step against the side of the stem just above the bearding of the forefoot, or against the foremost frame. They are edge-fastened to the knightheads and to each other. Care must be taken to locate the hawseholes before fastening, so as to avoid driving a drift or spike where it will be necessary to cut the hawseholes later.

The thickness of these timbers is fixed by the thickness of the frames in the hull; the sheer clamp must run inside the knightheads and the hawse timbers to the stem, and is fastened to each. These timbers are rather troublesome to fit due to the excessive bevels required at their bottoms and where the knightheads' sides bear on the sides of the stem. They should be well luted before being fastened. In V-bottom hulls these timbers are more easily fitted than in round-bottom hulls, as they step on the top of the chine logs. There is no practical reason for fitting knightheads in a light hull, of course. They are required in power hulls that will receive hard blows around the stem, as in tugboats and fishermen. In hulls that are very full in the bow, so that there is little space between the middle line and the bearding line of the rabbet on the bow, the knightheads give a better chance to fasten the planking to the bow. However, a stem apron fitted to the after face of the stem in about the same manner as the keel batten is fitted will serve the same purpose if made wide enough. Hence the use of these timbers has been reduced to those vessels having long or heavy bowsprits, or large enough to require support to the hawse.

Keel Types, Light Keels

Plate 23 shows the types of keels most common in small light craft, such as are usually built by home builders. The dinghy keel is made of a single timber on edge backed with a batten, or is made

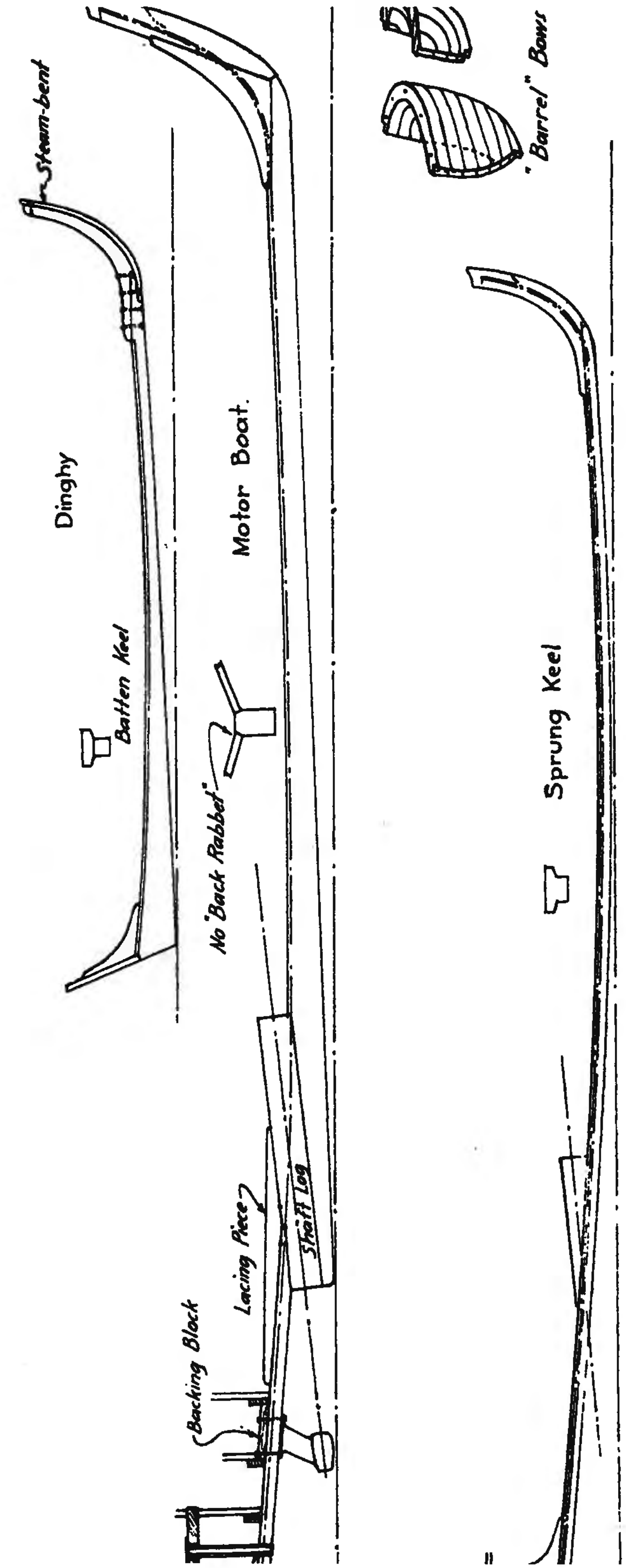


PLATE 23. *Common Light Keel Construction and Details*

of a timber of sufficient thickness to be rabbeted. The stem is made of a hackmatack or oak knee, usually in one piece if possible. The transom or stern is secured with a knee to the top of the keel structure. Power launches and cruisers usually have similar keels, but of greater width. Because of the greater length, keels of many powerboats are scarfed; the design should show how and where. In Chapter Two the lengths for scarfing are given. However, the rule is not strictly followed as conditions in a boat keel are not those of a simple beam. The line of a scarf is usually less than 13 degrees to the top or bottom of a timber. In the deadwood, laps or scarfs are often shorter since the necessary strength is obtained by the laminations of the structure. In this part of the hull the laps or scarfs are usually made long enough to permit two or three fastenings to be driven. Laps are usually longer than scarfs in the keel as there is generally less depth of timber involved.

Lacing pieces, which are merely long butt blocks, are used where there is not enough length to form a proper scarf or lap; a lacing piece is shown at the shaft log in the motorboat keel in the plate. Struts for the shaft are usually backed by blocks if the keel is lacking in thickness or depth. In boats having garboards over 1 inch in thickness the rabbet of the keel is sometimes omitted; the top edges of the keel are merely beveled to form the bearing for the edges of the garboard and there is no backing along the keel, and no bearding, of course. This is not very strong construction theoretically, but in practice it seems to work satisfactorily in hulls that have no outside ballast casting or excessive depth of keel outside of the rabbet line. It is not advised for centerboard hulls. The sprung keel is very popular in small or light boats. It may be in one piece, rabbeted, or may be laminated with the top piece forming a keel batten. If the keel must be scarfed due to the lack of timber of sufficient length, it is better to laminate than to attempt to make a proper scarf. If it is thought that the setup will not stand the strain of bending the sprung keel shown in one piece in the plans, lamination is the obvious alternative. Put on the laminations one at a time and fasten together with screws or nails between the molds. The usual method of fitting the shaft log in this type of keel is shown in the plate. A shaft tube is desirable. Lute all joints as the keel is assembled.

Keel Types, Heavy Keels

The keel structure of a heavy sailing cruiser is shown in Plate 24. The drawing is sufficiently complete to require little explanation. The heel of the sternpost is tenoned into the top of the keel. This is done to prevent the swelling and shrinking of the wood from opening the joint. The tenon is locked with a dowel driven athwart the keel. Usually this is of wood, but metal pins are also often used. The drawing shows the strongest method of building the horn-timber, or keel of a counter. Some designs show the horn-timber set on top of the after deadwood and drifted to it. This is a very poor method of construction as the drifts into the end grain of the deadwood do not hold well. If the design is for a sailing boat, the strains on the counter are great enough to make this method wholly unsuitable. The cheeks of the horn-timber in the plate were to be through-bolted with carriage bolts, through the deadwood. The drawing is supposed to show the whole structure, except the horn-timber, split lengthwise along the center line. The filler of the horn-timber often forms the outside keel of the counter, with the cheeks acting as the back rabbet or keel batten.

Keel Types, Fin Keels

There are countless variations of the basic types of keel construction, but the design being built from will show the required details. There are two special types, however, that are often used in sailing craft and which differ from the types already described. One of these is the fin keel. The hull of a boat having this type of keel may have a sprung or shaped keel, in a single timber, or laminated. The fin is made up of small pieces of timber edge-bolted and there is usually a ballast casting attached. The fin is attached to the hull with long through-bolts, usually passing through keel and floor timbers. The bolts are staggered athwartships or are raked, and each floor timber takes a ballast bolt and a floor bolt opposite it. This construction is necessary because of the strains set up by the deep fin. It should be added, perhaps, that these strains are not very great when the boat is under sail, unless the vessel is large; the greatest strains are set up when the boat goes aground or is hauled out for the winter. The serious disadvantages

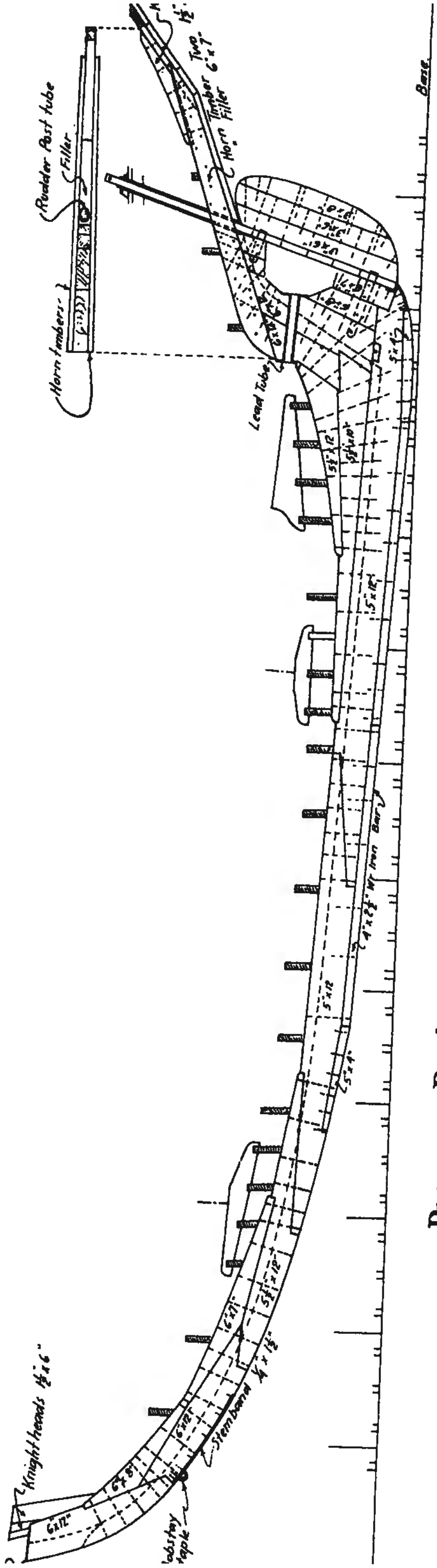
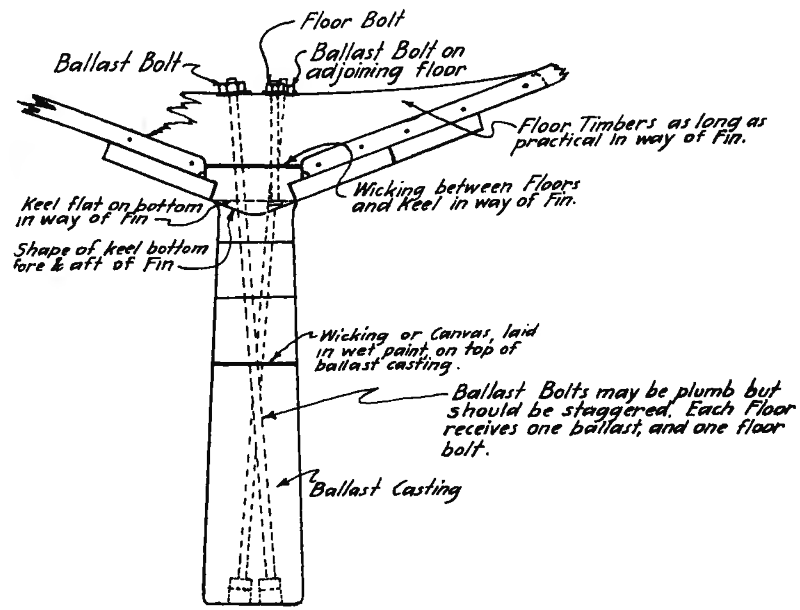


PLATE 24. *Deadwood Plan for a 41-Foot Schooner (Bent Frames)*

in bolting through the floor timbers are the difficulties in boring the holes for the ballast bolts in correct line and angle, and in stopping the leaks that usually appear under the floor timbers. These leaks are caused by water getting into the boltholes through the sides of the fin and leaking into the boat through the seam between the floor and the keel. This can only be overcome by careful fitting and proper calking.

It is very important that the keel bolts be tight fits in their holes,



53. Fin Keel Construction; See Text

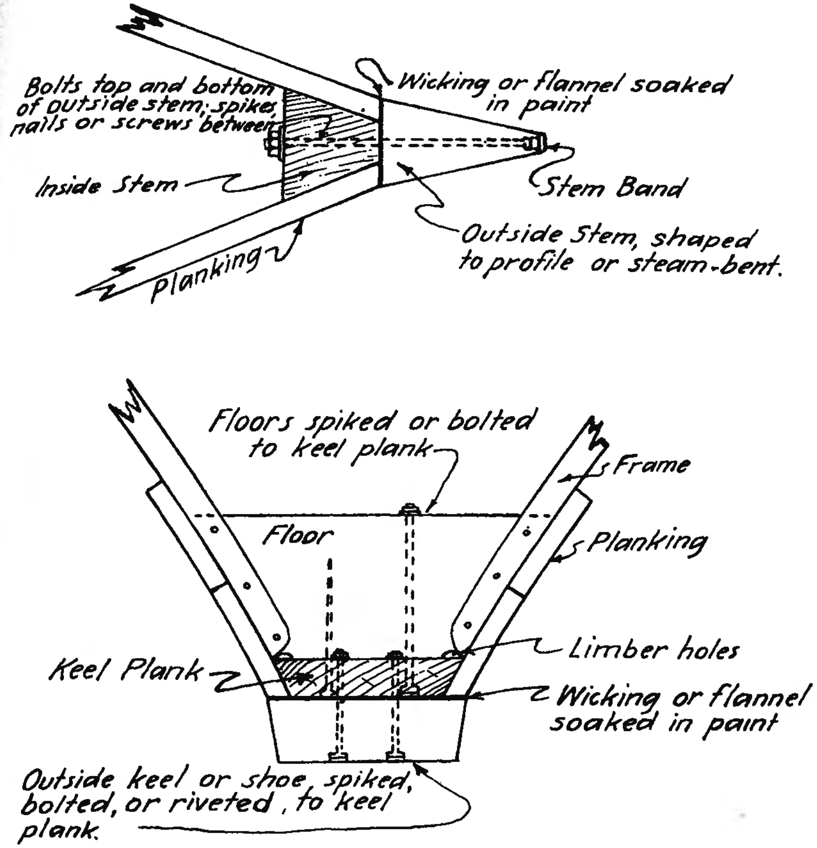
but due to practical difficulties in boring this is not easy to accomplish, except on paper. For that reason it is wise to place wicking or flannel saturated with paint under each floor timber before fastening it to the keel. The ballast bolts should have lead or cotton grommets at head and nut, under the washers. The top of the ballast casting is difficult to calk, so it is a good plan to put a sheet of wicking or canvas impregnated with paint between the keel casting and the wooden fin, before boring for the ballast bolts. All seams in the wooden fin, and between it and the keel, should be well calked; it is a good plan to lute the pieces making up the wooden fin before bolting it together. The wooden fin is most easily assembled by edge-bolting the pieces together in a unit with short drifts or spikes, taking care to keep clear of the places where the ballast bolts will be bored. The heads of the ballast bolts should be well countersunk in the ballast casting and plugged with cement or lead, or even wood.

In a well-designed fin-keel hull, the floor timbers are heavy in proportion to the size of the boat and are carried out to the sides as far as is practical. The keel forward and aft of the fin is usually faired off and the fin is streamlined. In some designs the top of the fin is shaped out of thick stuff so as to fair into the bottom athwartships. This shaping will have to be done with a large gouge and a hollow plane. A template should be made for each station in the way of such a molded timber, in order that the proper shape may be cut, and both sides of the fin be alike.

There are a number of designs having metal fins, such as the well-known Star Boat. The tops of these fins have a flange which should be let into the keel until it is flush. The use of a piece of saturated canvas between the metal and wood is also important here. The fin bolts pass through the fin and keel, sometimes through the floor timbers as well. Occasionally a design is seen in which the fin is made with a metal plate without a flange; avoid these, as it is quite impossible to properly fasten such a structure.

Keel Types, Plank Keels

The plank keel is another special type used in sailing craft. This form of keel is practical when there are very hollow garboards, the latter standing almost vertical in the midsection. If the keel is to be wide enough to allow proper fastening, the plank keel is easy to build. It is really a laminated keel, as will be seen in the sketch. Keels of this form are sometimes seen in deep centerboard hulls. The best way to build a boat having this form of keel is upside down. The molds having been set up, the inner keel is first put in place. The floors are spaced off and secured to the keel. The hull is then ribbanded and framed, and a garboard is clamped in place, its bottom cut flush with the bottom of the inner keel. After both garboards have been fitted, they are nailed in place and then the outer keel is bent and secured over the inner keel and the raw edges of the garboards. This is a cheap, strong construction and



54. *Two-piece stem, and below plank keel construction used in light hulls having "hollow garboards," either keel or centerboard, inside ballast.*

was used at one time in the old Tancook Whalers of Nova Scotia. It is also used in some small fishing craft in the United States. Canvas or wicking saturated with paint should be placed between the inner and outer keels. The plank keel is not suited to boats having outside ballast.

Laminated Stems

In some cases it is easiest to build up a stem, or a sharp stern, in two pieces, to avoid the labor of rabbeting. The inner stem is set up on the stocks and the hull planking allowed to run by it.

When the planks are secured, each plank is sawn off flush with the face of the inner stem. It is best to do this as each plank is fastened in place, not to wait until the boat is all planked. A piece of saturated wicking, flannel, or canvas is then put over the face of the inner stem and the raw ends of the planking. It may be held in place with a few copper tacks. The outer stem is placed on the inner stem and fastened with through-bolts, screws, and nails. This is the stem used in many flat-bottom hulls. It may also be used in round-stem hulls; the inner stem is cut to shape and the outer stem steam bent and put on cold. This is the practice followed in building the stems of the Jonesport Peapods, some Hampden boats, and many strip-planked hulls. If done with reasonable care, there is no serious objection to such construction.

Keel Types, Heavy Timber Keels

Plate 21 on page 185 shows the keel structure of a heavy and large hull. It will be noticed that the horn-timber is built in the same manner as that of the smaller hull in Plate 24 on page 206. The rudder port or well is built up like a centerboard case. The round stern is shaped with a laminated frame or "grub beam," or may be made of short, heavy timbers as shown in the plan view. There are really two sternposts; the inner is carried up to deck and tenoned into a block let in between deck beams, or is notched into a single, heavy deck beam. The outer post that supports the rudder is called a "prick post" and is also carried to deck. It forms the forward ledge of the rudder post well. Both sternposts are either tenoned or dovetailed into the top of the keel. The frames are sawn, of course. The drawing shows the detail of a frame in the bow or stern fitted with a strongback in place of a floor timber; this construction is used in the so-called "cants" (that do not actually cant or set at an angle to the center line of the hull) in modern wooden hulls. The strongback passes over the deadwood and is only necessary where great strength is required. The plate shows a strongback at every cant, except those in way of the sternposts; this is unusual, as strongbacks are generally placed only on every second or third cant frame. The keelson is laminated; if it had to be sprung, this is the best way to build it. All heavy fore-and-aft members—for example, the shelf and clamp—in such a boat as this can be laminated also.

The keel and molds are now set up on the stocks and the ribbands are in place. Before describing the framing and planking of a round-bottom hull that is the example of construction, the succeeding two chapters will be devoted to flat- and V-bottom construction. Before leaving the keel structure, however, a few remarks and suggestions are in order.

Remarks and Suggestions, Timber

In ordering timber for the keel, in fact for the boat at all, insist on air-seasoned stock rather than kiln-dried stuff. If air-seasoned stock is not available, as it probably will not be, it is better to accept the partially unseasoned stock received directly from a sawmill. Kiln-dried stock will swell and shrink very markedly and will therefore cause great difficulty in a boat after she is completed. If the boat is built under cover, kiln-dried decking can sometimes be used to advantage, however. If the home-built boat is small, the timbers will not be large and the partially seasoned timber from the mill will dry out quite fast. Another matter of importance in ordering timber for the keel is how it is sawn. This is not of great importance in very small boats or those having laminated or built-up keels, perhaps, but in a boat having a long keel in a single timber be careful to order that the "heart is to be boxed." A boxed heart timber has the heart of the tree inside the stick. A timber of this description will not take a "cast" or become permanently crooked when seasoning; neither will it "cup" or become bent across its greatest width. Nothing is more troublesome than a keel which is not straight and it is very difficult to spring a crooked keel into the stocks.

Marking

Another thing that is important: do not scribe the face of a timber (such as the face of the stem, or the top or bottom of the keel) along the grain with a timber scribe, scratch awl, or other sharp instrument. Such a scribed line will often start a severe check, particularly in green oak. It is safest to do all marking on the keel and other timbers of a boat with a carpenter's pencil.

Breaking Auger

If an auger breaks when boring a deep hole do not become upset. A good many boats have an auger bit serving as a drift in their keels. Many a bit has been broken after it has pierced two timbers; drop a clench ring over the broken end, cut off the projecting shank, and rivet the head. If the bit breaks inside the hole, draw out the remaining portion of the auger and fill the hole with hot tar or tallow and put a wooden plug in it. Then drill a new hole.

Drift Stuck in Hole

If a drift bends and cannot be drawn, cut it off, plug the bottom of the hole if it is for a through-fastening, and drill a new hole. These are accidents that happen in every yard or boatshop and are not the sole property of amateur builders. Through-fastenings can usually be driven out if the bolt fails, but even here it is possible to find that the fastening cannot be removed.

Graving

If there is a bad knot in a large timber, yet it is not so large as to seriously weaken the stick, cut it out with a chisel and fit a square or rectangular block into the hole. Make sure the bottom of the block is in reasonably close contact with the bottom of the hole. Pay the hole with luting or with hot pitch and drive in the block, fastening it with a few nails. This is called "graving" and is a form of patching that should be done more often than it is. A bad knot or damaged spot will be a fine place for rot to start if not graved. In oak it is not uncommon to find that what appears to be a small soft knot on casual inspection is a serious amount of rot when opened up for graving. Therefore, cut for graving before going to the labor of shaping a stick. In selecting a stick look at the knots, probe them with an awl or bore a small hole, and look at the ends for checks or "shakes" that indicate damage to the timber. Pitch pockets in yellow pine are not objectionable unless they are very large and deep.

Clear Stock

In choosing stock for the keel and heavy timbering do not expect to get all clear stock. This is a favorite specification with some designers, but, if followed, would result in a fortune being spent on timber; and then the boat would last no longer than one built of timber having a few knots, if reasonable precautions were taken. Perfection is easy to demand but very, very difficult to obtain. Long timber, clear of knots and perfectly sound, is something that exists largely in imagination, not in boatshops or yards.

Paying and Preservatives

Be careful to pay all joints in the keel and to plug all unused holes made by temporary fastenings or accidental drilling. Due to the lack of well-seasoned timber, many builders paint the keel and deadwood inboard of the rabbet with creosote or other wood preservatives. Care should be taken not to get the creosote outside of the rabbet on the stem and stern above the water line as paint will not cover it well. If an accident should happen, wipe off the creosote at once and put a little aluminum paint over the spot after the creosote has dried. Creosote is rather dangerous to handle; do not get it in your eyes.

Squaring Molds or Frames

In setting up molds and sawn frames, the method of squaring to the center line used by old-time builders is worth knowing. A nail is driven on the center line on top of the keel a few feet away from the mold or frame. A measurement is made from this to the sheer or a water-line mark on the mold or frame on one side, then checked against the mark on the opposite side. If the frame or mold is square to the center line the two measurements will be the same. Many builders do not cut the rabbet in the stem until the ribbands are being put in place; then each is notched into the stem at the proper bevel. These notches are then joined with a faired rabbet, cut with chisel and slick. There seems to be no particular advantage in this, compared to cutting the rabbet before setting up, if the loft work is done with reasonable care.

Checking

If a boat is built slowly, it is probable that the keel timbers will check somewhat; painting with orange shellac will prevent serious damage. If the checks are large enough to warrant filling, use deck-seam compound or luting; do not use anything that sets up hard and so prevents the wood from swelling tight again. The practice of filling checks or rents with white lead or putty is occasionally the cause of rot. If creosote is used there is no need to fill the checks.

Boxed Frames

If the heel of the frames are to be let into the keel, "boxed," that is, use a piece of framing stock as a gauge to ensure a reasonably close fit.

Sternpost Tenons

In fitting a tenon for a sternpost, drill athwart the keel, through the mortise, before stepping the post; then mark the position of the hole on the tenon of the post with an awl or pencil. Remove post and bore hole in tenon about 1/16 inch higher. This will cause the pin to pull the tenon into the mortise when the post is stepped and fastened. In a small boat 3/8-inch oak pins, cut long and with a slightly tapered point, should be used.

Fishtail and Gripe Plates

In large boats having a very heavy post, too heavy to handle easily, a dovetail is often used instead of tenon and mortise; it is backed up with two "fishtail plates," one on either side, and the two through-fastened. The top fastenings of these plates are in the post, the bottom fastenings in the keel. The plates should be let in flush. The forefoot of a large vessel is also tied together with a "gripe iron" in the same way. The "iron" takes different forms in each section: in some places the builders use "irons" shaped like wide horseshoes; in others they use circular rings or plates, or fishtails, or rectangular plates. These plates are either of galvanized wrought iron or of bronze, with the riveted fastenings of the same material as the plates.

Centerboard Slot

The method of cutting the centerboard slot has been mentioned; in detail, it is to bore a few holes at one end of the slot and, with a chisel or slick, open up the holes enough to permit sawing. With a ripsaw, saw down the line of the slot on both sides, working alternately from top and bottom of the keel. The use of a corner chisel will give clean ends. The slick can be used to true up and finish the slot. Some builders bore out the slot with a large number of holes, then chisel and saw. This is a good plan with thin keels, such as plank or sprung keels.

Close-Fitting Timber

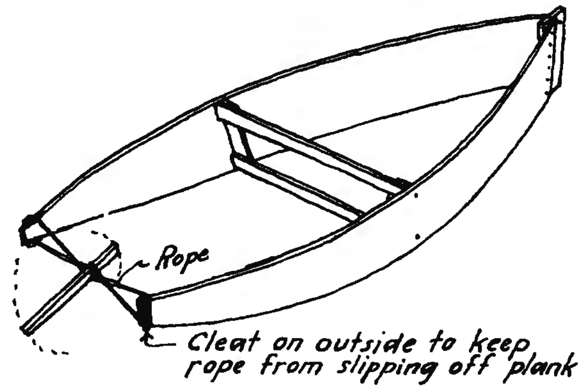
If a really close fit is required between two timbers, chalk one face of the joint with blue carpenter's chalk and join; when separated, the chalk deposited on the piece not chalked will mark the high places that need to be planed off. Builders of boats are ingenious and it would pay the amateur builder to watch some professional builders at work, as there are countless tricks of the trade.

CHAPTER FOUR

FLAT-BOTTOM HULL CONSTRUCTION

Building Methods

THERE are two ways to build flat-bottom hulls. One is to build "by guess and by God"—without plans. This is the method used by many skiff builders. A middle mold is made up with flare of sides to suit the builder's ideas; then a stem is made. Next two planks of sufficient width and length are cut to a suitable shape, for the sides. These are fastened to the stem, the middle mold inserted, and the two planks bent together at the stern with a rope made in a loop with a staff inserted and turned, as a Spanish windlass. The transom is cut and fastened, the ends of the planks of the sides sawn off, the bottom edges beveled, and then the bottom is cross-planked. A middle thwart or two is fitted and the center mold removed. With a dash of paint the hull is considered complete. Now this method turns out good boats—but only after a lot of experience. By trial and error, the builder learns how to cut the bottom of the side planks, either before they are fastened to the bowpiece and bent around the middle mold, or after. He also knows how to cut the sheer, but these rule-of-thumb dimensions only work when a fixed amount of flare is used for every boat the builder turns out. For this reason no variation in shape can be figured. There is no rule of proportion that will be practical to apply when flare is varied. It is obvious, then, that this method is not suited for amateur building, except in the roughest and most hurried construction. It should be added, however, that in some cases it is possible to build from a design by this method, if the shape of the sections permits the expansion of the side planks or if a half-model is made



55. Spanish Windlass

by which the sides may be expanded to scale. In most yacht construction, however, the flat-bottom hull constructed from plans must be built on molds and a set of stocks, like any other type. This second method is the best from all points of view. It permits the variation in model that makes building interesting.

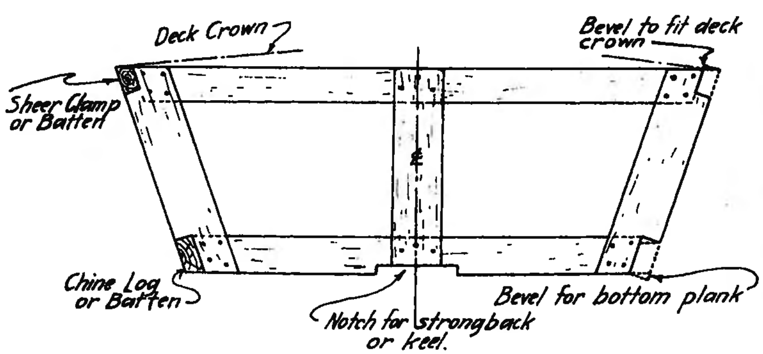
Importance of Good Design

The qualities of the flat-bottom type of hull have been discussed and so need not be dwelt upon again. For certain conditions and purposes there is no better type, in spite of the rather widespread prejudice against it. As in all other types, the excellence of a flat-bottom hull depends wholly upon the excellence of its design, careful building being assumed. Much of the criticism of flat-bottom hulls can be traced to an unfortunate experience with some poorly designed example.

Lofting

Assuming that a design has been found that appeals to the builder and fits the specifications of model mentioned in the chapter on plans, the first step is to loft the plans. The principles of lofting that were explained in the chapter on this subject will, of course, apply. As there are only two fore-and-aft fairing lines, the sheer and rabbet, and as the sections are usually straight sided, there is little work involved in laying down the lines. Do not permit this to lead to slighting the job, however, and it is well worth while to work out the construction drawing on the loft plans. If the sides of the boat are to be curved in section, the design will show how they are to be faired (beware of one that doesn't). Usually this is done by striking diagonals through the topsides in the body plan and then fairing in the half-breadth; in rare cases water lines are introduced. No buttocks are required and in the smaller and more simple designs there is no keel; in large craft there must be some form of keel, which will be detailed in the design.

After the lines are laid down and the body plan faired, the thickness of the planking and deck is struck off, on each section.



56. Typical Mold, Showing Fitting of Clamps and Logs

If the design calls for sheer clamps and chine logs these must be laid off on the sections so that the molds may be properly notched. These members are rectangular in section when roughed out, remember, and so will require a moment's thought. The top of the chine logs, and of the sheer clamps, will not parallel the bottom of the hull athwartships unless they are beveled, because of the flare. The outer and bottom corner of the chine log and the outer and upper corner of the sheer clamp must form the respective lines of chine and sheer at the inside of the planking. It is usual to cut the notch for the sheer clamp square to the sides, the depth of the clamp being taken at the inside of the side planking from the sheer. This brings its outer and upper corner to the sheer line at inside of planking and the top may be beveled off

after the sides are in place. The chine cannot be fitted in this manner; the thickness of the chine log is first laid off parallel to the flaring sides, and where the line of thickness crosses the inside of plank line of the bottom as a beginning point the required depth of the chine log is set off. A line through this square to the side of the hull is the top of the chine log. The bottom of the chine, at the outer and lower corner, will project beyond the correct chine line at inside of plank and can be beveled off before the side planks are in place, or both side plank and chine logs can be beveled together before laying the bottom plank. If a fine finish is desired, the top of the chine logs is beveled so as to parallel the bottom; this is particularly desirable in an open boat as it prevents water lodging on top of the chine, in the angle formed by it and the inside of the side planking. If there is no chine log or sheer clamp it is a good plan to loft battens in their place and to notch the molds for them. These battens will help a good deal in shaping and beveling the top and bottom of the side planks.

Picking Up, Molds, Bevels

The picking up of the stem, stern, and keel and the building of molds have been described in the chapter on lofting. The rabbeting of the stem should be lifted from the loft plan and the expansion of a raking transom should be developed there; there is no more reason for "try and fit" construction in a simple flat-bottom hull than in an ornate round-bottom cruiser. The number of molds required is governed by the shape of the boat. Experience is the only guide in deciding on a minimum number; it is safest to make a mold for every station shown in the loft body plan. The making of the molds for flat-bottom hull construction is too obvious to require explanation. Four or five pieces of timber will be used in each mold; be certain to get the molds strong enough. Where possible, a bulkhead should be utilized to take the place of a mold. This saves bother in fitting a bulkhead later and ensures a stronger boat. The bulkhead can be laid out in the loft plan and made to the proper fit and bevel without difficulty before setting up. The bevels of a flat-bottom boat can be lifted directly from the loft plan with an adjustable bevel, using the bottom or chine line in the profile, and the sheer and chine in the half-breadth plans.

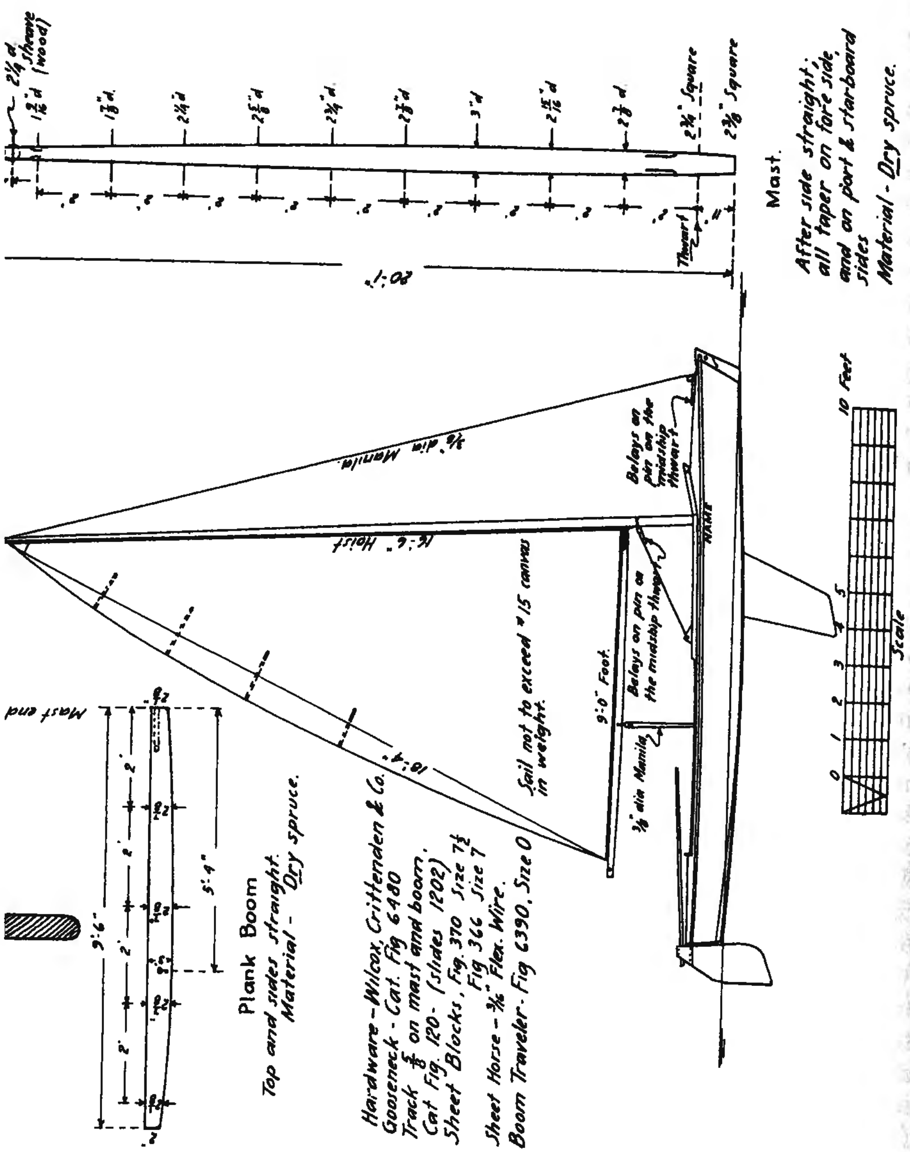
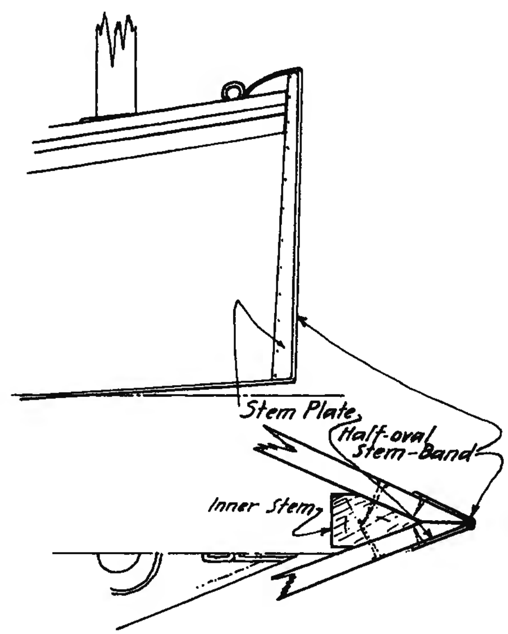


PLATE 25. Sail Plan for a 16-Foot Hampton Flattie

Stems

Stem construction in flat-bottom hulls varies a good deal. The most common in yacht designs is the regular rabbeted stem. In some cases the laminated stem is used, shown in the cut on page 209. Another variation of the stem is the "New Haven style." This is made without an outside stempiece and is best suited for straight stems (without any curve in the profile). The inner stem is a piece of oak, triangular in section. The sides are cut with mitered

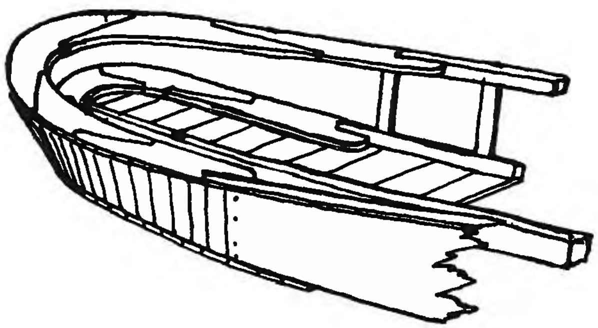


57. New Haven Stem Construction

ends and are fastened to the inner stempiece with screws or nails. The miter permits the ends of the plank to form the sharp edge of the cutwater. This is covered with a sheet of brass bent to form an acute angle and secured to the planking with brads or countersunk screws. By shaping the brass in two pieces and brazing these together it is possible to build a curved stem in the same manner. This form of brass cutwater was once popular in high-speed powerboats, though built with rabbeted stems. The brazed plate is rather troublesome to build, however, if for a curved stem. When the brass cutwater is used, its after edges do not parallel the line of the face of the stem in profile; the top, at the sheer, does not reach as far aft as does the bottom, at the chine.

Sterns

The three common sterns in flat-bottom boats are the transom (either plumb or raking), the sharp stern, and the round stern. The transom stern has been discussed in the chapter on lofting. The sharp stern is made like the bow. If the rabbet is straight, it is little trouble to fit the side planking in one length into both the bow and stern when these are set up on the stocks. If the rabbet is curved in both stem and stern, there is usually some difficulty; if only one is curved, fit that first and the end with the straight



58. Round or Elliptical Stern Frame

rabbet can be easily fitted afterward. The round stern can be made actually round, viewed from above, or in a flattened or sharpened ellipse. The stern in profile is usually given a sharp rake and makes a very handsome finish. The construction is not difficult, if understood. In the loft plan the shape of two frames, one horizontal at sheer level and the other at the slant of the chine in profile at its level, are laid out. The frames at sheer and the chine are expanded and beveled on the loft plan, following the general principles given for expansion of transoms. The forward ends of these frames are laid out so that they may be fastened to the chine logs or to the sheer clamps, as their position requires. The side plank is run as far aft as the shape of the half-

breadth of the hull permits, without having to steam-bend the plank. Beyond this point, and around the stern, vertical staving is fastened, fanwise. To give finish, a piece or two of thin wool is bent around the stern at the sheer [after being cut to fit without having to be bent edgewise (called "edge-set")] and over this a piece of half-oval or half-round oak is bent to form a guard. The drawing shows the appearance of this. Both the strip and the guard must be steam-bent, usually in two pieces.

Keels, Setting-Up

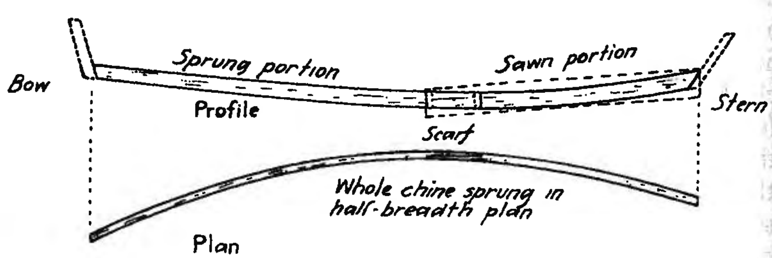
The keel construction will be shown in the plans and must be lofted. When built, it will form a backbone on which to set stem and transom, as well as molds, on the building stocks. Most flat-bottom boats are built upside down, as this is the easiest position in which to plank them. If there is a keel, the stem, transom, and molds may be mounted on it and the whole then secured upside down on the stocks. Any type of stocks suitable to building upside down may be used, and the one chosen should be worked out on the mold loft plan first so that the molds may be made to fit the setup with the minimum of labor. The remarks in the last chapter on placing the molds to allow for bevel should not be forgotten. When the molds are in place, the sheer clamps and the chine logs are fitted and fastened in place. Then planking of the sides can be started. If there is no keel, the molds, stem, and stern are set up on a bearer, or on the shop floor. In the latter case a temporary sprung keel of rough plank may be required. If there is a bulkhead it is set up exactly like a mold, except that it is beveled and so does not have to shift to face a station line. The sheer clamps and chine logs (or the battens in their places) are fitted and fastened, and then the planking of the sides is started.

Building Right Side Up

If the boat is too large and heavy to turn over, she must be built right side up. Such craft will have a keel on which the molds may be mounted. The keel should be supported by posts which can be moved; there must be no fore-and-aft bearer as it would be in the way when cross-planking the bottom. Use as few supports to the keel as possible and utilize shores, under the molds, in their place. Fasten the latter so they can be shifted easily. If the hull is fore-and-aft planked on the bottom, the keel may be set up like that of a round-bottom hull with fore-and-aft bearer. The important consideration in planning stocks for building any flat-bottom boat right side up is to allow enough room under the hull to plank the bottom. There should be not less than 3½ feet between the bottom of the hull amidships and the shop floor. This will give sitting headroom in which to work.

Chine Timbers, Bevels

The fitting of the chine logs has already been described in the remarks on lofting flat-bottom hulls in this chapter. Where possible, an attempt is usually made to obtain logs in one length. However, this is not always convenient, or possible, due to the shape of the boat, or its length. If the vertical curve is moderate, it is usually possible to edge-set the chine logs enough to give the proper curve. If this is not practical, then the logs must be sawn



59. Scarfed Chine

to the required vertical curve, scarfed, and bent in the molds to the desired curve in half-breadth. The scarfing of sprung, or sawn, chine logs is generally done with the cut of the scarf vertical; its length is usually about eight to ten times the smallest dimension of the chine log. To obtain the shape of a sawn chine log, clamp or temporarily nail a thin plank on the molds when set up, as though planking was being started. This plank should be wide enough to permit a reasonable length of the chine log to be laid off on it, allowing for the vertical curve of the chine line in the molds. Tick off the lines of the sections represented in each mold and the height of the notches cut for the chine logs in the molds

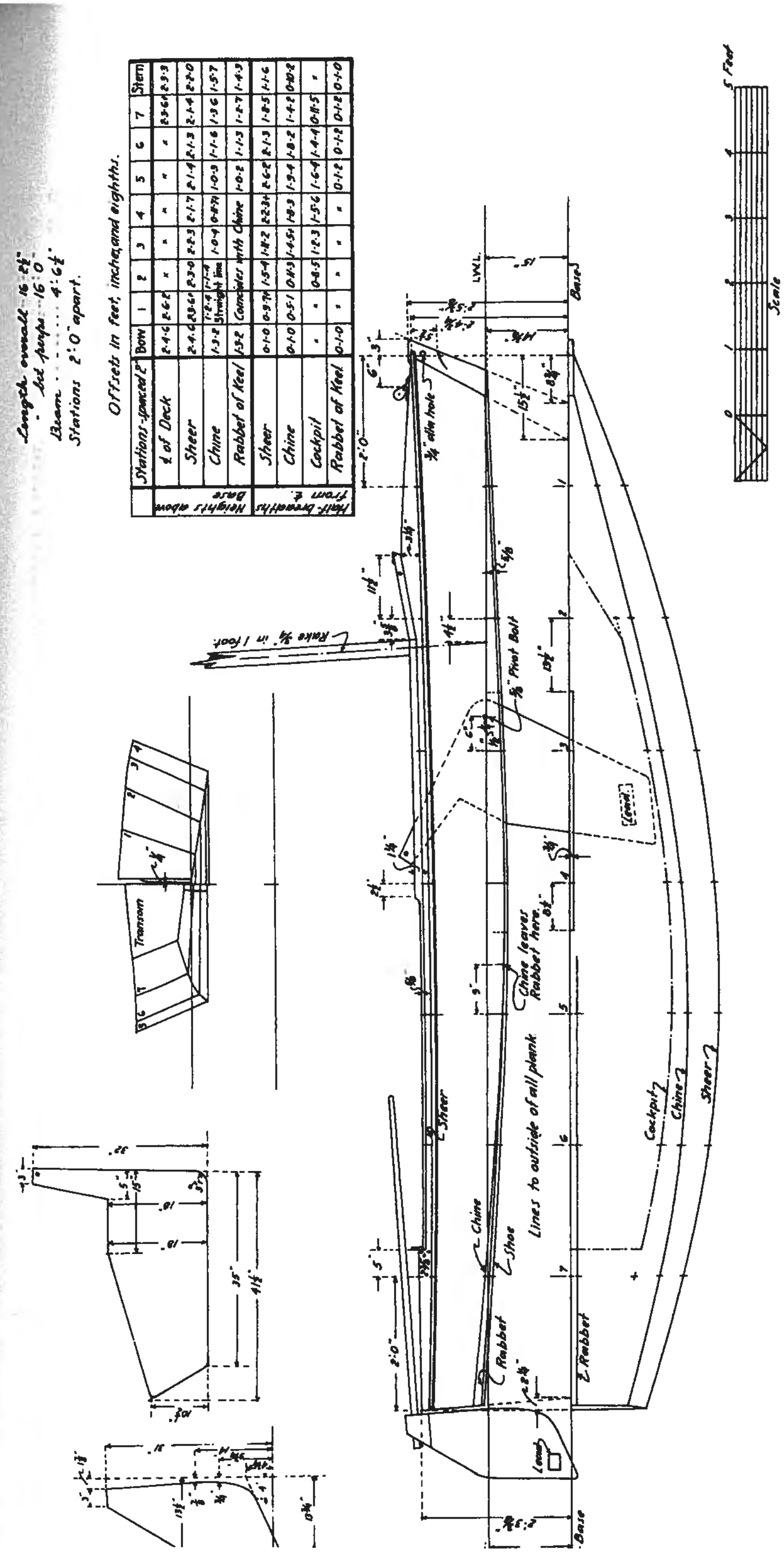


Plate 26. Lines for a 16-Foot Hampton Flattie

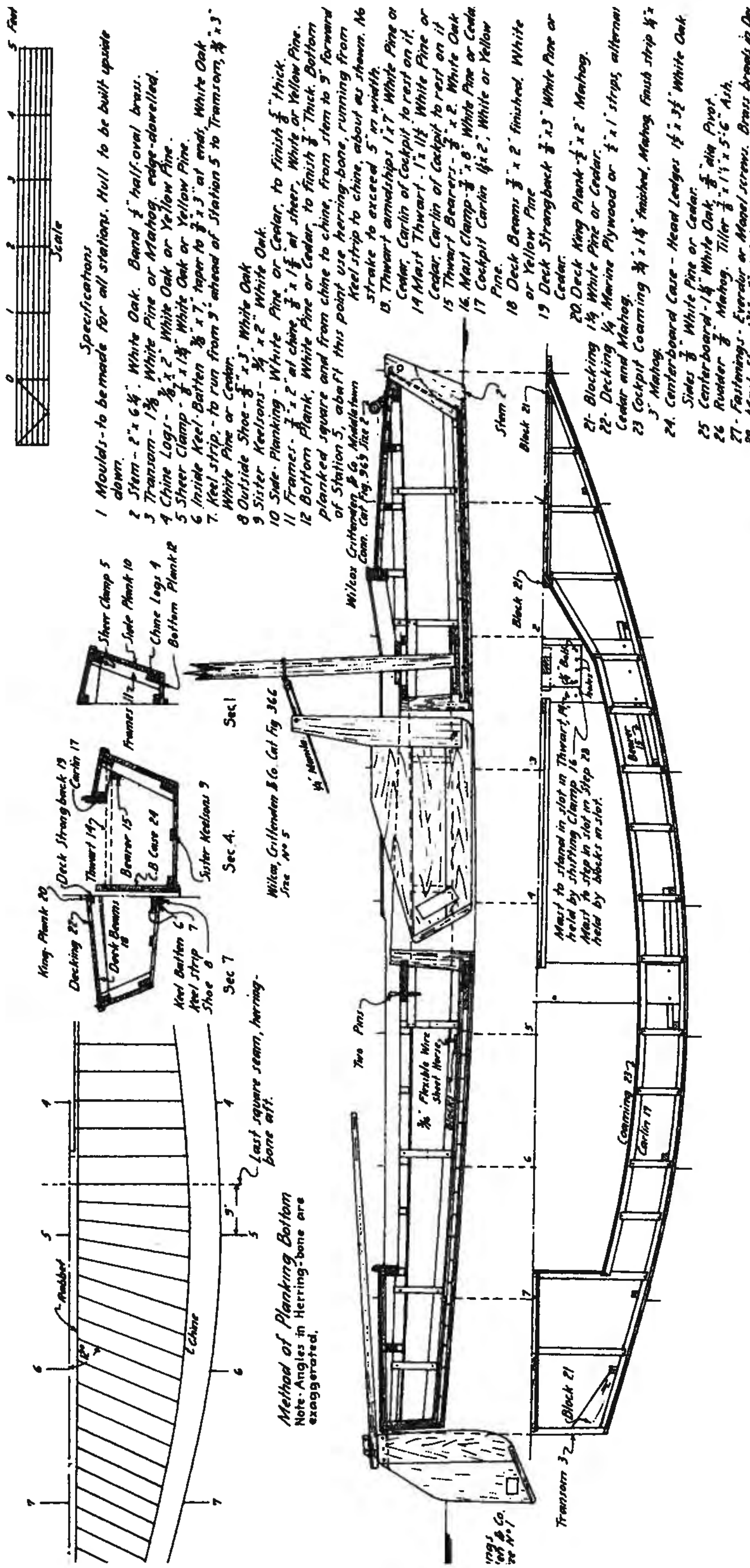


PLATE 27. *Construction Plan for a 16-Foot Hampton Flattie*

on the plank. Be sure to allow for the bevel of the top and bottom of the chine logs. When this plank is removed from the molds, the shape required for the sawn chine log can be obtained by connecting the notch tick-marks with lines swept by means of a batten. When the plank is cut to these lines, a template for the part of the chine logs to be sawn is obtained. If there is a twist, or roll, to the side it is easiest to cut the notches in the molds a little shallow and to bevel the outboard face of the chine logs after they are secured to the molds. If the notches are found to be too deep, shim out the logs when fitting.

In large hulls the whole chine log may have to be sawn, due to its size, but in small hulls the only part requiring to be sawn, as a rule, is the run, from abaft the midsection to the transom. The scarfs in the chine logs are sometimes staggered a little so as not to fall opposite and are well in the middle third of the length of the boat. However, most builders consider this an unnecessary refinement in construction and let the scarfs fall opposite and where the length of material dictates. Unless the boat is exceptionally light in scantling there is really no serious objection to this practice. Laminated chine logs are rarely necessary and should be used only when the flare of the sides is great enough to make avoidable the possibility of bottom, or side, fastenings being driven in the full depth of the seams between the laminations.

Sheer Clamp

The sheer clamp, if one is required, can usually be bent into the notches in the mold without difficulty, as it is ordinarily a lighter timber than the chine log. As a rule, the sheer clamp in a flat-bottom hull is really a batten at the sheer and is between the side planking and the frames. Occasionally, however, the sheer clamp is inside the frames and so cannot be put in until the frames are in place. The setup on the stocks and the details of design must control the sequence of fitting the sheer clamp, in this case. If the sheer clamp is too heavy to bend it should be laminated. Keep the fastenings in the laminated sheer clamp well away from the top where the clamp is to be beveled, and also notched for the deck frames. Single timber sheer clamps should be scarfed in the same manner as chine logs, but laminated clamps need only have the laminations butted and staggered.

Fastenings, Stem and Stern

Both chine logs and sheer clamps should be carefully fitted and secured to the stem and to the stern frame or transom. Screws or boat nails are commonly used in small boats, spikes and bolts in large craft. To secure the chine logs and sheer clamps to the molds, use the thinnest wire nail that will hold. Very often no fastenings are required to hold these members to most of the molds; the spring of their curves will suffice with the addition of a few cleats nailed to the top and bottom edges of the molds. Use as few fastenings as possible, as they will have to be cut when the molds are removed, later. The method used to fit the chine logs and sheer clamps to the stem depends so much upon the individual design that no hard and fast rule can be given. However, the ends of these members are usually beveled, or "snied off," to lay snug against the sides of the stem and may sometimes be through-fastened, with the bolthead and nut countersunk into the log and clamp and the countersink plugged with pitch or luting material. Through-fastenings are sometimes possible at the stern frame also. Care should be taken in placing such fastenings to avoid splitting the chine logs or clamps. Another common condition, at the ends of the chine logs and sheer clamps, is to find that they must butt against the inside of the stem and against a transom plank, without the use of a side frame or cleat. In such a circumstance, no direct fastening between the stem or transom and the chine logs and clamps is really effective; the strength of the joint is obtained by the side planking or by knees. For that reason the members may be held to stem and transom with temporary cleats. Notching the stem for the chine logs and sheer clamps is rarely possible and of doubtful value. The sheer clamps are sometimes secured to the stem by a horizontal knee, the "breast hook," and to the transom by "quarter knees."

Side Planking

The planking of the sides of a flat-bottom hull is usually a simple matter. There are two considerations: the length and width of material available and the shape of the hull, which, with the first consideration, will govern the number of strakes required. As to length, this is rarely of great importance except as far as labor

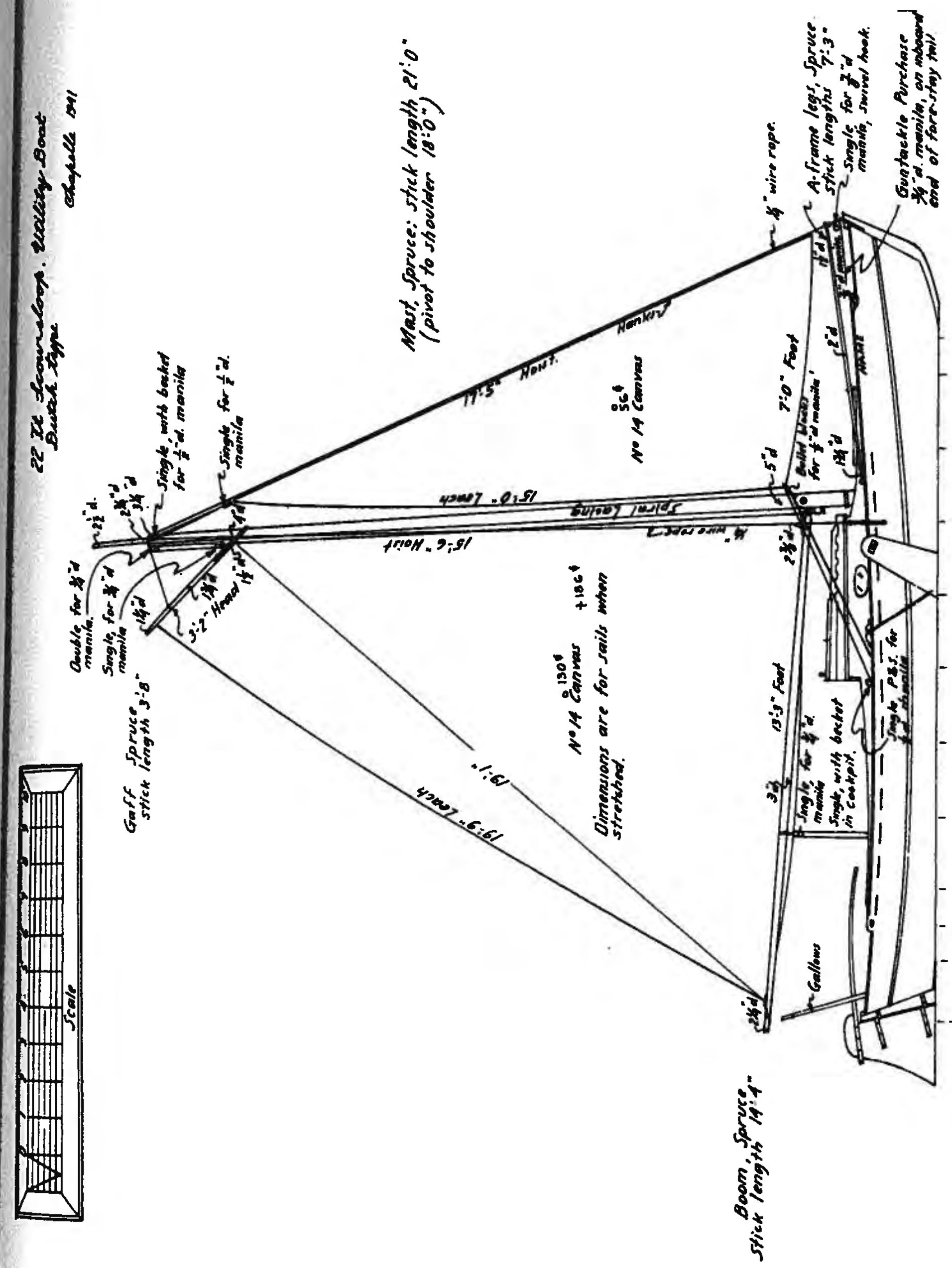


PLATE 28. *Sail Plan for a 22-Foot Scow Sloop, Utility Boat of the Dutch Type*

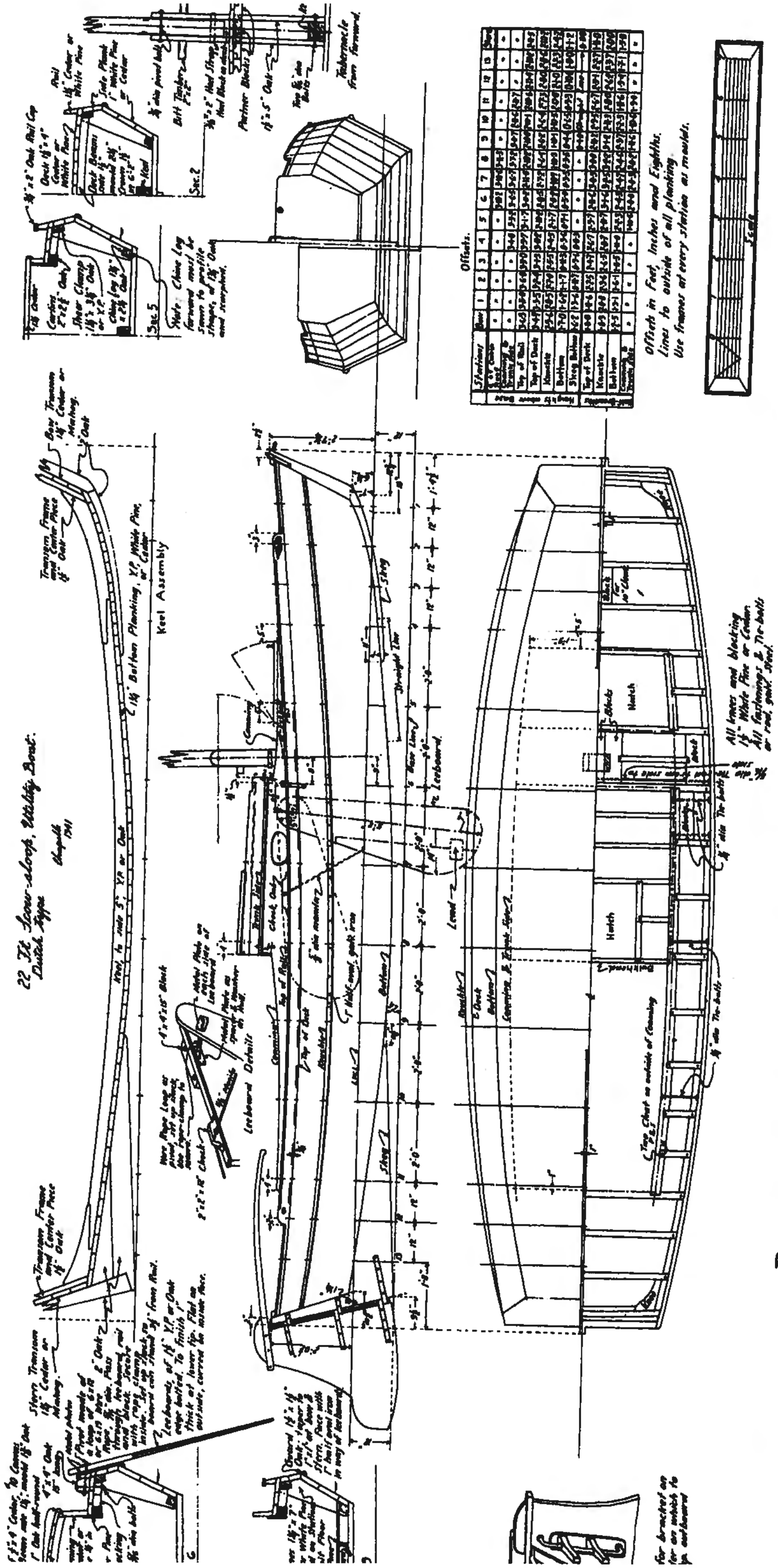


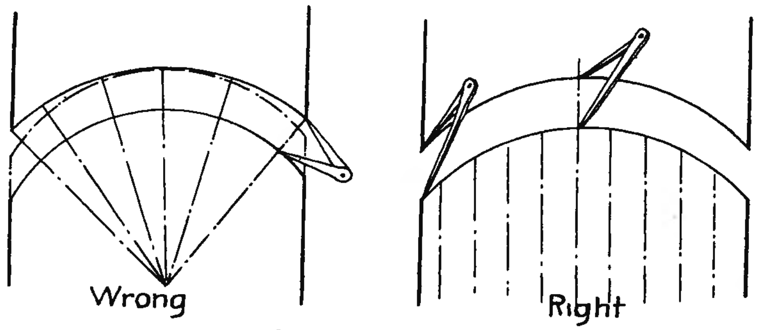
PLATE 29. Lines and Construction Drawings for a 22-Foot Scow Sloop

is concerned. Usually it is possible to get plank long enough to run from bow to stern in boats up to about 24 feet long, without great difficulty. If the hull is longer, the planks will have to be butted or scarfed. The width of the plank is more often a matter of difficulty and it is usually necessary to use two or more strakes to the side, or to piece up the sides at bow or stern to reach the height of sheer there. It is rare to find a design for a flat-bottom hull in which the side planking must be spiled. Boats having lap-strakes in the sides are an example. The rule that governs many builders of flat-bottom hulls is to use as few pieces of plank as possible in the sides, so as to save labor.

Sheer Plank, Scribing Butts

Assuming the hull is not lap-straked in the sides, the first step is to select a plank for the sheer strake, if the whole side cannot be made of a single strake. This must usually be a rather wide plank, due to the combination of sheer and flare. If plank long enough to run the full length of the hull is available, well and good; if not, the length must be obtained by using two planks. The sheer strake is sprung on the molds and shifted up and down until it appears that its position permits the greatest depth possible at the point of the least freeboard, or at the bow or stern. The bottom of the plank should be smooth and straight. The plank may be held in place on the molds by a few clamps to molds, or sheer clamp, or by a couple of helpers. The forward end of the plank should be brought into the bow rabbet as much as possible; it obviously will not fit until it has been cut to the proper shape. The after end of the plank may be allowed to lie where it will for the moment. While it is in this position, the rabbet of the bow must be scribed on the plank so it can be shifted ahead into proper position in the next fitting. In some cases this may be done by use of the compass. This is the art of scribing, which must be mastered by every boatbuilder.

To achieve a well-fitted joint by scribing, the beginner might start by drawing parallel lines on the end of the plank, say, an inch apart and parallel to the lower edge of the plank. Now the compass is opened enough so that, with its point in the rabbet (on the inner or middle line), the pencil point will be able to mark the surface of the plank at the point that the end of the plank is farthest from the rabbet. With the pivot point in the rabbet, and with the compass locked at the opening just described, the curve or straight line of a rabbet may be transferred to the plank by drawing the compass from top to bottom, taking care that it is slanted to the rabbet so that an imaginary line from the point to pencil always parallels the lines on the plank (parallel to the latter's bottom). The most common mistake in both scribing and spiling (the two are practically the same operation) is the



60. Principle of Scribing

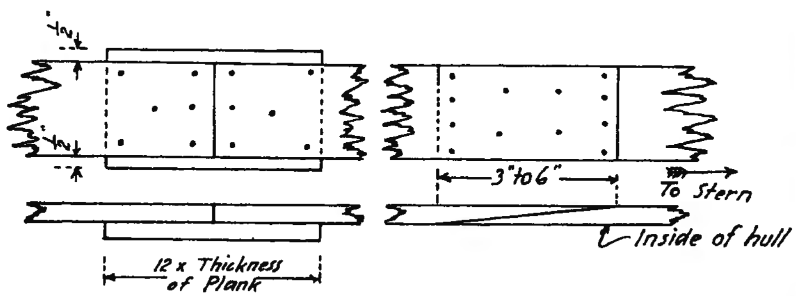
tendency to keep the compass line (point to pencil) perpendicular to the *arc* of a curve, as it is drawn along such a curve. If the arc of the curve of the rabbet were on a true radius, it will be apparent that scribing with the compass line (point to pencil) perpendicular to the arc would result in a scribed line, not of the same radius, but of a smaller one which obviously cannot fit (see cut).

When the end of the sheer plank or "strake" is scribed, its position is marked on the molds and the plank is removed; the end is then cut to the scribed line. If the rabbet line is straight, the scribing can be done by laying a 2-foot folding rule with one edge in the rabbet, or along its outer line, and the other on the surface of the plank; draw a line along the edge of the rule on the plank and this is the proper cutting line to fit the stem rabbet. When the end of the plank is cut and smoothed, it may be checked against the rabbet by holding the plank in its former position. This will prove the cut and also verify the angle of the rabbet. If any adjustment is needed it will be obvious now.

Now the plank is clamped into place, making certain that its

end is snug in the rabbet of the stem, and that it is in its former position in regard to depth. A line run along the top of the sheer batten or clamp can now be drawn on the inside face of the plank; this will be the line used to cut the sheer line in the sheer strake. Now note this. The pencil line must be drawn so that it will stand above the actual sheer on the inside of the plank (which is the upper and outer corner of the sheer batten or clamp) to allow for the bevel that will have to be cut there, in order to lay a deck, or washboard, or rail. The amount of flare to the sides will govern the bevel, of course. If the sheer batten or clamp is the same thickness as the planking, then its upper and inboard corner can be used as the guide line and the marking pencil held in a level or horizontal position while marking. Otherwise it is best to scribe with a compass, with the amount allowed for bevel picked off the loft plan or obtained by careful measurement from the work. If the boat has a transom and the plank runs by it, it will be enough to reference the end of the sheer, leaving the extra length to be cut off at the proper angle and bevel after the plank is secured and fastened in place. The plank is now removed and cut to the marked sheer; one sheer strake is now ready to be fastened in place. Use this as a template to get out a duplicate. When both are ready they may be fastened in place. It is best, usually, to fasten the plank to the stem, along the "bearding" (between the inner or middle line and the bearding line of the rabbet). Care must be taken that the plank is snug in the rabbet and sprung enough, around the molds, to ensure that it is set in the proper place and that the cut sheer of the plank stands above the actual sheer line on the molds, at the inside of the plank, sufficiently to allow for the bevel to be cut later. The plank may now be fastened, working from forward aft, to the sheer clamp, and temporarily nailed to the molds. When the transom is reached the plank may be sprung in by hand or by a Spanish windlass until it bears; after it is fastened, the overrun of the length is then cut off at the proper rake and bevel, so that the end of the strake is flush with the face of the transom.

When one sheer strake is in place, its opposite is then fitted and secured. If the strakes must be in two lengths their butts must be fitted when both lengths are clamped, or secured, in position. After the forward one of the two is cut, duplicated, and secured, the after is likewise marked, cut, duplicated, and secured. The butt or joint must fall between two molds and the butt must be spliced by a piece of plank fitted and secured inside. The length of the butt block should be about 12 times the thickness of the side planking and its width should be sufficient to allow it to overlap ½ inch, or thereabouts, onto the next course of strakes, or plank. The butt block, in a sheer strake, will fit snug against the bottom of the sheer clamp or batten, unless the latter is temporary; then the batten will have to be cut to fit the butt block.



61. Planking Butt Block and Plank Scarf Used in Lap-Strake Construction

In this case, cleat the butt temporarily until the whole plank is secured except for the butt; then cut the batten and fit the butt block. Use luting in the butt and on the faying surfaces of the butt block (in other words, between the butt block and the plank). The next pair of strakes need no fitting except at the stem, transom, and where they cross the chine at bow or stern. The marking of these strakes follows the same practice as the sheer strakes, where they need to be cut to fit. The bevel must be allowed for, along the chine, so the scribed line on the inside of these strakes must stand outside of the true chine line enough to allow for beveling. It is very easy to forget this and spoil a plank.

When the plank is fitted, it is well to lightly bevel its top, to allow for a calking seam; in a small boat the seam should be open a full ¹⁄₁₆ inch, or a little more, at the outboard face of the planking and closed at the inside face. When the plank is bent over the molds and partially secured at the bow, it is a good plan to nail blocks to the molds, below the bottom of the strake, on which to drive wedges that will force the strake against the one

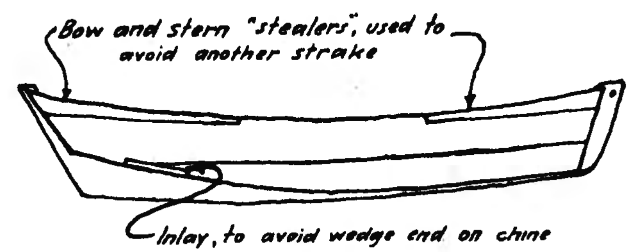
above, while it is being fastened. Take care not to mar the edges of a plank with wedges or hammer blows.

Shift of Butts

If there is a third band, or strake, of planking required, it must be fitted in the same way. Butts should be shifted fore or aft of the ones already in; three frame spaces is the rule, but this does not help much in deciding the shift in a boat having no frames. In this situation shift the butts about six to ten times the depth of the strake, from the butt above or below it.

Stealers

Very often there is a long, thin wedge of wood formed at each seam in the run, by the strakes intersecting the bottom of the chine logs at very acute angles. This wedge is apt to split or break. The best way to avoid trouble is to cut off the wedge so that a



62. Side-Planking Methods

butt is formed an inch or so wide. Then chisel a little out of the next strake, along the chine, so that a short, rectangular piece of plank, an inch or so wide and about a foot long, can be fitted in. This piece will cross the seam of two strakes at an angle, parallel to the run of the chine, and will be backed and secured by the chine log; it may be edge-fastened as well. If the stern is sharp and the rabbet of the sternpost is straight, there will be no difficulty in fitting the side planks, as the top and bottom of each strake is ticked for the rabbet, where the plank being fitted runs by the sternpost. If the sternpost rabbet is curved, and the strake is made up of two lengths, lap the butt, scribe, and fit the end of the plank to the rabbet; remove and cut. Then replace with the end of the plank fitted to the sternpost rabbet and mark the line of the butt on the inside of the strake; remove, cut, and replace. Take care in fitting plank to have the molds marked so that you can replace the plank in the same position for each step in fitting.

Another problem in fitting side plank occurs when the sides are in a single plank. Very often it will be found that the plank is wide enough at amidships but lacks width to reach from chine to sheer at bow or stern, or both. In this case, fit it to the hull as far as it will cover, marking where its top, allowing for bevel, crosses the sheer line. After the plank is completely fitted, remove and, at the points where the sheer crossed the top of the plank, cut down an inch or two; then rip from the bottom of this cut, or cuts, to the end of the plank, parallel to the original top edge of the plank. Now replace the plank on the molds and secure. Pieces of sufficient width may now be fitted in the gaps left at bow or stern, or both, by the strip cut out. The notch formed at the inboard end of these fitted pieces is of sufficient depth to avoid the objectionable wedges that would occur if the cutting down were not performed. The narrow butts formed at the inboard ends of the fillers, or "stealers," can be backed by butt blocks if they are not on the sheer clamp; they may be edge-fastened also.

Lap-Strake Sides

If the sides are to be planked lap-strake, the bottom strake of the sides must be fitted first and must be of sufficient width to bring the first lapped seam well above the chine. Because of this limitation, this form of planking (applied to flat-bottom hulls) is used only in small, light boats. The lines usually show the height of the laps and so can be established in the loft plan and transferred to the molds. The height of the laps should be marked at the edges of the molds, so that the marks can be seen when the plank is in place, being fitted. This done, the lower strake is fitted along the chine in the manner previously described. The top of the plank must be wide enough to extend above the marks

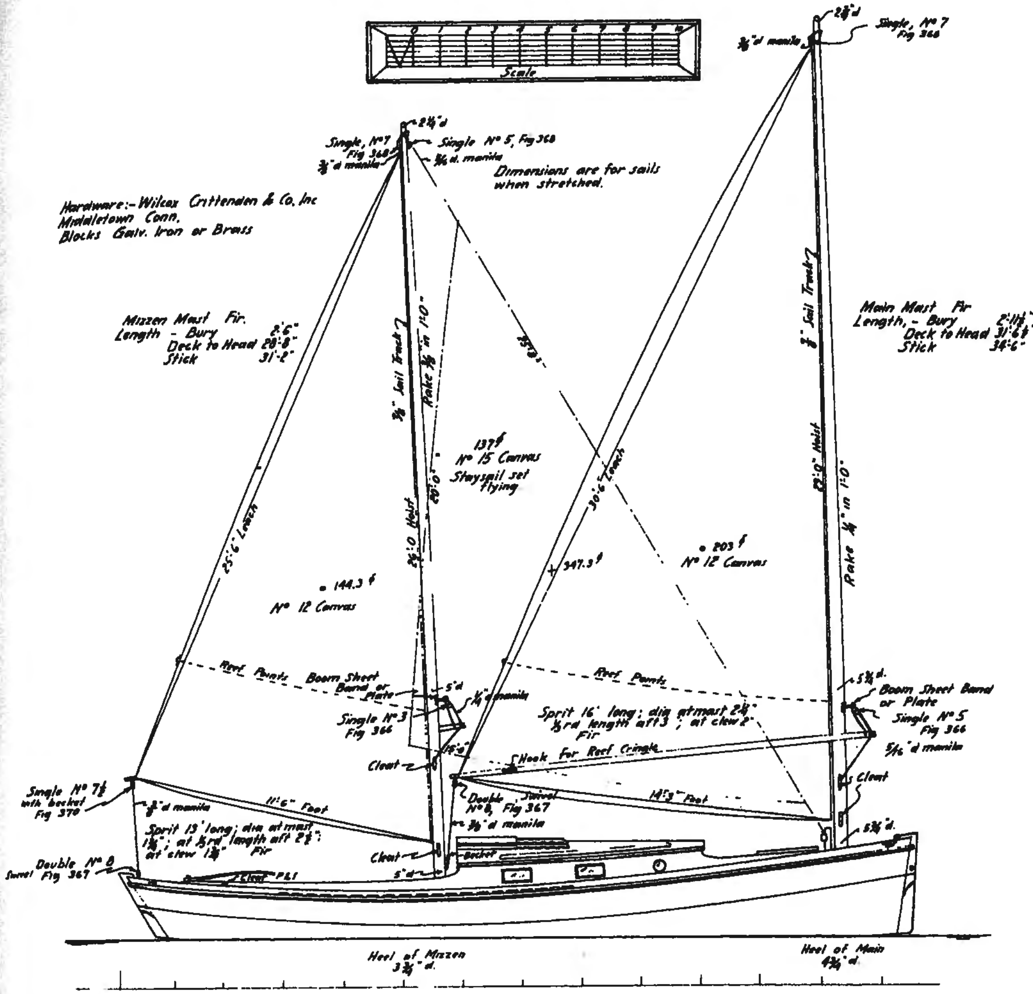


Plate 30. *Sail Plan for a 30-Foot Sharpie Cruiser*

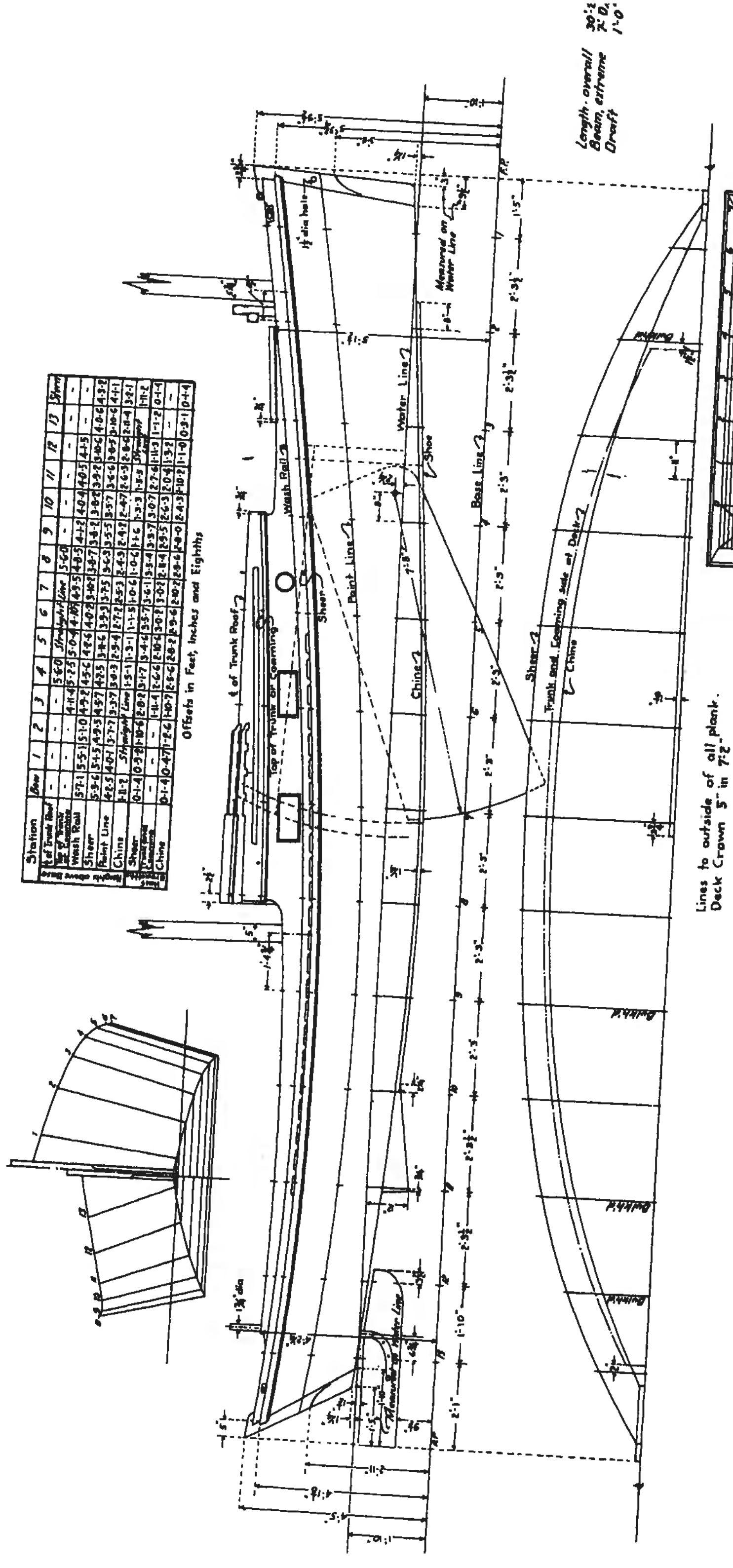
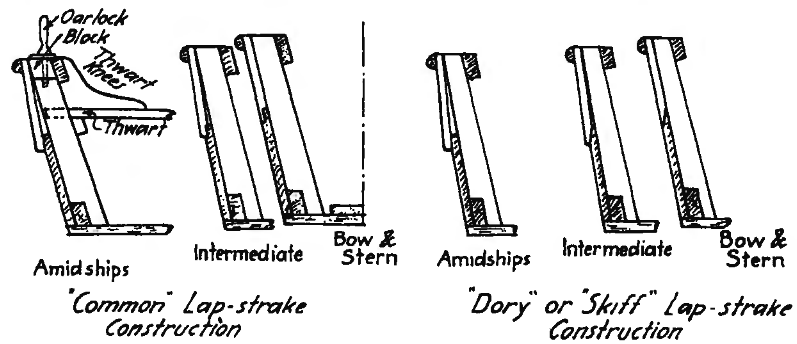


PLATE 31. *Lines of a 30-Foot Sharpie Cruiser*

the amount of the lap called for in the plans, at the least point. It is probable that the top of the bottom strake will not parallel the marks. When the bottom strake is otherwise fitted and clamped into place, the inside is ticked at the lap-line height from the molds. Then the plank is removed and, with the compass, new marks are made at the distance equal to the specified width of the



63. Lap-Strake Methods

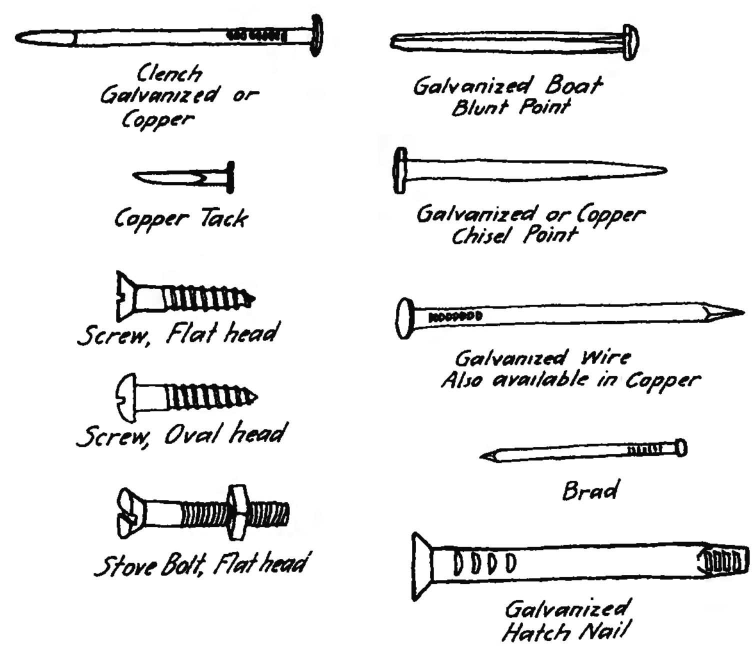
lap from the first series of marks. A line swept through the new marks gives the top of the lower strake. The top being cut, the strake is rabbeted at bow and stern, beginning at the outside face of the plank a couple of feet inboard of bow and stern and running to half the thickness of the plank at the ends of the strake, at bow and stern. The width of this sloping rabbet is the width of the lap of the two strakes.

The bottom strake is now secured in place. When fastened, its top edge must be beveled a little along the outside face of the strake, so that the next strake above will bear the width of the lap. Usually the width of the lap is drawn on the plank with a pencil; then a short staff of straight plank is made, its length equal to the width of the strake above. If the sheer strake is the one above, then the staff is as long as the greatest width of the sheer plank, measured off the molds. This staff is laid on a mold with its lower end at the depth of the lap and its top at the seam above or with its inside edge on the sheer mark. This serves as a gauge to measure how much will have to be cut off the top outer face of the bottom plank to give the correct bevel for the lap of the two strakes. When this is done, the planks for the next strakes are selected and one of them is sprung over the molds with its bottom at the lowest point, a little above the top of the lower strake. The bottom of the upper strake must now be scribed to fit the lower line of the lap bevel below. This is spiling, and is done on the same principle as scribing. The compass is set in the same way and is held perpendicular to the straight edge of the upper strake, not to the curve of the strake below. However, instead of sweeping in a continuous line, short arcs are marked on the upper strake 4 to 6 inches apart. When the upper strake is removed, the arcs are connected by a line swept in with the aid of a batten. This is the cutting line for the bottom of the upper strake.

The upper strake, when cut to shape, is placed back on the molds and fitted to the line of the bottom of the lap marked on the lower strake, to check. The end at the rabbet of the stem can now be fitted, care being taken in shifting and scribing so that the plank, when moved back into place, will fit the lap in the lower strake. This will usually work out without undue difficulty. At the stern, the upper strake should run past the transom in the usual manner. When the upper plank is fitted, it is clamped into its proper position and its upper edge is marked off from the molds in the same manner as the lowest strake; if the upper is the sheer strake then the sheer is scribed from the sheer batten or clamp. The end of the strake may be held in the rabbet of the bow by screwing a couple of cleats to the side of the stem, with one end of each overlapping the rabbet enough to hold the plank while fitting. When the top of the upper strake is marked and cut it is ready to fasten, after a duplicate has been made. The first step is to scribe the lap width on the inside of the strake. Then a rabbet is cut in the ends of the lower edge in the same manner as was done in the top of the lowest strake, but on the inside of the upper plank, instead of on the outside as in the lower. When the upper plank is set in place these rabbets will enter one another and so the projection of the lap disappears at bow and stern and the planking becomes flush along the rabbet of the stem and at the stern. If the upper is not the sheer strake then its top outer edge must be beveled and rabbeted as was the lower strake. If the upper is the sheer strake then the sheer must be marked and cut as previously described. Lap-strakes need not be butted; they should be scarfed in order to lap.

Fastenings, Nails

Fastenings for the side planking will normally be the same as used for the bottom. It may as well be said that there is a good deal of ignorance in regard to fastenings among yachtsmen. Where the thickness of the timber permits, the best plank fastening is the boat nail—if it is properly made and has a good head. Where cost and strength are prime considerations, the hot-dipped, galvanized-iron boat nail is unsurpassed. The nail should be chosen



64. Plank Fastenings

with care—the head should be large and regular, oval or round. The edges of the shank (it is rectangular in section) should be sharp and there is no harm in roughness. The galvanizing should be thick and bright. Smooth, thinly coated or plated nails, with small irregular heads and long-tapered shanks, such as are seen in horseshoe nails and ordinary "cut nails," should be rejected. The length of the nail should be decided by the timbers through which it is driven; the rule is that the "penny" of the nail should be the number of eighths of an inch in the thickness of the plank through which it is driven. If the nail is to be driven in softwood, however, the "penny" should be two eighths greater than called for in the rule. The application of this rule to hull planking is subject to some practical qualifications. If the framing is too thin to permit the application of the rule, the length of the nail is equal to the thickness of the planking, plus the thickness of the frame, minus ⅜ inch. If the nail is to go through two timbers and be bent back into the wood after it has passed through ("clenched," in other words), its length is equal to the total thickness of planking and frame plus ¼ inch if the head is countersunk and plugged; plus ½ inch, if not. Good galvanized-iron nails can be clenched. In choosing a nail, use as long and thin a nail as can be driven. Boat nails are supplied with a choice of two points, chisel or blunt. The latter holds best and should be used except for clenched fastenings, when the chisel point is best.

"Penny" is the expression of length; the following are the standard penny lengths and inch equivalents. Twopenny equals 1 inch; 3 equals 1¼ inches; 4 equals 1½ inches; 5 equals 1¾ inches; 6 equals 2 inches; 7 equals 2¼ inches; 8 equals 2½ inches; 9 equals 2¾ inches; 10 equals 3 inches; 12 equals 3¼ inches; 16 equals 3½ inches; 20 equals 4 inches; 25 equals 4¼ inches; 30 equals 4½ inches; 40 equals 5 inches; 50 equals 5½ inches; 60 equals 6 inches. The thickness of a boat nail varies somewhat with the make, and each make with the length. The holding power of the boat nail has been thoroughly tested both in practice and in laboratory experiments. Its only weakness is the relatively small head, which may allow soft planking to be pulled over the head without withdrawing the nail. If the planking is of softwood or is under ⅝ inch in thickness, when finished, the round-shanked "wire nail" or the "hatch nail" are preferred by many builders. These nails have less holding power in the shank but greater power in the head. The "hatch nail" is sometimes sold as a "light boat nail." Clench nails are made of both galvanized iron and copper (or alloy); these are round-shanked nails having oval heads. The shank is straight and without taper, until within a short distance of the point. These nails are rarely clenched; they are commonly used as rivets in planking. Copper tacks are used for nailing the laps in lap-strake boats; the tack is a small-cut nail and it is clenched

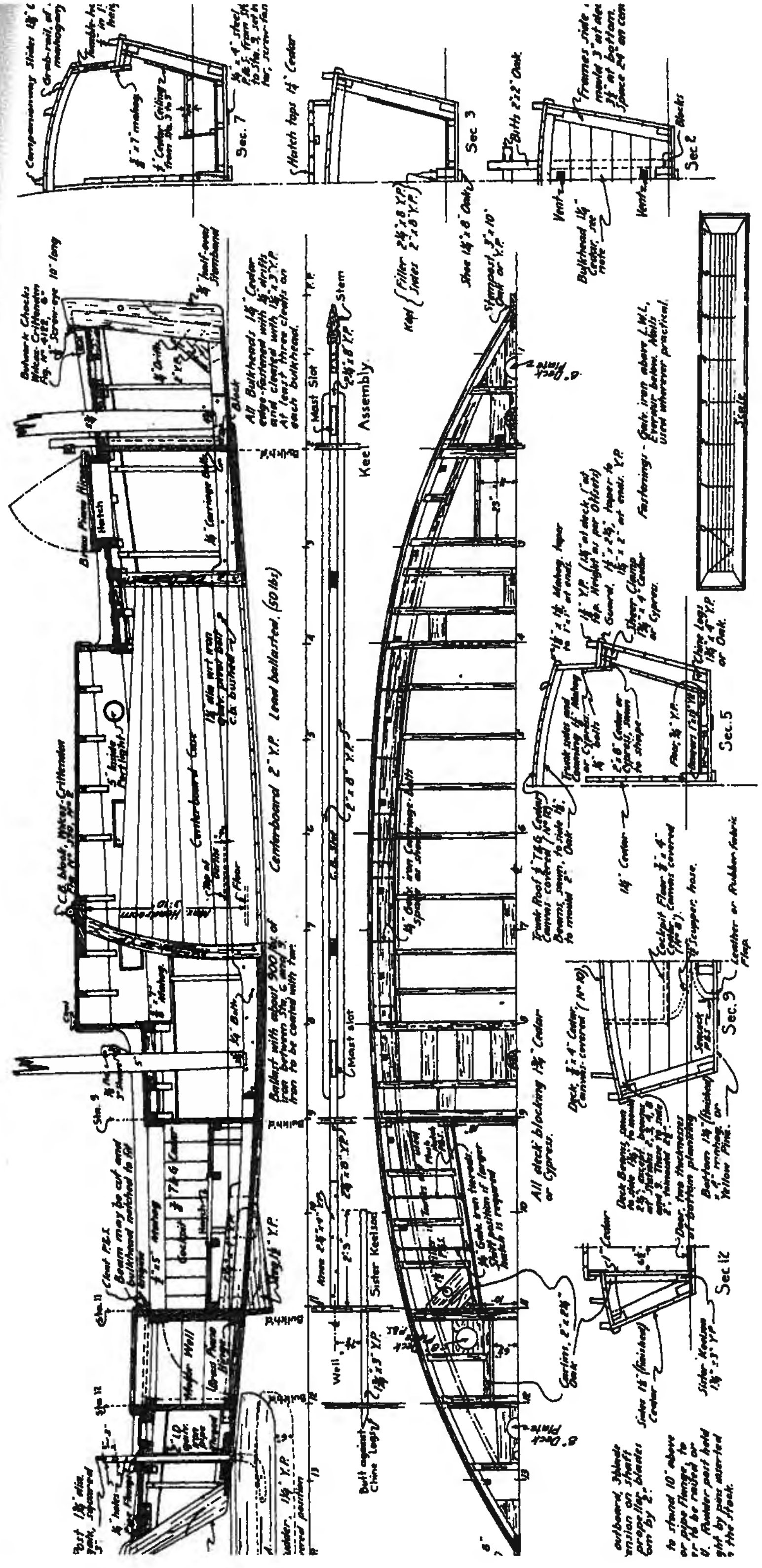


PLATE 32. *Construction Plans for a 30-Foot Sharpie Cruiser*

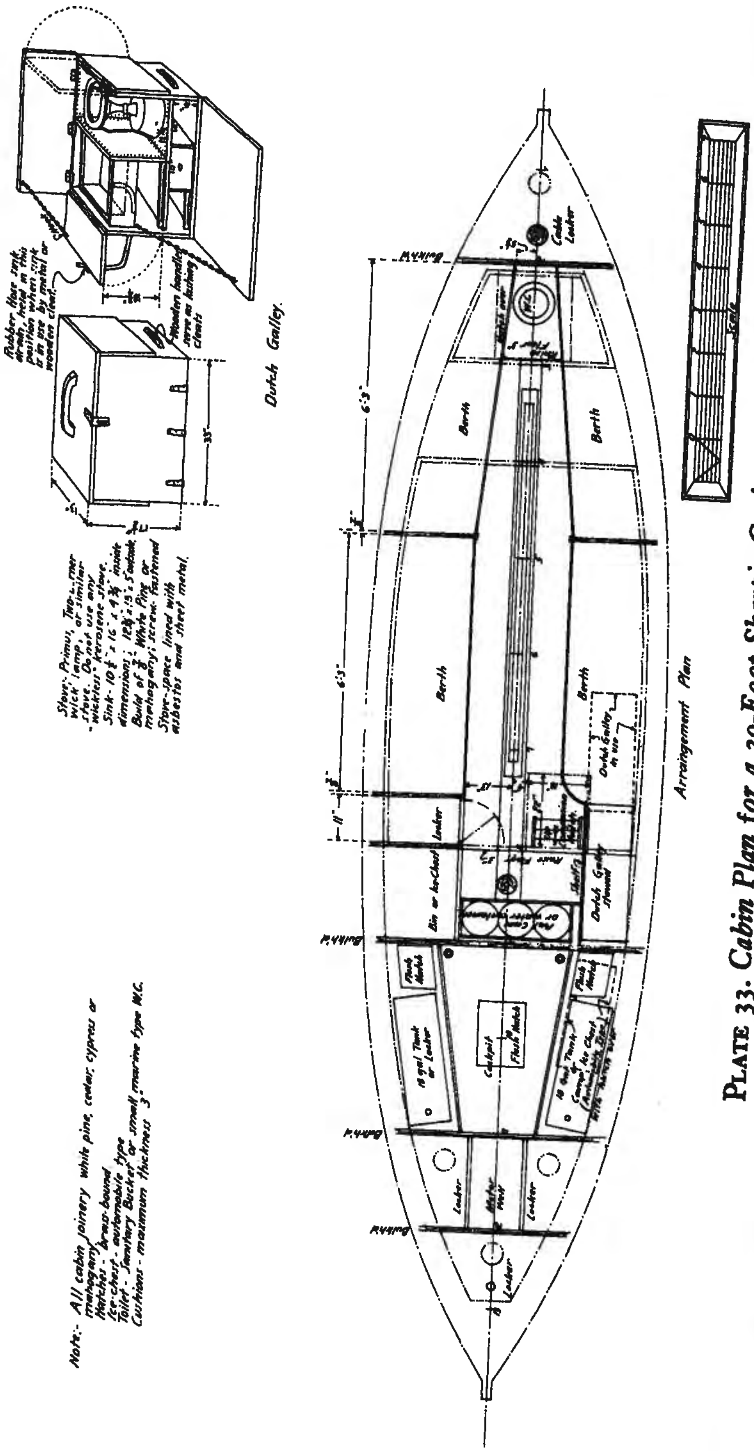


PLATE 33. *Cabin Plan for a 30-Foot Sharpie Cruiser*

over, after being driven through the laps. Except for the hatch and clench nails, most boatbuilders do not use round-shanked or wire nails in boat construction.

Boat and hatch nails are now obtainable in various noncorroding alloys. Also special forms of barbed nails of such alloys are available; these have excellent heads and good holding power. Most of the alloy nails are very expensive compared to galvanized iron. Copper nails of any description have very little holding power unless their points are clenched or riveted. Riveted fastenings are usually made with copper or alloy clench (or "clinch") nails with a small "burr" (washer) dropped over the point after driving through. The point is then cut off in the clear and the remaining portion of it riveted over on the burr; this will be explained later. Nails in the planking should be bored for; boat and hatch nails with drills, or auger bits, smaller than the shank of the nail. Clench nails are drilled for with bits about the same size as the shank of the nail, when of copper.

Fastenings, Spikes

Spikes, used only in heavy boat construction, run from 3 to 14 inches in length, and from ¼ to ⅝ of an inch square in the shank. All are chisel point, but may have conical, oval, or flat heads, as desired. They must be bored for in the same manner as nails. Spikes are usually of galvanized iron or steel, but may be obtained of noncorroding alloy.

Fastenings, Screws

Screws are much favored by yachtsmen. The galvanized steel screws are strong, but the galvanizing process roughens the threads and makes them very difficult to drive. This fault in their threads also damages their holding power. Alloy and bronze screws are more satisfactory in this respect, but are more expensive. On the whole, they are not as strong as the steel screws and unless properly bored for will often wring off when being driven. This is particularly the case when a power screw driver is used and the screw driven through some soft planking material into an oak or elm frame. It is not exceptional to find, on survey, 10 per cent of the screw fastenings broken under these conditions. Brass screws are of little value in boat construction as they corrode and are weak in resistance to wringing off. The screws having flat countersunk heads are most commonly used for plank fastenings; they are bored for and the heads are countersunk and plugged, or "bunged." Their length is measured overall. Round-headed screws are used where the fastening is temporary or subject to occasional withdrawal. Their length is measured from the bottom of the slot to the point. The proper length of screw to use is three times the thickness of the timber through which it passes. Standard lengths of screws range from ½ to 6 inches and gauges from 2 to 24, depending upon length.

The gauge of a screw should vary with the hardness of the wood in which it is to be driven, for given lengths. To drive a screw, first bore a hole slightly less than the diameter of the shank and of a depth at least one half the length of shank from head to thread. In hardwood it is usually necessary to drill deeper than this and the best way to decide the proper depth is by experiment. In hardwood it may be well to bore through the first piece of timber with a drill of about shank diameter, and then bore a leading hole about half the length of the thread in depth. If the screw is smeared with soft soap, before driving, it will go home more easily and with less danger of wringing off. If the head is merely countersunk, the hole should be prepared with a countersink bit. Drills and countersinks combined in one bit can be used for drilling for screws that are to be bunged. The round-shank twist drills are best for boring for screws, using a push or automatic drill for small screws and a brace or breast drill for large. Screws are used where the timbers being fastened are not of sufficient thickness to hold nails. For that reason the ends of planking in the bow rabbet or the butts in planking are usually screw fastened. In light material the screw is considered the best fastening—say, in planking up to ⅝-inch thickness, finished. Often the impact of driving a nail is undesirable for some reason; here the screw is the answer to the problem. The rule is: "use nails where you can, screws where you must."

Butts, Fastenings, Bolts

Planking butts in small boats can be screw fastened; in larger boats it is usually possible to employ nails. However, bolts can sometimes be used to great advantage. The bolts commonly used

are a form of short stove bolt having a round or conical head, with a slot in it like that in a screw. These are usually supplied with square nuts. Carriage bolts are also used for the same purpose in very large wooden hulls. The bolt will serve better than a nail or screw to pull a butt fair, so that the planks bear completely on the butt block. The heads should be countersunk and plugged. The use of rivets and clench nails will be described in the chapter on lap-strake construction.

Spacing of Fastenings

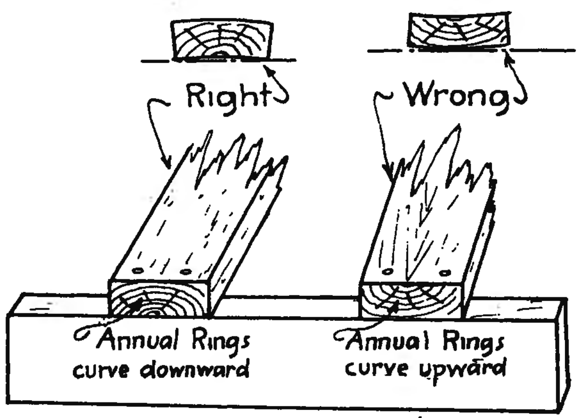
The spacing of fastenings in planking and elsewhere cannot be specifically laid down. In the stem and transom the fastenings can be spaced about 2 inches apart in the majority of hulls. Fastenings driven into end grain should be spaced around 1¾ inches apart. Planking is secured to frames, or to chine and sheer timbers, with fastenings spaced two or three to each plank, or 4 to 6 inches apart. Common sense is really the best guide, however.

Bottom Plank, Chine Bevel

With the sides in place, the bottom can be laid. First the chine logs and the lowest plank of the bottom must be beveled. If the hull is building upside down this is a simple matter. A straightedge long enough to reach across the hull from chine to chine is required, as are also a drawknife, plane, and broad hatchet. The straightedge will serve to check the bevel as it is cut. The outer and lower corner of the chine log is the correct line of chine. If there is a strongback down the center of the hull, made of a sprung plank, this must be secured in the notches in the molds and to stem and transom or stern. If there are two other strips parallel to this, or nearly so, on either side, these must be put in place. These are usually called "sister-keelsons" in flat-bottom and V-bottom hull construction. When the beveling has been completed, and the fore-and-aft members are in place, the plank for the bottom should be selected.

In a cross-planked bottom the board should be selected and prepared with a few points in mind. First, random widths can be used, but narrow stock is better than wide. Secondly, the board must be fitted to the hull with its end grain in the proper position, so that it will not "cup" and make the bottom like a washboard. Look at the end of a plank and note which way the annual rings of the wood turn in relation to the faces. The board must be laid on the chines so that these annual rings are curved *downward* against the chine. If they are allowed to be laid with the curve upward, they will cup. This rule should be followed when planking any flat or straight surface.

It is usual to begin planking a flat-bottom boat's bottom at the



65. How to Lay Plank

stern, if she has a transom or is square sterned; start amidships, laying plank square to the center line and working alternately fore and aft if she has a sharp or round stern. As each plank is fastened in place, its overrunning ends are sawn off along the face of the lowest plank of the side, at the bevel fixed by the flare of the sides and, where necessary, sawn at the centerboard slot. It is easier to saw off each plank as it is laid, rather than to wait until the bottom is completely planked. It is an excellent plan to nail or, better, clamp blocks to the chine logs, so that the inside edge of each bottom plank may be wedged against its neighbor, while being fastened. Clamps will assure that each plank is bearing on the chine logs and strongback. The fastenings should be completed in each plank before going to the next one. The edges of the bottom plank will require some beveling to allow calking; the same width of seam on the outside of the planking as was used in

the sides is required. Before starting to plank the bottom, lay strips of flannel, wicking, or calking cotton, soaked in paint, along the chines and centerboard case logs.

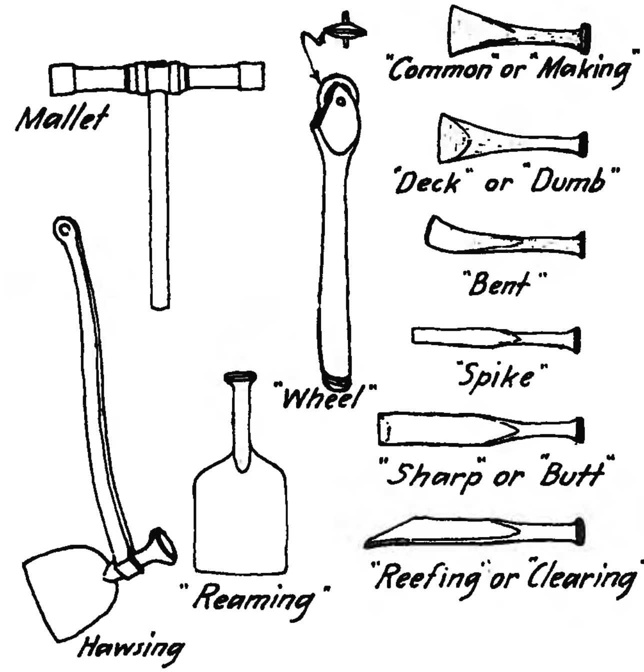
If the bottom is planked fore and aft, the boards should be so fastened that the curves of the annual rings shown in the ends of the plank curve against the frames. The construction of flat-bottom boats with bottoms planked fore and aft is sometimes quite different from that used in cross-planked hulls and will be described later. If the flat-bottom hull is built right side up and cross-planked on the bottom, the operations are no different from those already described, but beveling the chine logs becomes a rather tedious job. The roughing of the bevel is best done with an adz.

Smoothing, Calking, Tools

When the bottom is planked, it and the sides should be planed smooth, sanded, and then calked and painted. For calking material use calking cotton used by boatbuilders, not the short strand stuff used by plumbers. Calking cotton comes in bundles and strands may be shredded out so as to make one to fit the size of the seam. Start by driving the strand into the seam of a bottom plank at one chine, with a little of the strand projecting outboard from the end of the seam, which can be driven into the exposed end of the seam. Use a calking iron and a mallet to drive the calking. The irons may be obtained from a marine supply house and can be purchased in various sizes and shapes. Ten irons make a set; these will be described later. Take a "creasing" or "making" iron and drive the calking along the seam, gathering it in small loops with the iron each time it is driven. The loops should vary in size as the width of the seam widens or narrows. The loops or folds should touch one another when in place. After the seam is lightly calked and driven, go back over it with the iron and drive it home so that there is room for puttying or filling the seam and drive in the end into the exposed end of the seam. Driving blows should be of equal force all along the seam. The iron should be held so that its slightly curved blade edge is level in the seam; if it is tipped along the direction of the seam, the edge will cut the strands of the calking. The calking can be driven too hard as well as too lightly. It must not be driven through the seam, but should be in a hard bunch, or rope, about halfway through the seam. If the latter is too narrow, it can be forced open with a "dumb" iron. It is a good plan to paint the seam before driving in the calking. This binds the calking; the wet paint will swell the cotton so that all voids are filled. This is less messy than dipping the cotton in wet paint before driving. The calking can be driven dry, but will not last as long as if driven in wet paint. If driven dry, the calking should be payed, or painted. This can be done, after driving, with a thin brush having stiff bristles. There is a regular "seam brush" made for the purpose which can be obtained at water-front hardware stores, as a rule. The seam may be filled with white lead putty, or seam composition, or hot marine glue, as circumstances warrant. Calking requires some practice, but the principles are soon grasped. In very light boats the seam may be calked with a strand of wicking, which is run in with a "calking wheel." In this case there are no loops. The seam may be practically closed when the wheel is used; it is opened with the wheel before running in the strand of wicking. In using a calking wheel, great care is necessary to avoid having the wheel jump out of the seam. Operate the wheel by a pulling, not a pushing, motion.

Calking irons are designed for every type or position of seam. For calking planking, the ordinary calking iron, called a "making," or "creasing" iron will serve. This iron may be had in varying sizes, with blades of varying thicknesses to fit almost any seam. The sizes are BB, Crease, 1/32 inch thick; No. O, Crease, 1/16 inch thick; No. 1, Crease, 1/8 inch thick; No. 2, Crease, 3/16 inch thick; No. 3, Crease, 1/4 inch thick. The blades vary from 1 3/4 to 2 1/2 inches in width. For the garboard, along the keel, the "bent" iron is used; this has a blade bent sidewise so that it can be driven into an angle which could not be reached with the common iron. A deck or "dumb" iron is somewhat like the common, or crease, iron but has a thick blade and very little taper. It is used for widening narrow seams. A sharp, or "butt," iron has a long, sharp blade and is used for calking very short or narrow seams and corners. The "spike" iron is used for calking corners and fastenings or bungs; it has a very narrow blade. The "clearing" or "reefing" iron is a blade with a sloping edge; it is used to clear out old calking from a seam. The only irons an amateur builder really needs are a few creases, a dumb, and a bent. The calking

wheel comes in only one size; it is a small metal wheel held in a wooden handle. Professional calkers use a calking mallet as it drives better and relieves some of the vibration to be found in an ordinary mallet or hammer. A "reaming iron" is a large iron



66. Calking Irons and Tools

wedge with a wide, rather thin blade. It is driven into seams of large wooden vessels prior to calking, to open the seam and hold it open while the calking is being driven in. The "hawsing iron" is somewhat similar, but has a long handle attached; it is driven into seams after the calking has been set with a light iron, to drive it home or "hawse" it. The hawsing iron is used only in calking large, heavy boats.

Remarks on Calking

Calking will stay in place better in softwood than in hard. The cotton should make an impression on the sides of a seam, to stand properly. This forms a tight seam, with the cotton making a continuous groove in the sides of the seam as the wood swells. Very light blows are required to accomplish this with cedar or white pine planking. Mahogany and yellow pine require blows somewhat harder; oak and many tropical hardwoods require very heavy blows and hawsing. If an impression is not made in the sides of the seam the swelling wood will close the wedge-shaped seam and spew out the calking. Do not try to calk with a screw driver, chisel, or putty knife; it is just asking for trouble. In large seams, oakum is used; this is rolled or "spun" in strands of sufficient thickness and driven like cotton, but not looped. Drive very lightly when only a few strands of oakum are used; heavy blows will break the fiber. Oakum will last longer than cotton calking but is more difficult to handle in small seams. A "strand" of cotton or oakum is about the size of the seam opening, before being driven.

Finishing

A word about smoothing. This should be done before the calking and should be a finished job. Then, when the calking is completed and the seams puttied, a light sanding will make the bottom and sides ready for the first coat of paint. The bottom can receive two or more coats of antifouling bottom paint but the topsides may well be allowed to wait until just before launching, as they will become dirty and stained while the hull is being finished.

Righting

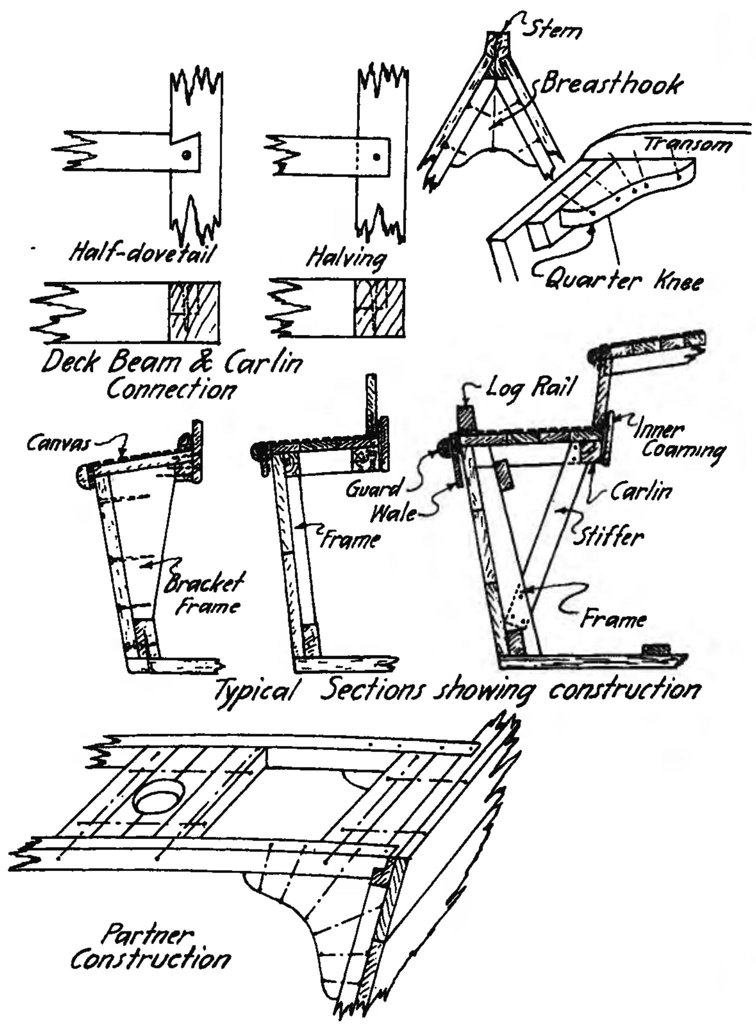
If the boat is being built upside down, she must now be turned over to finish the top and deck. Much depends upon the size and weight of the boat as to how this is done. If the boat is small enough for a few men to lift, friends of the builder can be called in. It is a good plan to insert some notched spreaders inside the sheer clamp between the molds to give additional strength. It may be necessary to rest the hull on its side momentarily while turning her over, and these spreaders will prevent undue straining. If the boat must be turned over by mechanical means, she should be strengthened with heavy spreaders fixed to the sheer clamps and extending outboard a few feet. These spreaders can be notched

so that they extend down a little inside the hull, or may be doubled with the shorter and lower piece a snug fit between the sheer clamps. Some builders nail these to the hull, or a lashing may be passed around the hull, outside the chines and bottom, to hold the spreaders in place. All the spreaders should be of the same length and their ends should be in line. Tackles or chain hoists are then rigged to the ends of spreaders, near each end of the hull, and to ridgepoles, or roof truss.

When all is ready the tackles are set up and the weight of the hull freed from the stocks. All shores, braces, and supports are removed and all tools and lumber cleared away. Sleepers are then laid on which the hull will rest when righted. The tackles are manned, the whole hull is lifted clear of the stocks, and then one side is lowered until the spreader ends are on the floor or ground. If the tackles are placed properly in regard to the hull, the upper side can now be lifted enough to bring the spreaders up and down. It should then be possible to force the hull over and to drop it right side up by lowering away slowly and carefully. If the boat is heavy the spreaders should extend a number of feet farther out from the hull on the side which will be lifted than on the side first lowered. The higher the boat can be lifted from the stocks before starting to turn her over, the easier the operation. Of course, a wide boat is much more troublesome to handle than one having a narrow beam. In most narrow boats one side can be lowered to the ground with jacks and the other side hoisted without first lifting the whole hull. When the hull is on the sleepers, it is blocked up level athwartships and a base line stretched inside from stem to stern at some water-line level. The blocking is adjusted to bring this base line level, using a string level. Now a base line is available by which superstructure, joinerwork, and construction can be measured and plumbed.

Frames

If there are to be frames in the sides of the hull, these can now be fitted. These frames, in a cross-planked flat-bottom boat, are really nothing more than cleats laid on the flat and nailed to the planking between the sheer clamp or batten and the chine log. In some designs these frames are deep enough to be notched over the clamp and log, and fastenings driven there. Usually the frames



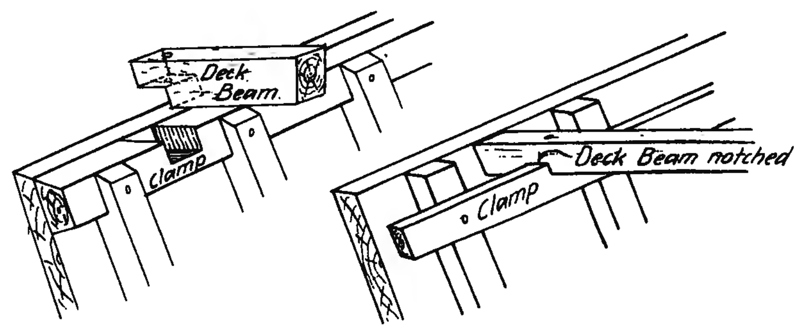
67. Flat-Bottom Hull Construction, Details Commonly Used

are not beveled, but allowed to stand square to the curve of the sides. If the boat has washboards, or narrow decks along the sides, the frames may be placed with their edges against the side planking and shaped deep enough to act as knees to support the deck, in lieu of beams or blocks. If these are beveled they may be laid off on the loft plan and their bevels lifted; or they may be

measured directly from the boat. If some of the frames are to be located where the molds now are, lay them aside until the molds have been removed. This can be done as soon as a few deck beams are in place, or when thwarts are fitted.

Fitting Deck Beams, Removing Molds, Etc.

The deck beams should be made up from the loft pattern and can be cut to the correct length prior to righting the hull, if desired. Their position being laid off, fitting may be started. It is usual to put in those nearest the middle of the boat first. If there are thwarts, these should go in before the deck. They should be made up from the loft drawing, as by that means the bevels of the thwarts can be predetermined. The thwarts may have to be notched for the frames and may be supported by bearers run fore and aft on the frames. Most small, flat-bottom sailing hulls require a thwart at the after end of the centerboard case and this should be well fitted and as snug as possible. Where the sheer clamp is against the side planking and at sheer height, its top is



68. Connection of Deck Beams to Sides

notched to a depth of one half the depth of the deck beam. The latter's ends are also notched on the underside to the same depth. This permits the deck beam to drop down so that its top is flush with the outboard and upper corner of the sheer clamp, which is the proper sheer height, of course. The bottoms of the notches should approximate the proper bevel; they rarely do, however.

The ends of the deck beams are secured to the sheer clamps by nails or screws driven down through the deck beams and into the sheer clamps, at the notches. This gives a strong and simple construction. If the sheer clamp is inside the frames and under the deck beams, the molds will have to be removed before fitting the beams. If some of the beams can be fitted before removing the molds, they should be made up and secured. If not, or if no thwart or beams can be secured amidships, the hull must be stayed together with temporary crosspieces. Three or four are usually enough; if in doubt, fit crosspieces between each pair of molds. These crosspieces may be the spreaders used for turning over the hull. In any case they should fit snugly inside the side planking, at the sheer, to prevent the sides from falling in when the molds are removed. The ends of the spreaders inside the hull should be temporarily, but firmly, secured to the sides with cleats. When this has been done, the molds may be knocked out or removed by sawing them and breaking joints. Fastenings driven into the molds can be knocked out and plugged if they are in the side planking, but must be nipped off if they are in the chine logs or sheer battens, unless the latter were merely temporary. If the sheer battens are to be removed, they should be cut and pulled out, after the molds are all out. Take care not to disturb the spreaders. If the molds are screwed together, they may be knocked down and preserved. If this is the case, reassemble and bundle them up with the templates, and store them away safely.

Deck Beams, Fitting and Fastening to Clamps

Once the molds are out of the way, the missing frames may be put in place and the sheer clamps made up. When these pass inside the frames they are usually pieces of plank nailed or screwed to each frame and secured to the stem and transom with cleats, knees, or blocks. The plans should show the designer's intent. Sometimes the deck beams are notched, so as to hook down over the top of the sheer clamps; this is usually done by fitting in the hull. If it is found that it is difficult to force a sheer clamp into the hull, it may be put in place in two lengths, scarfed or butted (butt block between clamp and side of hull), or made up in layers, laminated, of thin pieces. Once these members are in place the deck beams can be put in. Whichever the method employed, do not remove a temporary spreader until a deck beam or thwart is fitted and secured close to it. It is much better to

secure the deck beams to the sheer clamps than to attempt to fasten them to the heads of frames. If the sheer clamps are properly fastened to the frames, and this is easy to do, the deck beams fastened to the clamps are much stronger than those fastened to the heads of frames. It is usually difficult to drive a fastening through the side of a deck beam into the side of a frame, because of the curve of the sides and the obstruction of frames or molds.

Carlins, Fitting, Fastening, Tie Rods

Carlins are fore-and-aft members of the deck frame; they support the coamings of the cockpit, the cabin trunk sides, and the hatch coamings. Usually they are the same depth as the deck frames, but may or may not be as thick. The carlins supporting the cockpit coamings and the cabin trunk sides are often sprung, to allow these erections to follow the curve of the sides of the hull and the crown of the deck fore and aft. The ends of the deck beams are butted into the carlins, where the former are cut by the latter. It is more or less a draftsman's convention to show a half-dovetail to make this butt. The end of the deck beam runs into the carlin half the depth of the former and half or the whole width of the latter. The halving of the deck-beam end is shown with a half-dovetail and the carlin notched accordingly. The point of the half-dovetail is in the direction of bow or stern, working either way from amidships. The ends of the carlins are similarly shown, but with the points of the half-dovetail outboard, where they are cut by deck beams. This is a fine finish, but it is doubtful if there is any practical value to such a laborious butt joint in small boats under 60 feet overall as there is so little timber involved. The ends of the deck beams and carlins might as well be halved without the half-dovetail. A good fastening driven from the top of the deck beam, through the halving, into the carlin will give sufficient strength for most hulls. A still easier way is to butt the ends square and to hold in place with a lag bolt driven through one member into the end of the other. This is rather weak construction and tie rods between the carlin and sheer clamp on each side are necessary. Sometimes the ends of deck beams and carlins are not halved, but are half-dovetailed their full depth; this is only possible when the members to which they join are of greater depth. The method employed depends upon the amount of time the builder wishes to spend on workmanship. The various dovetails are pretty, but halving is the quickest method; in any case the decking will cover the workmanship employed.

Partners, Blocking

If there is a mast, the partners may be heavier in scantling than the rest of the deck beams. Also there will be blocking, or knees, worked in between the deck beam and partners, at mast and along the sheer. Blocks are also to be fitted for small deck openings and as foundations for deck fittings, such as windlass, winches, cleats, and fair-leads or deck blocks. All blocking should be snugly fitted between the members on which it bears. Fastenings are usually of less importance than fit in all knees and blocking. Around the mast, in a boat having a set of partners, the blocking, or blocking and knees, is through-fastened fore and aft, from deck beam to deck beam. If this is called for, the partners should either be made up outside the boat or assembled and secured before any other of the deck beams are set in place, to allow the fastenings to be driven. The most common through-fastening for deck blocking and knees is a rod, threaded at both ends, driven and set up with nuts and washers. On heavy boats the rod may be riveted instead. The depth of the blocking and knees is given on the plans as a rule. It should not be less than two thirds the depth of the deck beams where there is likely to be strain. Much of the blocking is not under strain and can be nailed or screwed to the beams, as the fastenings merely serve to hold the blocking in position until the decking is in place and the deck fitting secured.

Washboards, Covering Boards

If the boat has washboards it is probable that they are supported by the side frames, acting as brackets. The tops of these must be cut to the proper crown. Then the top of the sheer clamp and side planking must be beveled to fit this crown. The line of the sheer has been marked, either by the outer and upper corner of a sheer clamp, or by a pencil line traced along the top of the temporary sheer batten on the inside of the side planking. This is the control line by which the proper height of the top of the

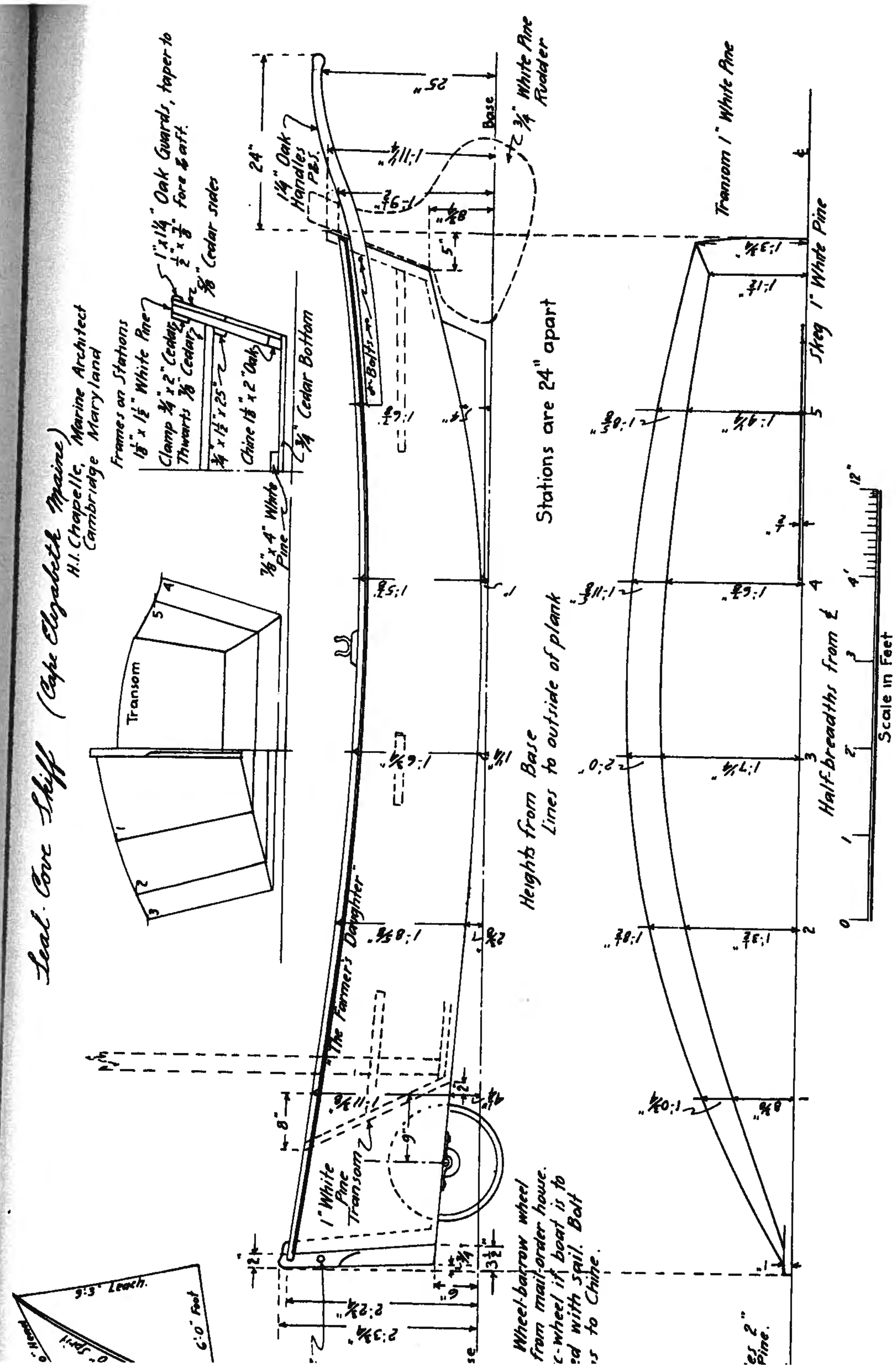


PLATE 34. Plans for an 8-Foot Seal Cove Skiff

brackets, and deck beams, too, is fixed at the sides. The bevel can be cut with the same tools used for cutting the bevel in the chine logs, and a short straightedge, or adjustable bevel, will serve to check the cut against the deck beams, or tops of the side brackets. When the bevel has been cut, the fitting of the washboards is a relatively simple operation. Usually the washboards are one plank wide; it is obviously impossible to make the plank in a single length and to spring it in place, edgewise. The usual practice is to cut the washboards out of wide plank in short lengths. Sometimes the butts are scarfed and edge-fastened; this is a strong and workmanlike finish. In many boats the washboards are merely butted, with butt blocks below deck. No directions are necessary for shaping and fitting the washboards; if in one width, they must be wide enough to permit beveling along the sheer to meet the flare of the sides, and along the inside of the carlins to allow the coamings to stand according to the plans. When the washboards are fitted they are fastened to the deck beams or brackets and also along the carlins and sheer clamp or strake. It is a good plan to insert calking, wicking, or flannel, soaked in paint, along the top of the sheer strake before fastening the washboards. The washboard is usually fitted when there is a deck laid; then it is called the "plank-sheer" or "covering board." Only when the deck is canvas covered is the washboard, or covering board, omitted.

Decking

The laying of the deck plank in a flat-bottom hull is usually made as easy and simple as possible. If the deck is canvas covered, the center plank is laid first, and then the planks on each side, alternating from side to side, until the deck is completely closed in. The long wedges formed by the deck planking along the sides of the deck are of no great importance as they will be covered with canvas; it is a good plan to edge-fasten them to the adjoining deck plank, however, with brads. The size of deck plank is given in the plans; when the deck is canvased there is no particular point in using very narrow stock. However, the deck plank should be laid with the annual rings curved against the deck beams or the deck will soon show seam ridges which will quickly cause wear in the canvas. If the deck is not canvased, it is usually wise to use plank not exceeding 4 inches in width. Where deck plank butt into the covering board they must be supported. A strip may be screwed along the inner edge of the covering boards to support the wedge-shaped butts of the decking in a small boat; blocking between the deck beams is necessary in a large hull. Tongue and groove stock is sometimes used for canvas-covered decking. It is hardly necessary to discuss a bright deck and the special methods of laying it, as it is rare that this class of deck is employed in a flat-bottom hull.

Canvasing Decks, Fastening, Painting

After the deck is laid, the openings for hatches, cockpit, and cabin trunk should be trimmed ready for coamings and the whole deck planed and sanded. Then the canvas may be laid on the deck. Canvas for decks and cabin roof tops usually ranges from 7 to 11 ounces, 10- or 11-ounce canvas for decks that receive much usage. The canvas can usually be obtained in lengths equal to the deck length, but often must be made up of more than one width to cover the expanse of beam. It is very common to find decks in which the canvas is glued or cemented to the deck plank. This, contrary to popular belief, is not a good practice as wood will often swell enough to put such a severe strain on the canvas that it splits along the seams. On the other hand, a canvas deck laid in wet paint will be as smooth as a cemented deck; yet the bond will break before the canvas splits and replacement of canvas is a much easier task. Very successful decks result from laying the canvas on a dry deck without cement or paint. Experience and observation indicate that the life and appearance of the canvas deck is not improved by cementing it to the plank; the method used to paint and finish it is the important consideration. Whether the canvas deck is laid dry, or in wet paint, the canvas should be perfectly clean and dry. The canvas should first be stretched along the center line of the boat, tacking it at the ends of the boat and along the center line, when it is stretched as taut as possible. In a small boat, two men can stretch the canvas hard by rolling the ends around a staff to give a grip for the hands. If the boat is over 20 feet long it is a good plan to clamp the ends of the canvas between two staffs, after rolling it around one, then to clap on tackles to give a fore-and-aft pull. A bridle can be secured to the ends of the staffs to take the hook of the blocks of the tackles.

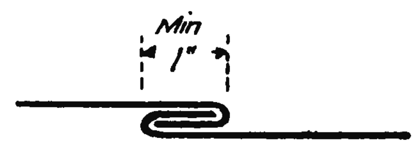
When the canvas has been stretched and secured along the center line, it is then pulled out to the sides of the hull and tacked along the side of the decking, or to the top of the sheer strake, if the guard is to be of sufficient depth to cover tacks so placed. The canvas should be secured with ½-inch copper tacks having good flat heads. Space the tacks about 3 inches apart, or a little less if the canvas is thin and light. If laying the canvas in wet paint, iron out all air bubbles and creases with a wooden block, before tacking. It is best to stretch the canvas over all deck openings and then tack, before cutting the canvas for them. Put tacks only along the seams and where required; do not scatter them promiscuously about the deck. At the cockpit coamings and cabin trunk sides, tack the canvas at the corners before cutting for the openings, then cut back enough to allow for a flap which will turn up or down, as shown in the plans. If it turns down inside the carlins the flap should be stretched and tacked as soon as cut; if not, it may be tacked along the opening on deck. When the canvas is stretched and smooth, it may be trimmed a little clear of the tack heads. If the canvas is laid in wet paint, it may be given a coat of priming; this should be thin and brushed into the canvas. If the canvas is laid "dry," most builders dampen it by sprinkling with a whisk broom dipped in water after it is in place. This shrinks the canvas, and painting is begun before the canvas dries out. After the priming coat is dry, two or three flat coats are put on, finishing with a good deck paint. It is well not to try to get a glossy deck, as the result will be a short-lived job of canvasing. If too much paint is laid on, the surface will crack, or "alligator," and in time the canvas itself will crack. Builders have many ideas about painting canvas; most of them seem to work well enough. Some dampen the canvas with water and paint while wet; others depend upon stretching well.

There are only a few "don'ts": do not use airplane dope, unless you expect to sell the boat before you have to recanvas the deck. Glue and cement should be avoided for the reason already mentioned; if you do use it, get rid of the boat before the deck requires recanvasing. These materials will cement the canvas to the deck so securely that it is easier to redeck the hull than to scrape or burn off the canvas, in most cases. Sometimes it is desirable to

paint a canvas awning on the top, yet not paint it underneath. This can be done by wetting the canvas thoroughly and painting the top while still sopping wet. The water will prevent the paint from penetrating the canvas and will retard drying enough to form a film, which will settle and cement to the surface of the canvas as the water dries out from underneath the awning.

Remarks—Seams, Spacing of Fastenings

The only important matters not yet mentioned in regard to canvas-covered decks are: be sure the deck is smooth and fair in crown, and thoroughly clean of dust and dirt, before laying the canvas. Rubbing in the prime coat of paint with a smooth wooden block (the paint being rather thick and the canvas dampened with water before the paint is laid on) will help to get a glossy deck, if you are willing to pay the price of such a bit of finish. If the canvas is to be made of two or more widths,

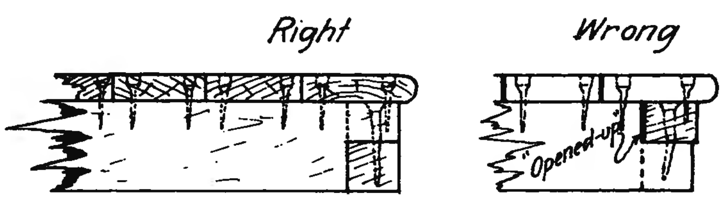


69. Deck Canvas Seam

the seam should not be formed by merely butting the canvas. The best way is to take the canvas to a sail or awning maker and have him sew the lengths together, with an inch overlap and a double seam. Another way, to be used when this is not convenient, is to double the edge of the piece first laid, with the edge upward; then lay the next piece with the edge doubled back, downward, to interlock with the first flap. The width of the flaps should be an inch or so. When the flaps are tacked together in wet paint, the result will be a tight seam. Tacks had better be spaced about 1 or 1½ inches apart, along such a joint.

Hatches, Deck Erections

The erections on deck can be built when the deck is completed and the guards, half-rounds, or rub battens fastened along the sheer. The construction of deck erections is shown in the plans and few comments are necessary. Generally speaking, it is best to set the coamings of cockpit and hatches, and cabin trunk sides, on top of the deck and secure them with through-edge bolts, or with long screws from under the carlins. The inside face of the carlin and the raw edges of the deck and canvas can then be covered with a thin "inner coaming," or finish piece. In half-decked boats, where a tight deck is of no particular moment, the coaming of a cockpit is often nailed to the inside of the carlins and a piece of quarter round is then run along the seam on top of the deck, against the coaming. The construction of a cabin roof is the same as that of the deck, but will be discussed in a later chapter. Hatches may be required in a flat-bottom hull and their construction may be detailed on the designer's plans. However the hatch is formed, there is one important point to remember in building a tight hatch cover: the corners of the frame must be halved together. In laying out the frames, note which way the planking of the top will run. Make the framepieces that cross the hatch-top seams with the halving cut from the bottom of the



70. Hatch Frame Construction

pieces; the framepieces running with the planking with the halving are cut from the top of the pieces. When put together, the pieces across the run of the planking will reach from edge to edge of the frame, and, when the planking is fastened, will prevent opening up of the frame. If this plan is not followed, the frame will open as the swelling of the planking will cause the end fastenings of the outside planks to tip the frame at the top of the corners.

Deck Fastenings

Fastenings in the deck and deck erections are usually nails and screws. The hold-down bolts in a cabin trunk can usually be

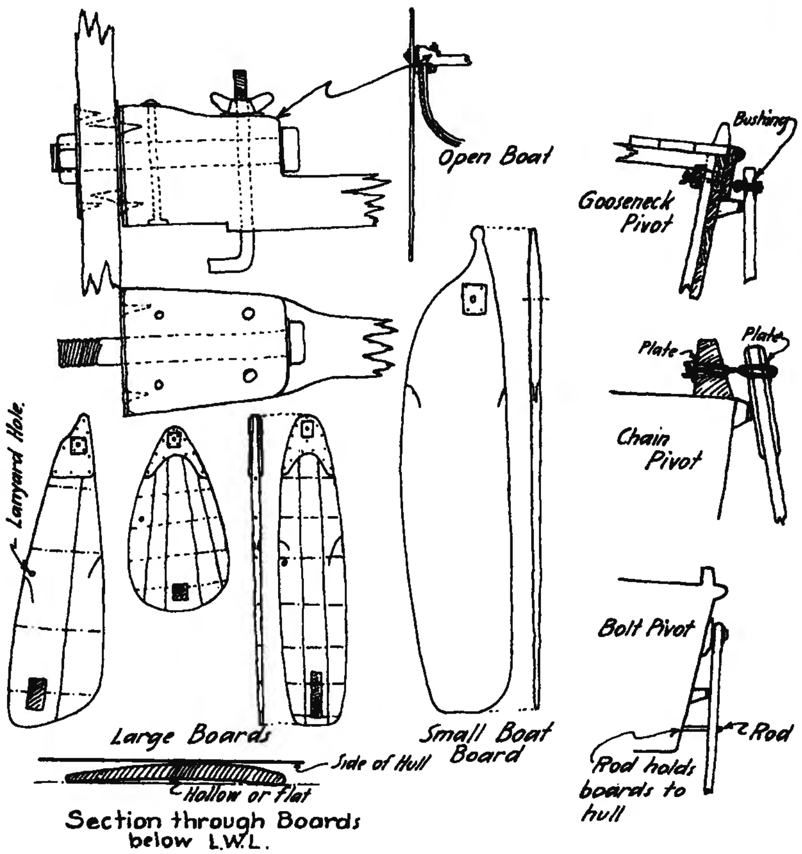
made of rod threaded at one end, or both, as desired. The bolts should be so arranged that they can be taken up from below deck. Space hold-down bolts about 12 inches apart when possible; keep clear of the portholes or cabin openings.

Centerboard Case

Centerboard cases should be made up and fitted to the hull, if not a part of the keel structure. When the case is completed, its bottom can be scribed to fit the bottom planking or the strong-back inside the planking. Fastenings are usually screws, or nails, driven from under the bottom. Take care that the board is placed exactly as shown in the plans; also that the mast partners and step are also exactly as shown there.

Leeboards

Leeboards are rarely seen in this country, but are useful alternatives to a centerboard. In a small boat, the leeboards may be pivoted to the sheer strake with a machine bolt. This should be placed so that it passes through a frame and the sheer clamp if possible, or through blocking bearing on the frames. In a large boat the pivot bolts are subject to heavy strains and should be so fitted that the leeboards can become "broken winged" without tearing loose from the hull. This is caused by neglecting to lift the weatherboard, which is then forced away from the hull by the leeway of the boat, bringing a tremendous leverage on the pivot bolt and often tearing the board away from the hull. This can be avoided by using a bushing in the board and using two eye-bolts, eye within eye. One eyebolt goes through the hull, the other through the bushing in the board, loosely. The bushing may be omitted by employing two eyebolts connected by a link. The best way to secure these bolts is to have slots cut in the shanks and to drive in wrought-iron wedges over washers. Nuts will corrode on the threads and make removal difficult. If the pivot is above the deck line, the same result may be accomplished by using a few links of chain as the pivot. In a well-finished job, the pivot bolts should be cast of bronze and made in a gooseneck or universal joint form, or eye-in-eye, or two eyebolts connected with a link.



71. Leeboards

Another plan is to confine the board to the hull with an iron bar, shaped to pass outside the board just above the chines, with its ends secured to the hull beyond the sweep of the board along the side. The leeboards should be made in a streamline form (cut lengthwise) in cross section or wing shaped. The flat side is faced outboard from the hull and the curved, shaped side against the hull. There should be a rub guard to take the chafing of the boards when down; this should parallel the water line or sheer. The boards should be ballasted so that they will sink. In rough water service the board is long and narrow; for smooth water service

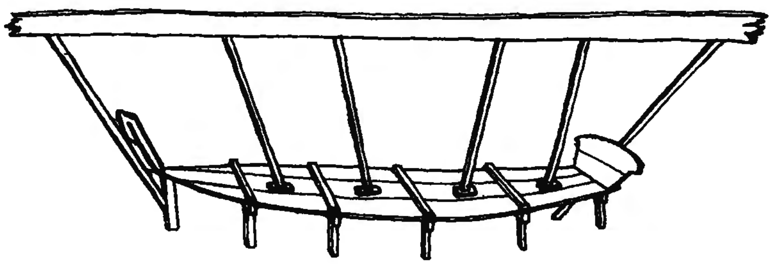
the boards are shorter and wider. The board can be proportioned roughly thus: one half the boards' length must be below the chine; their width should be about one half the length. The boards should be fixed so that they will tumble-home when both are down, that is, their lower ends should be farther from the center line of the hull than they are at the pivots. There are many ways of raising or lowering leeboards; heavy boards may be operated by a chain and a gypsy wheel, the latter mounted on the cabin roof and turned by a shaft and a crank in the cockpit. A trough over the cabin roof will prevent the chain from chafing. The gypsy may be locked by a catch on the crank. By this means one board is automatically lifted as the other is lowered. The boards should be also fitted for tackles, as emergency lifts.

Power Installation

Power installation in a flat-bottom hull requires mention. The engine beds should be fitted with cross-bearers that reach to, and rest on, the tops of the chine logs. Usually there is a great deal of pitch to the shaft line in a flat-bottom hull and it may be wise to check the angle before selecting an engine, as some will not operate well at marked angles of pitch. Universal joints can be utilized, but are not satisfactory if over a slight variation, between the angle of the shaft and that of the engine, is required. If an outboard engine is to be mounted on the transom, the latter must be cut to fit the engine height (shaft length) and be well fastened and braced.

European Setup—"Dory" Type

Flat-bottom hulls, with their bottoms planked lengthwise, are often set up in a manner entirely different from that described in this chapter. The bottom is expanded from the loft drawing and assembled with cross-cleats or frames. A setup is then made of posts, or cross-bearers, with their tops set to heights required to give the profile curve of the bottom. The latter is then set on these stocks and forced to the proper curve by stays or braces, wedged to the roof truss of the shop, or to a ridgepole and stem and stern setup. The sides are then put on with molds or frames to give the required flare. The sides extend down over the edges of the bottom and the chine logs are often omitted. When required, they are put in place just before the side planking is put on. This method is often used to build dories, but is more widely used abroad. The bottom is difficult to repair and the construction is not well suited to stand the strains set up in a sailing hull. The more common method of setting up a flat-bottom hull whose



72. Dory Setup, Used in Europe More Generally than in America

bottom is planked lengthwise is to set up frames as molds and to fasten keel, chine logs, and sheer clamps to them; then put on the sides, and finally the bottom. This is the usual setup used for V-bottom hulls planked lengthwise on the bottom. The edges of the bottom planking are exposed along the sides when the hull is built in this manner.

Bottom—Cross Planking vs. Fore-and-Aft Planking

The comparative advantages of cross-planking to lengthwise planking in the bottoms of flat-bottom hulls have been discussed in the first chapter. Many yachtsmen are under the impression that the seams of a cross-planked hull offer much greater resistance than when fore and aft. Observation of full-sized hulls does not bear this out and tank tests abroad are reported to have indicated some advantage in cross-planking at certain low speeds. At high speeds there appears to be some distinct advantages to cross-planking, but as yet the information is not sufficiently complete to draw definite conclusions. Ordinarily, the relative speed of the flat-bottom hull cross-planked with reasonable care is the same as that of a similar hull planked lengthwise on the bottom

with equal care. The question, then, is not so much a matter of relative speed as of relative ease of building.

Method of Expanding Side Planking

The expanding of the sides of a flat-bottom hull, so as to build without stocks from plans, in the "by guess and by God" method, is sometimes possible. It is doubtful that the results are as accurate as is desirable, but the possibilities vary with the design. To find whether this is practical, check the body plan in the loft drawing. If the sections there show that the sides are parallel to one another in *every* section, then the sides can be expanded. The process is somewhat like that used for expanding a transom. First a line is struck across the sides of the sections in the body plan; this is drawn like a diagonal and must be at right angles to every station it crosses. The two sides of the diagonal must correspond in the body plan; the diagonal must intersect on the center line and cross the base at equal distances from the center line. The first step will be to expand this line to find the true spacing of the stations. This may be done by fairing the line in half-breadth as a diagonal, marking the batten at each station in this elevation while it is on the floor. The batten is laid out on a straight line and the expanded spacing of the stations marked off. The stations are then drawn as perpendiculars to this line, extending a short distance above and below it. Next the distances from the diagonal, in the body plan, to the sheer and to the chine are laid off on a measuring staff for each station, measuring along the flare of the side. These measurements are transferred to the expansion and are set off on the corresponding stations there. So far there is little likelihood of trouble. The expansion of the ends of the sides is likely to be difficult, however. Perhaps the most accurate way is to draw another diagonal like the first and to expand its length, stern to rabbet of the bow, in exactly the same manner. If there is a reasonable difference in the height of the two diagonals in the body plan, the ends (when expanded) will be sufficiently decided to enable the proper rakes to be laid out. When the sides are being laid off, the two diagonals are parallel and the same distance apart in the expansion as they are in the body plan, measured along the flare of the sides, of course. When