

Developable Surfaces for Plywood Boats

Laying Out a Hull so that the True Surface of it can be Readily Determined

THE rapidly growing popularity of plywood and sheet metal for the construction of small boats and yachts makes the problem of designing developable bottom and sides one of timely interest to both professional and amateur yacht designers. Strangely enough, it appears that very few designers, even among the professionals, know the solution to the problem, and yet it is quite simple, and can provide the amateur with a lot of fun when he knows how the trick is turned.

All curved surfaces may be classified as "developable" or "undevelopable." The side of a cylinder is a familiar example of a developable surface, and a sphere an undevelopable one. A sheet of paper may be rolled into any form of developable surface, but it cannot be formed

into a sphere or any other undevelopable surface without crinkling or stretching.

It is generally supposed that a V-bottom boat with straight lines in all cross-sections is developable; but, as a matter of fact, it is not strictly developable unless the angle of deadrise is constant throughout the length, although it may be near enough to true developability to permit forcing plywood into it. A better shape of bottom, and one which is strictly developable, can be designed with slightly convex sections forward, and with the angle of deadrise increasing towards the bow.

A widespread and quite erroneous belief is that a developable surface cannot be curved in two directions at right angles to each other, e.g., longitudinally and transversely in a boat. The fallacy of this belief may be seen

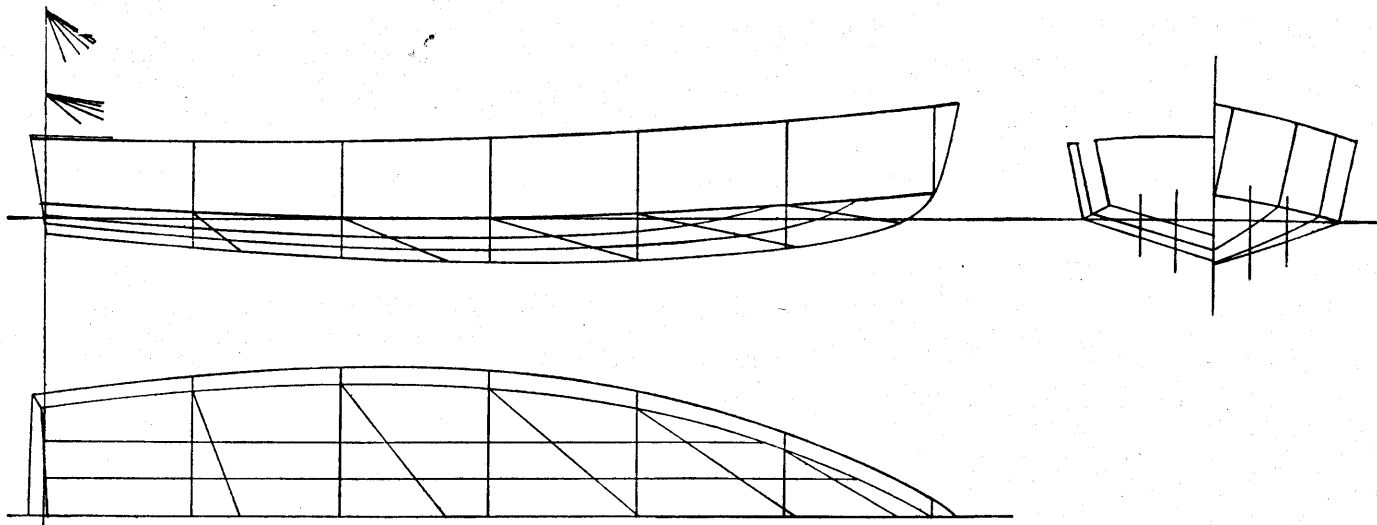


Fig. 2—A conically developable bottom which permits the designer more freedom in choice of form than that shown in Figure 1

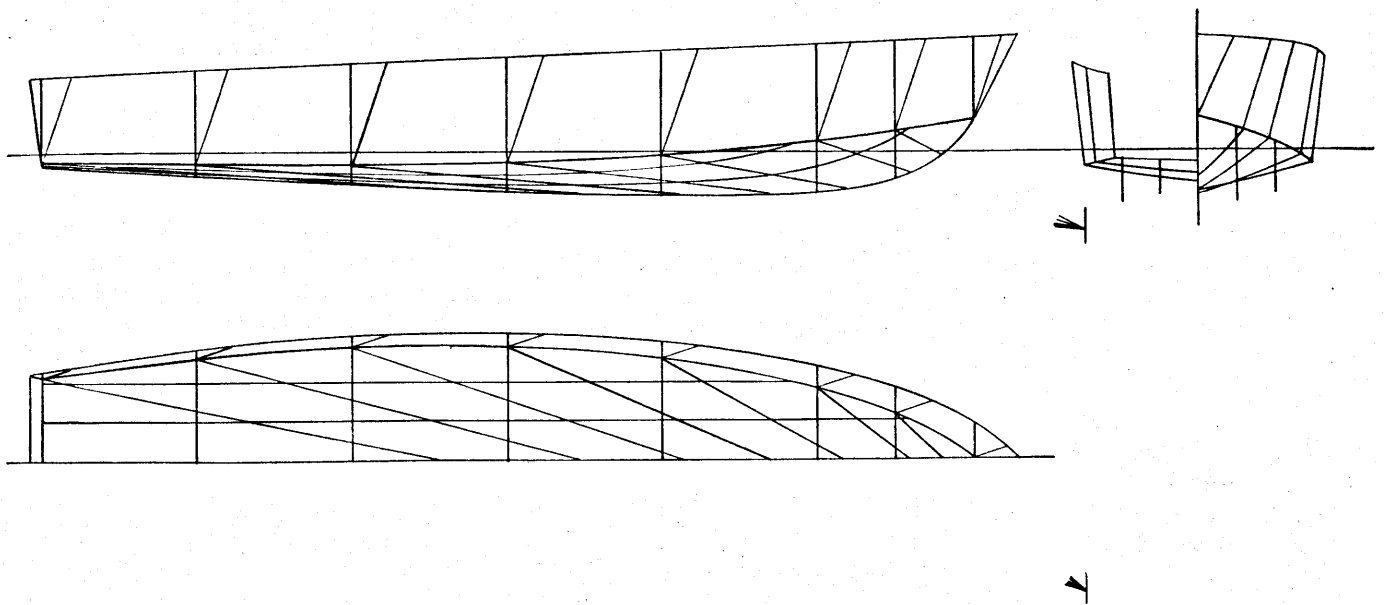


Fig. 3—A variation of Figure 2. The last two differ from Figure 1 in that the generatrix lines pass through a common point instead of being parallel to one another

at once by imagining two diagonal sections through a cylinder, intersecting one another at right angles. Both of these sections have curved intercepts with the surface of the cylinder. In fact, with the exception of lines parallel to the axis, all lines on the surface of a cylinder are curved; and yet a cylindrical surface is indubitably developable.

What, then, is the criterion for developability in a surface? The answer is that through any point on the surface it must be possible to run, in some one direction, a straight line which lies entirely within the surface and extends to its boundaries. Both cylindrical and conical surfaces satisfy the criterion for developability. It is further to be borne in mind that the solution is not confined to the special cases in which the cross-sections perpendicular to the axis of the cylinder or cone are circular. Cylinders and cones may have any shape of cross-section; and any motion of a straight line, except along its axis, which remains parallel to its initial direction, generates a cylindrical surface. Similarly, any motion of a straight line, which in all positions passes through a fixed point, generates a conical surface.

APPLICATION TO DESIGN

We shall now proceed to describe a simple method of designing cylindrical and conical boat bottoms.

The layout of a design with a cylindrical bottom surface is shown in Fig. 1. The design is begun by drawing the chine line in plan and elevation to suit the designer's taste. This line is called the "directrix." The line which by its movement along the directrix generates the bottom surface is called the "characteristic" or "generatrix." As many parallel positions of the generatrix as may be desired are then drawn in the plan. It is convenient to draw them to the centerline from the intersections of the

chine line with uniformly spaced cross-sections. To obtain increasing angles of deadrise forward, the generatrix lines must slope forward and down from the chine, as shown in Fig. 1. The more they are sloped, the greater will be the deadrise near the bow.

The positions of the generatrix in elevation are drawn next. It is obvious that the forward and after ends of each position of the generatrix must lie upon the same cross-sections in plan and profile. The forward ends are determined by the intersections of the generatrix with the centerline in plan. These positions are transferred to the elevation, where they determine the profile of the longitudinal centerline. The slope of the generatrix in the elevation is chosen to give the desired depth amidships. The buttocks are picked off and laid out on the elevation from their intercepts with the generatrix lines in the plan. Finally, the cross-sections are picked off from the buttocks and drawn in to make the body plan.

The form is entirely determined by the curve of the chine and the slope of the generatrix in plan and profile. It is bound to be fair if the chine line is fair and the drawing accurately done.

The topsides may be designed with straight, parallel sections, or given a twist and a flare forward by a generatrix sloping forward and upward from the chine, as shown in Fig. 3.

Conically developable bottoms, as shown in Figs. 2 and 3, permit the designer more freedom of choice of form than the cylindrical development. The design procedure is precisely the same as described for the cylindrical layout except that the generatrix lines pass through a common, arbitrarily chosen point, instead of being parallel to each other. The focal point must, of course, be on the same cross-section in plan and elevation.

Other lines than the chine can be used as the directrix, but that is usually the most convenient line for the purpose.