Laminated outlines

From Aeromodeller Annual 1964/65

Functional simplicity is all very well, but the resulting shapes are not always that pleasing and may carry unexpected penalties. The use of square-cut wing tips, for example, which has become more or less standard practice on duration models, means that such tips are usually carved from solid block, adding weight where it is least needed or desirable, and often unbalanced when the two tip blocks are of different density. Lack of stability in manoeuvres or vicious turning characteristics on a radio model are often traceable to overweight tips, or solid block tips which may be an ounce or more different in weight. The latter is particularly likely to occur in kit models where the tips are prefabricated. One shaped tip may weigh four or five ounces and the other only two ounces or so, because they have been cut from different stock. It saves a lot of bother to use the tips as supplied, but the unbalance added to the wing can only have a detrimental effect on performance. Adding more weight to the light tip to even out the balance is a classical example of expecting two “wrongs” to make a “right”. The other alternative—hollowing out the heavier tip—is not always feasible.

In any case square cut tips are poor aerodynamically, except where maximum performance is required only at low angles of attack—*e.g.* on a speed model. And the use of tips cut from block implies, almost inevitably, adding more weight to the structure than is necessary, as well as the weight being in the wrong place. If block tips must be used they should be carved from the very lightest balsa it is possible to find (4 to 6 lb density), or from expanded polystyrene (1 to 3 lb density).

Almost any shape is better looking than a square tip, although structurally more difficult to achieve. Typical construction for rounded tips a decade or so ago featured the tip parts cut from sheet, broken up into sections so that the grain of the wood ran substantially parallel to the curve (Fig. 1). The main limitation with this form of construction is the difficulty in obtaining a 100 per cent glued joint along the scarffed joints. Too often these broke up when carving and sanding the tip to final shape, or failed after the wing had been covered and was in service.

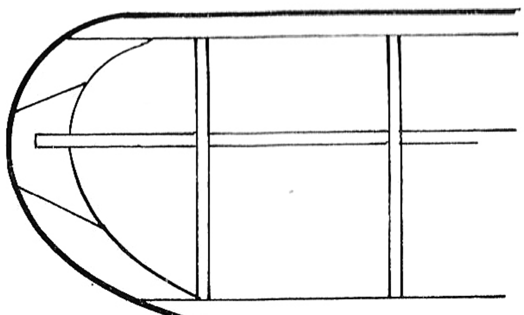


FIG. 1

One of the main reasons why this tip construction was not persisted with with kit designs, incidentally, is that the thickness of sheet required for a model of moderate size *i.e.* 3/16” or ¼” sheet, or even more, cannot readily be die-cut cleanly and accurately. Thus as die-cut sheet became more or less standard in kits, simpler square cut tip designs became favoured to dodge this question, although some kits have persisted in giving printed sheet for rounded tips and others have used similar rounded tip designs with layer-laminated pieces which can readily be die-cut from thinner sheet.

A layer-laminated tip can be stronger since joint lines can be staggered on adjacent layers. Unless all the parts are very accurately cut, however, the resulting glued up assembly can show gaps. Also final trimming to shape is not so easy when glue lines also have to be chamfered through. All these troubles can be avoided by using a simple outline lamination made from strip with the laminations vertical.

The vertical laminated outline is particularly versatile as regards the shapes to which it can be adopted, and also in width. By choosing strips of 1/32" thickness for small wings, 1/16" thick for medium size wings, or *3/32"* thick for large wings, and selecting flexible stock for cutting the strips (not stiff quarter-grain stock) most practical tip shapes can be bent with the wood dry. If necessary, too, additional strips can be added to the laminate to build up greater width at a particular point—*e.g.* at the trailing edge. The tip width can, in fact, change from a matching width at the leading edge to a matching width at the trailing edge, giving a balanced, economic structure (Fig. 2). This enables the average width of the tip to be less than that for a corresponding sheet strip, with a saving in weight, and the laminated tip will still be stronger.

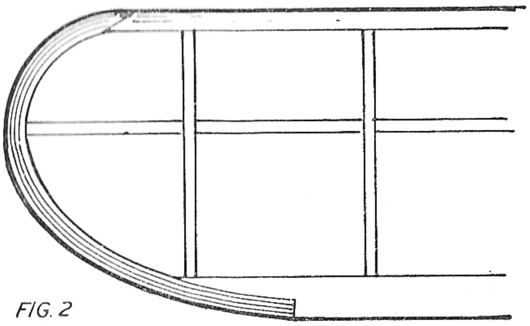


FIG. 2

Equally, of course, laminated construction can be applied to the complete outline of a wing panel which has an elliptic or curved taper planform with rounded tips (Fig. 3). About the only limitation is this respect is that if the peripheral length L is greater than 36" then individual strips cut from standard 36" long sheet will have to be jointed in length.

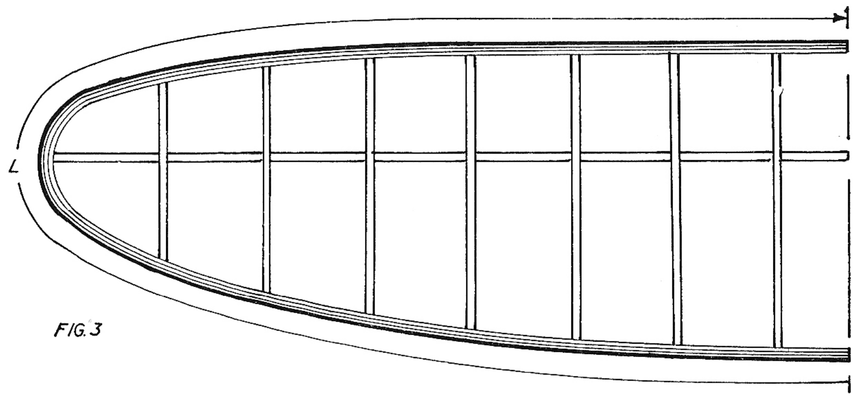


FIG. 3

In the case of an elliptic planform tailplane the whole outline may be laminated as one or, usually more conveniently, using a solid section for the bulk of the leading edge where the curve is moderate and a laminated outline for the remainder (Fig. 4).

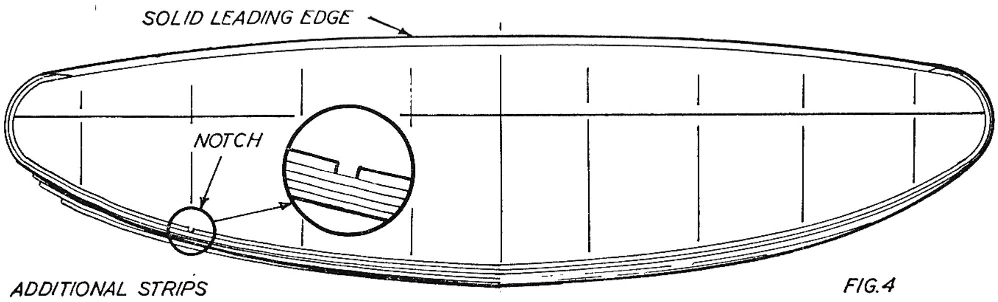
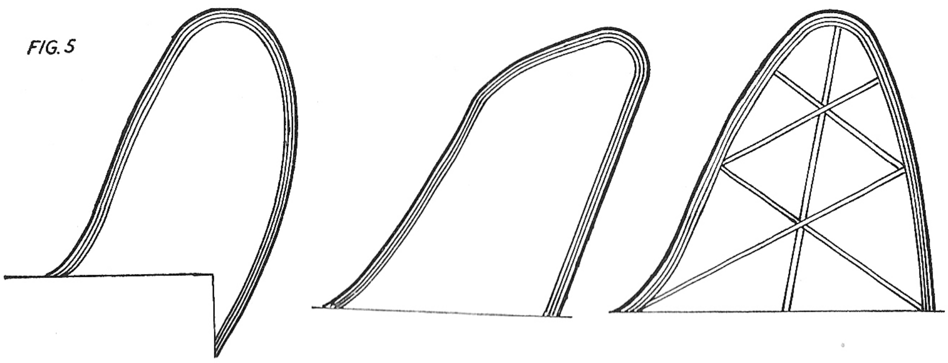


FIG.4

An additional advantage provided by the vertical glue lines in the trailing edge is good resistance to warping, laminated outline being more resistant to distortion than built-up structures. There is also no objection to notching the laminated outline to locate and recess ribs, restricting the depth of cut to the first layer only (or two layers at the most in the case of a wide trailing edge section).

Compound outlines can also be accommodated readily with laminated outlines, such as a curved fin shape (Fig. 5).

FIG. 5



Used in conjunction with geodetic ribs the resulting structure is very light and extremely rigid - virtually completely proof against warping - although not as easy to make as a conventional built-up structure or a fin cut from solid sheet. Although the latter form of construction has become more or less universal for power models, a relatively thick fin section can be an advantage on R/C designs since it is less prone to stalling than a thin flat plate section. Carved from thick sheet, even of the lightest density available, a solid fin can be relatively heavy. A laminated outline with geodetic ribs with thin sheet covering (or tissue covering) will be very much lighter.

Laminated construction was also very popular at one time for formers for streamlined fuselages, a “hoop” former being very much stronger and more rigid than a built-up or cut-out sheet former, as well as being fighter. Lightweight streamlined fuselages are rarely called for these days, however, and where streamlined sections are employed it is usually on models where weight is not a critical factor and so rounded sections can most conveniently and easily be produced by using solid or partially hollowed balsa blocks on sheet sides.

Laminated construction has virtually nothing to offer for the production of square or rectangular formers since it cannot accommodate “square” bends and where a lightweight former of this type is required it is a simple matter to build it up from strip (Fig. 6). This gives the best grain direction on all sides and is preferable to a former cut from sheet which will always be weak in compression at right angles to the grain direction, unless a generous thickness of sheet is used. The strength and rigidity of a light former built up from strip may, however, be improved by the addition of a laminated ring, as shown in the second diagram of Fig. 6, where the weight saving afforded justifies the additional work involved.

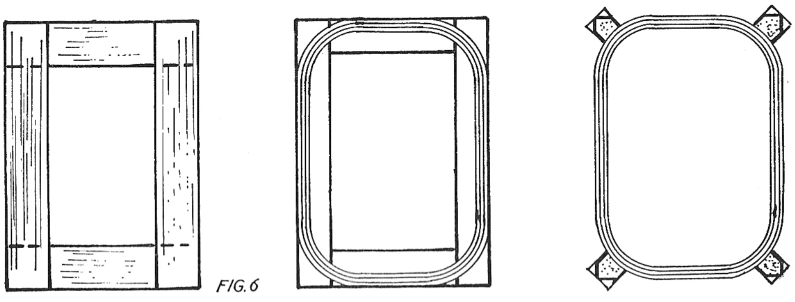


FIG. 6

So much for the general design applications of laminated outlines. Now let us consider the practical details involved in making up such outlines. Starting point is selection of a suitable strip thickness for the individual strips, as previously mentioned, and then deciding the width of the laminate required (which fixes the number of individual strips). Width of the finished laminate can be decided, basically, as the same overall dimension which would normally be chosen for a solid strip section, assuming that such a solid section could be formed to the required curve; or in the case of a wing tip, as “matching” widths conforming to the existing leading and trailing edge widths, as previously mentioned. In a complete outline, thicker strips can be used to build up width where required, using thinner strips for the more sharply curved regions where a small width may be required (Fig. 7).

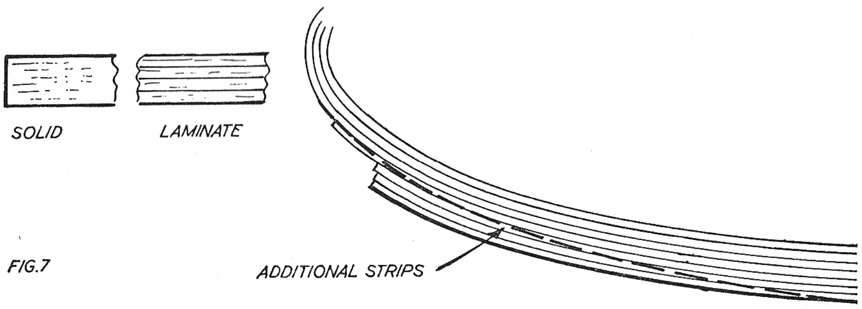


FIG. 7

Rather than select the number of strips required from strip stock, these are best cut from a single sheet of the required grade and cut. Light density wood is perfectly adequate, and will usually bend better in any case, avoiding quarter- grain stock and selecting a sheet which will bend readily end to end. The cutting width for each of the individual strips must then be decided.

Where identical pairs of laminated outlines are to be produced - e.g. a pair of wing tips - these should be made as one, and subsequently cut down the middle to separate. Strip width for laminating must therefore be equal to twice the actual section thickness, plus an allowance for the cut to separate them, plus a further allowance for cleaning off. A generous allowance will be two and a half times the finished section depth required (Fig. 8) but this can be reduced a little if preferred and you can be sure of making an accurate cut to separate the laminate into two matched pieces.

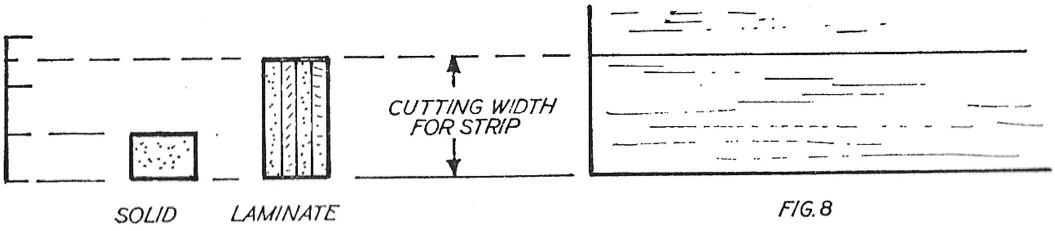


FIG. 8

Suitable adhesives for laminating are balsa cement, casein glue or UF resin glue (the latter two types being standard woodworking glues). Balsa cement is suitable for making small laminates, but UF resin is usually to be preferred, although taking longer to set. It also has a further advantage in that it is a water mixture and the wetting the strips receive in applying the glue will assist in bending them.

A pattern is needed around which the laminate is to be formed. This is best cut from fairly thick balsa sheet, if the size is not too large, cut to the exact inside outline shape required, carefully smoothed down and the edge then well wax-polished by rubbing with a candle. All of the strips for the laminate should then be individually glued and stacked one on top of the other, ignoring any extra layers for the moment (i.e. additional strips to be used to build up a trailing edge width.)

Now pin the stack of glued up strips in place at the starting point on the pattern. Rest the pattern on a suitable flat surface and pull the strips around the curve, making sure that they are kept in close contact with the contour of the pattern and that all strips are pressing tightly against each other. Pin at intervals, as necessary, until the whole laminate has been formed. Working on a flat surface the bottom edge of the laminate will be flat and true. Follow the basic stages in Fig. 9. If additional strips are required, these are added after completing the main outline, again making up the additional strips as a separate stack, each strip coated with adhesive, and then pinning up in place. Now leave until the laminate has set completely—overnight if using UF resin and at least four or five hours if using balsa cement.

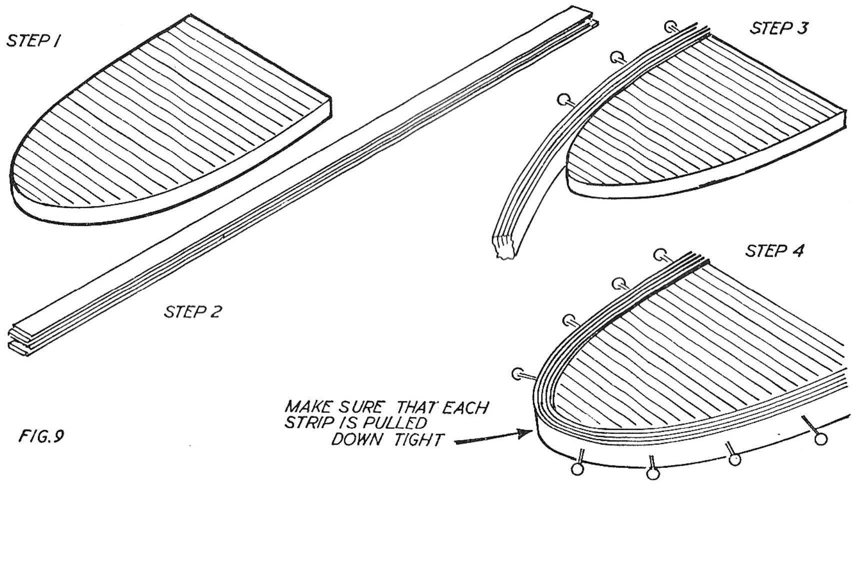


FIG. 9

Before removing the laminate from the pattern sand both top and bottom surfaces perfectly flat and true. These will then represent finished surfaces which will require little or no reworking when finally assembled. It is far easier to do this at this stage than when a wing tip has been added to a wing frame. Then cut the laminate down the middle using a fine saw to separate into the pair of identical parts, if necessary. From then on the laminate can be treated as any other piece of solid balsa for trimming to fit and cementing in place to the rest of the structure.

Where the laminate is large and it is not convenient or economic to use a solid sheet balsa pattern, it can be laid out around a jig of pins, as shown in Fig. 10. There is, however, the distinct possibility that the pins will kink the inner strip on the sharper bends, so to overcome this set the pins up on an outline one strip thickness in from the final inner outline required and use a spare strip length as the first layer which is *not* glued up when making the stack of laminates. This strip is then removed and discarded when the laminate is finally removed after setting. It will probably have stuck in places, but can easily be trimmed away as necessary. Alternatively the strip can be rubbed with a candle in the first place to prevent it from sticking.

Faults which are likely to occur in making laminates are invariably “material” or “technique” faults, which may be summarised as under:

Strips crack when bending to shape around the pattern the usual cause being that the wood selected for the strips is too rigid, or the thickness of the strips is too great for the radius of bend attempted. To check the suitability of a strip for bending, try bending dry without adhesive around the pattern first. If satisfactory, other strips cut from the same sheet should make a suitable laminate. If the strip cracks, try to select a more “bendable” piece of sheet, or use a thinner sheet for the strips.

Separation of strips on the final laminate. This can be caused by a variety of reasons:

- Glue drying before the strips are set up in place on the pattern— usually only applicable when using balsa cement.
- Insufficient glue—leaving dry spots in the laminate.
- Wrong glue mixture—such as too much water, again leading to dry spots.
- Failure to keep all strips in the laminate tightly pressed against each other in bending to shape—this allows gaps to develop, producing a break in the glue line.

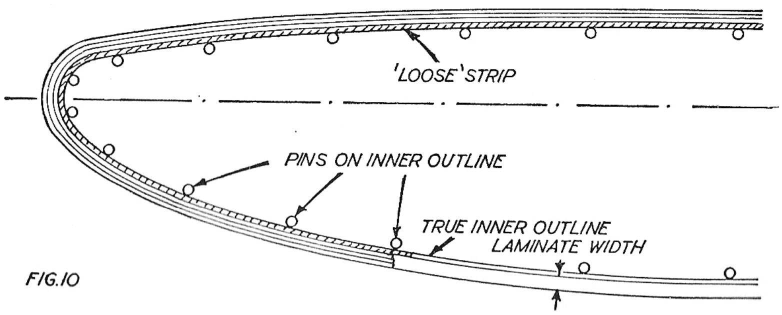


FIG.10

Modern materials update

Now that ply of all sizes is available I make formers out of 6 mm liteply. To avoid strips cracking they should be soaked in water for ten minutes then clamped, unglued, around the former and left to dry. In the July 2017 newsletter I described a soaking trough made from guttering. Then remove, glue and return them to the former. For the clamps I use small balsa blocks pinned down to a SLEC balsa building board. If using a PVA type glue, for example Evo-stik or Titebond, there is usually no need to wet the strips before laminating as the glue wets the wood and it also soaks in to increase strength.