CHAPTER 7

WINGS

WING DESIGNING. The wing of a model airplane, being its main supporting surface, should be given the builder's utmost care in design and construction. As it is usually the largest part of a model, it must be designed so that its weight will be at a minimum; yet, as it receives the maximum of air pressure, its strength must be maintained. During the growth of the model airplane, many unique and ingenious wing designs have made their appearance. Practically all of these are the result of fighting the model plane's greatest enemy—weight. Some designs have failed because the builder has sacrificed strength in his effort to eliminate weight, but great advances have been made and all model builders should be familiar with them.

When building solid, built-up, or flying scale models, little designing of wings is required, because the wing of the real ship must be followed closely. On solid and built-up non-flying models, every dimension of the wing on the real ship should be scaled down and a true copy of it constructed for the model. In the case of flying scale models, the general form of the wing of the real plane must be adhered to, but it is often necessary to enlarge its proportions, since the exact scale of the wing may prove too small to sustain flight.

It therefore follows that when we speak of wing designing we refer to wings that are to be used on stick or commercial models.

When designing a wing, the builder has from three to six important steps to consider. These are *size, type, weight, camber, sweepback,* and *dihedral.* On all wings the first three must be considered, and on many the builder will find all six desirable. By size we refer to the actual length and width of the wing. Aeronautical engineers have perfected the wing of real planes through a thorough study and careful application of aerodynamics, but for the average model that would require far too much time and effort for the results gained. Too many factors enter into the case, such as type of model, weight, speed, and strength, to permit a hard and fast rule for choosing proper wing size on any given model.

As a guide by which the builder can obtain an approximate idea of

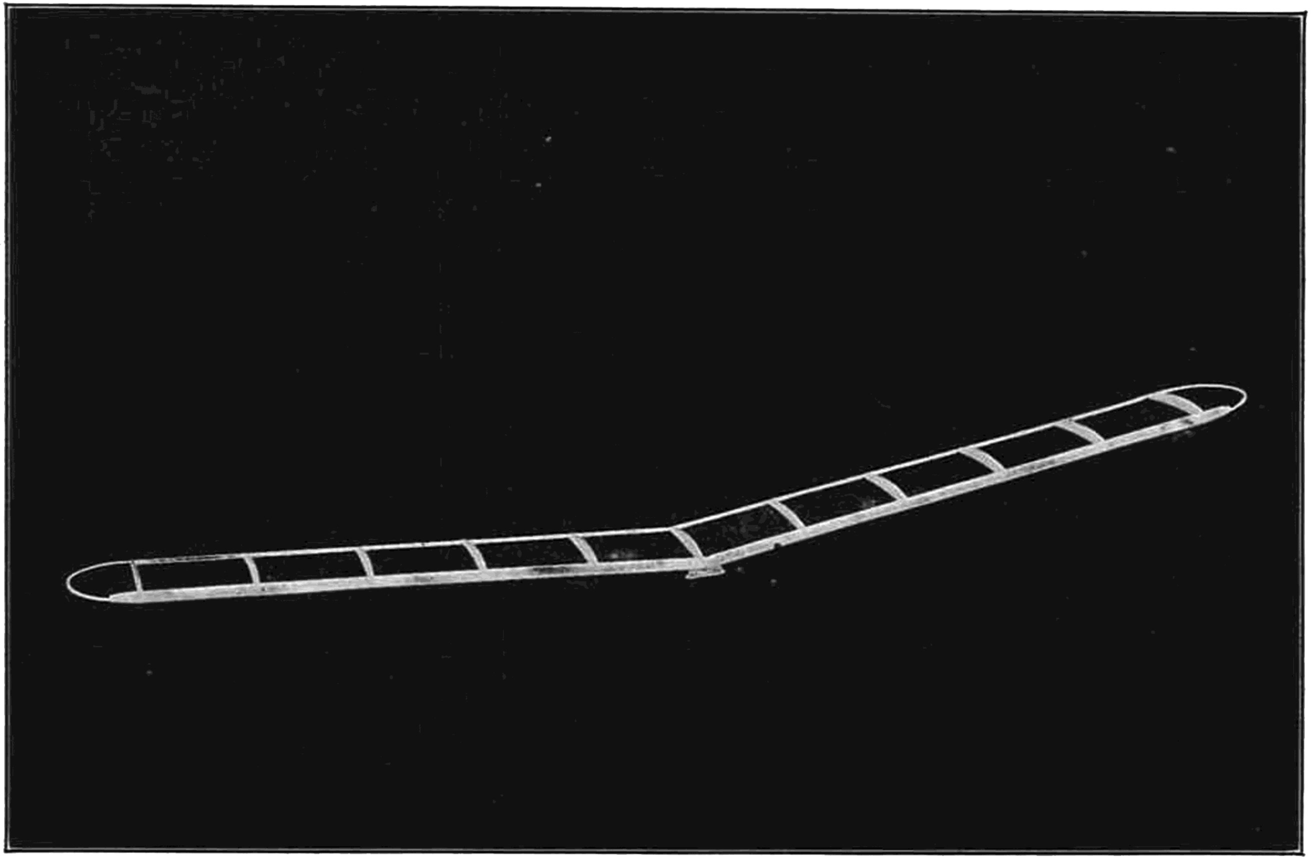


FIGURE 18. STRAIGHT WING

wing size in relation to length of motor stick, the author has chosen twenty model airplanes, all of which have won honors at national meets. These can be safely followed on models the builder designs, but the value of experimentation cannot be too strongly stressed.

A careful study of the models given here will show the wide variation these expert model builders have used on their planes, and yet we find every one a winner. Undoubtedly chosen after careful trial flights, each wing size has proved best for the particular model on which it is attached. Experience will soon bring perfection in such choices, but the beginner should make many attempts before deciding that his model has the most efficient wing.

As a start, the amateur can safely follow the sizes given here. It is recommended that this chart be referred to when designing a wing, until the builder feels confident of his own judgment.

WING SIZES OF CHAMPIONSHIP MODELS

LENGTH OF MOTOR BASE	TYPE OF MODEL	WING WIDTH	WING LENGTH
8″	Stick Tractor	2″	15″
8″	Stick Pusher	2″	13″
8½″	Stick Tractor	2¼″	15″
9″	Stick Pusher	2½″	12″
10″	Stick Tractor	1½″	12″
15″	Stick Tractor	3½″	25″
15″	Stick Pusher	3″	20″
15″	Stick Tractor	3¼″	28″
16″	Stick Pusher	2½″	19″
17″	Stick Tractor	3¼″	22″
17¼″	Stick Tractor	3½″	23″
18″	Commercial	3″	26″
20″	Stick Tractor	3″	24″
24″	Commercial	4½″	34¾″
25″	Stick Tractor	3½″	30″
30″	Commercial	4½″	42″
36″	Twin Pusher	4½″	32″
40″	Twin Pusher	4¾″	32″
41″	Twin Pusher	4⅛″	31½″

The next step in wing designing is to choose the type of wing desired. For all practical model purposes only two require consideration. The first

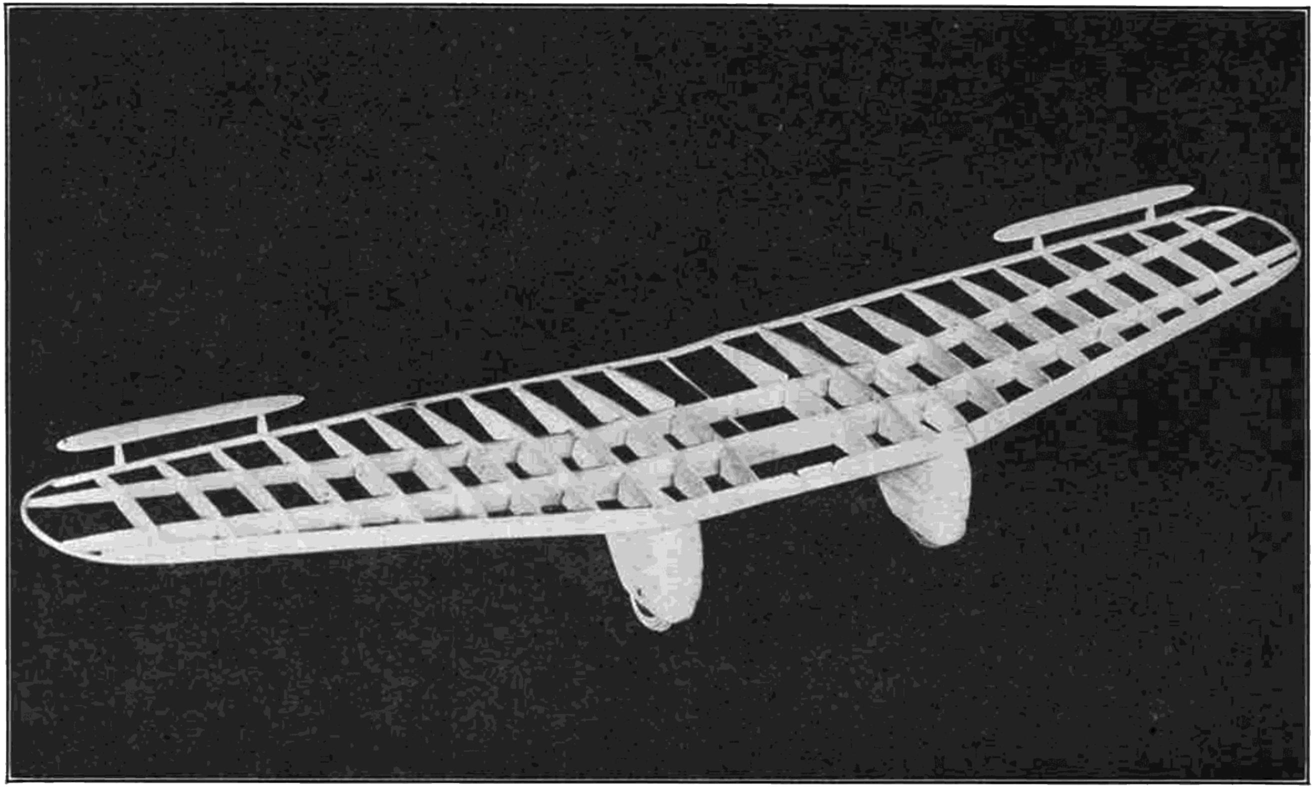


FIGURE 19. TAPERED WING

of these is the *straight wing,* so called because it retains the same width and thickness throughout its entire length. (See Fig. 18.) Because it is strong, light, and simple to build, it is by far the most popular wing today on all single-stick models. It must be remembered that the *shape* of the wing is now being discussed and not the method by which we gain that shape. Such straight wings can be built-up, made exceedingly heavy, strong, and durable, or they can be of the lightest construction, very fragile, and fit only for the smallest and lightest endurance models.

The second type is called the *tapered wing,* because it tapers in width and thickness from its center toward both ends. (See Fig. 19.) A tapered wing can be built as light in weight as a straight wing, and is often used on endurance twin pushers. It requires more construction work, as each rib is different in size, but when completed gives a better appearance than the straight wing. Aside from this, however, the author has been unable to find any advantage it may have over the straight wing.

The third factor in wing designing is the most important of all. This is the weight of the finished wing. A good rule to follow, when considering the weight of a wing, is to make it as light as possible without weakening its structure too much for efficient use. There are many ways to accomplish this. A wing is made up of five main parts. These are its tips, ribs, leading edge spar, trailing edge spar, and inner spar. The last named is often left out, but on all large wings it is necessary for proper bracing.

The various ways and means employed to lighten these five parts of a wing are more a question of wing construction than design, so this subject has been dealt with in detail under "Wing Tip Construction," "Wing Rib Construction," "Leading Edge Spars," "Trailing Edge Spars," and "Wing Inner Spars."

Camber is simply the curve of a wing from its front, or leading edge, to its rear, or trailing edge. From an aerodynamic standpoint, it is a form designed to produce a maximum of lift with a minimum of resistance. If you would remember the meaning of the word, think of it in terms of shape. Camber is the shape of a wing, after covering, when viewed from the end. To obtain this shape, one, two, or three parts of the wing are employed. The ribs are the part of a wing that chiefly determine its camber. As these are formed, so will the greatest portion of the wing's width be formed. Study Fig. 22. No. 1 completes the entire form from leading to trailing edge, while No. 7 requires the leading edge spar form to complete the camber. No. 13 needs both the leading and trailing edge spars to give perfect streamlining.

Sweepback is a term that practically explains itself, inasmuch as it means the distance the wing extends backward from its own leading edge, or the distance it sweeps back. This is measured from a straight line passing through the leading point of the leading edge and registering an equal distance from both wing tips. The distance must be taken at right angles to this extended line, and is usually expressed in inches. The proper method of measuring sweepback is shown in Fig. 20. Note that a straight edge, such as a ruler or T-square, is placed against one half of the wing along its leading edge spar, and that the distance from this straight edge to the leading edge at the wing tip is then measured. This measurement represents twice the sweepback of the wing, as the sweepback of each half of the wing

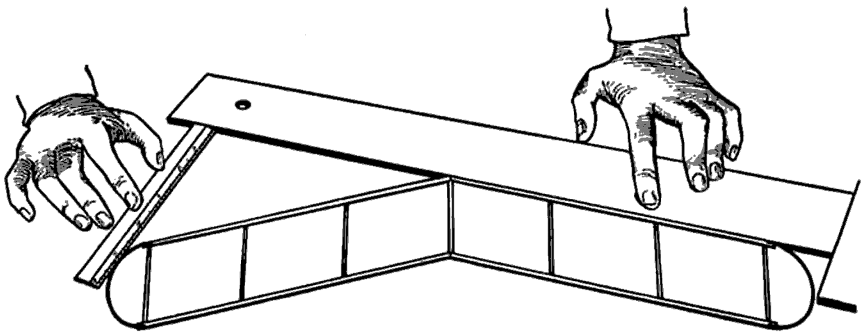


FIGURE 20. MEASURING SWEEPBACK

is the distance usually specified as "wing sweepback." In other words, if the measurement taken in the manner shown in the illustration should prove to be 6″, the sweepback of the wing would be 3″.

Our last step in wing designing is one of the most important of all. It is the angle at which each half of the wing extends up from its own center. Its proper name is *dihedral angle,* so called because of the angle the wing forms with level. For model work, this is usually referred to as "wing dihedral," or simply as "dihedral." It is indicated on all plans in this book by the latter word. It is obtained by inclining the wing of a model up from the center of the fuselage so that the tips are higher than any other portion of the wing.

All stick and commercial flying models should have wings with dihedral, as it is the greatest means of obtaining stability in flight. For example, let us assume that a perfectly straight, flat wing is in flight. Suddenly a gust of wind strikes one half of it and forces one side up and the other down. The result will be that the wing will "slip" through the air to the ground. On the other hand, if the wing has a dihedral and the same thing happens, the half that is forced down by the upward pressure on the other side will move down from its inclined position to one of level flight, thus sustaining the other half of the wing until its position is corrected. This prevents "slipping."

The dihedral angle of a model wing is usually given in inches. If the plan shows a dihedral of 3″, it means that each wing tip must be that much higher than the center of the wing. A simple method of measuring the dihedral of a wing is shown in Fig. 21. Lay one half of the wing on a flat surface, and note the distance of the opposite wing tip above the surface.

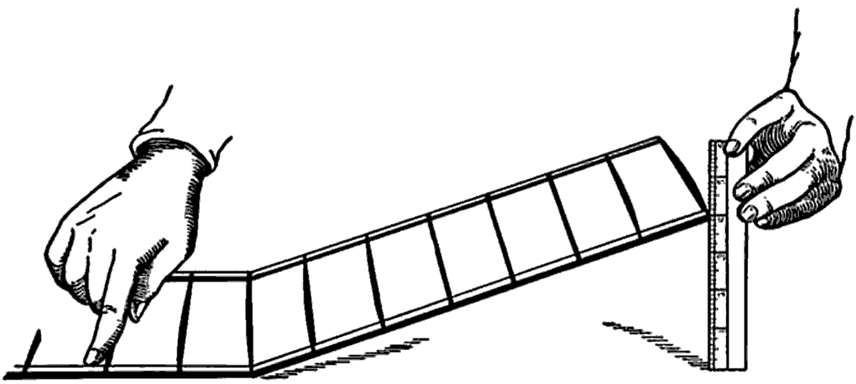
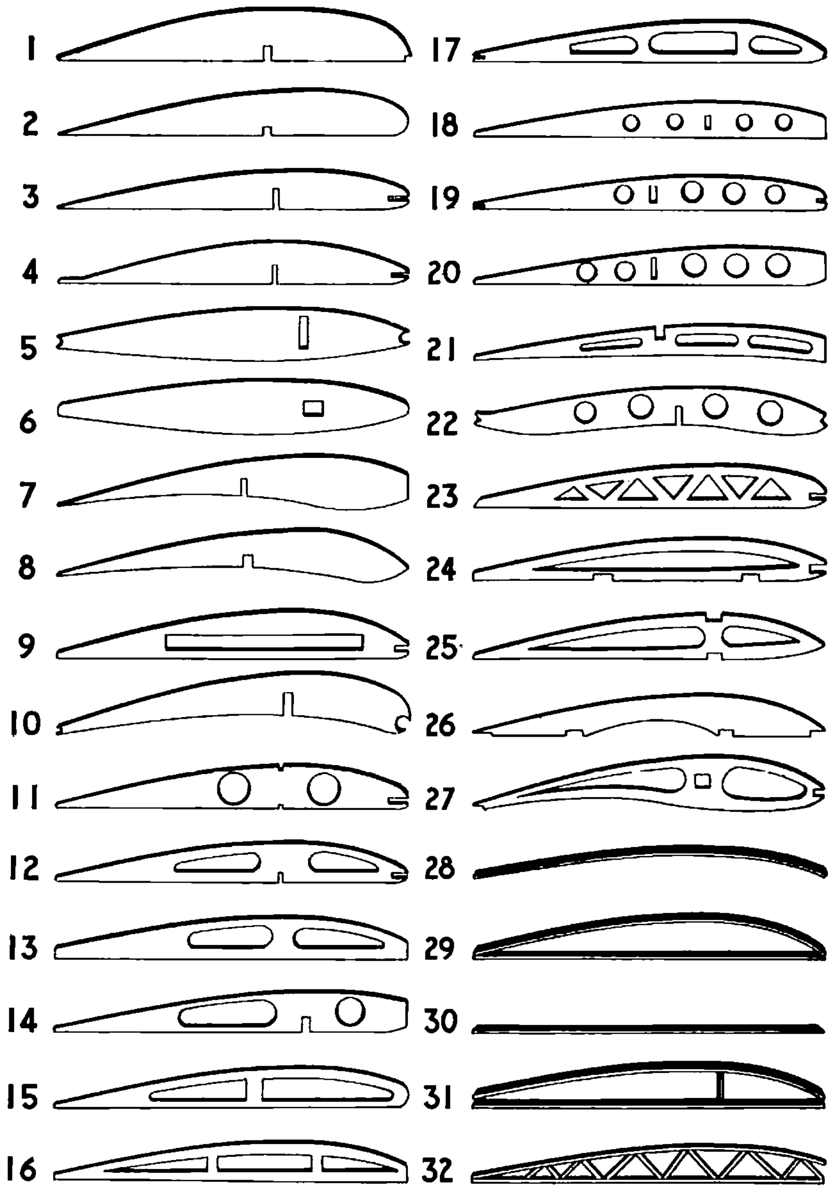


FIGURE 21. MEASURING DIHEDRAL

This distance represents twice the dihedral of the wing, as the tip being measured is extended twice its normal distance above level due to the other tip being on the level. If this distance measures 3″, the dihedral of the wing would be 1½″, or the height each wing tip would be above the level if both were extended equally, as in flight position.

WING RIB CONSTRUCTION. The importance of proper rib construction becomes apparent when one considers that a wing is merely a series of ribs held together by two or more spars. "Wing Designing" explains that the ribs of a wing largely determine its shape from leading to trailing edge. They also largely determine the weight and strength of a wing, as they make up the greatest portion of its framework.

There have been any number of rib forms introduced for model aircraft, but experimentation has proven that the "Clark-Y" form is best for general model wings. In Fig. 22 will be seen thirty-two ribs that have been successfully used on models in the last ten years. The Clark-Y form is shown by Nos. 1, 2, 3, 9, 11, 12, 13, 15, 16, 18, 23, 29, 31, and 32. It must be understood that the designation "Clark-Y" refers only to the outside form of the



WING RIBS

FIGURE 22

rib, or the form the wing will take when covered, and that it has nothing to do with the means by which that form has been gained. A close study of the ribs referred to above will show that each is alike in outside outline, although each gains that outline in a different way. Their greatest difference lies in the fact that their excess weight has been removed in varying ways, although each would give a covered wing the same general shape.

Another difference lies in their relations to leading and trailing edge spars. While such spars are used to hold the ribs together, some ribs are so formed as to use these spars to complete their streamline form. On Nos. 1, 2, 3, and 9, spars add nothing to the outline of the ribs. Nos. 13, 16, 18, and 31 depend on the leading and trailing edge spars to complete their form.

In the past, wing ribs were solid, as shown by Nos. 1 to 8, 10, and 26. When, however, the importance of weight became apparent, it was found that such ribs contained an excess of weight. In an effort to lighten models, the ribs were cut out in various forms. Note Nos. 9, 11 to 25, 27, 29, 31, and 32.

The actual construction of ribs is not a difficult task, but one requiring great care. For all single-stick, endurance models of light weight and small size, single stick ribs are used, as shown by Nos. 28 and 30. The latter, being without any camber, is not desirable.

These simple ribs are usually cut from $\frac{1}{32}''$ or $\frac{1}{16}''$ balsa. They may be square, or about twice as wide as they are thick. A $\frac{1}{32}''$ square, a $\frac{1}{32}'' \times \frac{1}{16}''$, a $\frac{1}{16}''$ square, or a $\frac{1}{16}'' \times \frac{1}{8}''$ single stick rib is considered good practice on light models, the size increasing according to the size of the wing, which is covered on the top side only.

As it is difficult to bend individual sticks exactly alike, it is best to obtain a wide piece of sheet balsa of the thickness required, bend the sheet, and then cut the ribs, after it has dried in the desired shape.

Wing ribs for all larger models are cut from sheet balsa wood of various thicknesses. For light models, a $\frac{1}{32}''$ sheet balsa should be used, and this thickness increased according to the size and weight of the model being built. Such ribs are used on all wings which are to be covered on both sides.

It is seldom necessary to use wood thicker than $\frac{1}{8}''$, although on some very large models the author has seen $\frac{3}{16}''$ ribs. This gradual increase in rib thickness should also be applied to built-up, non-flying models. While strength and weight mean very little on such models, the thickness of ribs should be kept in relative proportion with other members of the framework.

To cut such ribs, the builder should draw his rib on paper and then trace its outline on the wood. This is then cut out with a razor blade and inside excess weight removed. The circles are punched out with the eraser ferrule of a lead pencil. (See Fig. 23.) The eraser is removed and its small, round holder slowly pressed into the wood with a screwing motion.

Where the wing must come in contact with a strut, a heavy-duty rib may be inserted, as shown in Fig. 24. This is left solid for strengthening the

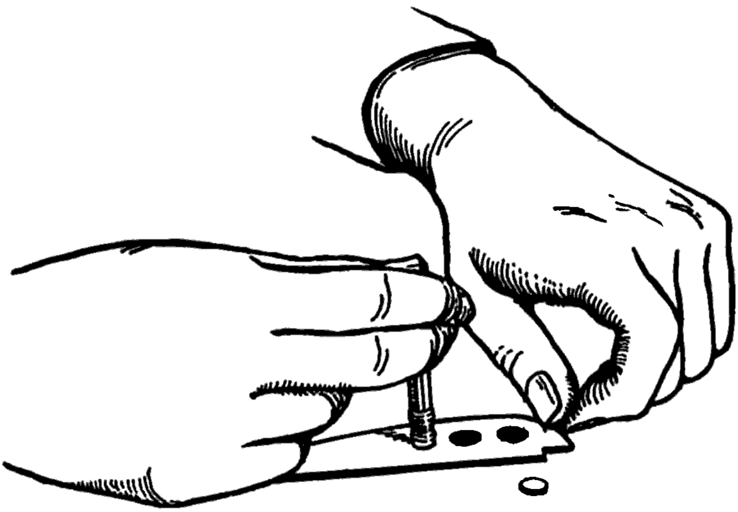


FIGURE 23. USING PENCIL FERRULE FOR LIGHTENING RIBS

structure and insuring it against breaking. Such ribs are usually twice the thickness of the ordinary ribs, and are given their same shape.

The ribs in Fig. 22 should give the beginner considerable aid in choosing proper design and construction for all and any models on which he may work. All notches shown between the ends of the rib, whether on top or bottom, are made to accommodate inner wing spars, while those at the front end of the ribs are for leading edge spars. Those at the rear are for the trailing edge spars.

Most ribs are cut from solid sheeting, as has been explained, but some builders prefer the built-up rib as shown by Nos. 29, 31, and 32 in Fig. 22. The first consists of two balsa lengths. The top one is bent in the Clark-Y form, and the bottom stick left straight. Their ends are then cemented together. No. 31 is constructed in the same manner, except that a small brace is added, because the ends are not cemented together. These are left open to accommodate the leading and trailing edge spars, which are rounded to complete the form of the rib.

No. 32 presents the greatest construction problem, although it is by far the strongest. It consists of two balsa lengths, one of which is bent in the Clark-Y form and is used for the top of the rib. Short braces are then cut and inserted into place, being held with cement, after the two ends of the balsa lengths have been cemented together.

Those other than the Clark-Y form are shown as a comparison between

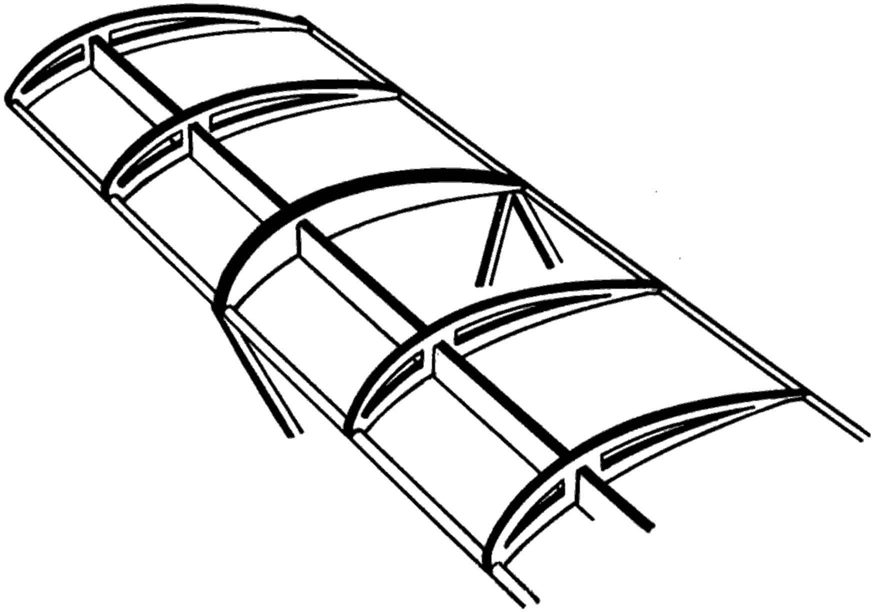
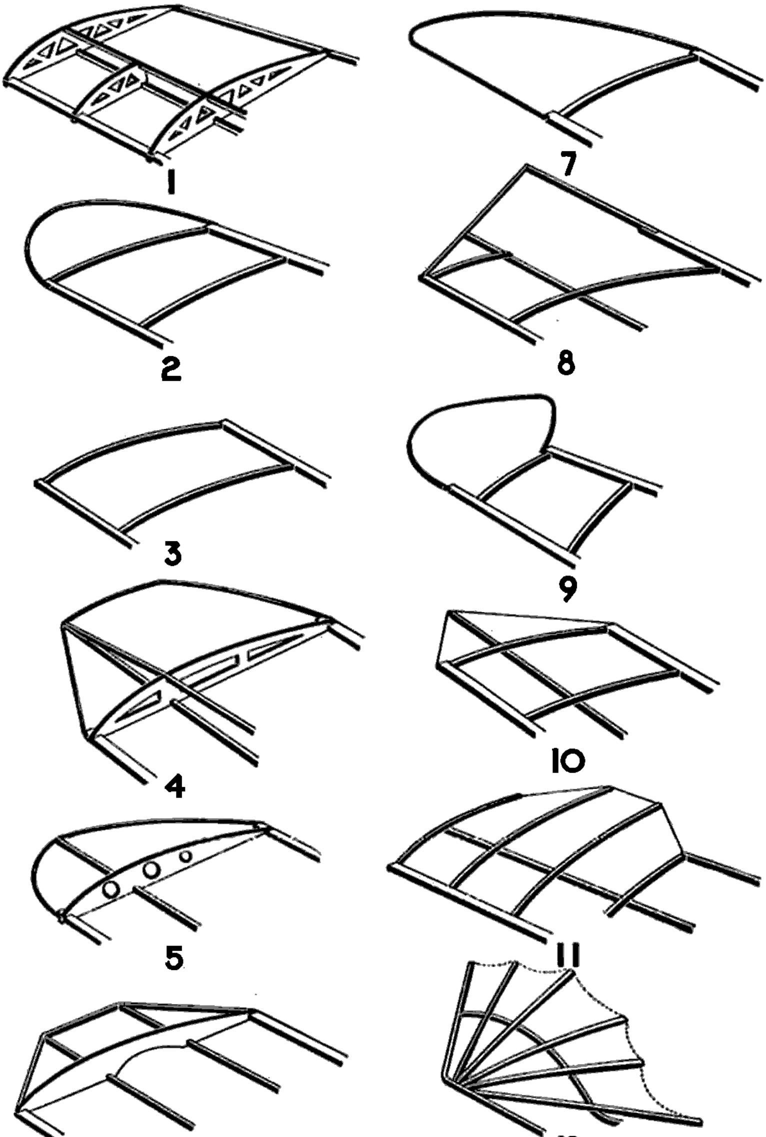


FIGURE 24. HEAVY DUTY RIB

it and various other shapes, and the author recommends the beginner to experiment with various forms.

Fig. 25, No. 1 shows a false rib, which is often employed to strengthen the front of a wing structure, and yet add less weight than a full-length rib. They are made in the same manner as the full rib, and are usually inserted between full-length ribs, alternately along the wing structure.

WING TIP CONSTRUCTION. The various tests made from time to time on wing tip efficiency tend to show that tips with a negative rake prove more efficient on airplanes. This means a rounded tip having a longer leading edge than a trailing edge. (See Fig. 25, No. 7.) Note that both wing spars are equal in length, but that the tip is given such a shape as to cause the leading edge of the wing to extend beyond the trailing edge.



WING TIPS

FIGURE 25

Many model builders confuse the leading or trailing edge of a wing with its leading or trailing edge spar. Both are different. The former refers to the edge of a wing only, without consideration as to how that edge is gained, while the latter refers to a structural member of the wing, so placed as to lead or trail the wing.

Either of these edges may be formed by a single spar, or by a number of short spars. In No. 7, one is formed by the spar and the tip combined, or, as in No. 11, a trailing edge may be formed by a trailing edge spar and thread. No matter how they are made, the front and rear edges of a wing are called the leading and trailing edges of that wing, while the leading or trailing edge spar indicates that spars are used to form all or part of these edges.

The fact that tips with a negative rake prove more efficient might be taken to mean that all wing tips should be of this form, but the author has found through tests that the difference is so slight on the model airplane as to be practically negligible.

As a guide for the beginner, twelve wing tips are shown in Fig. 25, all of which have proved successful on model airplanes. Before going into actual construction, let us consider the merits of these. No. 1 shows the blunt, square end of a wing having no specific wing tip. Note the false rib between the leading edge spar and the inner wing spars. This wing, having sheet balsa ribs, gives a very blunt appearance at the end, which makes it unpopular with model builders, more because of its ungraceful form than through any lack of efficiency. Single surface wings, having only one side covered, are sometimes left square, and while their appearance is not as graceful as the wing with a formed tip, they are not as blunt as the thick wing. (See Fig. 25, No. 3.)

Possibly the most popular tip for wings covered on one side only is the rounded tip shown by No. 2. It will be found on more models than any other. This is because it is easy to construct, and gives the wing a finished appearance. No. 7 shows practically the same tip, though more difficult to construct, because of the necessity of keeping its front on a line with the leading edge spar to serve as a portion of the leading edge of the wing. It, also, is for wings covered on one side only.

No. 5 is designed to give approximately the same lines to a thick wing as No. 7 gives to the thin one. The inner wing spar extends out beyond the leading and trailing edge spars to further strengthen the tip structure. Such a wing is covered on both sides. Both these wings have negative rake.

No. 4 tip is similar to No. 5 in general lines, but is not curved. It is often used on large wings having two inner wing spars, one located over the other. The curved tip of No. 5 can also be applied to such a wing structure, and should prove slightly more efficient. No. 6 tip is an interesting treatment of a wing having two inner wing spars located parallel to each other on the same level. Note that the two inner spars are longer than the other wing spars.

Nos. 8 to 12 are designs for thin wings covered on one side only. No. 8 was taken from a fuselage model which won the English record for endurance in 1928. Aerodynamically, such a form is not considered good practice. No. 9 shows the tip used on the tailless model given in Chapter 29. These tips bend slightly up with their trailing edges higher than their leading edges.

No. 10 is made of a thread outline to which the single tissue covering of the wing is attached. Such a tip is not at all strong and will break at the slightest touch, but eliminates weight.

No. 11 is wider than the main portion of the wing, on the order of the tailless model tip. The inner wing spar and the leading edge spar are the same length, both being longer than the trailing edge spar. The trailing edge of this tip is formed with thread.

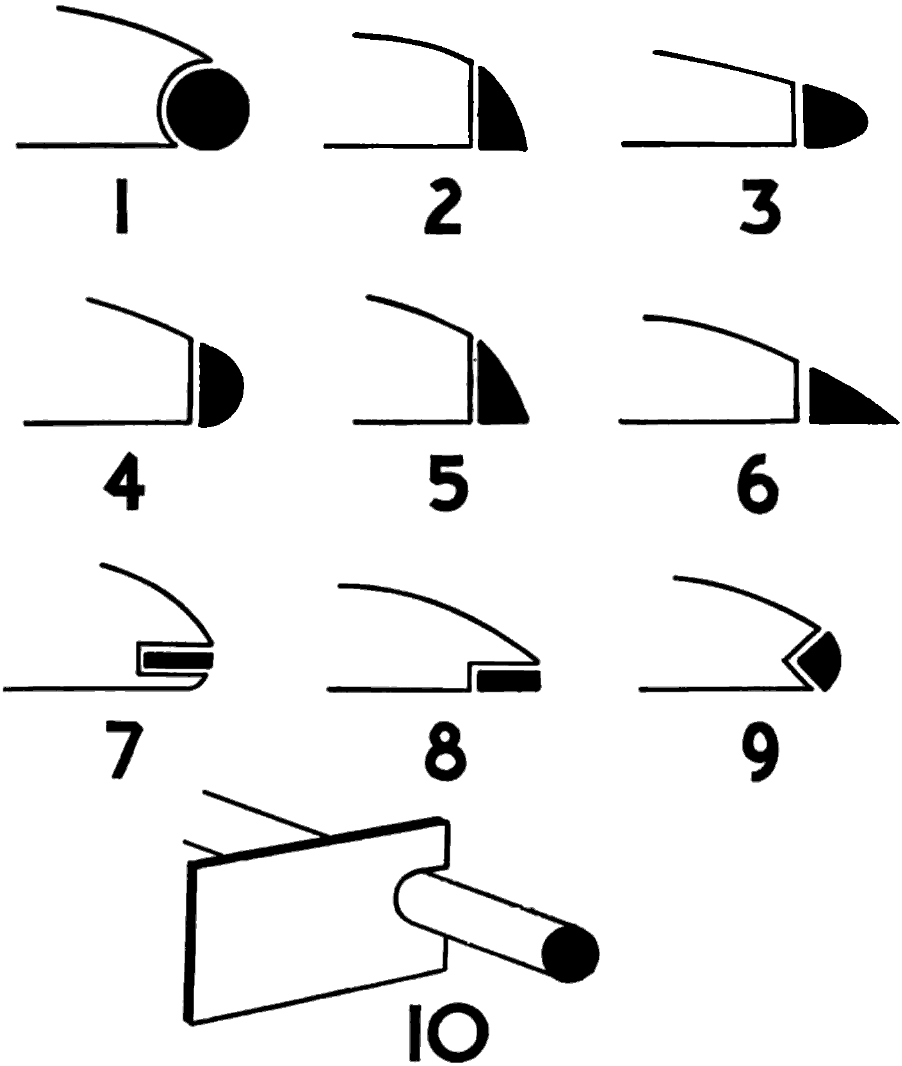
No. 12 has nothing along the trailing edge on which to fasten the tissue covering. The paper is cut to form, and cemented in place. Many small, light, endurance models of modern design appear with this feature, although the general lines of their wings may differ in many respects.

In the past 1/32″ or 1/16″ split bamboo has been the most popular material used on wing tips, but balsa is fast replacing it for this purpose. Balsa can be bent quite as easily as bamboo, and while it is not as tough, it is far lighter.

Some wings are built in two half-sections, and completed by joining them together. The tips are then added. When bending tips, bend wide enough stock to make both tips, and then split the wood in half. This assures the builder identical tips.

As the tip is not expected to contribute toward the strength of the wing, it must be as light as possible, so excessive weight will not be added to the wing structure. However, on flying models it should be given a design strong enough to withstand shocks in case of wings striking the ground when the model lands.

LEADING EDGE SPARS. It is hardly necessary to define the term "leading edge spar," as the name is self-explanatory. It is the spar of a wing that would lead all others if the wing were put in forward motion. In other words, it is the spar that leads. Its chief purpose is to hold the ribs of the wing together at the leading edge.



LEADING EDGE SPARS

FIGURE 26

But leading edge spars often serve another purpose. This is as a means of completing the desired form of the wing ribs. On all thin wings, having single stick ribs and covered on one side only, such as those shown in Fig. 25, Nos. 2, 3, 7-12, leading edge spars play no part in the camber of the wing, but on those having thickness, through the use of sheet balsa ribs, leading edge spars are often called upon to complete the desired rib form.

Fig. 26 shows a number of these leading edge spars. Note how Nos. 1, 2, 3-6, 8, and 9 carry on and complete the general streamline form of the ribs to which they are attached. Strictly speaking, Nos. 7 and 8 also complete this outline of the rib form but over such a short length as to be practically useless as an addition to the rib contour. In other words, a tissue covering attached over such ribs and leading edge spars would continue on in the general rib form even if the spar was not there, while on the others, a covering over the ribs without the continued lines of the leading edge spars would result in an entirely different and undesirable contour.

Whenever ribs are used requiring their leading edge spars to complete their form, the builder must take every precaution to see that his spars are so shaped as to continue the lines of the ribs in one perfect outline. In Fig. 26 various forms of leading edges are shown in black, with their corresponding ribs outlined. Nos. 7 and 8 will require nothing but squaring up a length of balsa, but all the others must be shaped. As balsa wood is very soft and easily worked, sandpaper is the best tool for roughing out these shapes. When completed, the shape is perfected. The first edge of the spar to be finished to exact size should be the one fitting against the rib, so that it can be placed against it from time to time as a guide when shaping the other sides.

One of the best methods of shaping such spars is to make a number of small brass scrapers such as shown in Fig. 26, No. 10. These should be made of stiff brass. At each end of the scraper, a small slot is cut in the form desired for the spar. The builder should make a set of these scrapers of various designs used for spars, so that he will be prepared at all times to cut a spar to any shape desired. When the wood has been roughed out, the scraper should be used to complete the job. Rub the scraper back and forth over the wood until it is perfectly smooth and has the exact form desired. This can be followed with No. 00 sandpaper, but care must be taken to see that the original form is not changed. Do not be disappointed if you spoil a few spars in your first attempts, for shaping such pieces requires skill which can only be gained through experience.

TRAILING EDGES. Unlike the leading edge of a wing, which is always equipped with a leading edge spar, the trailing edge is not dependent on such a spar. For wings having single stick ribs, no inner spars, and covered on one side only, a trailing edge spar is a necessity, as shown in Fig. 25, Nos. 1, 2, 7, and 9. But when the same type of wing has inner spars, a trailing edge spar is not necessary. In Fig. 25, Nos. 8, 10, 11, and 12, such construction is shown. If an inner spar is used, it can be made to serve the same purpose the leading edge spar serves at the leading edge of a wing, which is to hold the ribs together.

Fig. 25, Nos. 11 and 12, give two examples of this use of inner spars. No. 11 is equipped with a trailing edge spar, but if the builder desired he could safely continue the thread outline shown at the tip along the entire trailing edge of the wing. If this was done, the inner spar would be sufficient to hold the ribs in place.

Fig. 25, No. 12, shows a wing having nothing along its trailing edge. In this case the inner spar serves to hold the ribs together, while the tissue used to cover one side of the wing is cut to shape the trailing edge, cemented firmly along the entire rib lengths, and left without further support along the trailing edge.

In wings having sheet balsa ribs which require covering on both sides, a trailing edge spar is always used. This is due to the fact that the two sides of the paper must have a structural member of the wing at the trailing edge for proper attaching. Such spars are usually made of balsa lengths, though many builders use bamboo stripping for this purpose. In some cases, the trailing edge spar completes the form of the rib, as many leading edge spars do, but this is not as common as in the case of the leading edge spar. However, in Fig. 22, Nos. 5, 10, 13, 22, 24, and 31, will be seen ribs requiring various trailing edge spar forms to complete their general outline, so it is sometimes necessary to form trailing edge spars in the same manner in which leading edge spars require shaping.

The same method is used on these trailing edge spars as has already been explained in the section on leading edge spars. When bamboo is used, it is never shaped in this manner, being merely a 1/32″ or 1/16″ split bamboo length.

WING ASSEMBLY. After all ribs, spars, and wing tips have been cut to size and properly formed, the wing is ready to be assembled. The first requirement for this work is a full-size plan of the wing. If the builder has not been working from full-size plans, he should draw such a plan, showing the top view of the wing. (See Fig. 27.)

Each piece of the wing structure is then placed in position on the plan to see that all parts fit perfectly.

Except in the case of straight wings having no sweepback or dihedral,

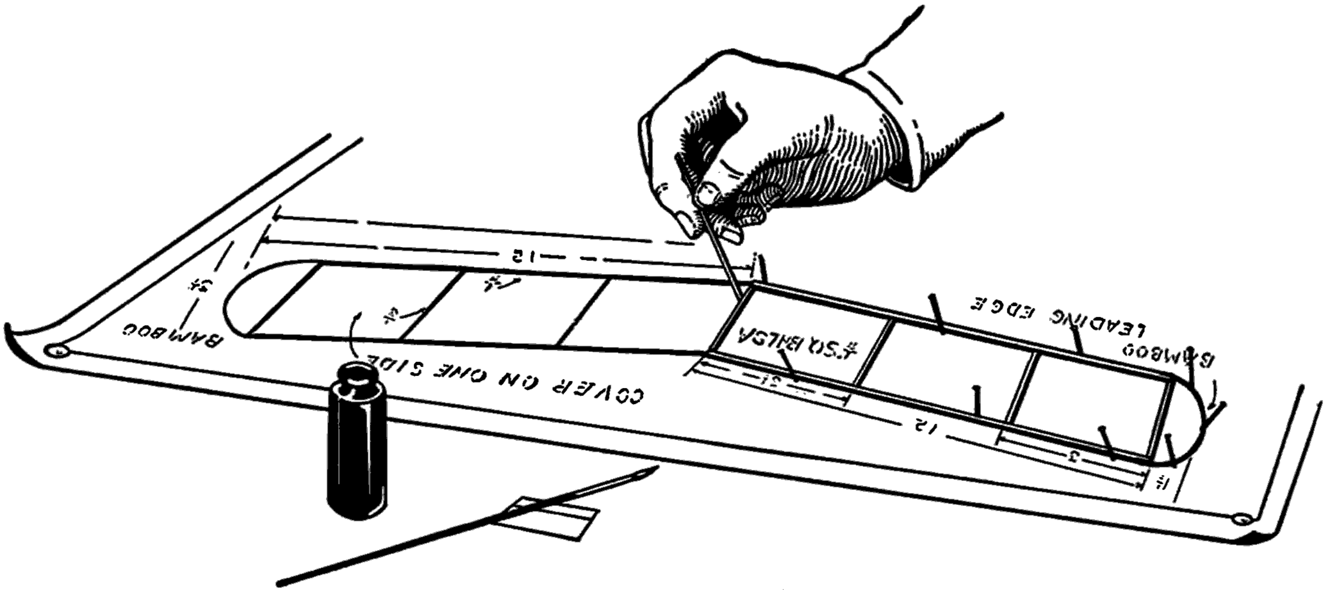


FIGURE 27. ASSEMBLING WING ON PLAN

all others are made and assembled in two parts. Note how one half of the wing is being assembled in Fig. 27. After both halves are assembled separately, they are joined together with cement.

For wings covered on one side only and having single-stick ribs, the process of assembly is quite simple. All parts of the wing are held on the plan by model pins. These are placed on each side of the piece, as shown, and serve to hold it firmly in position during cementing.

Place the leading and trailing edge spars in position on the plan and hold them with pins. The stick ribs are cemented in place between them,

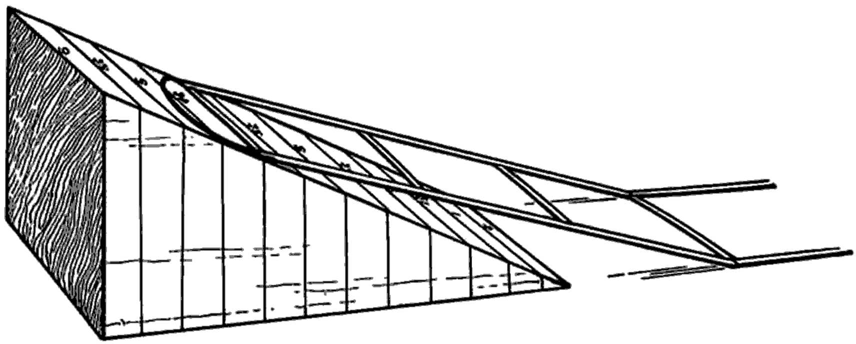


FIGURE 28. DIHEDRAL BLOCK

followed by the wing tip, which has already been bent to proper form. Allow the cement to dry thoroughly before starting work on the other half. This is merely an added safeguard against possible shifting of the parts already assembled, while working on the second half. After both halves have been assembled and all joints are perfectly dry, they are ready to be joined. The wing dihedral is obtained at this time. This is found on the edge view in the plans of the wing. (See plan in Chapter 21.)

Many builders have experienced trouble when giving a wing its proper dihedral. It not only requires proper measuring, but also careful holding while the cement at the joint dries. As the tip of the wing must be held up in position, only one hand is available for cementing, which is often difficult and clumsy. To eliminate this awkwardness, make a dihedral block, shown in Fig. 28. This is simply a triangular block of wood with a height of 6″. Along its base, points are marked off every ½″ as shown. Lines are then drawn up both sides and across its top, which complete it.

To use the block, place both halves of the wing in position on a level table, and slip the block under one tip. While holding one half of the wing flat on the table, continue to slip the block under the other half until its tip reaches a line on the block which represents twice the desired dihedral. For example, if the wing calls for a dihedral of 1½″, the block should be moved under the wing until the wing tip reaches the 3″ line. The two halves of the wing are then cemented together, and the structure left in this position on the block until dry. This eliminates all difficulty in measuring, holding in position for cementing, and keeping that position during drying.

As the plan calls for a 1½″ dihedral, which means that each wing tip must be raised 1½″ above level, giving one wing tip twice the dihedral while the other tip remains at level results in the correct angle for both halves of the wing, or the desired height of 1½″ for each tip. Such a block being 6″ high can be used for all wings having dihedrals of 3″, which will be found sufficient. If extraordinarily large models are being built, the block may be made higher so as to produce larger dihedrals.

After the wing has been assembled, it should be given a light sandpapering to remove excess cement, rough and uneven joints, and other blemishes. It should then be carefully tested for proper balance. Many model builders neglect this step, which often results in a model flying with one wing low. A novel wing balancing apparatus is shown in Fig. 29. It consists of a flat base, about 1″ x 4″ x 48″, with a back of the same dimensions, but which can be cut from thinner stock. In the center of the base, a 1″ thick, 3″ wide, and 4″ long block is nailed on its edge, as shown. Into the upper edge of this block, four safety razor blades are inserted. These are cemented in place. A number of lines are drawn along the length of the back board parallel to the base, each being numbered at both ends. This completes the apparatus.

Its design accommodates both single and double wings. Fig. 29 A shows a single wing being balanced. Needles are thrust into the leading and trailing edge spars exactly in the center of the wing. They are then placed through the holes in the upright blades. If the blades used on the apparatus have no such holes, small notches should be filed in their top edges to accommodate the needles.

The lines on the back board are used to aid the builder in judging the balance of his wing. If the wing levels with both its tips along the same line, the wing is perfectly balanced, but if one tip is lower, the heavier side must be corrected. To do this, remove the wing, and lightly sandpaper the spars of the heavy side, frequently testing its balance in the apparatus until perfected.

The type of wing having sheet balsa ribs and no inner spars is assembled in the same manner. If the wing has one or a number of inner spars,

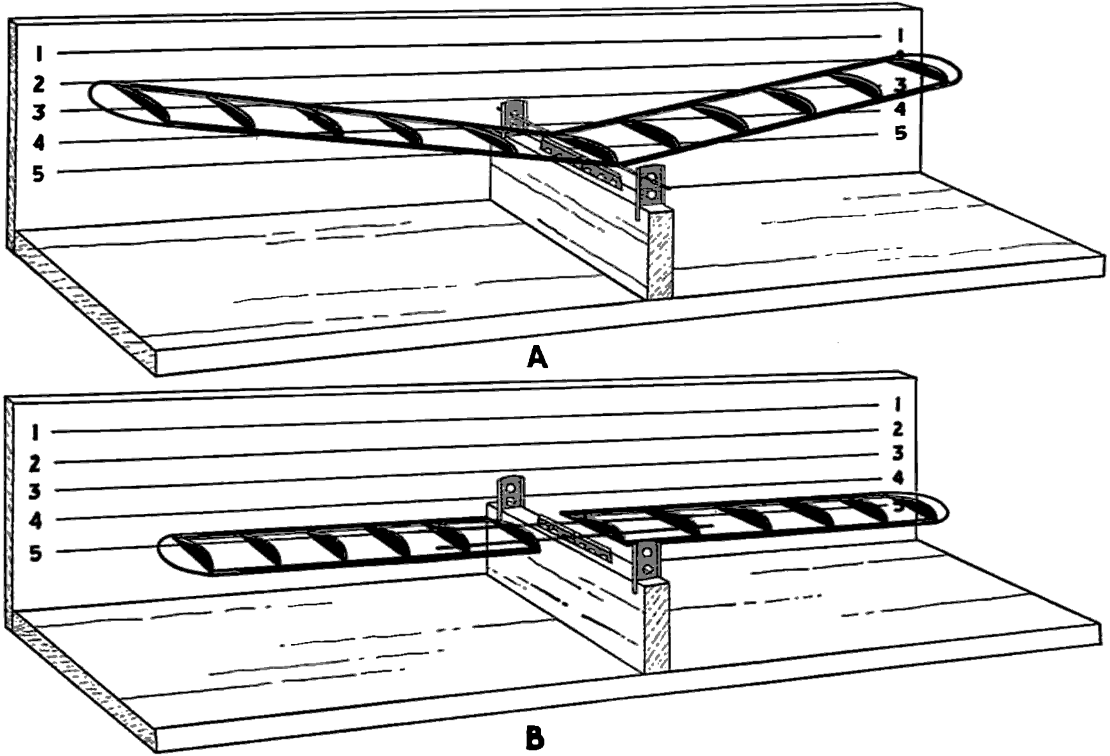


FIGURE 29. TWO-WAY WING BALANCING APPARATUS

the inner spar or spars should be cemented in place to the ribs before attaching the leading and trailing spars. After the inner spars are in place and the cement hard, the process of finishing the assembly is the same as that of the wing having single-stick ribs. This procedure of attaching inner spars before leading and trailing edge spars must also be followed for wings having single-stick ribs and such spars.

On practically all biplanes (airplanes with upper and lower wings) the lower wing is made in two parts, as in Fig. 30. It is attached against the sides of the fuselage. Both these halves must be perfect duplicates and of the same weight. In such wings, the assembly procedure is the same as described for wings with inner spars, but the balancing is obtained in a different manner.

The same balancing apparatus is used, but in this case, the wing rests on the center blades, as in Fig. 29 B. Two long needles are thrust through the two center ribs of each half of the wing. If needles cannot be found long enough for this work, two lengths of music wire can be cut and inserted in the same manner. The centers of these wires are then balanced on the lower two blades of the apparatus and the wing's balance checked as in the case of a single wing. If one proves heavy, it must be lightly sandpapered until it balances equally with the other. Always thrust the needles or wires through two ribs on each half, as they will not hold the wing up if only inserted through its center ribs.

WING COVERING. The covering of a wing often decides the success or failure of a model. This is true with both flying and exhibition models. In the former case, a poor covering may result in loss of speed and endurance, or in an uneven flight, while in the latter case, the careless appearance of a poorly covered wing is usually enough to make an otherwise splendid model lose all consideration of the judges.

All thin wings having single-stick ribs are covered on one side only, while wings of thickness are covered on both sides. The covering of both these types is the same, except that the latter requires more steps to complete the job. While such work requires considerable practice, any beginner can master the art of wing covering. To do so, however, he must be willing to spoil a few wings in the process, and must not get discouraged when he does.

After a wing has been assembled and balanced, it is ready for covering. For wing covering materials, see Chapter 3—"Covering Materials." As the majority of models are covered with Japanese tissue, the first step is to obtain your paper. As this is often wrinkled when purchased, it should be

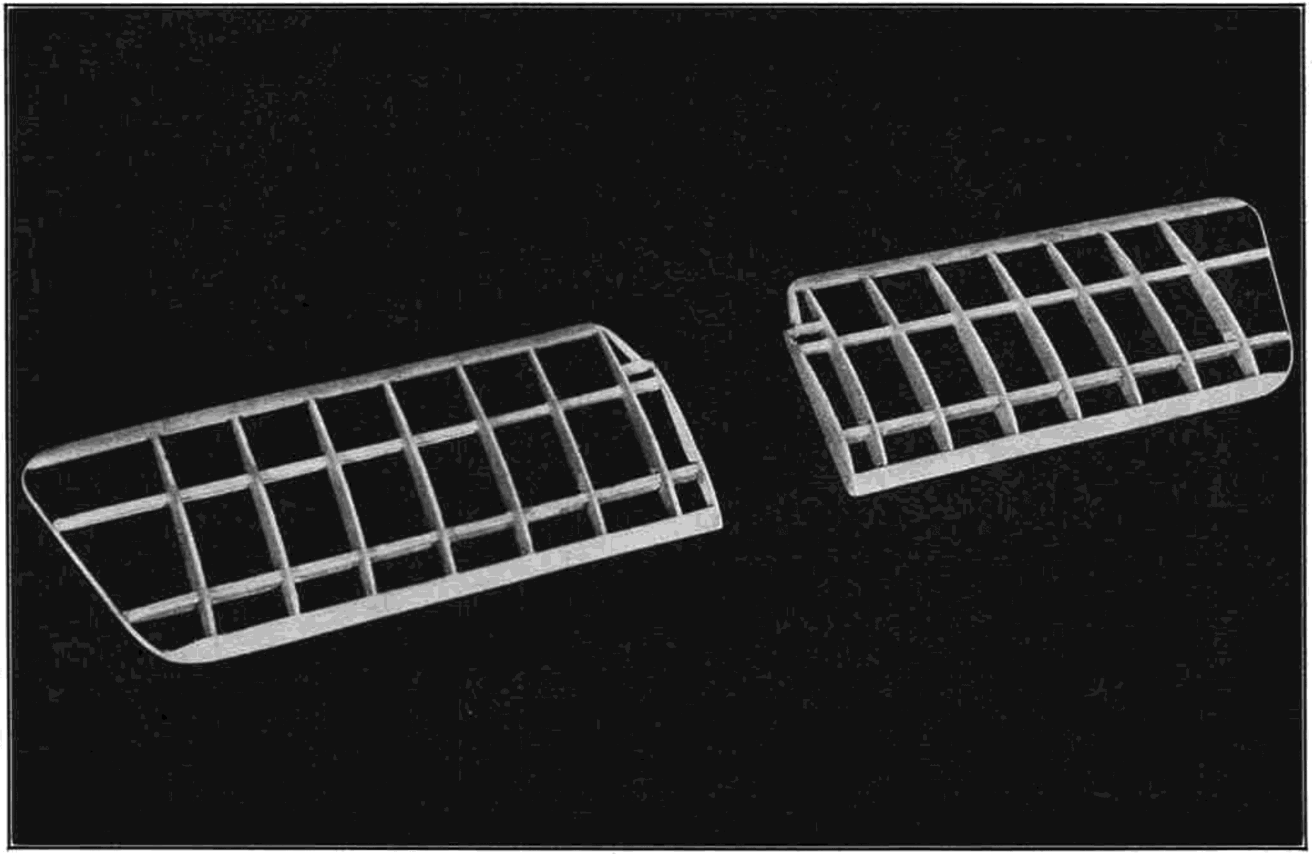


FIGURE 30. LOWER BIPLANE WING

carefully ironed out before being used. (See Fig. 31.) The wing is then placed on the tissue and the tissue cut to approximate size. (See Fig. 32.) The paper should be cut so as to provide generous margins beyond the dimensions of the wing itself. On double surface wings the paper is cut over twice as wide as the wing's width, but for a wing with covering on one side only, the paper is cut the width of the wing plus about 1″ over on each edge.

For double surface wings, the covering is applied to the under side

FIGURE 31. IRONING TISSUE

first. Turn the wing over and give all its spars and rib edges a thin coat of clear dope or banana oil, as shown in Fig. 33.

As soon as these parts have been coated, turn the wing over on the paper and press it gently along all parts. Make sure that it adheres to all points on the structure. When completed, the upper edges of the ribs and spars are given a like coat of dope or banana oil, and the paper quickly turned over and pressed in place on them. (See Fig. 34.) The wrinkles appearing in the tissue at this time can be quickly removed later.

The next step is trimming the excess paper from the wing. (See Fig. 35.) A razor blade does this splendidly if care is taken not to cut into the spar as the blade is moved along the edge. Nail scissors also do a good job, as they cut much closer than ordinary scissors with little chance of cutting the spar.

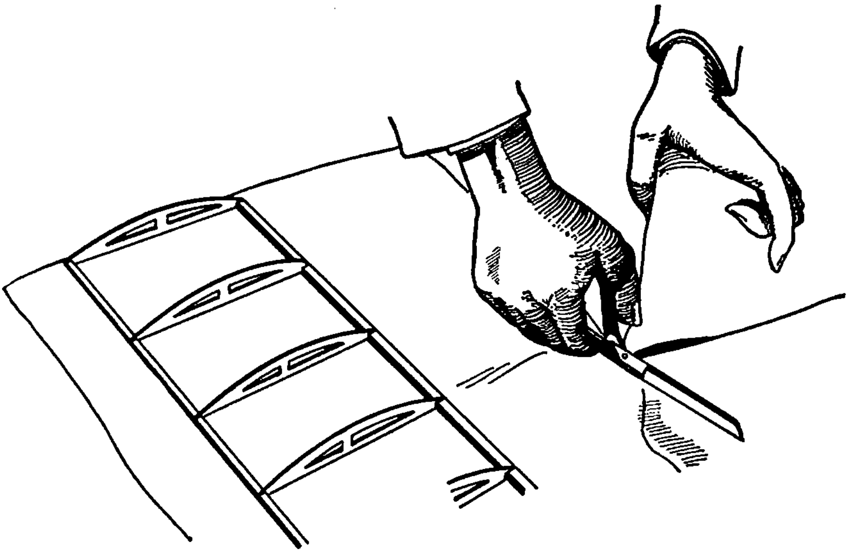


FIGURE 32. FIRST CUTTING OF TISSUE

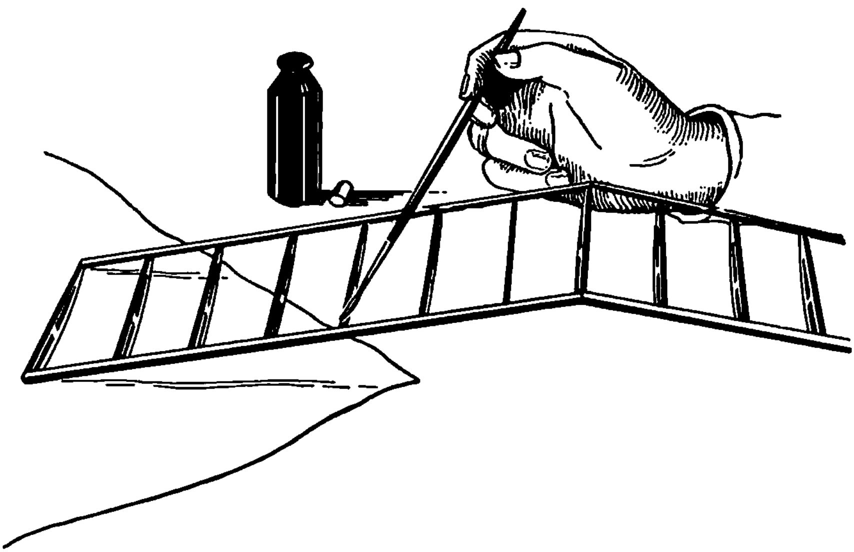


FIGURE 33. DOPING WING STRUCTURE

As the paper has been turned over the wing spar, at least one spar will be covered with it, and this paper should now be removed. (See Fig. 36.) No. 00 sandpaper is used for this work. Lightly sandpaper all edges of the covering to remove the paper's loose edges and leave the spars open. Do

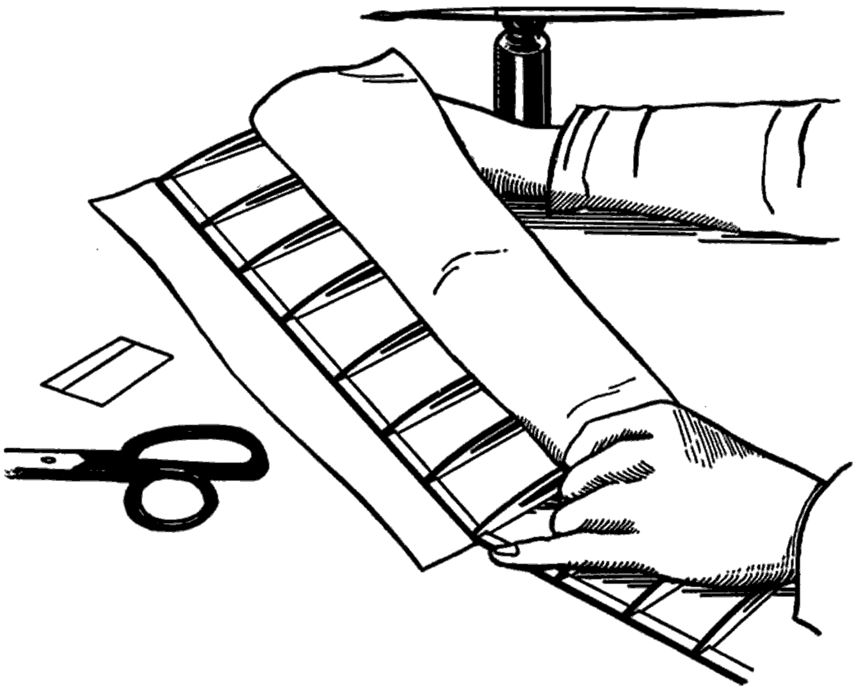


FIGURE 34. ATTACHING TISSUE TO WING STRUCTURE

not sandpaper on the top or bottom of the spars, as this will loosen the paper.

The paper on the wing is now tightened. Flying models should not have their wings doped, as this adds weight and often warps a light structure. On all single-stick twin pushers and flying commercial models, the wings are left without dope. To tighten the covering on the wings of such models, clear water is used. Many modelers apply this with a small sponge, as in Fig. 37, but the best method is to use a mouth spray. (See Fig. 38.) Such a spray can be purchased at any drug store for a few cents. A mouth spray allows the builder to apply the water in a more even manner than with a sponge. On very light wings, even water is dangerous, as the shrinking of the paper often pulls a wing out of shape, and for this reason many leave the tissue without any treatment at all.

For all exhibition models, the wing should first be sprayed with water and when thoroughly dry a coat of clear dope should be applied. This can then be followed with color dope or lacquer. (See Chapter 13.)

The author recommends spraying one half of a wing at a time, so that the part just sprayed can be placed under a light weight to insure it against

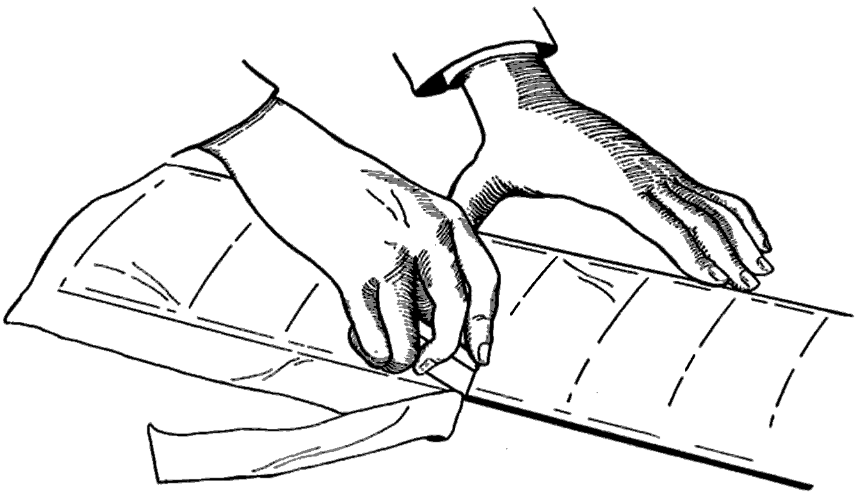


FIGURE 35. TRIMMING EXCESS TISSUE

warping. When thoroughly dry, the wing can be removed from under its weight and the other half sprayed. When water or dope is applied to a wing, it causes the paper to shrink, which removes the wrinkles, but at the same time pulls the frame of the wing. Care must be taken to prevent this pull from changing the shape of the wing.

Another method is to steam the wing instead of using the water-spray. This requires a kettle of boiling water. The wing is moved back and forth over the jet of steam until all parts have been covered. The steam does a splendid job, and has the advantage over the water method of drying immediately.

MICROFILM. This is a new wing covering for indoor endurance tractors, which has become popular at meets because it is twelve times lighter than ordinary tissue paper. So thin that a sheet of it cannot be touched with the hands, it nevertheless makes a more efficient covering than tissue if properly attached.

There are a number of formulas from which Microfilm can be made, such as rubber cement, nail polish, acetone, banana oil, and wood alcohol, but the author can recommend a mixture of three parts of collodion and

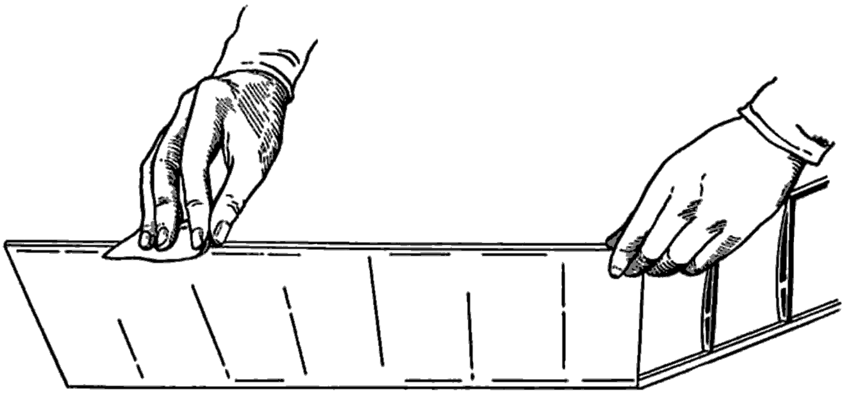


FIGURE 36. REMOVING EXCESS TISSUE FROM SPARS

one part of liquid ether, both of which can be purchased at any drug store. As the sheet cannot be handled, a wire frame must be made. This should be of 1/8″ wire and slightly larger than the wing being covered. Fill a tub

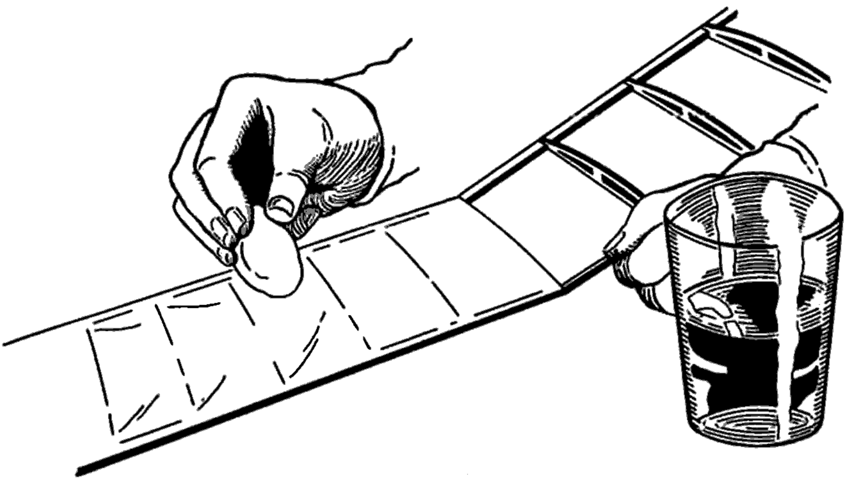


FIGURE 37. OLD METHOD OF APPLYING WATER

with water, place the wire frame in it, and then pour a half teaspoon of the mixture on the surface of the water. The contact with the water will immediately turn the mixture into a thin sheet of Microfilm.

The wire frame is brought under the sheet and it is lifted from the water, which will bring the Microfilm with it. Lay it in place on the wing and hold its edges to the wing frame with a diluted rubber cement.

FIGURE 38. NEW METHOD OF APPLYING WATER

Excess Microfilm can then be trimmed from the edges of the wing. This new substance will readily bend to any contour of a wing, but must not be touched at any time. Model builders should experiment on waste wing frames, before attempting to cover good wing frames.

SOLID WING CONSTRUCTION. Solid wings are used on two types of model aircraft. Their most popular use is on the solid scale, exhibition

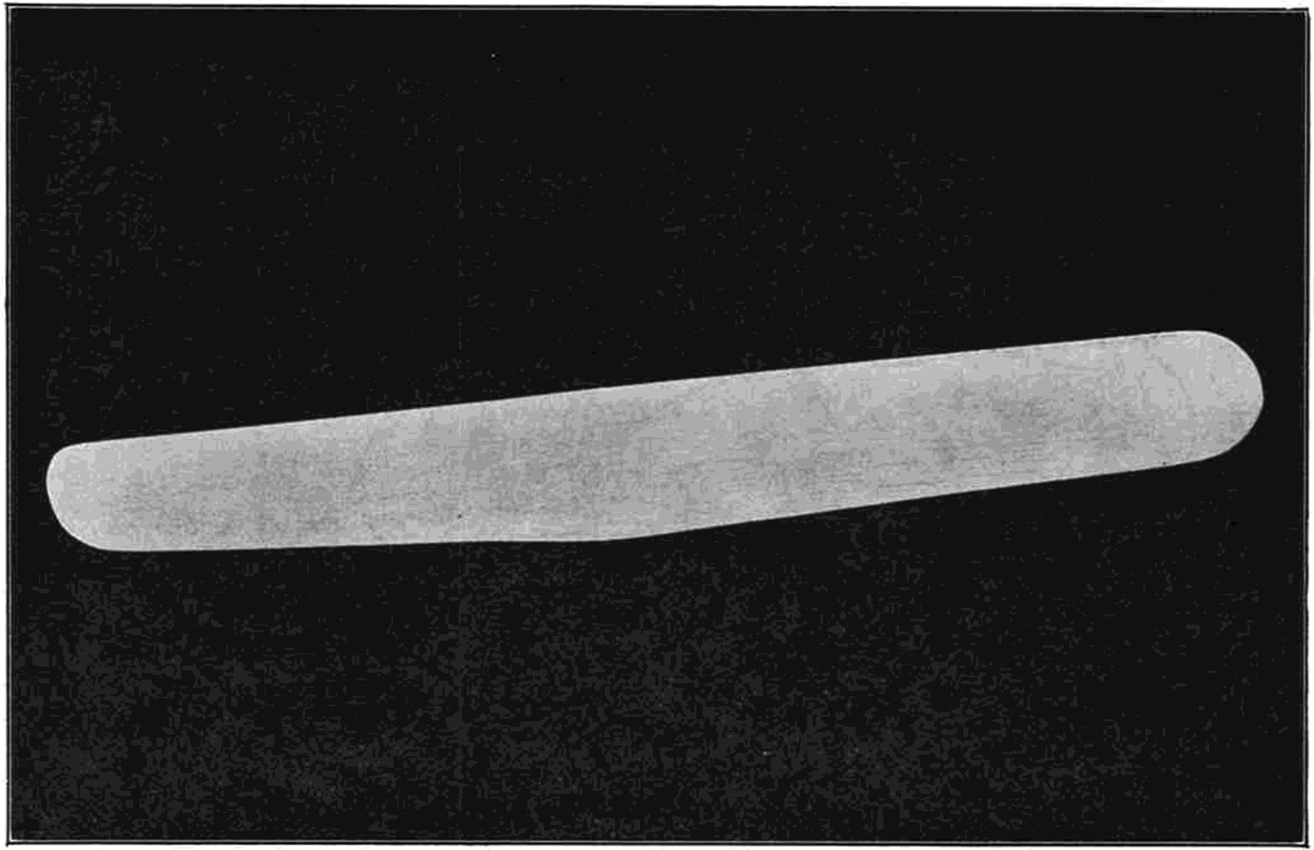


FIGURE 39. SOLID WING

model, but they are also used on solid balsa flying models. (See Chapter 17.)

Solid balsa gliders and flying planes of solid construction usually have their wings made from 1/8″ sheet balsa. (See Fig. 39.) This thickness increases or decreases in relation to the size of the model being built. The wood is cut to the necessary length and width, squared up, and then given its wing camber, or curve, with sandpaper. As balsa is extremely easy to work, sandpaper can replace the block plane on all stock under 1/4″ in thickness. The camber is gained by shaping the top surface only, while the under side is left flat. The wing is sandpapered to make a curved tapering surface from leading to trailing edge. The leading edge is left quite thick, while the surface tapers off to a sharp edge at the trailing edge. When this has been completed, the leading edge of the wing is rounded to complete the form of the Clark-Y rib. (See Fig. 22, No. 2.)

The wing tips are now rounded and the wing carefully balanced, as shown in Fig. 29 A. To obtain a dihedral in a solid wing it is necessary to cut it in half, and then cement it together with the desired angle. (See Fig. 28.) When dry, it is given a final sandpapering to remove excess cement.

Solid wings for exhibition models are usually made of balsa wood because of the ease with which it can be worked, but some builders prefer pine. In both cases, the process is the same. Fig 40 shows the six necessary steps to complete such a wing.

Step 1 shows the shape of the wing being traced on the wood stock. To obtain such a tracing, it is necessary to draw a full-size pattern of the wing you are building. Make the pencil marks heavy, so that when completed they may be seen through the paper. The side on which you have marked the outline is now placed on the wood face down and traced with the pencil. This transfers the pattern to the wood.

Step 2 illustrates the cutting of the wing form. This can best be done with a coping saw. The next step is cutting the camber in the top surface. Do this with a knife, unless the structure is of such a thin nature as to make it possible to do this work with sandpaper, as is done with flying models.

The wing shown in the illustration is of the tapered type. It not only tapers in width toward the tips, but also in thickness. All such wing forms are gained by cutting the wood away from the top side of the wing, while the under side is left flat. (Note Step 3.)

After the proper camber and taper have been given the wing, its leading edge is rounded. This can be done with sandpaper held in the palm of the hand, or a small block plane can be used, as in Fig. 40, Step 4. When the rounded form has been obtained, the entire wing should be given a careful sandpapering. (See Step 5.) The small notch in the leading edge of the wing

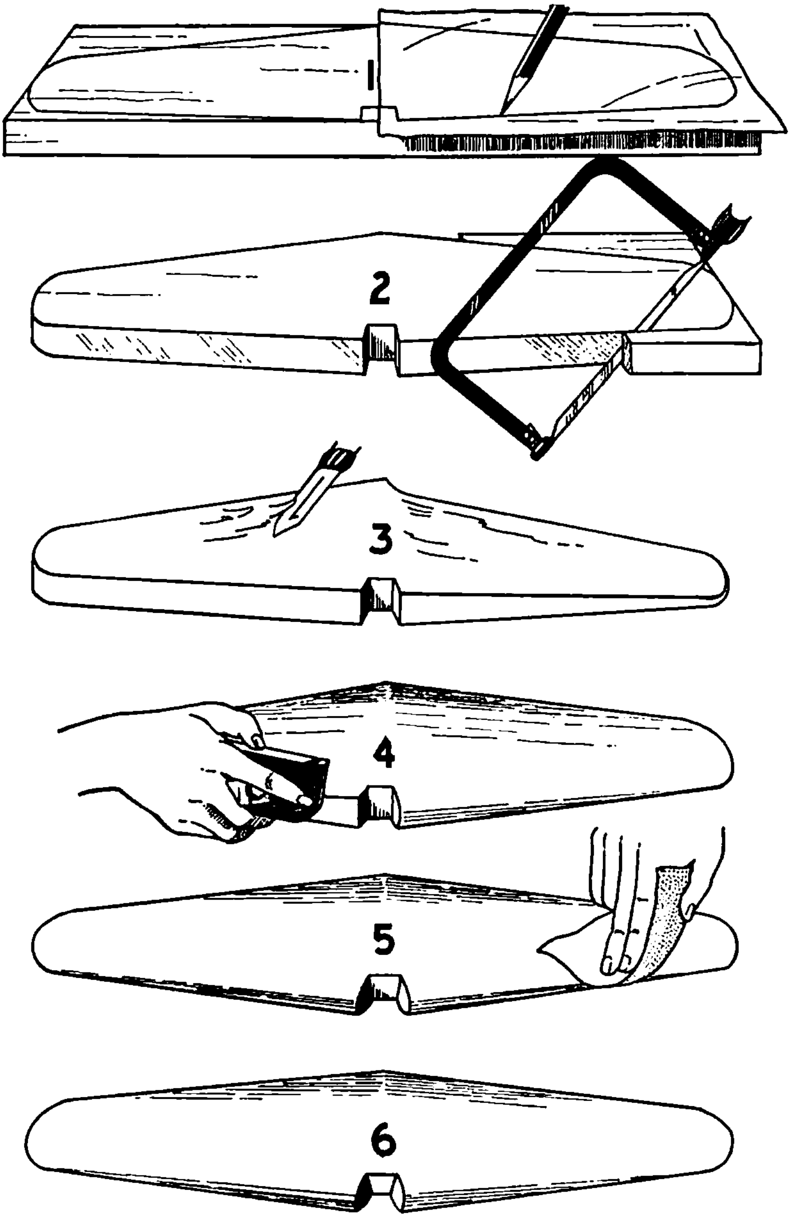


FIGURE 40. PROCESS OF CUTTING SOLID WING

is cut out to form the front of the inclosed cockpit of the Lockheed Vega which is used for illustration purposes, and has nothing to do with the making of ordinary solid wings.

Step 6 shows the finished wing. When the entire work has been done, it should be carefully checked to see that all dimensions have been followed. If the model is to be hung up, the wing should be given a balance test to see that each half of the wing is equal in weight. (See Fig. 29.)