COMPLETE MODEL AIRCRAFT MANUAL

REVISED EDITION

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Boys' Life
Avio News
St. Nicholas
Flying Stories
Everyday Mechanics
The Country Gentleman
King Features Syndicate
Popular Science Monthly

To my aeronautically-minded nephew
Ernest Bevier Wright

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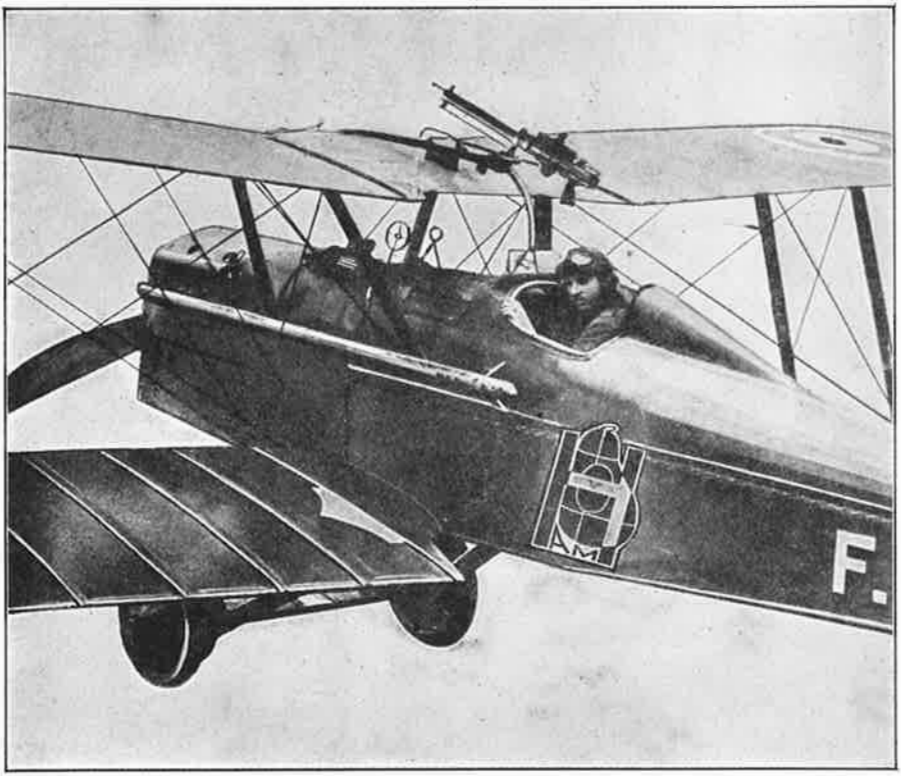
COMPLETE MODEL AIRCRAFT MANUAL

NEW AND REVISED EDITION

PLANS BY THE AUTHOR AND FRANK MONAGHAN
ILLUSTRATIONS BY G. RUTH TAYLOR
PHOTOGRAPHS BY RALPH SOMMER



DODD, MEAD & COMPANY
NEW YORK



THE AUTHOR IN HIS S.E.5 SINGLE-SEATER PURSUIT PLANE WHEN AN OFFICER IN THE BRITISH ROYAL AIR FORCE DURING SERVICE IN THE WORLD WAR

See Chapter 49 for instructions for model of this plane

by the same author

TIN CAN CRAFT
THE BOY BUILDER
PRIZES AND PRESENTS
HANDICRAFT FOR GIRLS
POPULAR CRAFTS FOR BOYS

COMPLETE MODEL AIRCRAFT MANUAL

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COMPLETE MODEL AIRCRAFT MANUAL

CHAPTER 1

AIRPLANE ALPHABET

THE first step toward becoming a model airplane builder is to be able to recognize and name every part of a model. Some beginners know the name of a part but are unable to locate it on a model, while others find themselves in the predicament of knowing a part by sight but not by name. The latter problem presents the greater difficulties, as all building instructions refer to parts by their correct names. This is true, not only here, but in all magazines, manufactured kits and other model books where plans are given, so it is most important to master names of parts if you hope to be able to read plans.

This chapter has been prepared as a solution for such problems. Whenever you require the name of a part, look for it here. Two illustrations have been provided to cover both stick and scale models. When finding a name, the illustration showing the type of model you are building should be consulted. As will be seen, each part is designated by a letter which appears in its alphabetical order in the listing below. After each letter appears the proper name of that particular part, together with the chapter in which are given the building instructions for it.

If you wish a definition for it, the name may be looked up in the glossary of terms. If you wish the definition covering that particular part on a real airplane, it can be found in the aviation dictionary. It must be remembered, however, that all the parts appearing on a model airplane do not necessarily belong to real planes, in which case they would not appear in the aviation dictionary.

STICK MODELS: FIGURE 1

LETTER	NAME	CHAPTER
A	Propeller	9
B	Washers	6
C	Propeller Bearing	6
D	Propeller Shaft	6
E	Can Hook	6

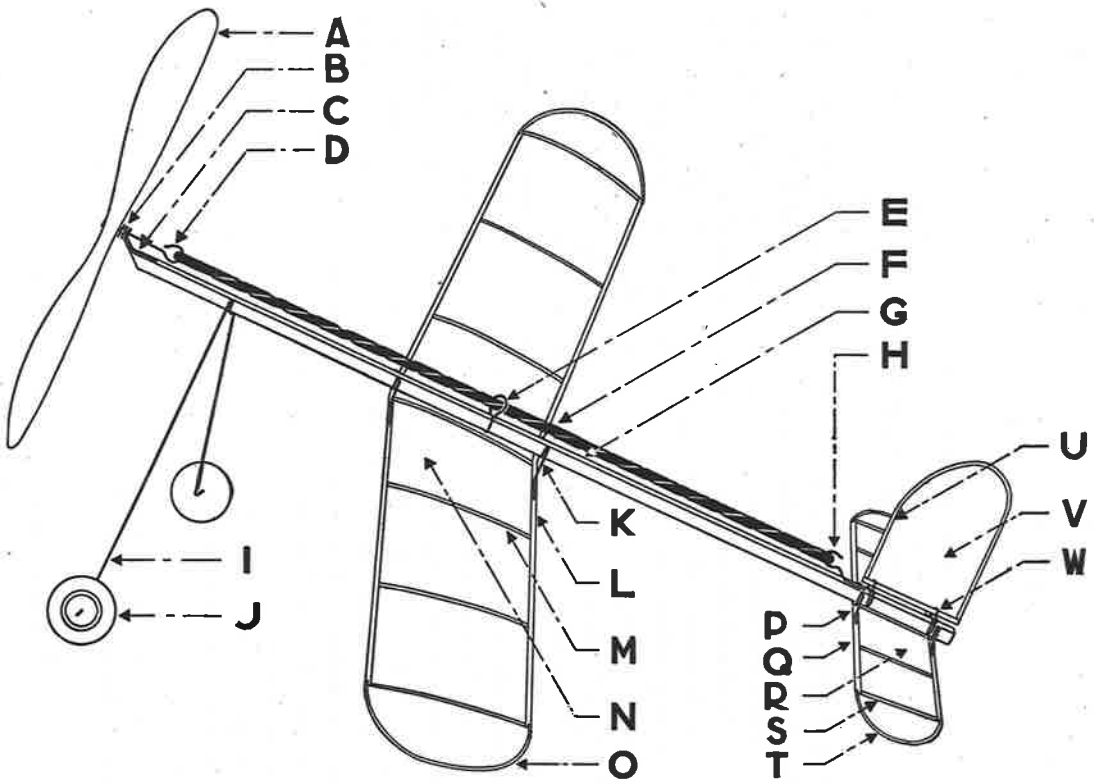


FIGURE 1. STICK MODELS

AIRPLANE ALPHABET

LETTER	NAME	CHAPTER
F	Rubber Motor	12
G	Motor Stick	12
H	End Hook	6
I	Landing Gear	10
J	Wheel	10
K	Wing Clip	6
L	Trailing Edge	7
M	Wing Rib	7
N	Wing	7
O	Wing Tip	7
P	Elevator Clip	6
Q	Leading Edge	7
R	Elevator	Any Stick Model Plan
S	Elevator Rib	48
T	Elevator Tip	7
U	Leading Edge	7
V	Rudder	Any Stick Model Plan
W	Rudder Clip	6

SCALE MODELS: FIGURE 2

LETTER	NAME	CHAPTER
A	Fuselage	8
B	Instrument Board	15
C	Windshield	15
D	Control or Joy Stick	15
E	Pilot's Seat	15
F	Leading Edge Spar	7
G	Inner Wing Spars	7
H	Wing Tip	7
I	Wing Rib	7
J	Trailing Edge Spar	7
K	Cockpit	15
L	Fin Outline Stringer	Any Flying Scale Model Plan
M	Fin	Any Flying Scale Model Plan
N	Tail Braces	Any Flying Scale Model Plan
O	Rubber Motor	12
P	Fuselage Stringers	8
Q	Fuselage Formers	8

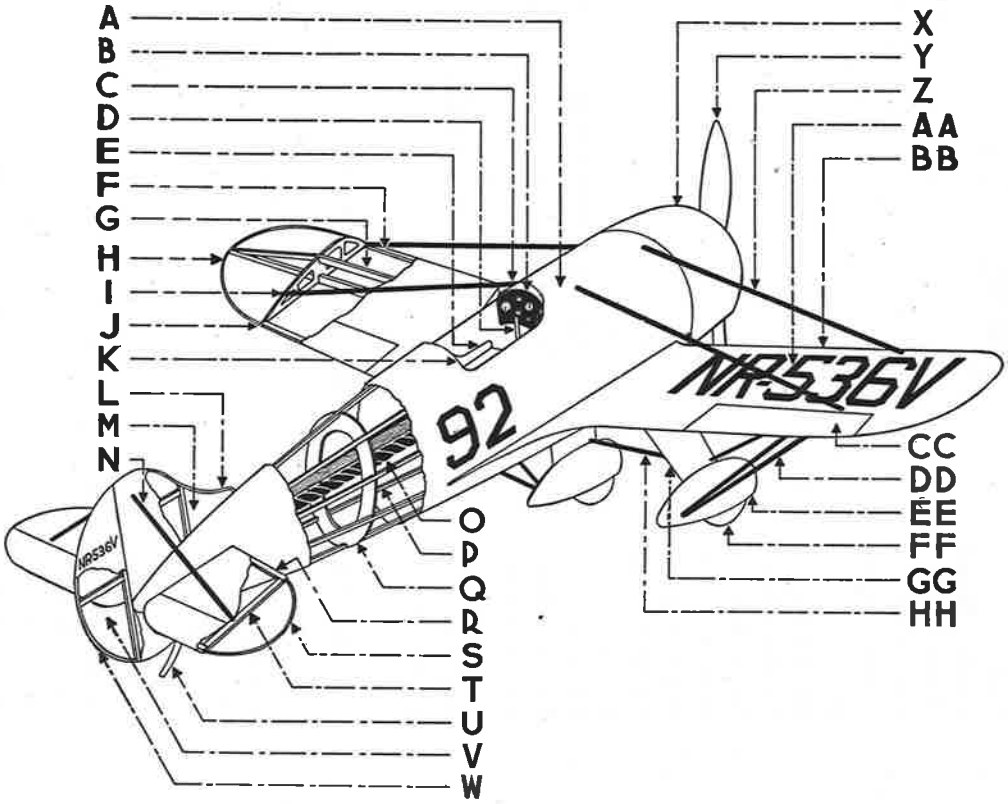


FIGURE 2. SCALE MODELS

AIRPLANE ALPHABET

LETTER	NAME	CHAPTER
R	Elevator Leading Spar	Any Flying Scale Model Plan
S	Elevator Tip	7
T	Elevator Rib	Any Flying Scale Model Plan
U	Tail Skid	6
V	Rudder	Any Flying Scale Model Plan
W	Rudder Outline Stringer	Any Flying Scale Model Plan
X	Engine Cowling	11
Y	Propeller	9
Z	Landing Wires	49
AA	License Numbers	3
BB	Leading Edge	7
CC	Aileron	49
DD	Flying or Lift Wires	49
EE	Wheel Pants	10
FF	Wheel	10
GG	Landing Gear Strut	10
HH	Landing Gear Brace Wire	10

CHAPTER 2

TOOLS

ONE of the reasons behind the world-wide popularity of model airplane building is that it is a hobby requiring few and inexpensive tools. Many model airplane builders use only a pocket knife, a razor blade and sandpaper, but the ten tools shown here form an assortment complete enough for all model work.

The two pairs of pliers shown in Fig. 3, Nos. 1 and 2 are recommended for this work. The round-nosed pliers shown in No. 1 are splendid for bending all wire fittings, especially those requiring round hooks, such as can, rear and "S" hooks, and propeller shafts. (See Chapter 6.) By bending the wire around the round ends of the pliers, perfect circles can be obtained.

The pliers shown in No. 2 are flat-nosed and have side cutters. These are good for making square bends over the square edge of the ends. They also serve for gripping and straightening wire. The side cutters are used to cut the wire. Both these pliers can be purchased at most five-and-ten-cent stores or at any hardware or model airplane supply house.

The coping saw shown in No. 3, helps in cutting out propeller blanks, solid-scale wings and fuselages, and sawing thick pieces of balsa. The frame and saws to fit it can be purchased with the pliers.

Razor blades make good tools for cutting and trimming balsa, slitting bamboo, and trimming tissue coverings. In Chapter 3, Figs. 4 and 5 are balsa cutters which use razor blades for cutting. They make quick and clean cutting jobs on all balsa pieces.

A small hand drill, known as a "pin vise," is of great use for boring propeller hubs, wheels, and other holes required in solid and built-up models. Tiny drills of $\frac{1}{64}$", $\frac{1}{32}$", $\frac{1}{16}$", and $\frac{1}{8}$" diameter can be purchased to fit the chuck of this type of drill. The drill is held in the hand and rotated through the wood. Model airplane supply houses and hardware stores handle these. Such a drill is shown in Fig. 3, No. 5.

The knife shown in No. 6 is a propeller carving knife, which should be used for all propeller carving. While this knife can be used for all cutting work, it is best to keep it for propellers only. Use a regular pocket knife for other jobs. Model supply houses handle these knives and their cost is trivial.

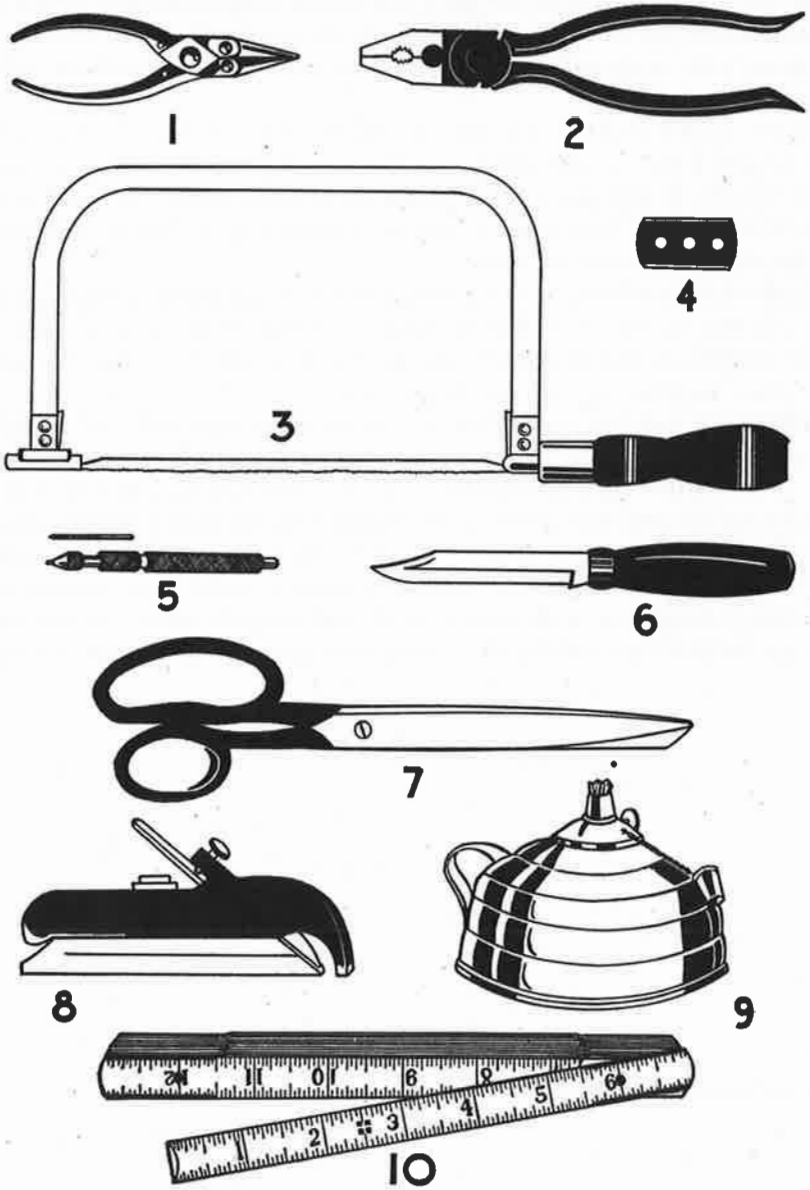


FIGURE 3

In No. 7 will be seen an ordinary pair of long-bladed scissors, which will come in handy for cutting tissue paper for all coverings, as well as ordinary trimming jobs. Such scissors should also be used to cut strands of rubber used for motors.

Many model builders use ordinary block planes for all heavy cutting and shaping jobs, but the author recommends the Stanley bull nose rabbet plane No. 75. It will prove most useful for shaping wings and fuselages of solid scale models. Such a plane can be seen in Fig. 3, No. 8, and can be purchased at any hardware store.

Bamboo is best bent over a flame, and for this purpose a small alcohol lamp, shown in No. 9, should be kept on hand. With such a lamp, the model builder is not dependent on gas fixtures, which cannot be moved from place to place, as can this simple lamp.

The tenth and last tool of our list is the most necessary and useful of them all, as nothing can be built from a plan without its aid. This is the rule. The Stanley zig zag, four-foot rule No. 404 can be purchased at all hardware stores and will answer every demand of the model builder. Simple home-made tool accessories will be given in the various chapters to follow, and the builder will soon find himself designing useful new ones as occasions arise. Keep your tools sharp, clean, and in good order, so that when they are needed they will be in condition to give you the required service.

CHAPTER 3

MATERIALS

BALSA WOOD. Today balsa wood is used exclusively on all flying models, and, because of the ease with which it can be worked, many builders use it on exhibition models.

Balsa wood comes from a tree found in the tropical jungles, which resembles the North American cottonwood. It has a smooth bark and grows to considerable height. The name balsa is the Spanish word for raft, applied to this particular wood because its logs were used for rafts on which heavier woods were floated down the rivers from the interior to the seacoast.

Balsa is the lightest wood that grows, being about half the weight of good cork and averaging about six pounds per cubic foot. It is comparatively strong, extremely light, and so easily worked that it can be cut with the thumb nail. All model airplane supply houses carry balsa wood in a number of sizes, and usually in three weights, known as soft, medium, and hard.

Balsa sticks of varying widths and thickness can be purchased, or "sheet balsa" in the form of thin boards can be obtained and cut into sticks. The builder should use the latter type of balsa when cutting his own strips. As all companies charge for cutting balsa wood into various sizes, the builder will find it cheaper to purchase large boards and do the cutting himself. With this in mind, the author has developed the small balsa cutter shown in Fig. 4. This consists of a $\frac{1}{4}$" x $2\frac{1}{2}$" x 9" block of wood to which is nailed another piece of the same thickness as you wish to cut your wood. The second piece should be as long as the first but only half as wide. (See Fig. 4, No. 1.) For example, if you wish to cut $\frac{1}{16}$" square strips, this second piece should be $\frac{1}{16}$" thick and the stock used in the cutter should be the same.

A safety razor blade is now nailed in position, as shown in 2. One corner of the blade should extend about $\frac{1}{8}$" beyond the edge of the second piece of wood. On this assembly a third piece is now nailed. It should be the same length and width as the second piece but about $\frac{3}{8}$" thick. A top view of this assembly is shown in 3, while the end view appears in 4. Note the edge of the blade protruding from the second and third pieces of wood.

The edges of the second and third pieces serve as a guide for the stock

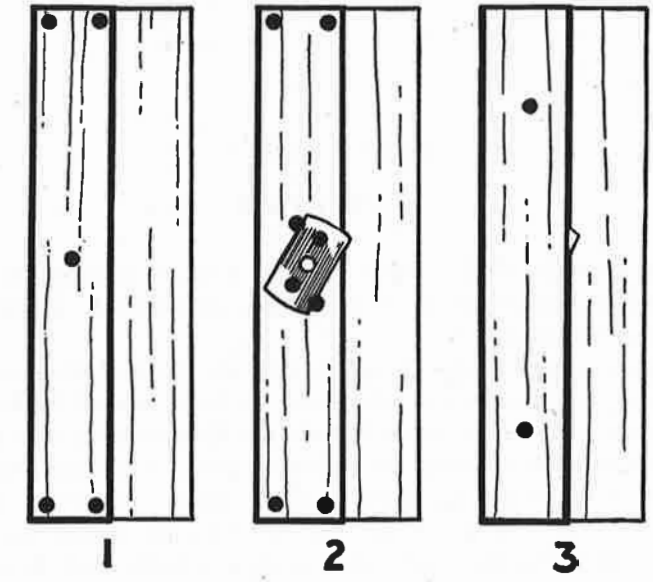
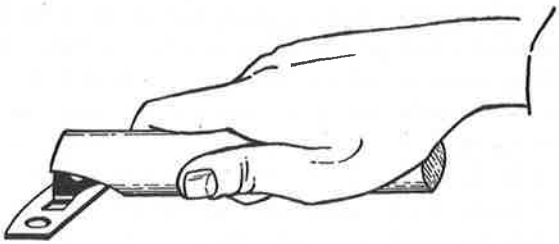


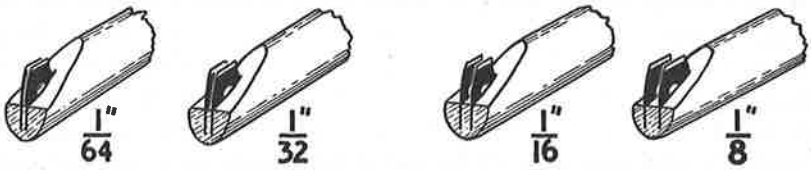
FIGURE 4





HANDY CUTTERS





STRIP CUTTERS

BALSA CUTTERS

FIGURE 5

being cut, which is moved along them and at the same time pressed against the first piece of wood, which serves as a base for the cutter, as shown in 5. The resulting strip of balsa is shown in 6. It will be found that the best results can be obtained when the cutter is held in a vise.

Another method of cutting balsa strips is shown in Fig. 5 under "Strip Cutters." The handle consists of a round length of wood, about 1" in diameter. A dowel stick would serve splendidly. It should be about 6" long. Its end is beveled, and two safety razor blades are cemented into slots cut in the stick for that purpose, as shown. The edge of the blade should extend

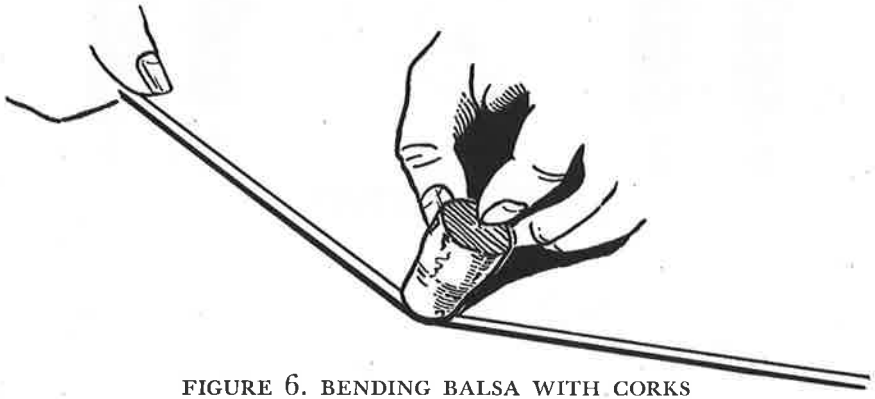


FIGURE 6. BENDING BALSA WITH CORKS

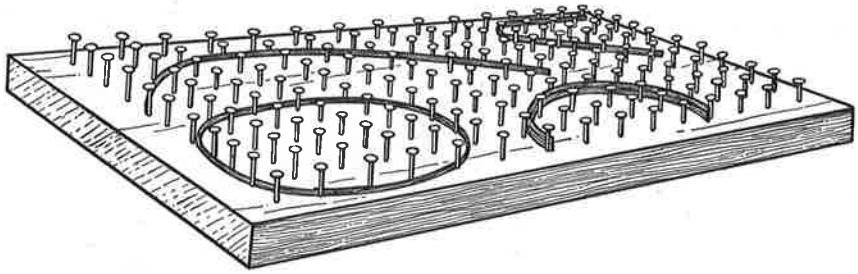
out of the beveled portion of the stick about 1/8" to 1/4". The distance between these two blades is determined by the width of strips you wish to cut. If this distance is 1/4", the strips cut will be 1/4" wide, etc. Four of the most popular sizes are shown. Note how the cutter is held while being used. A rule is used to guide the cutter. In this manner, strips of any desired width can be cut with ease. Always cut your wood with the grain.

When cutting circles, holes, or balsa wood to proper length, the blade of a safety razor will be found best. Another type of balsa cutter, designed expressly for such work, is shown in Fig. 5 under "Handy Cutters." For such a cutter, the blade has one edge cut or broken until only the desired length of the blade remains, as shown. It is then assembled in the same manner as the double-bladed cutter. Bevel the end of your stick, cut a slot, and cement the blade in place, allowing the edge of the blade to protrude about 1/8" from the stick, as shown. A number of these cutters in different sizes should be made and kept handy for various cutting operations.

Because of its texture, balsa wood lends itself to bending quite easily. To do this, the balsa wood is usually soaked in hot water from five to ten

minutes, after which it can be safely bent. Another novel method, one which eliminates the soaking of the wood, is to heat corks by boiling them in water and then to apply them to the point on the wood where the bend is to be made. This is shown in Fig. 6. Keep applying the corks and keep bending the wood until the desired form is obtained.

Many builders find difficulty in holding the balsa wood in position until its fibers "set" through natural drying. To improve the usual method of pinning the wood in position to a base while drying, the author has designed two presses to do this work. In Fig. 7 will be seen a stick balsa press,



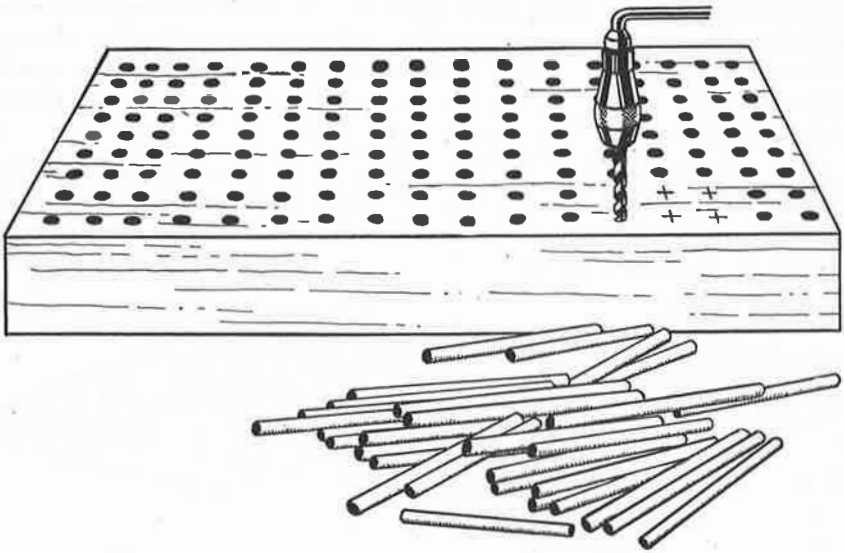
STICK BALSA PRESS

FIGURE 7. BENDING BALSA STRIPS

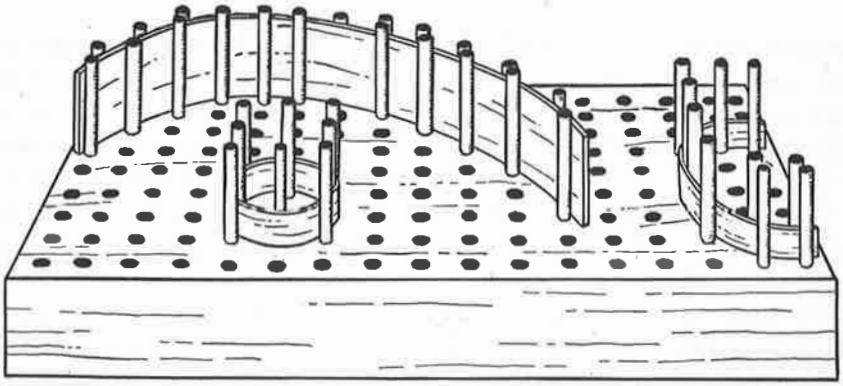
especially useful for the holding of all small pieces, such as single ribs, wing tips, light-weight formers, etc. It consists of a flat board into which small box nails have been driven in rows. The board should be of any desired size and about ½" thick. The nails should be driven into the board until they extend about ¼" above its surface. Large-head nails are used to prevent the balsa sticks from slipping up and off them, when forced into position. The wood is soaked, and then placed on the press in the desired position until dry.

For wide balsa boards, the sheet balsa press, shown in Fig. 8, will be found best. When cutting a number of ribs, it is often easiest to bend a piece of sheet balsa to the proper wing rib camber and then cut the ribs from this. In this manner, the builder is assured that all the ribs will have the same identical curve. Sheet balsa formers, cowling covers, etc., can be easily handled in this press.

It consists of a board of any desired size and about 1" thick. In its top a number of holes are bored in rows, as shown in Fig. 8, No. 1. These should be 1/16" or ⅛" in diameter and about ¾" deep. Into these, 1" or 2" long



1



2

SHEET BALSA PRESS

FIGURE 8

dowel sticks are fitted, which must, of course, be the same diameter as the bored holes.

Fig. 8, No. 2, shows how the press is used. The wood is soaked and bent as desired, and then placed on the press, where the dowel sticks are inserted into as many adjoining holes as necessary to hold it in position until dry.

BAMBOO. Bamboo is a wood consisting of a round, hollow cane, divided into sections by knotty knobs, or joints, called "nodes." One of its surfaces has a hard, glazed coat, which is the portion best suited to model work. In early days, model builders used a great amount of reed, but with the necessity of cutting down weight on model construction bamboo soon replaced it.

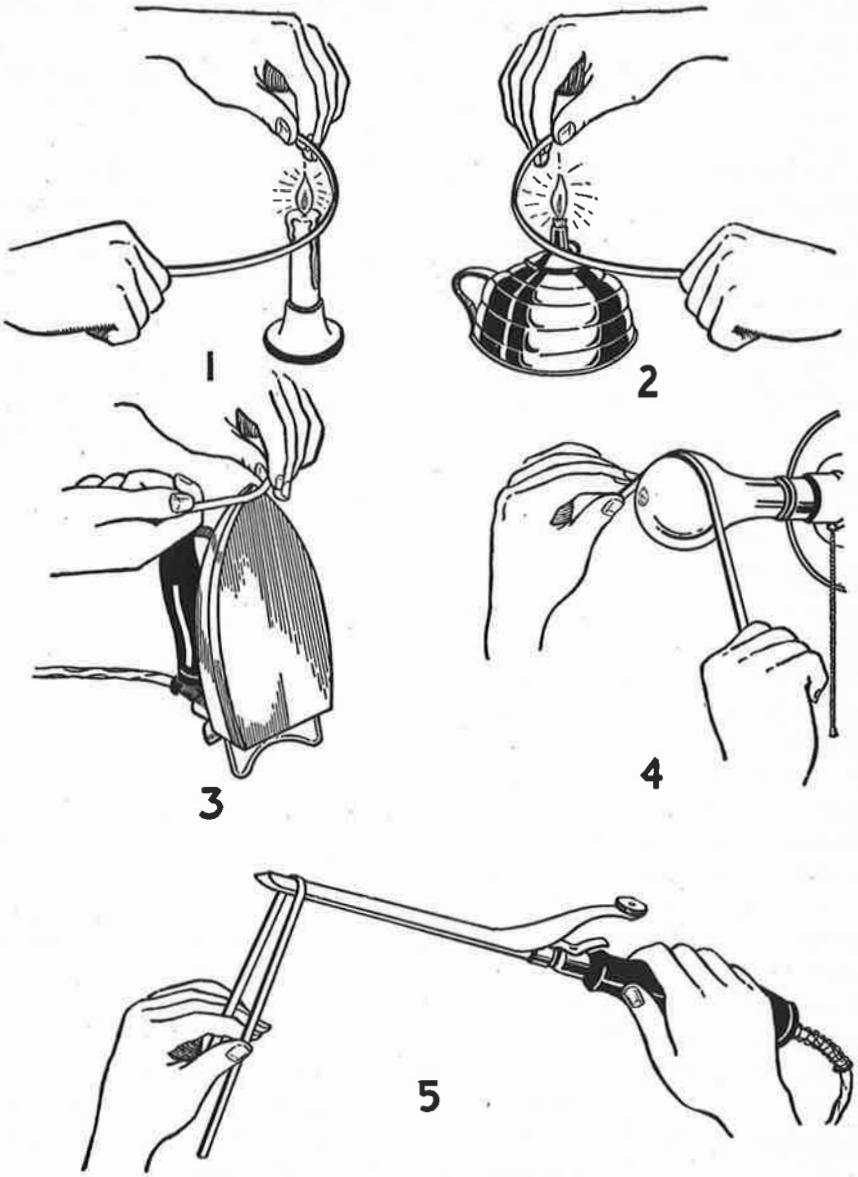
This was because of several qualities found in bamboo and lacking in reed. The former could be split to very small diameters, such as $\frac{1}{64}$", $\frac{1}{32}$", etc. It is tough, straight-grained and flexible in fiber content, which allows it to be easily worked, makes it practically unbreakable, and permits bending to any required form.

Split bamboo can be purchased in any model supply house, or the builder can secure a pole and do his own cutting. Cut the piece into sections at its nodes, and then split its shiny side into strips. These can be smoothed with your block plane. For model work, only the parts having the original glazed surface are suitable.

Bends can be easily made in bamboo and will hold indefinitely. Heat is used for bending it. In Fig. 9 five methods are illustrated. The oldest of these is the open flame, shown in 1 and 2. Here the bend is made over the flame of a candle or alcohol lamp. Builders use this method today, but the danger of scorching or burning the wood is great, and experience is required to make proper bends in this manner.

A safer method is shown by 3. Here the bamboo is bent over the tip of an electric iron. This eliminates the danger of burning the wood, permitting sharp bends to be made. An electric light bulb can also be used, as in 4. If the bend is circular in form, this method is splendid, although sharp bends cannot be made.

For sharp bends the end of a regular electric curling iron gives ideal results, as shown in 5. After the heat has made the fibers of the wood thoroughly pliable, it should be removed from the heating device and allowed to cool while held in position. It will then retain its curve. Bamboo is used for such parts as wing tips, landing gears, ribs, and skids. Modern construction of very light, small, endurance models, on which every part must be as light as possible, has replaced bamboo parts with balsa to a great



BENDING BAMBOO

FIGURE 9

extent, although the beginner will find the former much easier to handle and bend than the balsa.

PINE. While balsa wood is now used for flying models of all types, many builders prefer pine for certain parts on exhibition planes such as solid scale and built-up, non-flying models. This is done chiefly to strengthen such models against the wear and tear of handling and moving them from exhibition to exhibition. Pine will stand such rough usage better than balsa wood, and as weight is not a factor for consideration in non-flying models, the former wood is often preferred. Many builders prefer to use pine for cutting solid scale fuselages, but chiefly because pine is more easily obtained and costs less.

Aside from these factors, balsa wood will be found superior, as it can be worked with an ease impossible with pine. Pine sticks and boards of various sizes can be had from any model supply store.

RUBBER. After long experimentation, it has been found that the most efficient rubber for motive power on model airplanes is pure Para rubber. It can be obtained from all supply houses in various sizes. (See Chapter 12.)

FILLER. Wood fillers can be used to fill cracks, make small parts, streamline cowlings, wings, and fuselages. There are several of these on the market which are obtainable at model supply houses, hardware stores, or five-and-ten-cent stores. Possibly the best known of these is Plastic Wood. The Northrop Gamma shown in Chapter 48 has its wing tapered into the fuselage with the aid of such a filler, and the builder will find it of aid in forming small parts, such as gun mounts, exhaust pipes, steps, and many other minute parts.

Plastic Wood can be purchased in cans and has the consistency of putty. When it becomes dry it is practically wood, and can be sawed, planed, cut, or sandpapered. For its proper use, follow the instructions on the can.

COVERING MATERIALS. *JAPANESE TISSUES.* These are classed as rice and bamboo papers. Of the former, two grades are the most popular in model building. These are superfine Japanese tissue and Hakone tissue. The former is the best of these, but it is also the most expensive. Hakone is a very popular paper, being extremely light and tough.

Both are splendid for all models weighing less than four ounces, but for models of greater weight bamboo tissues are preferable. Throughout this book all reference to Japanese tissue indicates rice paper of either grade.

Bamboo tissues are extremely tough and at the same time light enough for all flying models over four ounces. All model supply houses handle a full line of these papers, and the novice should experiment with various strengths, weights, and grades of these tissues in determining the kind best

suited for his models. For instructions on using these tissues see Chapter 7, "Wing Covering."

SILK. Many builders prefer to use Japanese silk for covering non-flying scale models. All supply houses handle this silk. The method of using it is the same as that for tissue coverings, except that the silk should be pulled taut to prevent it from sagging. If the model is not painted, the silk must be given a preservative to make it air-tight. After stretching it with the usual water-spray, a thin coat of clear banana oil should be applied. This fills up the pores and makes it air-tight. All other instructions covering the use of Japanese tissue apply to silk.

Silk for covering flying models is not recommended because of its excess weight and the possibilities of warping fragile construction. On solid scale models silk is sometimes used to imitate built-up construction. (See Chapter 7, "Solid Wing Construction.")

GOLD BEATER'S SKIN. This is sometimes used for model airplanes, but does not enjoy the popularity of either tissue or silk. It is an animal product stripped from the lining of a cow's stomach. It is by far the strongest covering obtainable, and is tough, thin, and quite light. It can be purchased in a variety of colors, and has more resistance against puncture than silk or tissue. It is not suitable for flying models, but is quite adaptable for others.

WIRE. Practically all metal fittings necessary on flying models are bent from wire. Because of its strong tensile properties, a high grade of piano wire is used for these parts. It can be purchased in various diameters from all model supply companies. Because of its great strength, stiffness, and toughness, this wire can be used in extremely small diameters with perfect safety, while other types of wire would require larger diameters to produce the same strength and consequently would weigh much more. (See Chapter 6.)

WASHERS. On all parts requiring free motion, small $\frac{1}{16}$" or $\frac{1}{8}$" outside diameter washers of either brass or aluminum are used. These can be purchased at model supply houses, and are necessary for propeller shafts, landing gear wheels, etc. In some cases, beads and spangles have been substituted for these washers, and they are quite efficient on all small, light flying models, but for the larger types of flying planes, the regulation washers should be used.

CEMENT. The demand for a quick-drying, waterproof, light-weight adhesive produced a number of first-class cements. The most popular of these is known as "Ambroid." This is still used by many model builders, but colorless cements are fast replacing it. The adhesive power of these cements

is so great that minute parts can be joined together so tightly that the surrounding wood will break before the cemented joint will give.

DOPE. Another liquid well-known to the model airplane world is a rather thick substance known as "dope." Its main use is to pull the covering of a model taut, giving it a smooth, drum-like surface. It preserves and strengthens the covering and protects it from dust, dampness, and wear.

It is also widely used as an adhesive to hold the covering to the framework. Many builders strengthen propellers on larger models by brushing a coat of dope over their surface.

The best known of these so-called "dopes" is banana oil, which is often thickened with celluloid. While some builders purchase banana oil and mix it with celluloid, this is not recommended inasmuch as it requires considerable knowledge to do. It is better to purchase regular dope prepared especially for model airplane work. This comes already mixed to proper consistency. Clear dope can be purchased for models that do not require color, or, if desired, dope can be had in a variety of colors.

For all large models, the dope can be safely used as it comes, but for all those of fragile construction, it should be thinned with acetone. Some builders use clear banana oil for fastening their coverings over models, and then thin it with acetone for stretching the tissue or silk. Silk can best be tightened and made air-tight by a thin coat of clear banana oil. This is given the silk after the usual water-spraying. (See Chapter 7, "Wing Covering.")

Dope often becomes very thick and sometimes turns completely hard. When this occurs it can be restored to its original consistency by adding acetone, but when it is perfectly hard it will be found best to throw it away and purchase a new supply inasmuch as the acetone may cost as much as a new can of dope.

EMBLEMS AND LICENSE NUMBERS. Various emblems and insignia, as well as license numbers, are required for true scale models. The former can often be purchased from model supply stores, although these are usually limited to war insignia. For this reason 120 of the most commonly used insignia have been reproduced in Chapter 14 with full instructions for their proper use.

License numbers are another important detail of the true scale model. They may be painted directly on the wing, or can be drawn, cut out, and glued to the surface. Another method is to cut the numbers from large calendars. Small calendars provide splendid numbers for tail units and fuselages, but it must be remembered that these must be the correct size. The large wing license numbers should have a height equal to two-thirds the

width of the wing. They are located on the under side of the left wing and on the upper side of the right wing. The under numerals should read from the front of the plane, while the upper ones should read from the rear.

PAINT. See Chapter 13.

MODEL ACCESSORIES. In Chapter 15 a number of model airplane accessories are shown together with full instructions for making each, but the average model supply company can furnish these if you do not wish to make them. Bombs, machine guns, steps, instrument boards, seats, cowlings, engines, parachutes, and many other accessories can be purchased to improve the appearance of scale models. In Chapter 11 the building of motors and cowlings is fully covered, and in Chapter 10 such things as wheels, wheel pants, and various types of landing gears are given. All model builders should keep a library of dealers' catalogues, so that they can become familiar with all the various parts and accessories these companies have to offer.

CHAPTER 4

READING AND USING PLANS

STICK MODEL PLANS. For each model appearing in this book complete plans are given together with step-by-step directions for its construction. Because of the simplicity of the average stick model, the plan for each of these has been confined to one page, except in one or two cases. All dimensions have been shown on the plan and are again repeated in the instructions.

Before any actual construction is begun, the builder should carefully study the plan of the particular model he intends to build, together with its written instructions. Turn to the first instructions in the text and then locate that particular part on the plan. Read the instructions and at the same time follow each item by locating it on the plan, checking its dimensions against the text, and then carefully following it on the plan from end to end. In this manner, its proper location on the model can be quickly seen.

Do not proceed to the next part of the text until you feel confident that you thoroughly understand all details of the one you are studying. Most motor sticks are shown in two views, the top and the side. On the top view will be seen the elevator top view, while the side view of the motor stick will usually contain the side view of the rudder. In this way, the construction of these parts can be seen together with their proper location on the motor stick. All parts are clearly marked. Wing construction is also shown by a top and edge view. The edge view shows the necessary dihedral angle of the wing. (See Chapter 7, "Wing Assembly.") The propeller is usually shown by a perspective view of the propeller block from which it is carved. (See Chapter 9, "Carved Propellers.")

If the model has a landing gear, this is usually shown by a side view of the gear attached to the motor stick, which shows its location on that member. Another plan of the front view of the landing gear, showing its dimensions, construction, and material, is also given in most cases. If the wing has sheet ribs, a side view of these is given on squares, so that the builder can quickly draw full-size rib plans.

To do this, rule a sheet of paper with cross lines, making squares of the

size called for in the plan. The outline of the rib is then drawn through these squares, which act as a guide. To make an exact copy of the rib, each line crossing each square must be located in exactly the same position as that in which the same line crosses the same square in the plan.

On wings having a sweepback, a full-size copy of the top view of the wing should be made. In this manner each part of the wing can then be cut to match the size shown on the full-size plan, placed on the plan in proper position, and the assembly made directly on the plan. In this way the necessary sweepback of the wing is obtained automatically. This is a good plan to follow whenever a wing, fuselage, rudder, or elevator has a difficult or peculiar outline.

When reading plans the builder must keep in mind that the written instructions are quite as much a part of the building instructions as the plan itself. For this reason constant checking of written instructions should be made while the model is being built.

SOLID SCALE MODEL PLANS. Because of the various sizes in which model builders construct solid scale models, these plans have been made up to cater to all tastes. To do so, a plan had to be devised whereby a model of any size could be made from the plans covering each of them. It can be readily understood that it would be impossible to give complete plans for models having a 6″, 12″, 18″, 24″, or 36″ wing length, so the graph method of presentation has been used.

With such a plan, the builder can make his model any size. To use such a graph plan is quite simple once the procedure is understood. These solid scale model plans are drawn up with twenty-four squares from wing tip to wing tip. If these squares were to be drawn 1″ square, the model built from that plan would be a 24″ model. If, however, a 6″ model is desired, each of the squares would have to be drawn ¼″ square.

The first step in the work is to rule off a piece of paper with squares of a size corresponding to the size you wish your model. Each of the three views of the model is then copied from the page plan in the book on your ruled paper. This is done by guiding the pencil through each square, making sure that the line being drawn passes through the square in exactly the same location it takes on the page plan.

When a full-size duplicate of the page plan has been drawn, it becomes a simple matter for the builder to cut his various parts exactly the size given on the plan he has drawn. With the three views, side, top, and front, each part is shown three times, so that its length, width, and thickness will appear on the plan. To aid the builder further, instructions accompany each plan and give the various sizes necessary for each part. These are given for models

measuring 12″ from wing tip to wing tip. If a 6″ model is being made, these written dimensions would have to be cut in half, or if a 24″ model is desired, each dimension appearing in the text would have to be doubled.

Such written instructions are given merely as a further aid to the builder, and the 12″ model has been taken as a standard.

BUILT-UP, NON-FLYING AND FLYING SCALE MODELS. These plans are more closely allied to their accompanying text than any of the others, because space would not allow full dimensions to be printed on the plans. To avoid a crowded page, the author has used letters and numbers to indicate the various parts of the model, and has then given the length, width, and thickness of each of these in the text, together with step-by-step instructions on assembling.

Fuselages have been given in great detail, many of them taking a full page and sometimes two full pages of plans. Each former of a fuselage has been given in graph, or squares, so that the builder can easily redraw them full-size.

All longerons and stringers of the fuselage have been numbered or lettered, the sizes given in the text, and full data on location clearly shown. Most fuselages appear on the plans in three views, side, top, and bottom. Each of these shows only that particular side of the fuselage. In other words, if a bottom view of the fuselage is shown, only the braces, formers, and stringers along the bottom appear. If a skeleton model of the fuselage was held bottom side up, a number of parts on the top of the fuselage would be seen, but on the bottom view of the plans these are not shown, because of the possibility of confusing them with those of the bottom. This is also true with the top and side views of the fuselage in the plans.

Each former location on the fuselage has been numbered or lettered and these numbers or letters appear under each individual drawing of each former in the plans. Top and edge views of the wing have been provided in the plans. The first shows the location of all ribs, wing tips, inner wing spars, and leading and trailing edge spars. The latter shows the necessary dihedral angle of the wing, given in inches, and appearing under "Dihedral." All wing ribs are numbered or lettered on the top view of the plan. These ribs are then shown in squares in the plans under their particular letters or numbers. Thus the builder can see at a glance the exact location on the wing of each rib. All ribs appearing in the plans in graph require redrawing full size, as already explained for solid scale models.

Various other parts having curved outlines, such as wheel pants, landing gears, etc., are also given in graph.

A three-view plan in graph appears with each flying or built-up, non-

flying scale model, as an aid to the builder when assembling his model. These do not require redrawing, since for assembly work only locations are required, and they can easily be found on the plan as it appears on the page. These three-view plans have been given in graph so that the builder can make from them a solid scale model of any of these flying or built-up, non-flying scale models. The same procedure is used for these models as for the solid scale models and their plans.

With each flying or built-up, non-flying scale model, two photographs are provided. One of these shows the model assembled uncovered, so that the model can be studied by the builder. The second shows the finished model. While these are not part of the plans, the builder will find them of assistance when making the model.

CHAPTER 5

MODEL CARRYING CASES

A CARRYING case for the model builder is quite as important to him as a brief-case is to a lawyer. Any well-made airplane model is a delicate affair at best, because of the fact that the lightest of woods are used in its construction and its wings are usually covered with tissue paper. Each part is so fragile that great care must be exercised in handling and especially in transportation.

Here are two boxes designed for just this purpose, and they are so simple in construction, so handy to carry, so cheap to build, and so useful that no first-class modeler can afford to be without one.

They are carried like a suitcase, and will be found commodious enough to hold ten stick models, all extra parts, necessary tools for repairs, and a winder. Lids are provided for the compartments where small articles are stored, so that they will not spill out when the box is opened. Some builders cover their boxes with oilcloth, and the author recommends it. Such boxes are often placed on the ground at outdoor meets, where dampness from rain or dew might ruin weeks of work and many dollars' worth of materials.

Two designs are given, complete with plans, so the builder has only to choose the one he prefers. The first one (see Figs. 10 and 11) is the shape of any common suitcase, and requires the following pieces of pine:

2 pcs.—3/8" x 11 1/4" x 42" —Box bottom (E) and Lid Bottom (G)
2 pcs.—3/8" x 6" x 42" —Box sides (A and C)
2 pcs.—3/8" x 6" x 12" —Box ends (B and D)
2 pcs.—3/8" x 3" x 42" —Lid sides (F and H)
2 pcs.—3/8" x 3" x 12" —Lid ends (I and J)
2 pcs.—3/8" x 5" x 5 7/16" —Box partitions (1 and 2)
1 pc. —3/8" x 5" x 11 1/4" —Box partition (4)
1 pc. —3/8" x 5" x 35 13/16" —Box partition (3)
2 pcs.—3/8" x 2 1/2" x 3" —Lid partitions (1 and 4)
2 pcs.—3/8" x 2 1/2" x 20 1/4" —Lid partitions (2 and 3)

Each of these eighteen pieces should be squared up, planed smooth, and then finished with sandpaper. We are now ready to assemble our box. Nail the two side pieces A and C to the sides of E. Complete the box by nailing

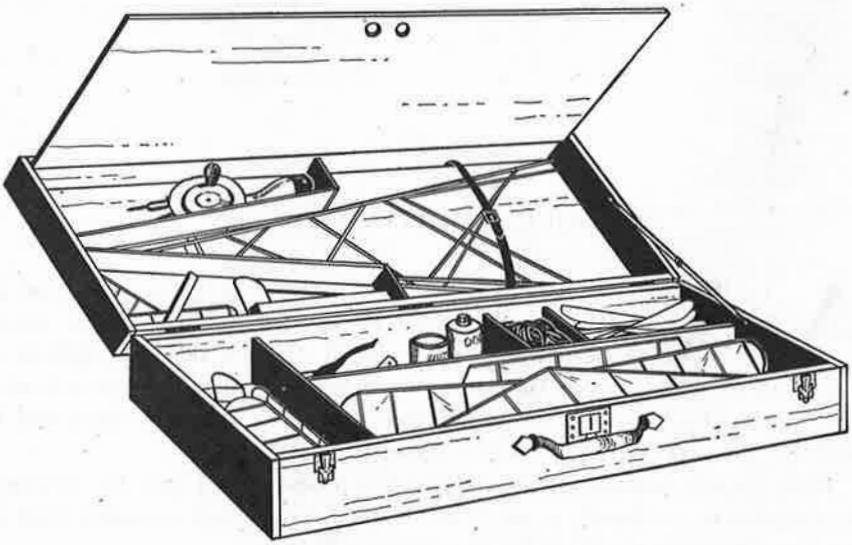


FIGURE 10. CARRYING CASE—SUITCASE TYPE

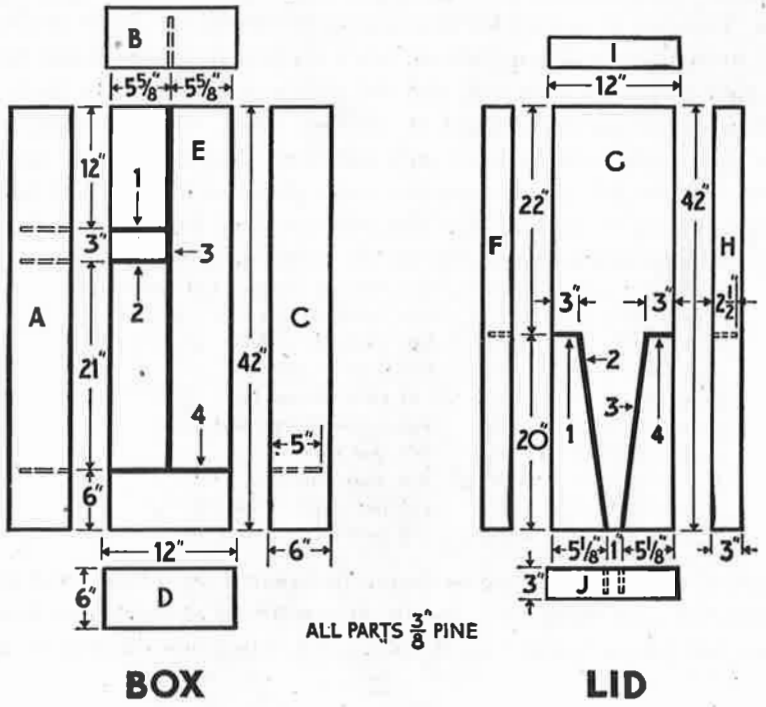


FIGURE 11. PLAN FOR CARRYING CASE—SUITCASE TYPE

the ends B and D to the bottom piece E and the side pieces A and C. The partition boards are attached. Piece 4 is nailed between A and C, and further strengthened by nailing to piece E. The long partition board 3 is nailed between piece 4 and the end board B. This should also be nailed to the bottom board E. The partitions are completed by nailing the two short pieces 1 and 2 between partition board 3 and the side board A, which completes the box portion of our case.

The lid is now assembled. Proceed in the same manner, nailing the side boards F and H to the sides of the bottom board G. Nail the end boards I and J to the ends of F and H, as well as to the ends of bottom board G. The four partition boards are now assembled. Nail the short ones 1 and 4 to the sides F and H. These should also be nailed to the bottom board G. The two remaining partition boards 2 and 3 are nailed to the ends of boards 1 and 4, and then nailed in position to end board J. These should also be nailed securely to the bottom board, completing the lid with the exception of its cover. This should be made of 1/8" stock, so that it will come flush with the top of the lid's sides. Cut it 11 1/4" wide and 42" long, and attach it, as shown in the illustration, with three hinges. Two small holes can be bored in it to aid in lifting.

Three 3" hinges are used to hinge the lid in place on the box, and it is then equipped with regular fasteners such as are used on ordinary suitcases. A suitcase handle and a lock complete the box. When packing it, all "A-Frames" are placed in the lid, as well as the winder and spare parts, as shown. The long compartment holds wings, being long enough to take a 36" length, while the small end compartment holds all elevators and rudders. The other three compartments are for propellers, rubber motors, and miscellaneous tools, dope, ambroid, etc.

The second box is made in the shape of an "A-Frame," as shown in the illustration. (See Figs. 12 and 13.) It requires the following pieces of pine:

2 pcs.—3/8" x 15" x 48" —Box bottom (E) and Lid bottom (G)
2 pcs.—3/8" x 6" x 48 3/4"—Box sides (A and C)
1 pc. —3/8" x 6" x 15" —Box end (B)
1 pc. —3/8" x 6" x 9" —Box end (D)
2 pcs.—3/8" x 3" x 48 3/4"—Lid sides (H and J)
1 pc. —3/8" x 3" x 15" —Lid end (I)
1 pc. —3/8" x 3" x 9" —Lid end (K)
1 pc. —3/8" x 5 5/8" x 36 3/4"—Box partition (2)
1 pc. —3/8" x 5 5/8" x 13 1/2"—Box partition (1)
2 pcs.—3/8" x 5 5/8" x 5 1/4"—Box partitions (3 and 4)
1 pc. —3/8" x 2 1/2" x 48" —Lid partition (F)
1 pc. —3/8" x 2 1/2" x 5" —Lid partition (E)
1 pc. —1/8" x 5" x 48" —Partition cover

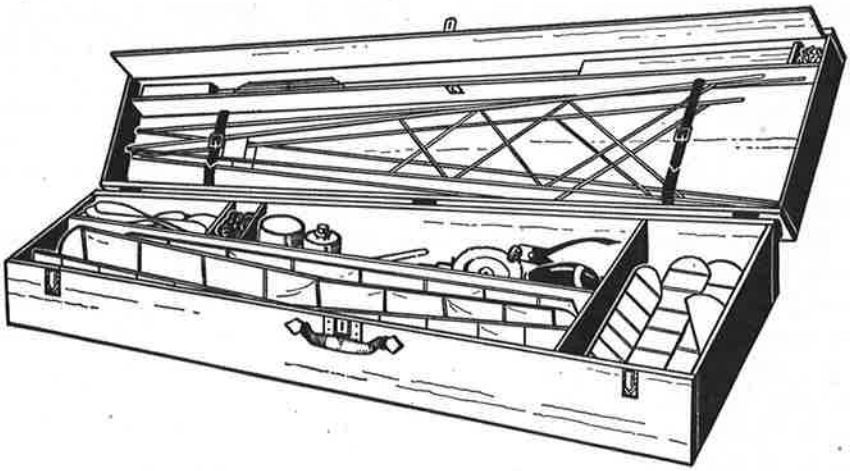


FIGURE 12. CARRYING CASE—TRIANGULAR TYPE

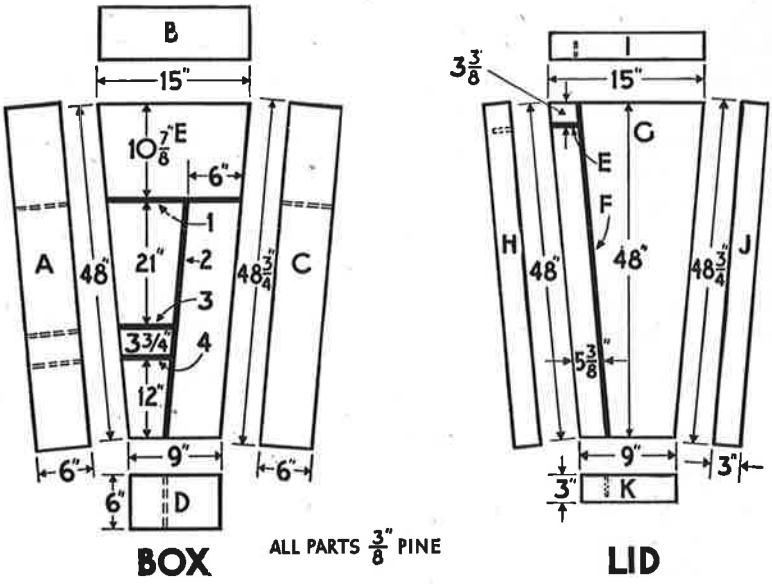


FIGURE 13. PLAN FOR CARRYING CASE—TRIANGULAR TYPE

The two bottom pieces E and G should be cut, as shown in the plans. One end of these two pieces measures 15″ and the other 9″ in width. Take all measurements from a line drawn through the center of each board along its length.

When these pieces have been sawed, the entire seventeen should be planed smooth and completed with a careful sanding. The box is now assembled. Attach the side pieces A and C by nailing them to bottom piece E, after which the end boards B and D are nailed in place between side boards A and C. These end boards must also be nailed to the bottom E.

The partition board 1 is nailed between A and C 10⅞″ from the 15″ wide end of E. Nail this to the bottom board E as well as to the sides. The long partition board 2 is now attached between end board D and partition board 1. This is placed 6″ in from side C, parallel with it, and nailed securely to partition 1, end board D, and bottom E.

The two short partition boards are now attached. Board 4 is nailed between partition 2 and side A 12″ from end D, while the other partition (3) is located 21″ from partition 1, or 3″ from partition 4. These should be nailed to the bottom E, the side A, and the partition 2, completing the box part of our case. We now assemble the lid.

The sides H and J are nailed to the sides of the bottom G. Nail the end pieces I and K between the sides H and J. Strengthen them by nailing to the bottom piece G. The long partition board F is nailed between the end pieces I and K 5″ from the side board H. The short partition board is nailed between the long partition board F and the side board H 3″ from end board I, as shown. The cover for the narrow lid compartment is held with three hinges, being fastened to the side board H.

Hinge the lid of the case to the box with three 3″ hinges, and cover it carefully with oilcloth, attaching it with glue. The large compartment in the lid holds "A-Frames," motor sticks, and extra long sticks, while the small corner one is for metal fittings. The third lid compartment is for spare wood pieces.

In the box, the largest of the five compartments is for wings, while the end one holds elevators and rudders. The third compartment in the opposite corner holds propellers, while that next to it is for rubber motors. The fifth compartment holds dope, tools, winder, and other necessary materials.

CHAPTER 6

METAL FITTINGS

THE construction of a model airplane requires metal parts which must be of such quality as to give the necessary strength and at the same time add a minimum amount of weight. Experimentation has proved that a high-grade piano wire has these qualities. All model stores handle this wire, but the purchaser should specify piano wire. Having an unusually great tensile strength, it allows the thinnest wire to be used and guarantees strength and lightness.

While all fittings are not made of this wire, the few exceptions are made from the lightest possible metals, as explained later. The diameter of wire is designated by a gauge number. There are times when it becomes necessary to know the actual diameter of the wire in inches, which the gauge number represents. The most common sizes are:

GAUGE NUMBER	WIRE DIAMETER
5	0.014″
6	0.016″
7	0.018″
8	0.0197″
9	0.022″
10	0.0236″
11	0.026″
12	0.0283″
13	0.031″
14	0.033″
15	0.035″
16	0.037″

For the average model work, Nos. 6, 8, 10, 12, and 14 will be all that the builder will require. Bending of wire parts is difficult. All the various parts shown in Figs. 16 and 17 can be purchased from model houses, but their cost is far greater than the price of the wire, and the types of fittings available are limited. An end hook may be purchased, but seldom more than

one type will be available, so if you wish another form of end hook you must bend your own.

Special wire cutters should be purchased, as piano wire will ruin an ordinary pair of pliers in a short time. Round-nosed pliers should be used for bending piano wire, and two pairs will be useful. While one holds the end of the wire, the second can do the bending.



BENDING WIRE

FIGURE 14

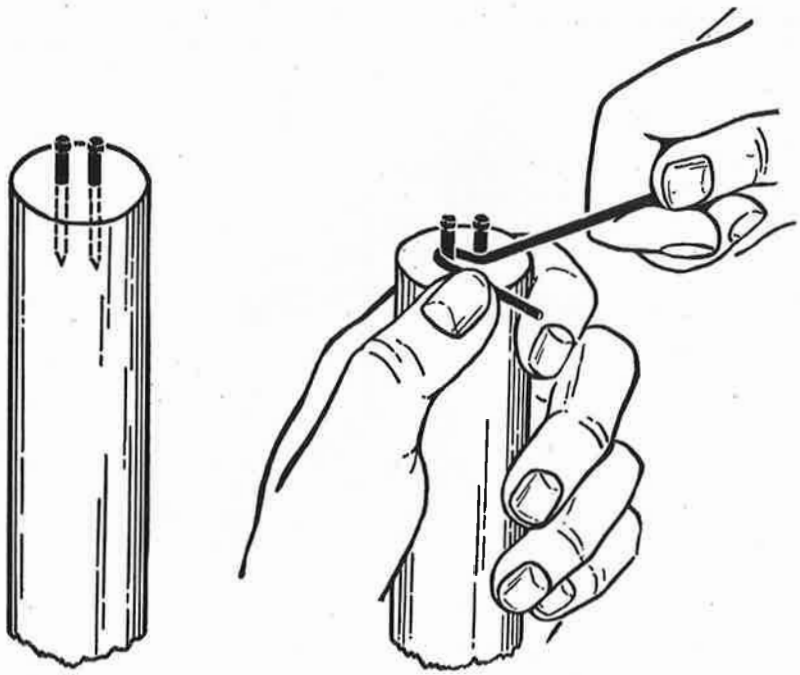
Fig. 14 shows the usual method of bending wire. The pliers hold the wire at the point of bend, while the hand or a second pair brings the wire over for the bend. Small circles can be made in this manner.

Fig. 15 shows a simple wire bender. It consists of a short length of 1″ dowel, or piece of broomhandle, into the end of which two small brads have been driven. The heads of the brads keep the wire in place. The illustration shows how the bender is used. Several of these benders can be made, each with nails of different diameters for bends of different sizes. The handle is 6″ or 8″ long.

TAIL SKIDS. In Fig. 16 six popular tail skids are shown. These are bent to shape and cemented to the under side of the fuselage or motor stick.

It will sometimes be necessary to strengthen the connection by binding the wire with silk thread, after which it should be given a coat of cement.

"S" HOOKS. These are bent in the form of a letter "S." They are used as a connecting link between rear hooks, as well as nose hooks, and the rub-



WIRE BENDER

FIGURE 15

ber motor, as in Fig. 16 B. Such hooks are necessary only when the motor carries a number of strands. Their main use is to give the strands a loose connection on which to turn. The rubber strands are looped over one half of the hook, while the other half is connected to the nose or end hook. For especially large motors, the hook for the rubber is made larger than the connecting hook, as shown by A. B shows the most commonly used "S" hook, while C, D, and E show various forms of it. The builder can make his own choice of these, as they all function alike.

METAL FITTINGS

CLIPS. There are four main uses for clips. The wing and elevator clips hold these parts in place on the motor stick or fuselage. The rudder clip holds that member in position, while the motor stick clip holds the motor stick in position in the fuselage.

A in Fig. 16 shows a popular wing clip for single stick endurance models. It can be used on models carrying the wing above or under the motor stick, as the small squared portion at the top is bent to fit the width and thickness of the motor stick. With such a clip, the wing can be hung from the stick or supported above it. Two are required for each wing. A large one is used on the leading edge, while a small one is cemented to the trailing edge, as shown in B. The type of clip shown by B is possibly the most common on stick models where the wing is above the motor stick. The view shown is from the under side of the wing. Two of these clips are used for each wing, as in the case of the A clip.

The clip marked C is another form of B clip, with the bend in front of or behind the main supporting wires rather than at their sides.

Both these clips are used as motor stick clips inside a fuselage model where cross top struts or cross bottom struts have the clips cemented to them. If these clips are attached to top struts, the motor stick becomes a "hanging" stick, while it is called a "supported" stick if the clips are attached to bottom struts. Another clip is shown by D. This has a small saddle bent in it, which serves as an extra support along the motor stick. A single wire support often allows the wing to "rock" on the stick, but the saddle on this one prevents this because of the surplus purchase it has on the stick.

For twin stick models, the wire clips shown by F make splendid wing fasteners. These are bent to fit around the members of the A-frame, and the wing is held with a single rubber band stretched across the top surface of the wing and held by the small hooks of the clips. Four such clips are necessary for each wing, two being placed as shown on each beam.

The odd-shaped clip shown by F can be used for motor sticks as well as rudders. The ends of the wire fit over the bottom rib of the rudder, where they are cemented in place, while the lower portion is bent to the size of the motor stick, fuselage longeron, or the center rib of the elevator. For motor sticks, the ends are cemented to the top center stringer, while the lower portion is bent to fit the motor stick tightly. This clip can be used only for hanging motor sticks.

Clips A, B, C, and D can be used for elevators on single stick models. They are made proportionately smaller than when used for wings.

CAN HOOKS. These are used for a two-fold purpose on all models having strong rubber motors. They keep the rubber in place on the stick, and

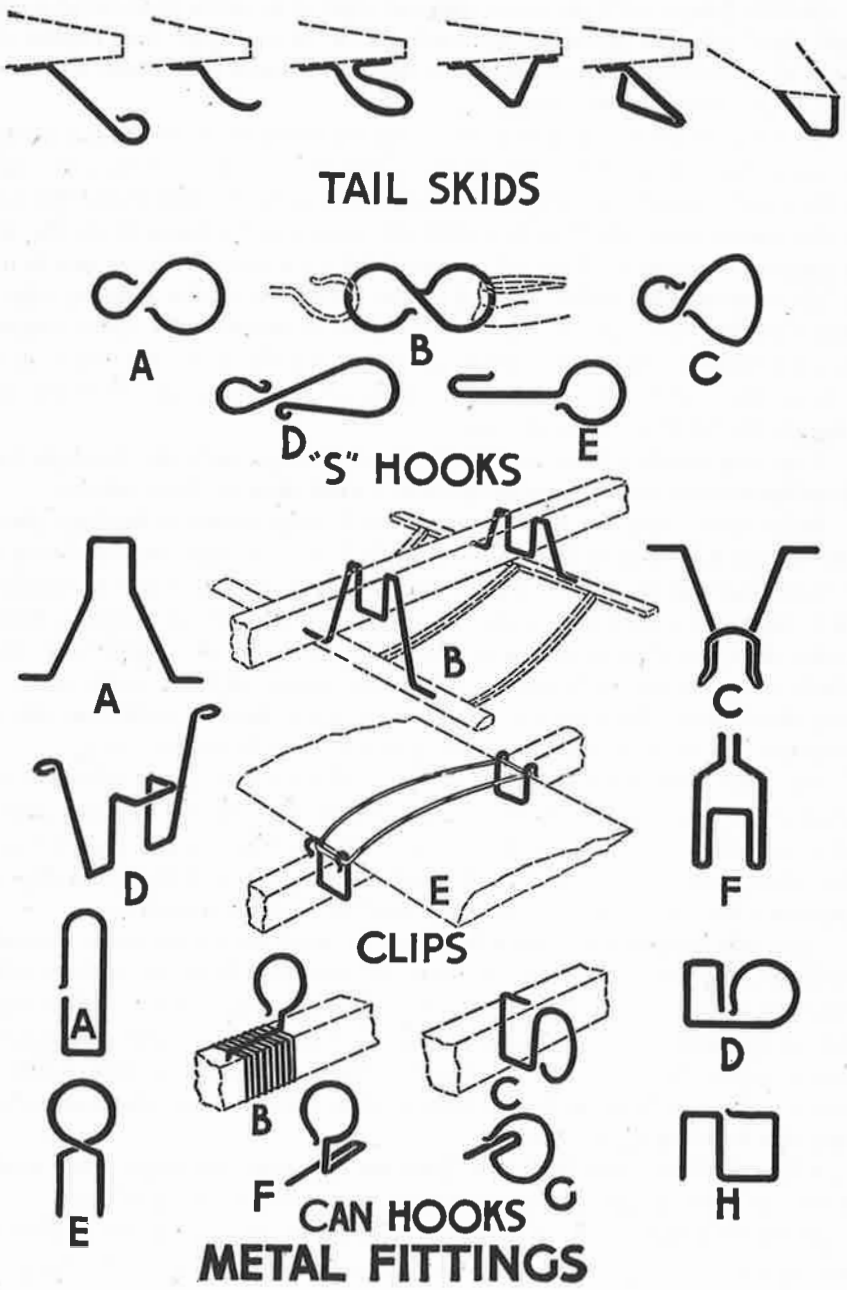

TAIL SKIDS
A
B
C
D
E
"S" HOOKS
A
B
C
D
E
F
CLIPS
A
B
C
D
E
F
G
H
CAN HOOKS
METAL FITTINGS

FIGURE 16

aid in distributing the tension of the wound motor. Practically all outdoor endurance models are equipped with one or more can hooks, depending on the length of the motor stick. For short sticks carrying only two or three strands of rubber, one is placed at the center of the stick. When more are used, they should be equally spaced.

Can hook A, Fig. 16, is bent to fit over the motor stick on its top or bottom, the lower bend being made to fit around the stick, where it is cemented in place. B may be attached to the stick on either side, top or bottom, where it is cemented and bound with silk thread. Can hooks C and D show two side hooks of common variety, while E shows a top or bottom can hook of simple lines. This is made with its ends crossed and then bent to fit the motor stick, where they are cemented in place.

F and G are two side can hooks usually found on twin-stick pushers. The closely bent portion of the wire is cemented and lashed with silk thread against the side of the A-frame beam, allowing the large circle to extend out from it. F has a small extension which keeps the rubber well away from the beam. This is usually used on motors having a great number of strands. For smaller motors, the G hook will serve.

H is another side hook. The smaller square is cemented around the stick, while the rubber fits through the other square.

PROPELLER SHAFTS. Every propeller must have a shaft by which it is attached to the fuselage. This shaft should be of the same gauge wire used for the rear hook, which must be sufficiently strong to stand the strain of a wound motor.

From a length of piano wire a hook is bent as shown by Fig. 17 A. The straight end of the wire is then thrust through the center of the propeller's hub. When through the hub, the wire is bent around, as in B. The wire is then pulled back until its end is forced into the wood of the hub, where a drop of cement holds it tightly in place. Washers are then threaded over the hook, which in turn is passed through the hole in the propeller bearing, as in C.

PROPELLER BEARINGS. These are often called "thrust bearings," being the metal or wood part holding the shaft of the propeller in place on the motor stick or fuselage. A simple needle bearing is shown in Fig. 17 A. It does away with all drilling. For small indoor models, a $\frac{1}{32}$" diameter needle serves well, while a darning needle should be used for larger models. It will save time if a needle having an eye large enough to admit your propeller shaft is found. The temper must be taken out of the needle before it can be bent. Heat it to a white heat and allow it to cool naturally. Do not

place it in water. When cool, bend it to the required shape. If too long, it can be cut to any length with pliers or tin snips.

Try the propeller shaft through the eye. If the eye is too small, heat to a cherry red and while still red, force the shaft through. The needle must now be retempered. Heat it again to a cherry red and plunge it into a glass of cool water, continuing the process until it is a blue color; but do not temper it too much, as it will become brittle and break.

A propeller bearing can also be made with a nail. Cut the head from any nail of desired diameter. Place it on a steel block and hammer its end flat. A hole slightly larger than the diameter of your propeller shaft is bored through the nail, which is bent and cemented to the motor stick, shown by Fig. 17 B. If too long, it can be cut. Many builders prefer to substitute a cotter pin for the nail. When this is done, the cotter pin is broken in half, leaving a single flat length of metal, which is then bored and bent.

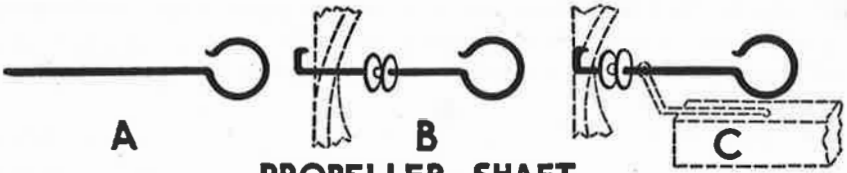
C shows a bearing made from piano wire, which can be used on small models. The wire is bent around a nail, its ends brought together and bent to form the bearing. This is then cemented to the motor stick. If further binding is desired, the ends of the wire can be bent down, forced into the wood of the motor stick and cemented and lashed.

On fuselage models having no motor stick, the bearing is made from a plug which fits into the end of the fuselage, or is cemented in place to the ends of the stringers, as shown in D. (See Chapter 35.) Through the center of the nose piece, a hole is made large enough to allow the propeller shaft to turn freely. Some fit a bushing eyelet into the plug. If this is done, it must have an inside diameter slightly larger than the propeller shaft, but not so large as to make the fit too loose, or the propeller will not turn true. This can be purchased at most model houses.

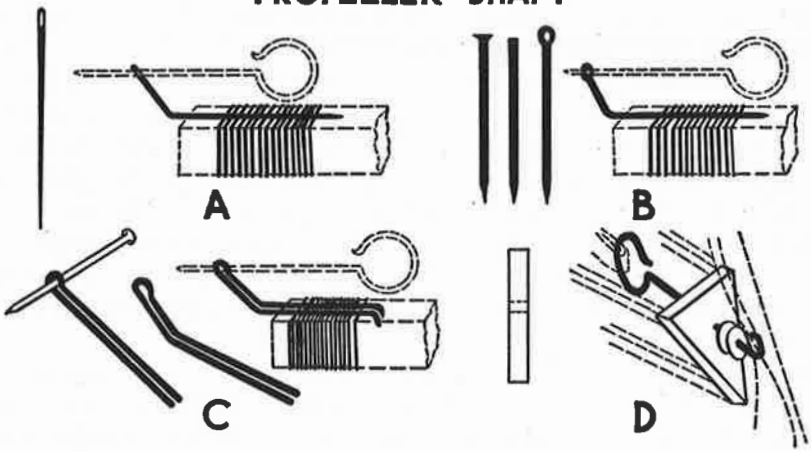
END HOOKS. End hooks are used on all tractor models powered with rubber. They form the rear connection for the motor. On most large models, the end hooks are equipped with "S" hooks (see Fig. 16), but those having small motors usually attach the rubber directly to the hook. These are sometimes called "Rear Hooks."

A in Fig 17 shows the most commonly used end hook. A short arm extends the hook above the top of the motor stick, while its end is bent and buried in the wood. Another is shown by B. Here the hook is bent around the end of the stick, making a strong connection. Such hooks are extensively used on fuselage models with removable motor sticks.

The double hook C is used on some commercial models. The extra hook extending out from the rear of the model allows the motor to be wound with a winder. The rear plug shown on the hook is removable, so that the



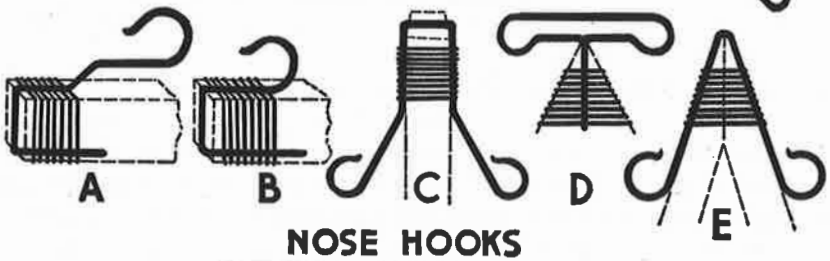
PROPELLER SHAFT



PROPELLER BEARINGS



END HOOKS



NOSE HOOKS

METAL FITTINGS

FIGURE 17

rubber can be stretched before winding. Such a hook is not cemented to the plug, as the pull of a wound motor will hold the plug in place, and at the same time pull the outside hook tightly against the outer side of the plug. (See Chapter 35.)

Sometimes solid blocks are used to plug the end of a fuselage. When this is done, a combination end hook and tail skid can be used, as shown by D. The wire is firmly cemented to the block through which it passes, one end forming the skid and the other the end hook.

Another combination end hook and tail skid is shown by E. While D is designed for fuselages without motor sticks, this fitting is expressly for single-stick models. One end forms the hook above the stick while the center of the wire is bent around the end of the motor stick, and the other end forms the skid. These are cemented and then lashed with silk thread.

NOSE HOOKS. Nose hooks hold the rear end of rubber motors on pusher models. On such models, the opposite end from the propeller becomes the nose of the model inasmuch as the propeller pushes the model in front of it.

The nose hooks shown by A and B in Fig. 17 are exact duplicates of those shown under the same letters for end hooks, so will require no further explaining. The double hook C is fashioned for single-stick, twin-propeller models. Few of these are made today, having been replaced by the twin-stick pushers, but are given for the builder wishing to experiment along this line.

The double nose hook D is a hook seldom used today. It is bent from a single length of piano wire with its ends brought together between the ends of the A-frame beams, which are cemented and lashed together.

The most popular nose hook for the twin-stick model of today is E. A single length of piano wire is bent in a "V" to conform to the angle made by the joining beams of the A-frame. Its ends are then bent to form hooks over which "S" hooks are placed. The hook is cemented and bound with silk thread to the beams, which holds it tightly in place and at the same time strengthens the joint of the A-frame.

WASHERS. Washers of various sizes can be purchased at all model supply houses or the builder can easily make his own. For this work an ordinary paper punch, which can be obtained at any stationery or five-and-ten-cent store, should be used. Such a punch will work on sheet tin or copper of the usual washer thickness. After punching out the washer, complete it by carefully driving a small brad through its center. Small beads or dress spangles also make excellent washers for propeller shafts. A spangle between two washers will be found the best combination.

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

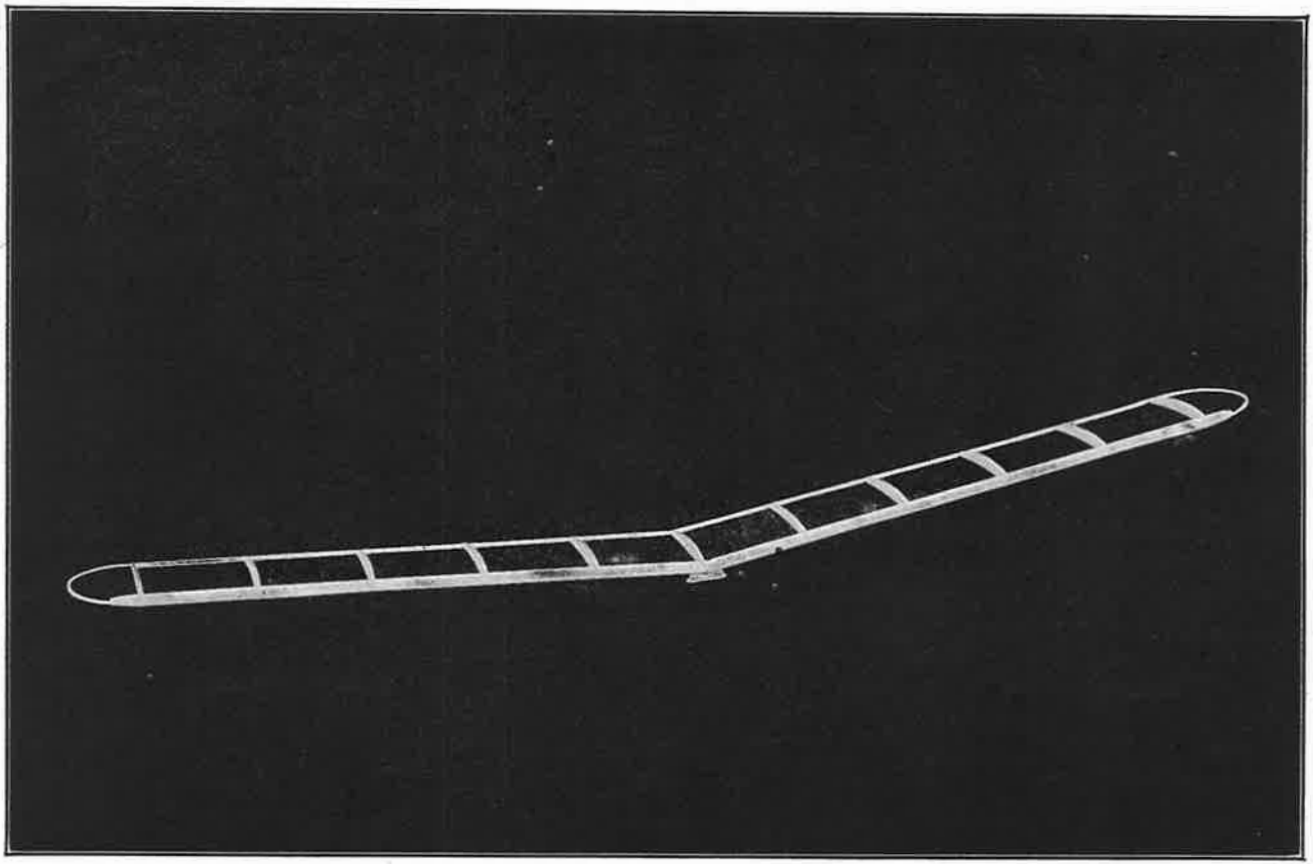


FIGURE 18. STRAIGHT WING

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

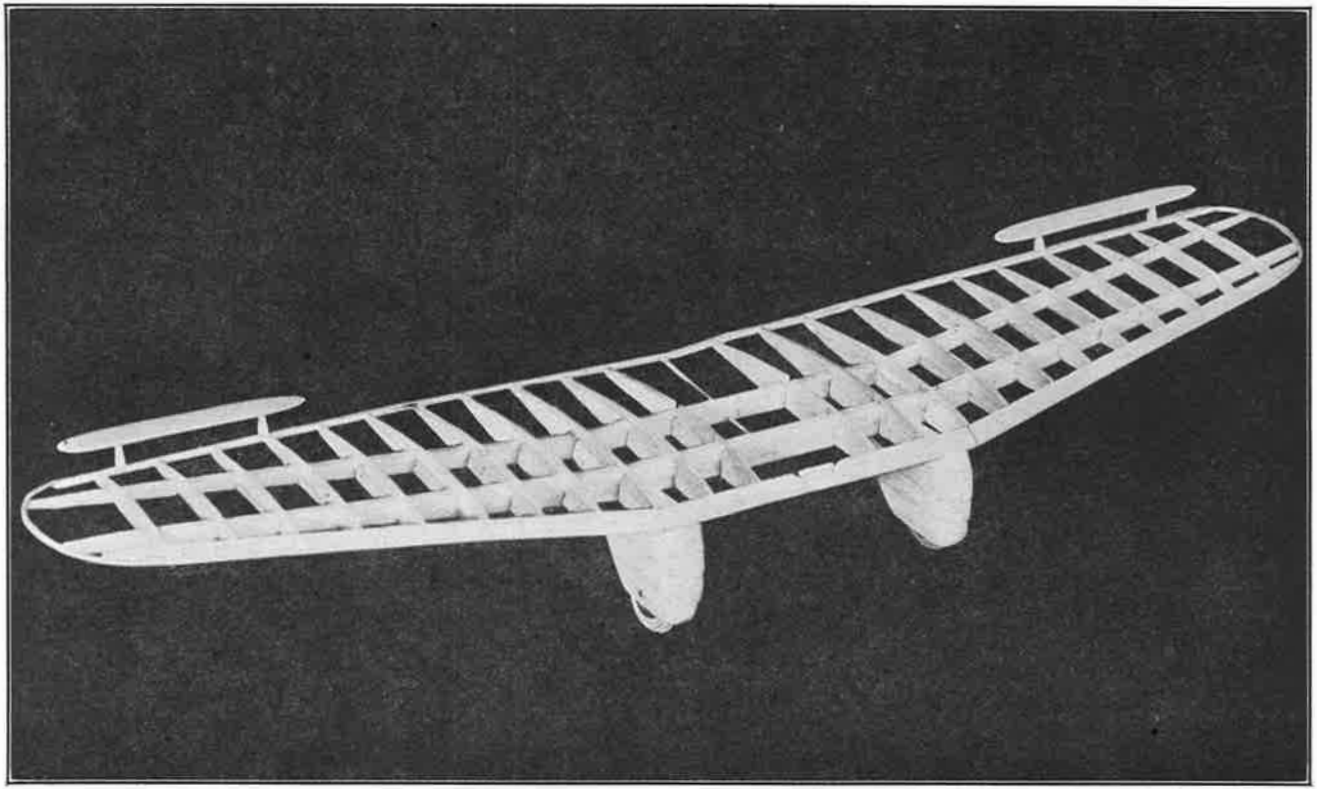


FIGURE 19. TAPERED WING

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

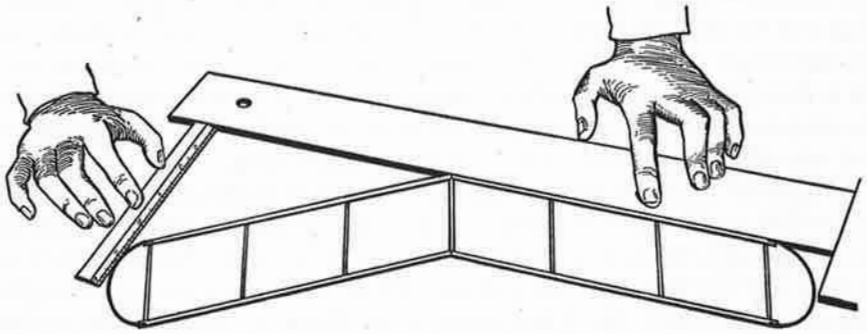


FIGURE 20. MEASURING SWEEPBACK

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.

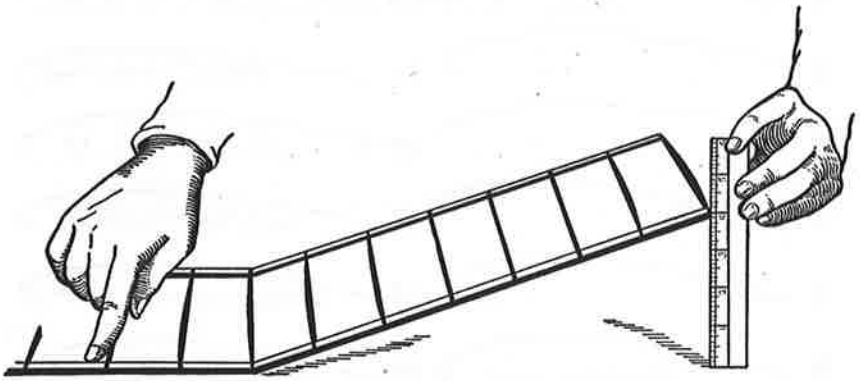
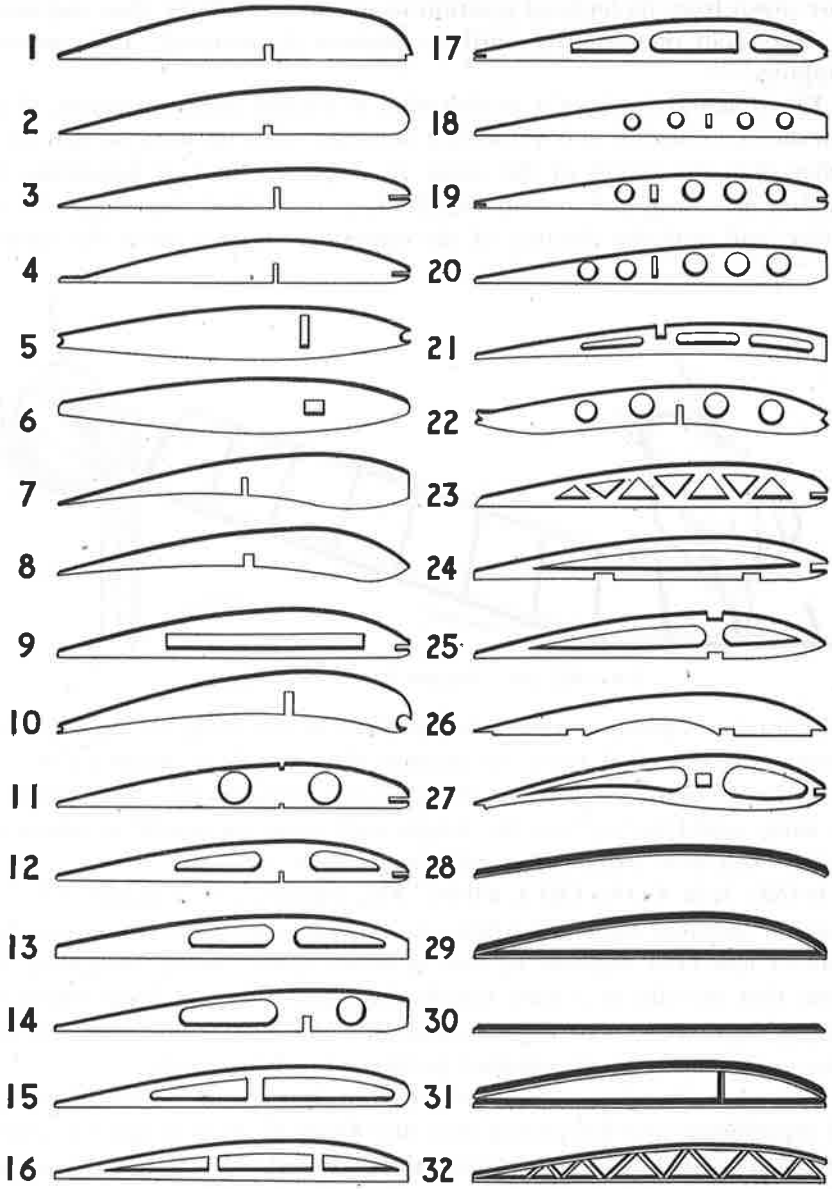


FIGURE 21. MEASURING DIHEDRAL

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 1/32" or 1/16" balsa. They may be square, or about twice as wide as they are thick. A 1/32" square, a 1/32" x 1/16", a 1/16" square, or a 1/16" x 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 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 1/8", although on some very large models the author has seen 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

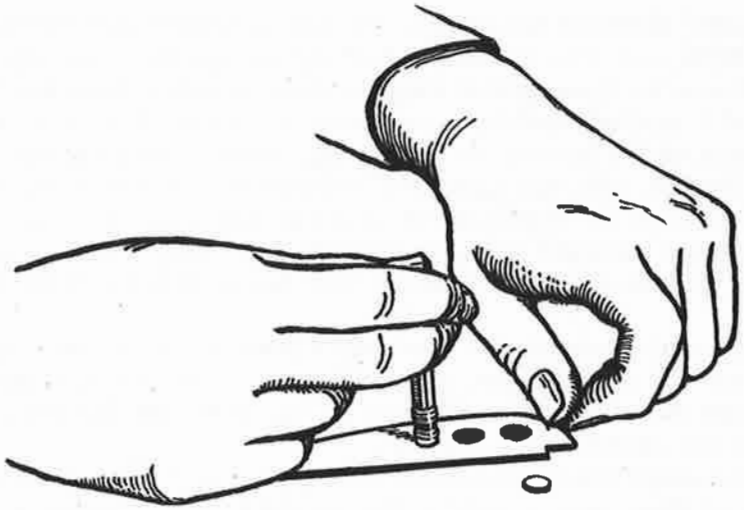


FIGURE 23. USING PENCIL FERRULE FOR LIGHTENING RIBS

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

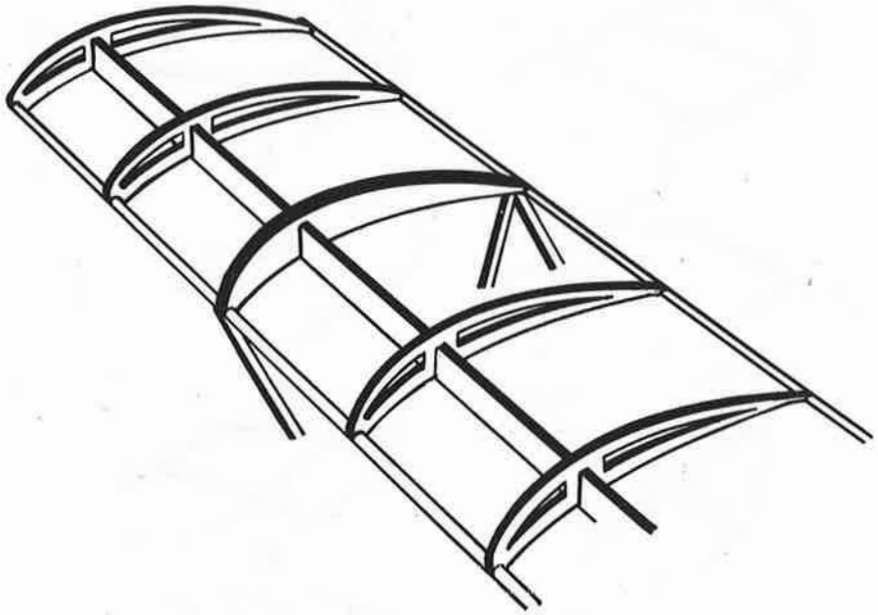


FIGURE 24. HEAVY DUTY RIB

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.

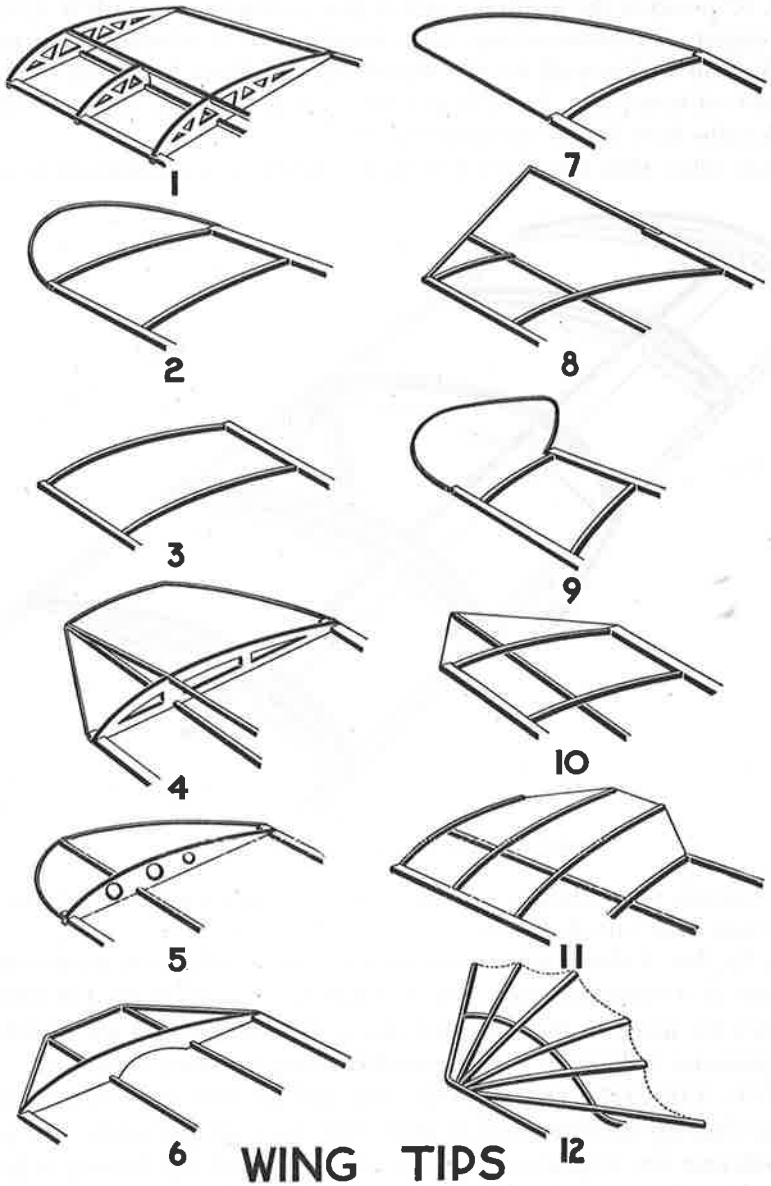


FIGURE 25

WINGS

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.

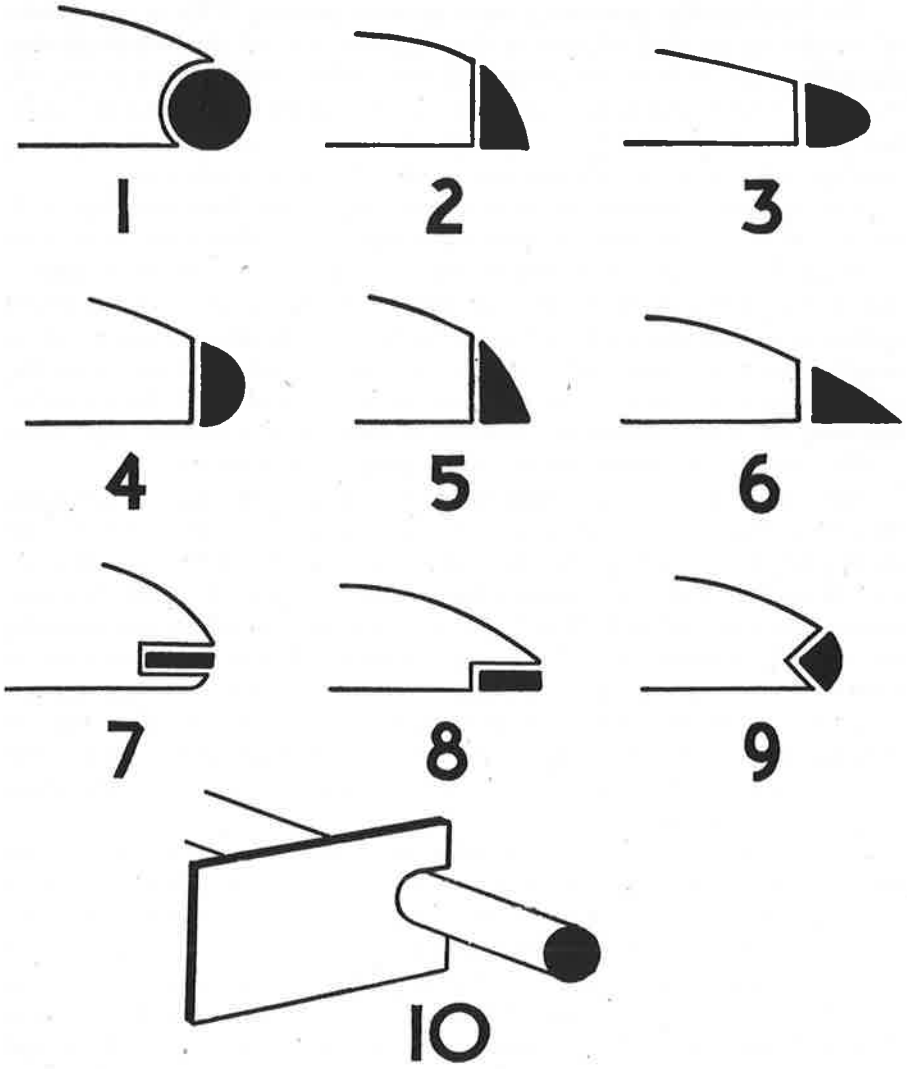
No. 12 has nothing along the trailing edge on which to fasten the tissue covering. The paper is cut to form, and cemented in place. Many small, light, endurance models of modern design appear with this feature, although the general lines of their wings may differ in many respects.

In the past $\frac{1}{32}$" or $\frac{1}{16}$" 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 $\frac{1}{32}$" or $\frac{1}{16}$" 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,

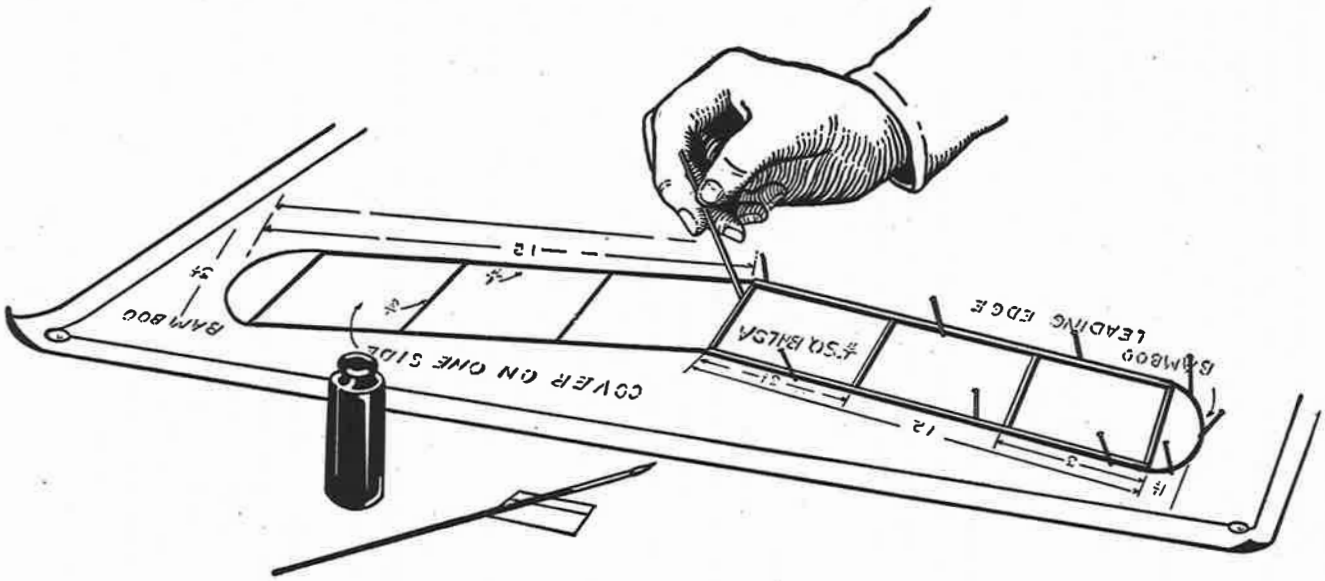


FIGURE 27. ASSEMBLING WING ON PLAN

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,

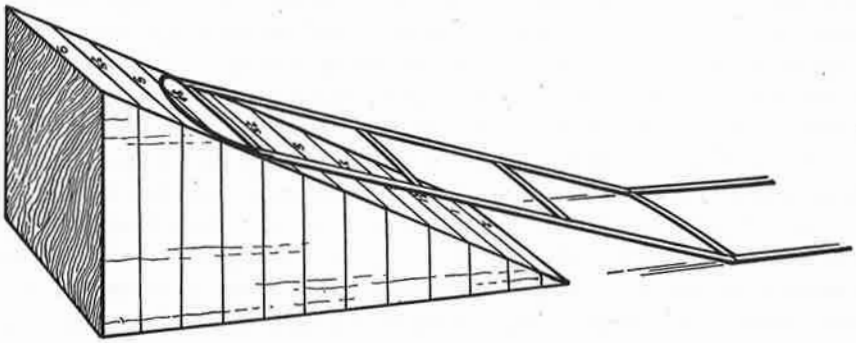


FIGURE 28. DIHEDRAL BLOCK

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,

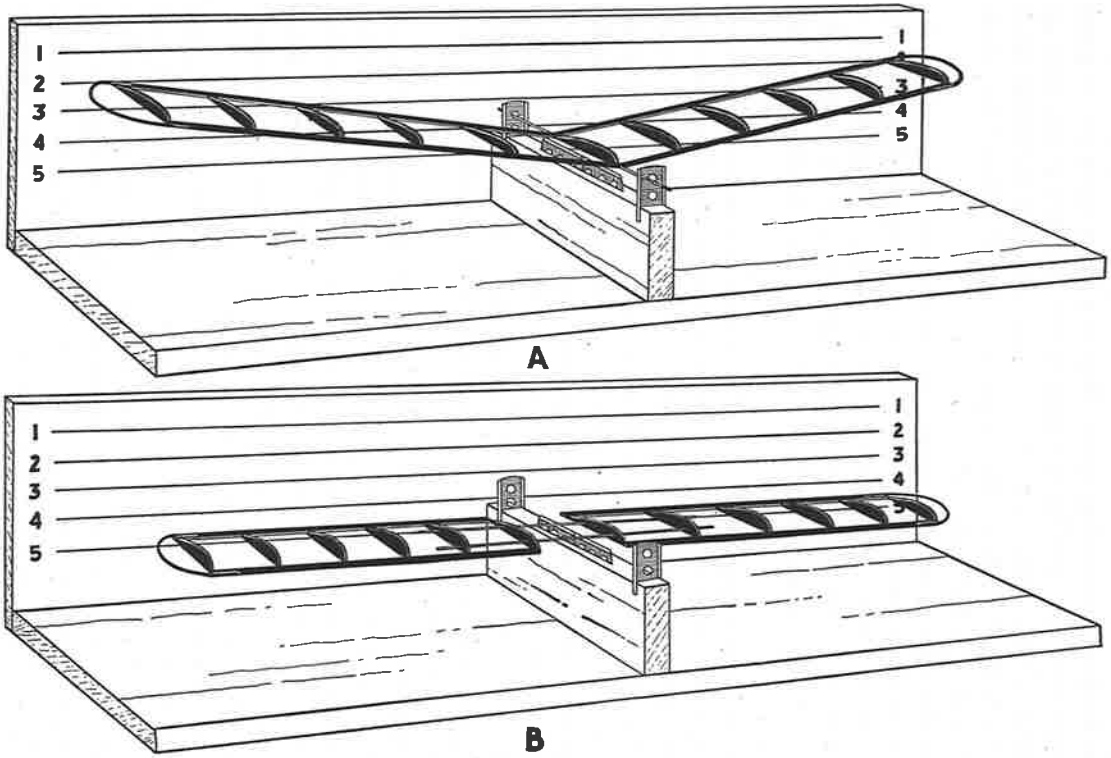


FIGURE 29. TWO-WAY WING BALANCING APPARATUS

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

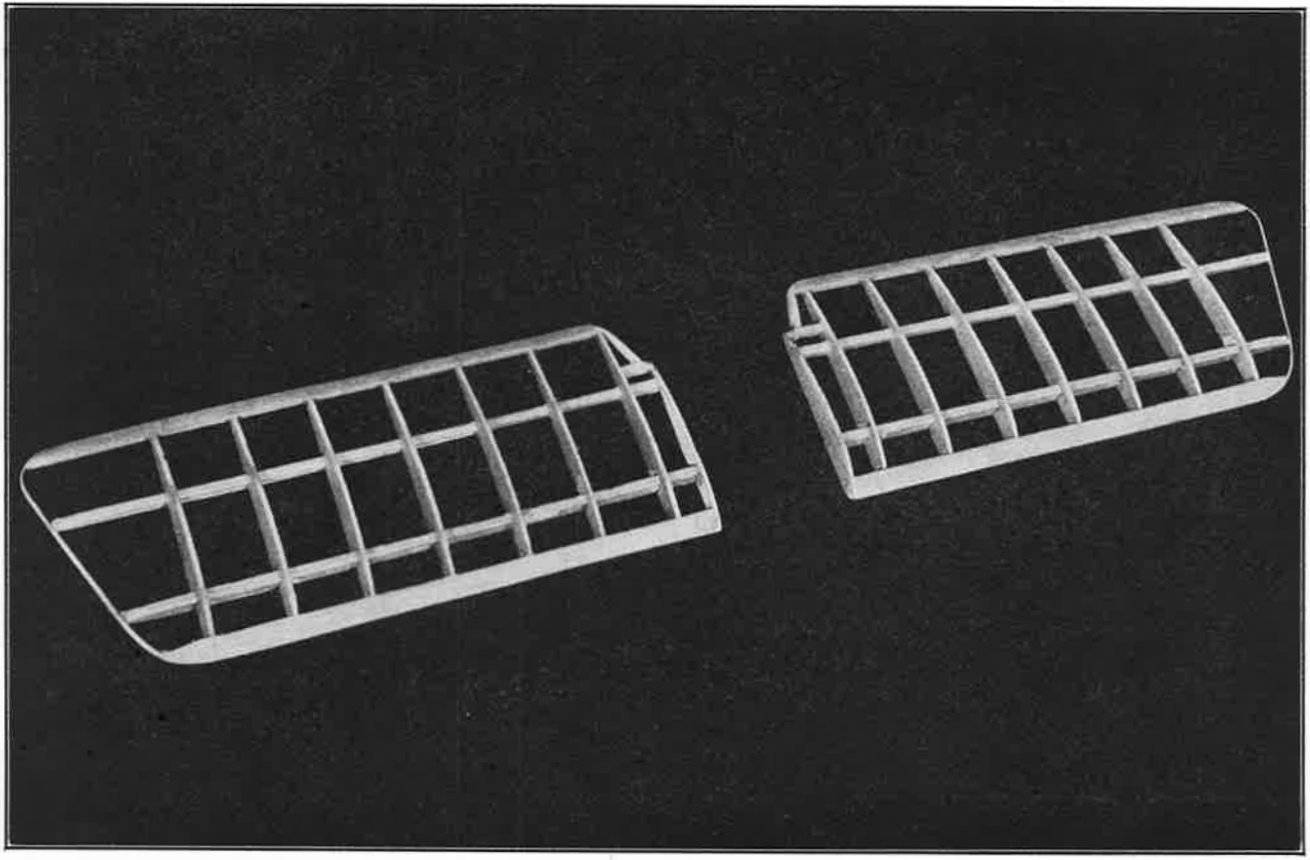


FIGURE 30. LOWER BIPLANE WING

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.

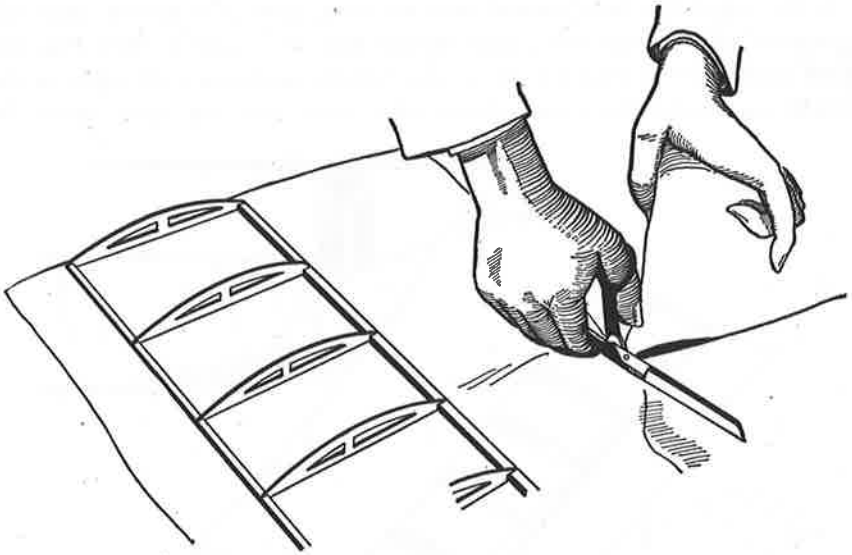


FIGURE 32. FIRST CUTTING OF TISSUE

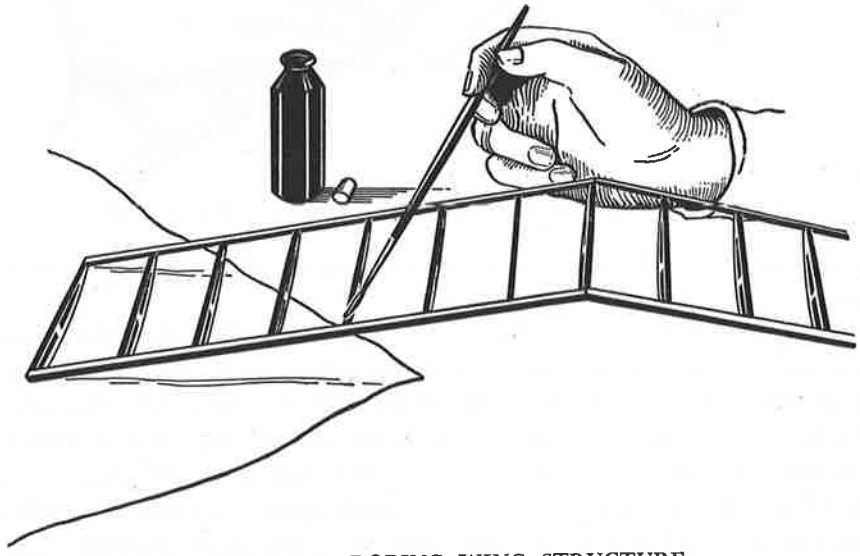


FIGURE 33. DOPING WING STRUCTURE

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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

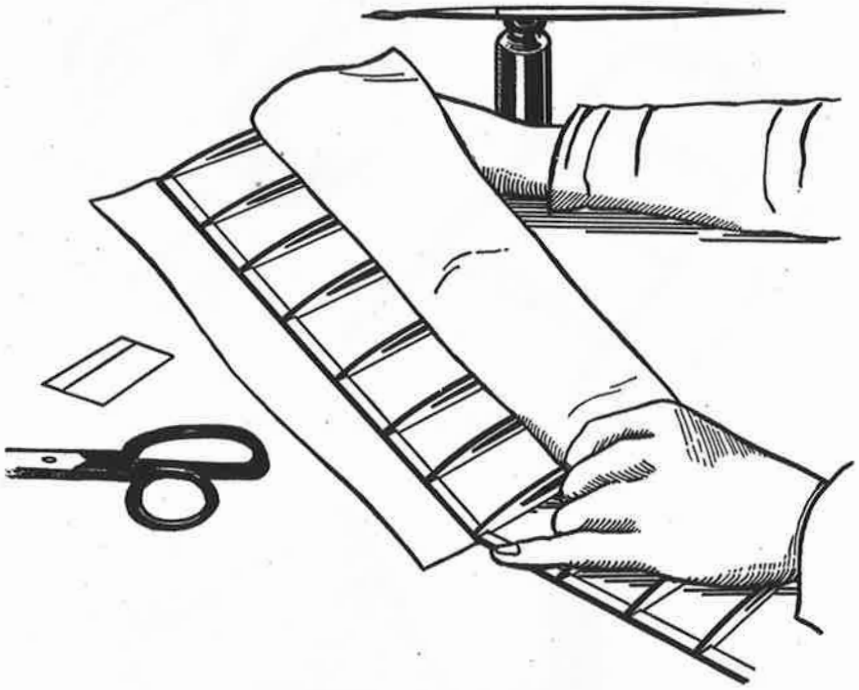


FIGURE 34. ATTACHING TISSUE TO WING STRUCTURE

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

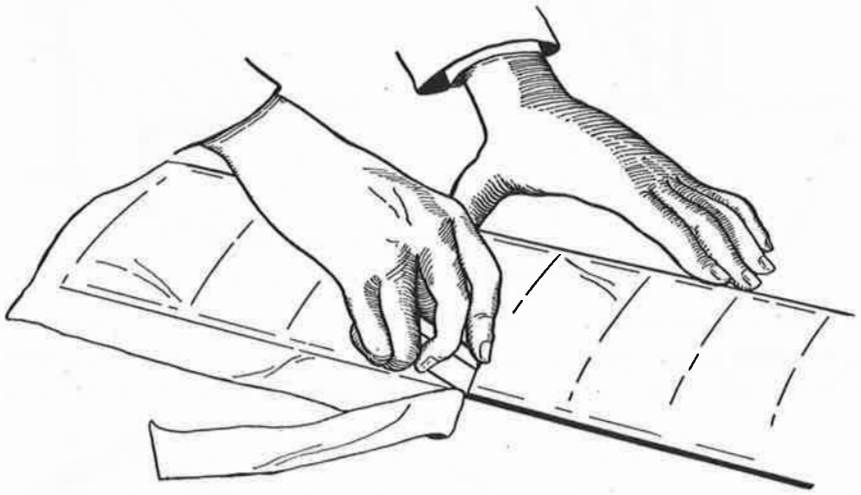


FIGURE 35. TRIMMING EXCESS TISSUE

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

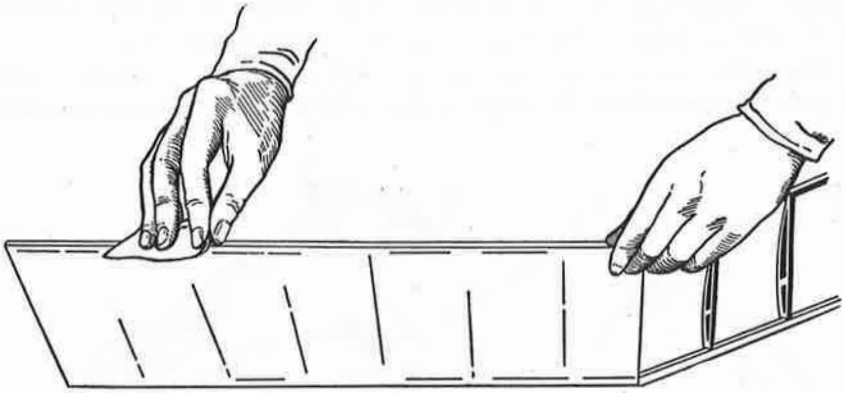


FIGURE 36. REMOVING EXCESS TISSUE FROM SPARS

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

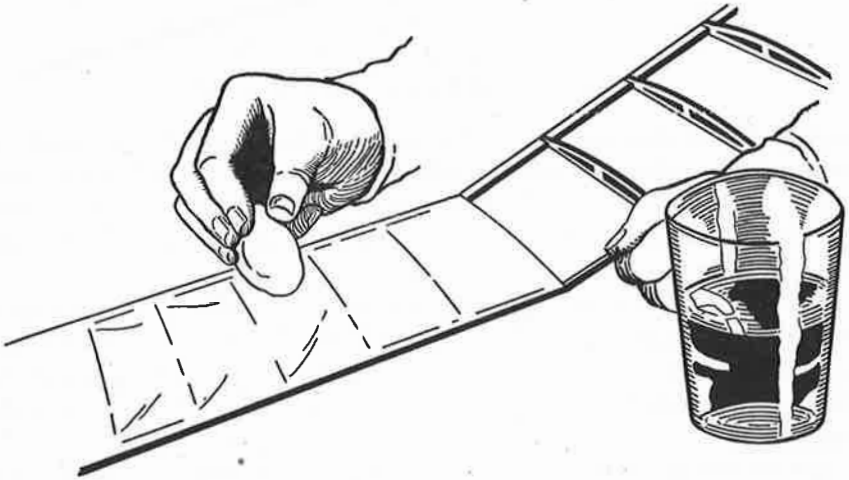


FIGURE 37. OLD METHOD OF APPLYING WATER

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

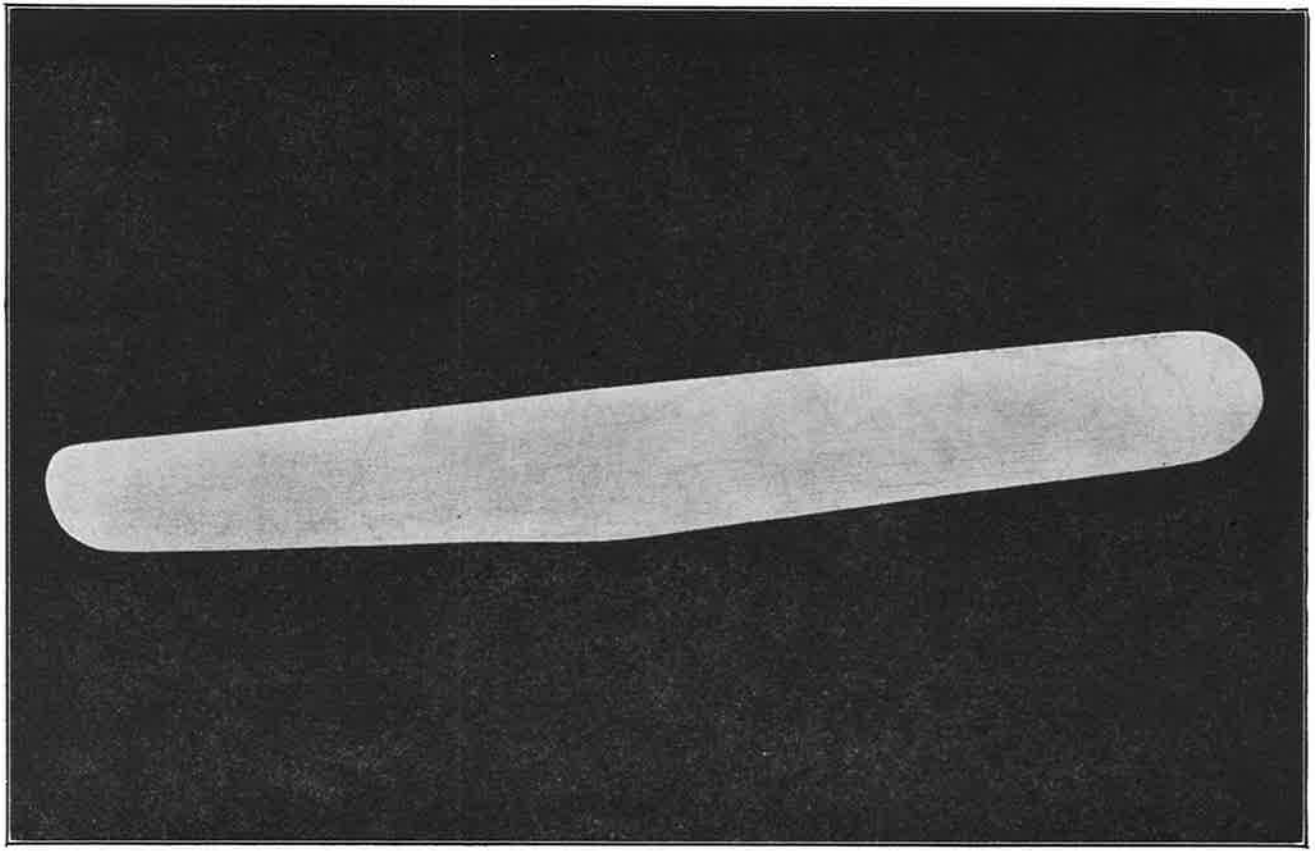


FIGURE 39. SOLID WING

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

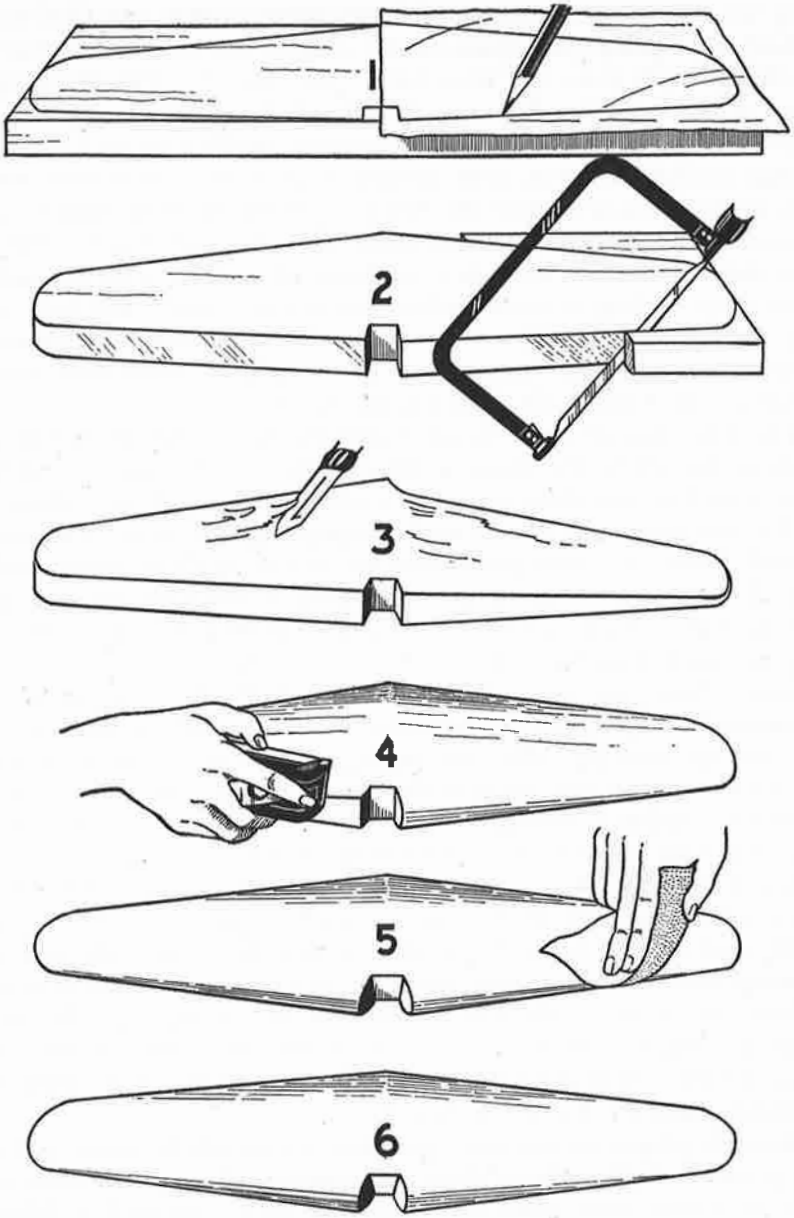


FIGURE 40. PROCESS OF CUTTING SOLID WING

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.)

CHAPTER 8

FUSELAGES

THE proper construction of the fuselage is of utmost importance. It must have the structural strength to support the motor, motor stick, wings, elevator, rudder, landing gear, tail skid, and propeller; and, on the other hand, being the second largest unit of a model, it must be designed for lightness.

FUSELAGE FORMS. For built-up, non-flying scale models, flying scale models, and commercial models, there are six common shapes given to fuselages which are shown in Fig. 41. The first one is triangular shaped, often found in commercial models. (See Chapter 35.) It consists of three longerons, or stringers, separated by upright struts and cross braces. No motor stick is used in this form of fuselage, as its strength is sufficient to hold the motor alone.

The second is a half-round and square-shaped fuselage, which is a common one among real planes. The one shown here is taken from the S.E.5 in Chapter 49. It has a number of formers along the upper portion of the fuselage, which are connected by stringers. The lower portion is made of stringers connected by upright struts and horizontal braces.

A rectangular shaped fuselage is shown by 3. Because of its squared corners, no formers are required to give it shape. It consists of four longerons, connected by upright struts and horizontal cross braces. Such fuselages are seldom found in a real plane of today, but War models often had them. Portions of modern fuselages have this form, such as the Curtiss-Wright Junior in Chapter 46. While the front of this plane is rounded, the rear is rectangular.

The square fuselage, shown by 4, is of the same construction as the rectangular one, 3, except that diagonal braces have been added for strength. This is a popular commercial shape, but is seldom found in real planes.

5 shows the oval fuselage, which is a popular form of fuselage in real planes of today. Note the Curtiss Shrike YA-8 Attack in Chapter 52 and the Waco Taper Wing in Chapter 47. The oval form is obtained through the use of oval formers connected by stringers, as shown.

The round fuselage, shown by 6, is another shape popular in real planes,

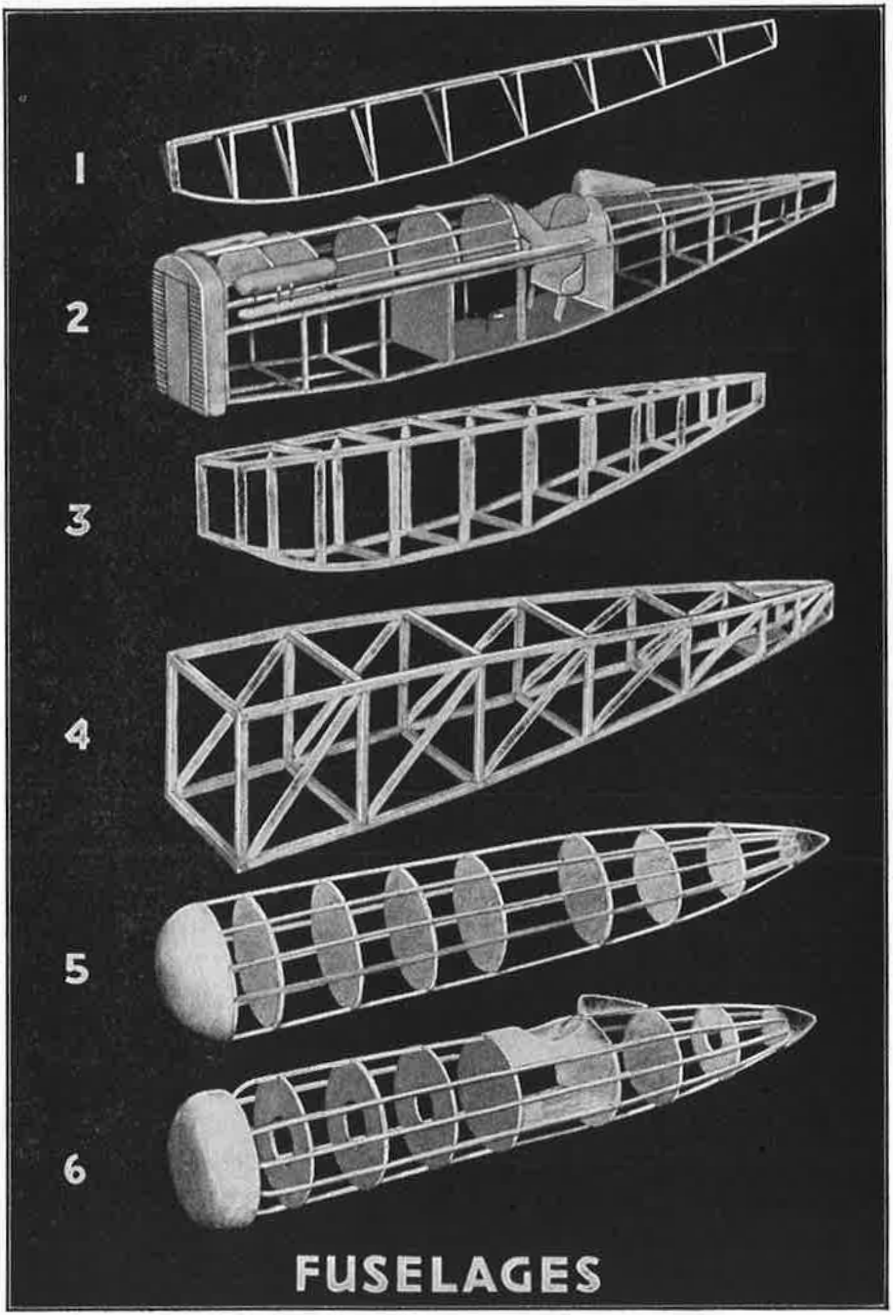


FIGURE 41

although few are perfectly round as in Chapter 48. This is made of formers connected with stringers running the full length of the fuselage.

All these fuselages can be made to carry motor sticks, or carry motors without motor sticks, or they can be made as non-flying models. In 6, a few of the formers have been cut out to show their construction for flying scale models, while in 5 they are left solid for exhibition models.

In the last two the formers must be full height to give the bottom of the fuselage its shape as well as the top. In 2, however, the formers give the fuselage its shape only on the top, so these need only be half-round forms, as shown.

FUSELAGE CONSTRUCTION WITHOUT FORMERS. Fuselages can best be made without formers when their shapes are square, triangular, or rectangular throughout. If they have rounded or curved portions, however, formers should be used.

There are many ways of making fuselages, but the three steps given here will be found practically foolproof, if followed correctly. These are layout, cutting, and assembly. Fig. 42 shows these steps.

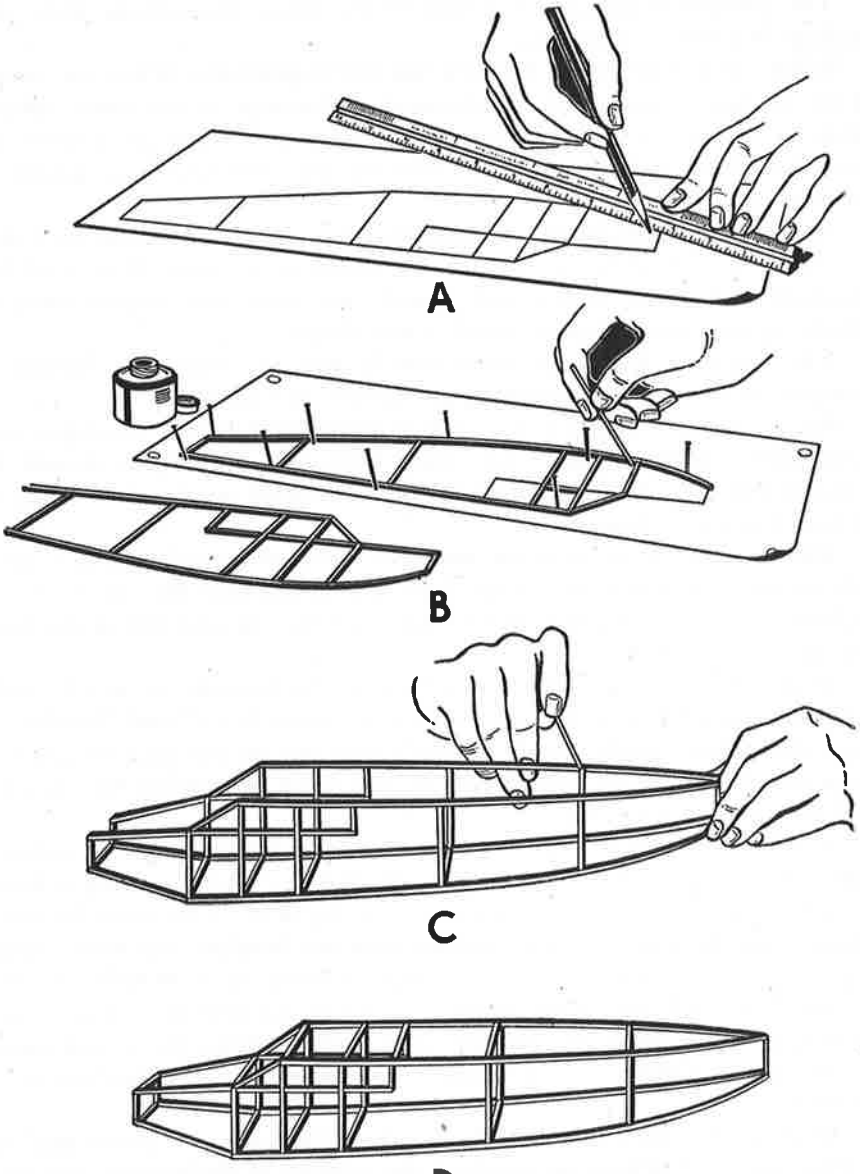
A shows the making of the *layout*. This is a full-size copy of the plan from which the fuselage is being constructed. The best view is the side of the fuselage, as both sides of any fuselage are alike. Care must be taken to insure correct dimensions because actual construction is done on this layout sheet.

When completed, the longerons, struts, and cross braces are cut to proper length and size. (See Chapter 3, "Balsa Wood.") Complete all *cutting* before assembly starts. The parts for each side, top, and bottom should be in separate piles for quick identification.

Fig. 42 B shows the *assembly*. One side of the fuselage is assembled at a time. Lay each part in its proper position on the layout sheet. Hold the longerons in place with model pins, as shown, while the struts are slipped between them. To make sure that each part fits perfectly, assemble the entire side on the sheet before doing any cementing.

While the longerons are held with pins, cement all struts and braces between them, as in B. Allow the structure to dry while in this position. A duplicate side is made in the same manner on the layout sheet.

When both sides are dry, the top and bottom cross braces are cemented in place, as shown in C. Though the sides of the fuselage may have a slight fore-and-aft bend in them, they should be assembled on a flat surface, and, when the top and bottom cross braces are ready to be applied, they are then bent.



FUSELAGE CONSTRUCTION
WITHOUT FORMERS

FIGURE 42

The completed fuselage is shown in D. These illustrations show the fuselage of a Stinson-Detroiter.

FUSELAGE CONSTRUCTION WITH FORMERS. When the shape of the fuselage is round, oval, half-round and square, or any other curved form, its construction will require the use of formers. These are usually cut from sheet balsa and take the place of struts and cross braces on square or rectangular fuselages.

It is obviously impossible to illustrate the constructional steps for every curved form of fuselage, so the Curtiss Shrike in Chapter 52 is used for illustration purposes. It has oval, round, and flat-round shaped formers, which are the most commonly used former shapes.

The necessary four steps are shown in Fig. 43. These are cutting of stringers and formers, two bending operations, and assembly.

Fig. 43 A shows the first step. All stringers must be cut to proper size with their lengths slightly longer than necessary. All formers should be redrawn full size from the original plan, and traced on the sheet balsa, as shown. These are then cut out.

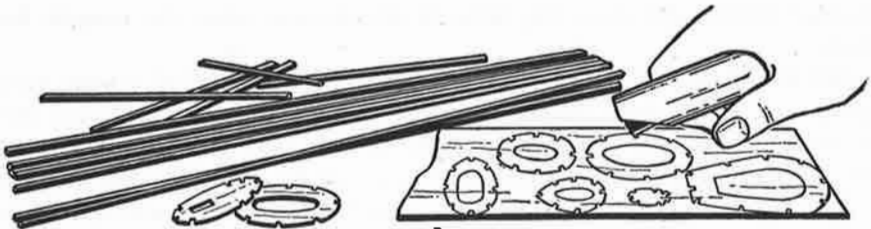
The next step is bending the stringers. On most curved fuselages, these will require two bends—the shape from side-to-side and the one from top to bottom. For this bending, full-size views of the top and side of the fuselage are drawn from the plans.

Draw a full-size plan of the side view of the fuselage, as in Fig. 43 B. The stringers are now bent. (See Chapter 3, "Balsa Wood" and "Bamboo.") Bend the stringers until each fits its particular line on the side-view plan. If balsa has been used for these, place the wet balsa in position on the plan and hold with pins until dry.

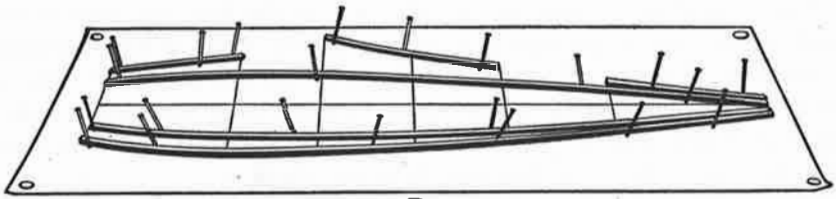
A full-size plan of the top view of the fuselage is drawn from the original plan, or laid out by the builder himself, and the various stringers again bent to conform to their side shapes, as in Fig. 43 C. Care must be taken when doing this, as the second preparation for bending the wood makes it pliable again and it might lose its original bend. Many builders, for this reason, make only one bend in their stringers, depending on force, carefully applied, to bring the stringers into position along the second curve.

When the stringers are bent and the formers cut, the fuselage is assembled.
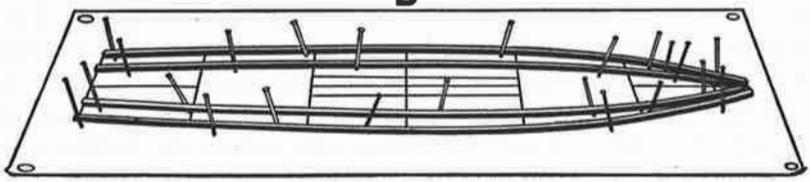
D shows the assembling of the fuselage. One stringer, preferably the bottom one, is cemented into each of the formers. If this stringer has been bent perfectly, the position of the formers will be exactly as desired when the other stringers are added. E shows the finished fuselage. The three top stringers are cut to form the front and rear cockpits. These should be



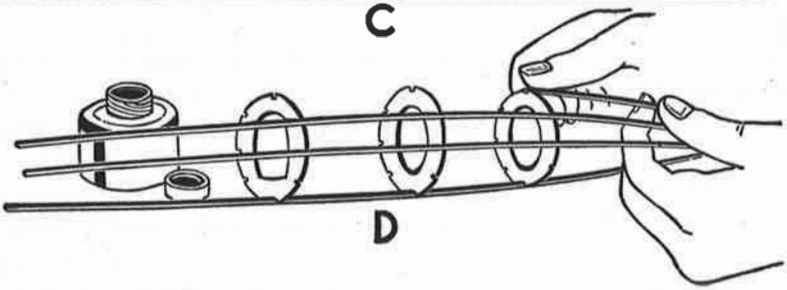
A



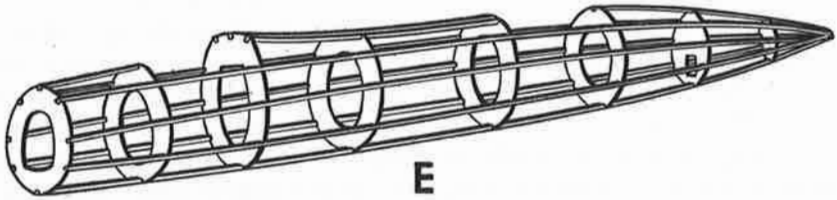
B



C



D



E

FUSELAGE CONSTRUCTION WITH FORMERS

FIGURE 43

attached whole, and then cut between the formers after the cement has dried.

SOLID FUSELAGE CONSTRUCTION. The carving of a solid fuselage is done in six steps, shown in Fig. 44. Some builders use pine for this, but balsa is recommended because of the ease with which it can be carved. The block of wood is first squared up. It should be as long as the fuselage, as wide as its widest part, and as thick as its height. If the cowling is to be carved from the same block, the length of the block must include it.

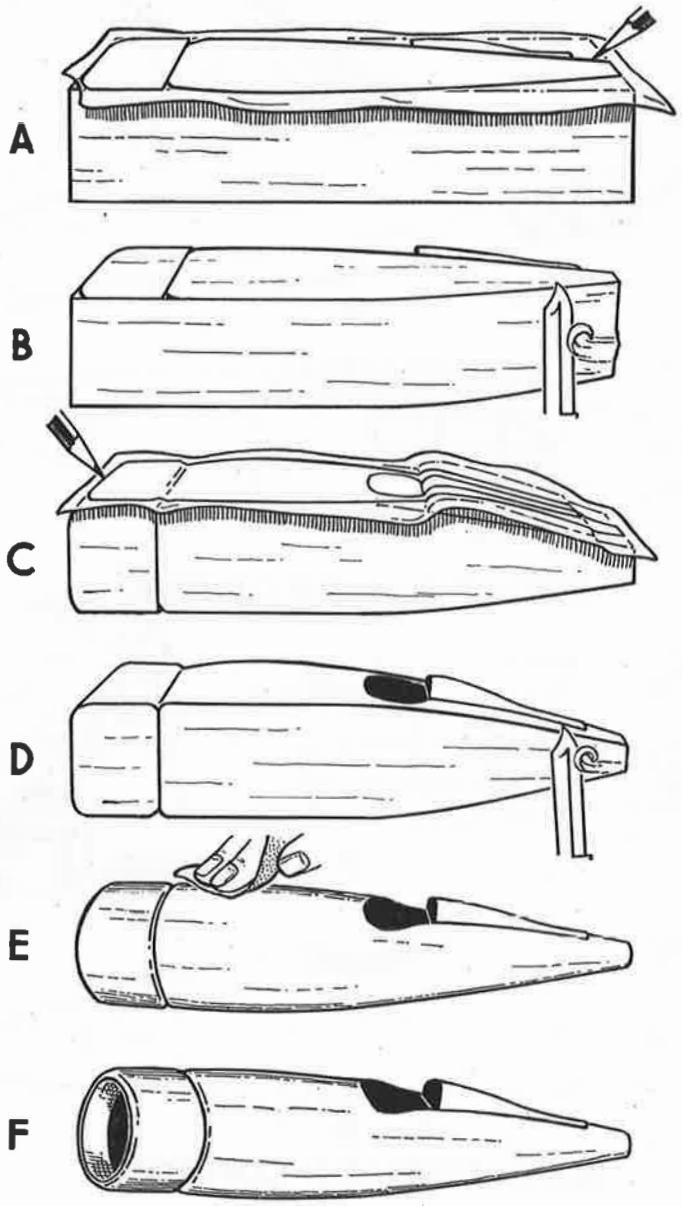
Make a full-size drawing of the side view of the fuselage. This is then traced on the side of the block, as shown in Fig. 44 A. When completed, the block is cut along this outline, as in B. A full-size drawing of the top view of the fuselage is made, and traced on the top of the block, as in C. The block is cut along this outline, as in D. The block has the general lines of the fuselage at this time, but not its proper shape.

This is obtained with sandpaper, as shown in E. Here the builder must follow cross-section views given in the plans, descriptions in the text, or photographs of a like model or the real ship. While the three-view plans given for solid scale models in this book do not carry cross-section views, the general shape of the fuselage is given in the text, and a photograph of the completed model is shown. From these two sources, the builder will experience little trouble in finishing the fuselage to its proper form.

When the fuselage has been carved and finished smooth, its cockpit should be cut out and equipped, as described in Chapter 15, "Cockpits." If an engine is to be added, the cowling requires hollowing out, as in F, to accommodate it. If this is not done, it is left solid and later painted with a black circle to represent the engine. (See Chapter 11, "Engines.")

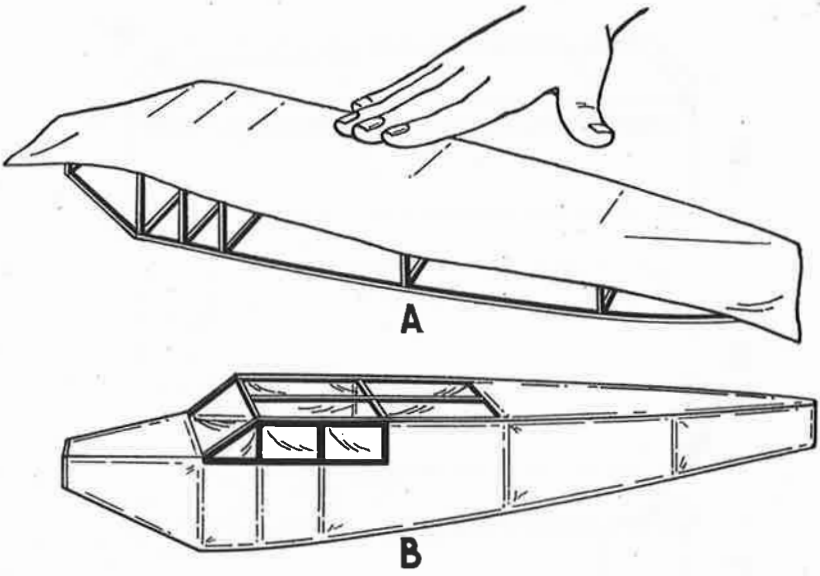
BUILT-UP FUSELAGE COVERING. The proper covering of a fuselage is a more difficult job than the covering of the average wing, as its curves, various bends, and open spaces for cockpits present a task requiring careful handling. The same covering used on the wing of a model should also be used on its fuselage. (See Chapter 3, "Covering Materials.")

For square, rectangular, or triangular fuselages, the covering is done as shown in Fig. 45, "Built-up Fuselage Covering." One side at a time is covered on such models, as in A. Coat the structure with clear dope or banana oil, and, cutting the covering to approximate size, press it in position on the side. If tissue is used, it should be ironed free of wrinkles before being applied. When dry, the overlapping material is trimmed away. Nail scissors are best for this work, as small curves can be easily cut with them. Each of the sides is covered in the same manner. When completed, the material should be water-sprayed. (See Chapter 7, "Wing Covering.") This will re-

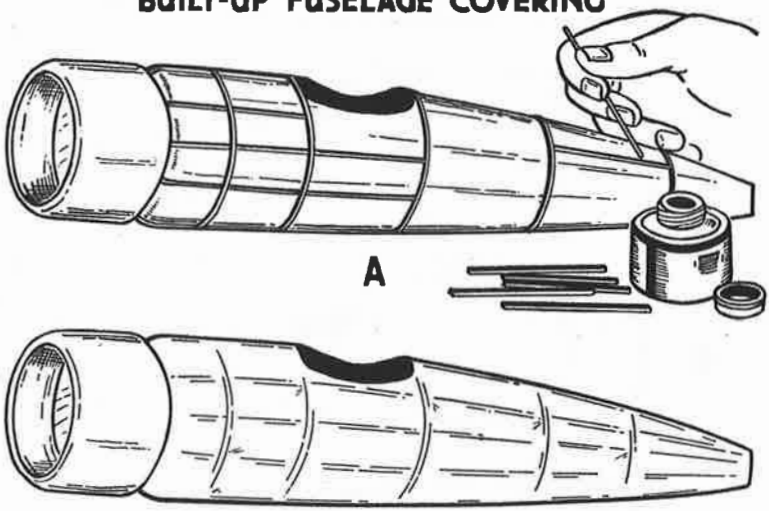


SOLID FUSELAGE CONSTRUCTION

FIGURE 44



BUILT-UP FUSELAGE COVERING



SOLID FUSELAGE COVERING

FUSELAGE COVERING

FIGURE 45

move any sagging, or wrinkles. For a drum-like tightness, the material must be doped. Give tissue a coat of clear dope, but if silk is the covering material, clear banana oil should be used.

The method of covering round, oval, or half-round fuselages is the same, except that the covering material should be cut into strips before being applied. These strips run the entire length of the fuselage and are wide enough to cover the space between three or four stringers. Each must be carefully trimmed before the next strip is applied. The fuselage is then finished in the same manner as the square one.

SOLID FUSELAGE COVERING. Solid scale models can be covered in such a manner as to look like built-up planes. The model is completed, but not assembled. Before this is done, $\frac{1}{64}$" or $\frac{1}{32}$" square balsa strips are cemented to the solid surface to represent formers, struts, and cross braces, as in Fig. 45, "Solid Fuselage Covering." Ordinary string is sometimes used to build up solid fuselages.

When all outline strips have been cemented in place on the fuselage, it is covered with a heavy-grade tissue or a very fine grade of silk. The process is the same as covering the built-up fuselage. The covering is water-sprayed and doped in the same manner as any covering. When this construction is used, the builder must remember that not only the fuselage must be outlined with the strips, but also the wing, elevator, and rudder, so that the entire model will look like a built-up job. The completed fuselage is shown in Fig. 45 B under "Solid Fuselage Covering."

CHAPTER 9

PROPELLERS

THE heart of a model airplane is its propeller. No matter how aerodynamically perfect in design, how light in weight, how skillful in construction, or how beautiful in workmanship a model may be, its propeller determines its success or failure when launched.

If a model is tested, without power, in respect to its gliding ability and maintains a long, smooth glide, it will fly well provided the correct propeller and motor are applied.

PROPELLER TYPES. Fig. 46 shows eight of the most popular types of propellers. The difference between these propellers is the form of their blades. The Langley propeller was made famous on the airplanes of Samuel Pierpont Langley. This shape of propeller is popular among model builders desiring endurance flight. Its corners are rounded to increase efficiency.

The Wright propeller is similar to the Langley, except that one corner has been cut off, while the Columbia is an adaptation of the Wright propeller with its corners rounded. The Standard propeller is an efficient copy of the Langley, widely used on models of today. It is the reverse of the Columbia propeller, with a slightly longer curvature along the blade. It makes an efficient speed propeller.

The Cecil Peoli propeller was the design used on early models made and flown by this New Yorker. In 1911, Cecil Peoli made his model fly over 1,600 feet, which was considered at that time a wonderful feat. His model became both famous and popular over night, and even today we find model builders making and flying this early bird.

The U. S. Navy type of propeller is basically a Columbia propeller, except that both its edges are rounded. The Carter propeller makes a good speed propeller, being slender in blade width, which allows the blades to cut through the air at a faster rate of speed than wide blades could do. The toothpick propeller, so named because of its narrow blades, is a development of model builders for use on speed planes. It is an adaptation of the Carter propeller, being narrower in the blades and having their projecting points along the edges opposite each other, while those of the Carter blades are slightly staggered. Builders should experiment with all these

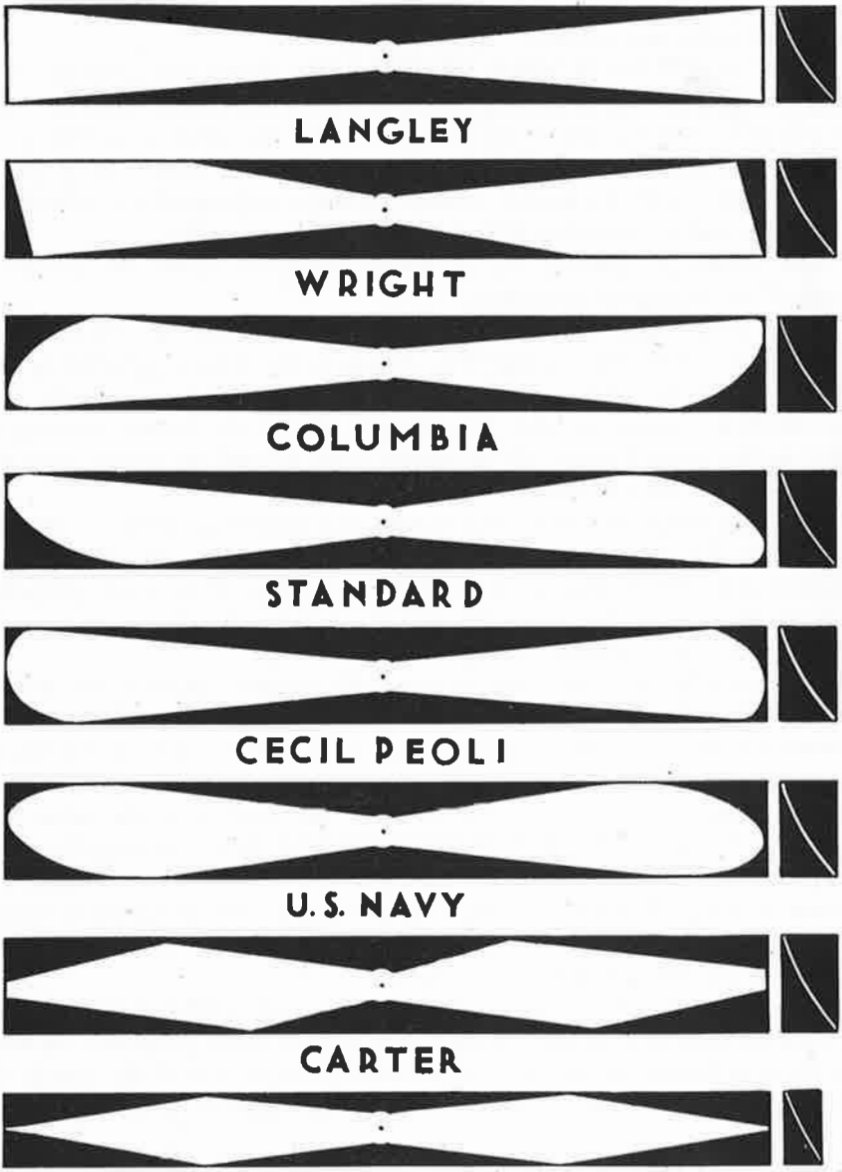

LANGLEY
WRIGHT
COLUMBIA
STANDARD
CECIL PEOLI
U.S. NAVY
CARTER
TOOTHPICK
PROPELLERS

FIGURE 46

forms of propellers and choose that which they consider best for their speed and endurance models.

TRACTOR AND PUSHER PROPELLERS. When the propeller is in front of the main wing of an airplane, it is known as a tractor propeller, and the plane is called a tractor airplane. Most of the modern airplanes are tractors, although the new Curtiss-Wright Junior, in Chapter 46, is an exception. This is called a pusher airplane, because its propeller is behind the main wing, and its propeller is known as a pusher propeller.

The tractor is "pulled" by its tractor propeller, while the pusher is "pushed" by its pusher propeller.

Many model builders have difficulty in recognizing the difference between tractor and pusher propellers. As far as the actual propeller is concerned, there is no difference whatever. Both are carved in exactly the same way. Both are mounted with the concave side of the blades trailing. In other words, when viewing the propeller from behind the model, you will always see the concave sides of the blades.

The only difference between a tractor and pusher propeller is that the hook of the propeller shaft extends out from the hub of the propeller on different sides. Study Fig. 47. This shows two views of the same propeller, and yet one is a pusher propeller and the other is a tractor, because the propeller shaft extends out on opposite sides.

The propeller shaft of a *tractor* propeller extends out from the hub on the *concave* side of the blades. The propeller shaft of a *pusher* propeller extends out from the hub on the opposite, or *convex,* side of the blades. A tractor propeller can be changed into a pusher propeller by simply changing the propeller shaft so that the hook of the shaft is on the other side.

RIGHT AND LEFT HAND PROPELLERS. When a propeller turns clockwise, when viewed from the rear or concave side of the blades, it is known as a right hand propeller. This means that the propeller is wound in the opposite way, and that when released it turns in the same direction as that in which the hands of a clock turn.

When the propellor turns counter-clockwise, when viewed from the rear or concave side of its blades, it is known as a left hand propeller. In other words, it is wound in the same direction as that in which the hands of a clock travel, but when released, it travels in the opposite direction to those of a clock.

When only one propeller is used on a model, it is the custom to make it a right hand propeller, but when two propellers are used, one must be a right and the other a left hand propeller. All illustrations in this chapter show right hand propellers, except where two propellers are illustrated.

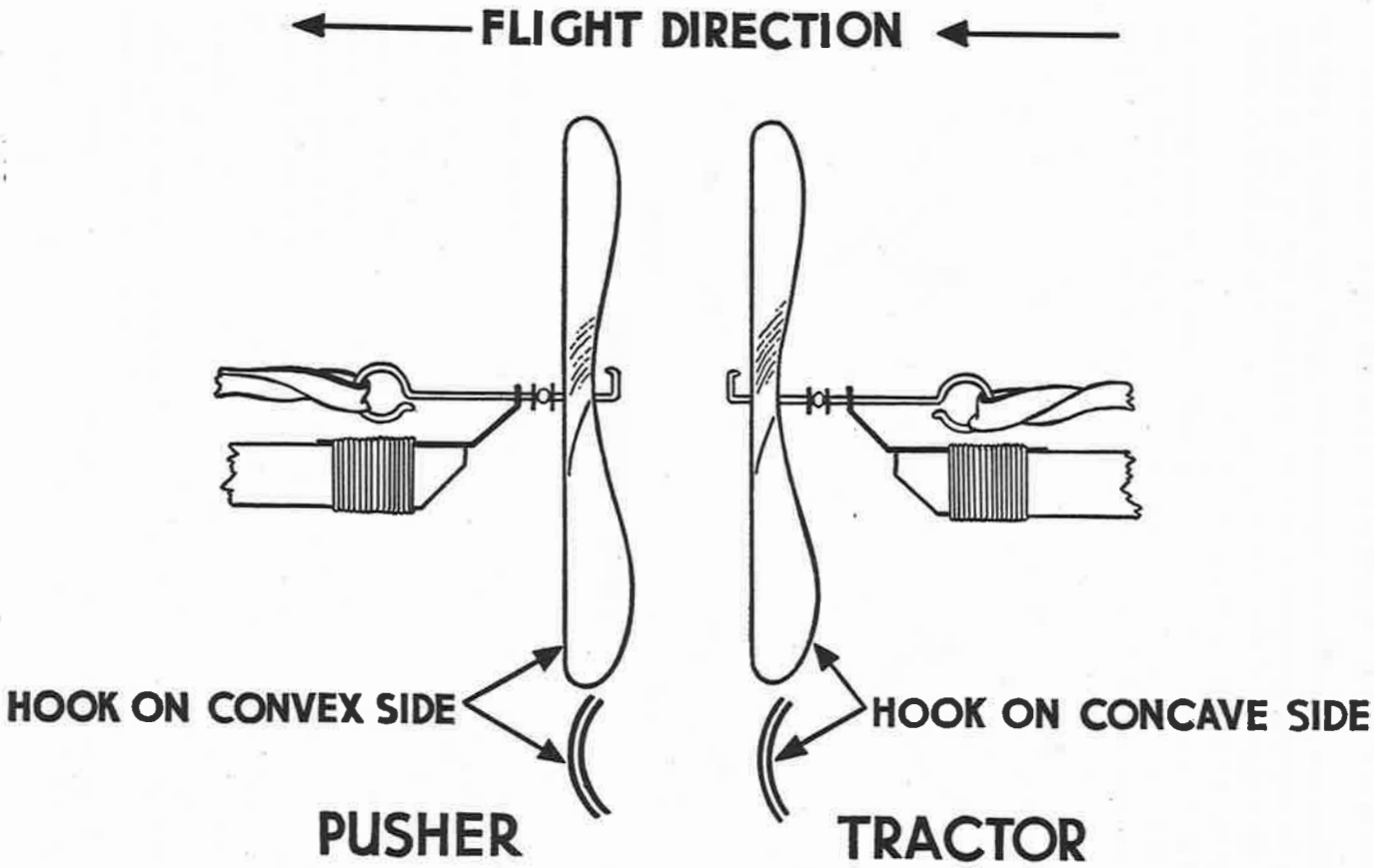
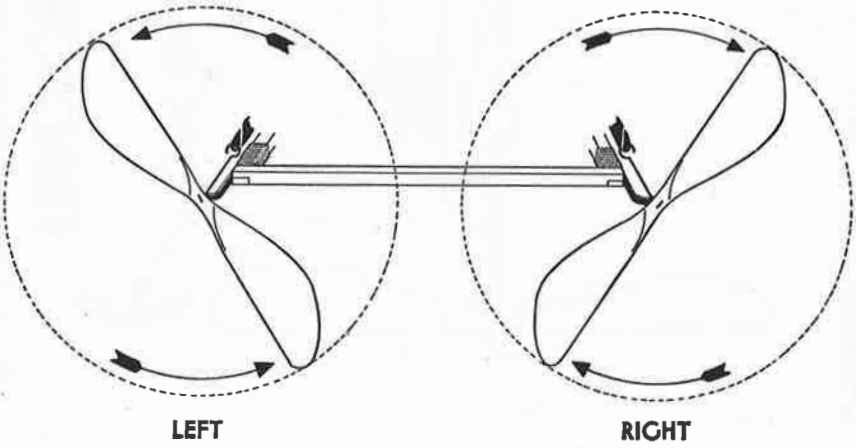


FIGURE 47. PROPELLER ASSEMBLY FOR TRACTOR AND PUSHER MODELS

When two propellers are required on a model, they must be made to turn in opposite directions so that the directional pull of one propeller will offset that of the other. For this reason, twin propeller units are always made up of one right and one left propeller.

The most common use for twin propeller units is on twin pushers, so called because of their two propellers. These should be mounted on the A-frame so that both turn up and out, as shown by the arrows in Fig. 48.



TWIN PROPELLERS

FIGURE 48

This shows the view of the model from the rear, so the eye rests on the concave side of the propeller's blades.

The carving of a left hand propeller is opposite to that of a right hand propeller. Fig. 49, No. 3, shows the start of carving a right hand propeller. The cut is made along the right top edge at the front. If a left hand propeller was being carved, this cut would start along the left top edge at the front, which would make the blade slant from the rear top edge to the front bottom edge. On the right hand propeller, this slant would be from the front top edge to the rear bottom edge. On the right side, the cut of the blade would slant from the front top edge to the rear bottom edge, or exactly opposite to that of the right hand propeller, as in Fig. 49, No. 3.

The method employed to carve a left hand propeller is the same as the right hand propeller, and the steps in Figs. 49 and 50 can safely be followed once the opposite slants of the blade cuts have been correctly started.

PROPELLER SIZES. Before it is possible to decide the size of a pro-

peller, the builder must know whether his model is a speed or endurance flyer. With this in mind, the builder should glide his model, observe its speed and general behavior, and through these observations decide its type. If the model is fast in gliding, a speed propeller should be applied; while if slow, an endurance propeller is indicated.

After determining the type of propeller required, the builder must choose its correct size. This is largely a matter of trial and error. All plans for model building carry with them propeller specifications. The builder will do well to follow these dimensions, for it is assumed that they have been thoroughly tested by the designer and found best for the model in question. With this in mind, the builder should study the propeller sizes used on the various models contained in this book, as these have been carefully tested on the models to which they are attached.

Indoor endurance models are usually equipped with propellers about half the length of the wing span, while outdoor models have propellers about a third of the wing length.

However, this rule is not a fast one by any means, and a check of the propeller lengths with relation to wing lengths will prove many discrepancies. When fitting a propeller on a model with a wing span not comparable to a known success, the approximate length should be chosen, the propeller carved, and then tested on the model by actual timing of its flights. Other tests should follow with other sizes and lengths until the one best suited to the model being fitted has been found.

The extra propellers can be kept for future use on other models. In time the builder will be able to determine the correct size of propellers without much actual testing.

All model supply houses carry propeller blocks such as in Fig. 49, No. 1. They also sell propeller "blanks," which are cut to the general shape shown in Fig. 49, No. 2. Purchasing such blanks eliminates steps 1 and 2 of Fig. 49. However, the laying out and cutting the block into a propeller blank is a simple task.

Propeller blocks and blanks can be had from 5″ to 15″ long, or other lengths can be cut by the builder himself from balsa planks. All model airplane catalogues will list the various sizes obtainable.

PROPELLER WOODS. Before weight was discovered to be of such importance, propellers were carved of pine, or other woods, but today practically all model propellers are of balsa wood. While some still use other woods on exhibition models, they are not recommended, as balsa is far easier to work.

A hard, straight-grained, kiln-dried, and good grade of balsa wood should

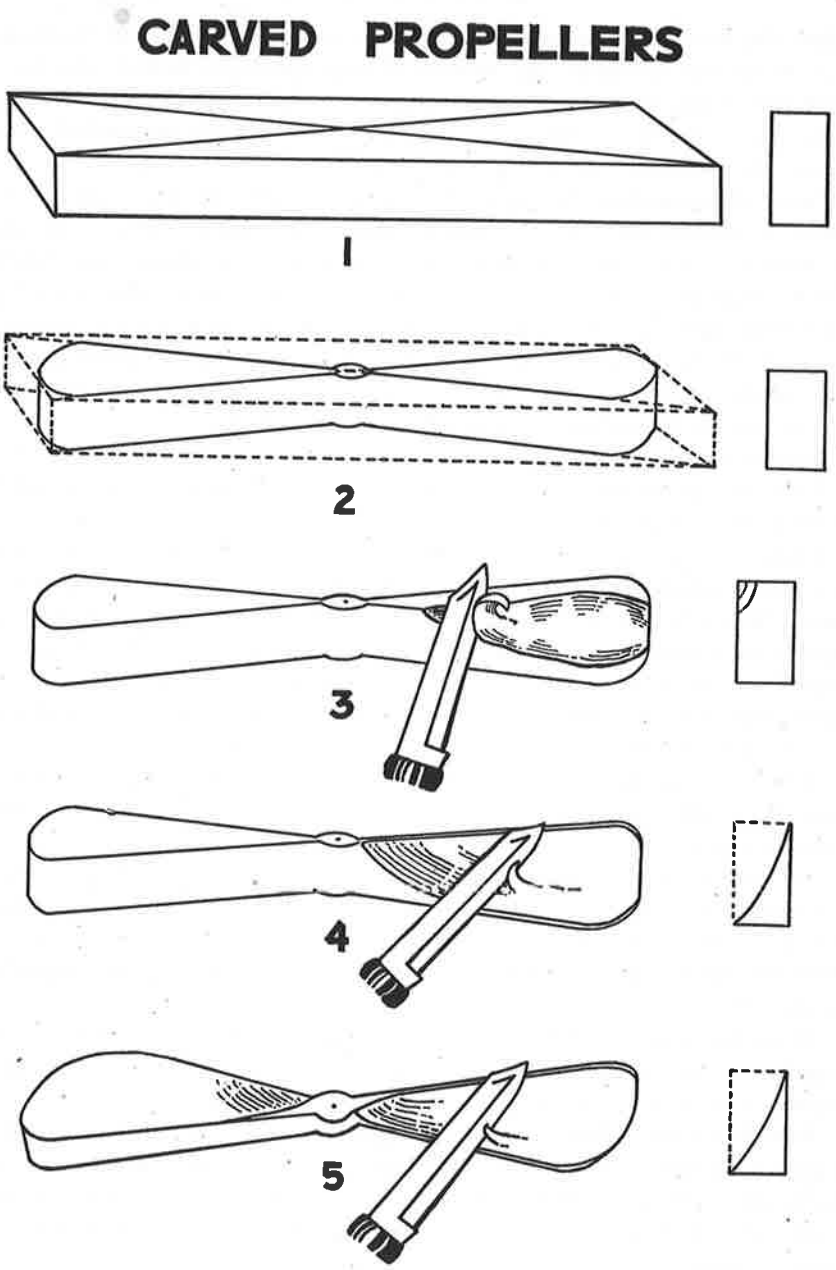


FIGURE 49

be chosen for propellers. The purchaser must remember that all balsa wood is not fit for model building. Some of it is bias-grained, pithy, and generally unfit for model work of any kind, and the propeller requires even better balsa wood than other parts.

CARVED PROPELLERS. After the proper size of propeller block has been obtained, diagonal lines are drawn across its face from corner to corner, as in Fig. 49, No. 1. The shape of whatever type propeller has been chosen is now drawn with the diagonal lines acting as edge guides. The blank is cut out with a coping saw or knife, as in No. 2.

Step 3 shows the first cutting operation. The blade attacks the right top edge at the front with a scooping motion to give the cuts a concave form. Step 4 shows this same operation being finished, as the knife removes the wood in a concave form which slants from the rear top edge to the front bottom edge.

Step 5 shows the blank turned around, and the knife making a duplicate concave cut on the other side, or the original left side of the blank. All cuts are made from the hub toward the ends of the wood, to eliminate false cuts or possible splitting. The hub is left its original thickness, while the carving is being done.

At this point both concave cuts have been made, and when the blank is viewed from on top of the hub, both these cut sides must appear on the same side, while the untouched sides will not be seen, or will appear on the opposite side.

The blank is now turned over and the convex sides are cut. The first cut is shown in Fig. 50, No. 6. These must run parallel to the concave cuts on the other side, and should be continued until the blades of the propeller are about 1/8" thick, gradually increasing toward the hub.

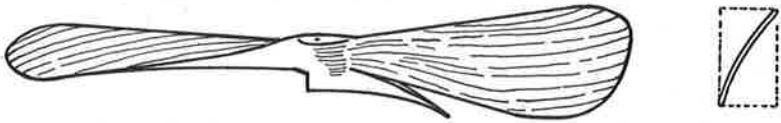
Following the carving of the blades, the hub of the propeller should be cut away, as this is the most inefficient part of the propeller. Experts cut the hubs of their propellers down to 1/8" thickness, but the beginner should leave his hubs at least 1/4" thick. As the thickness of the hub decreases, the possibility of breakage increases.

Step 7 shows the cutting down of the hub. On ordinary propellers this should be done at this time, but on extremely light endurance propellers, it should be deferred until after the blades have been sandpapered. Some complete their propellers, cement the shaft in place, and then cut down the hub by removing the excess thickness around the projecting shaft.

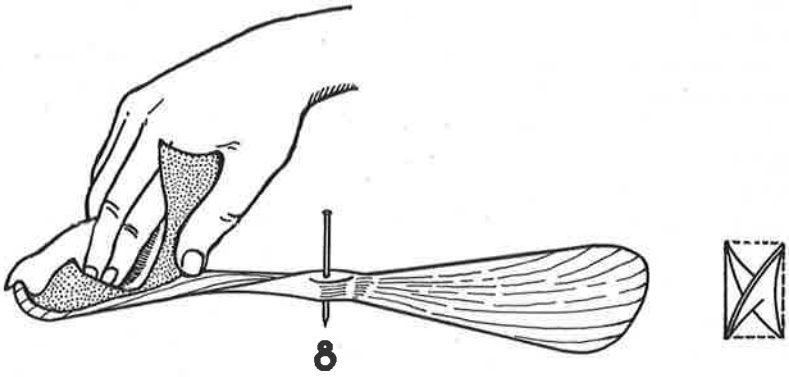
As the shaft of a tractor propeller extends out from the concave side of the blades, it therefore follows that the excess hub material is removed from that side.



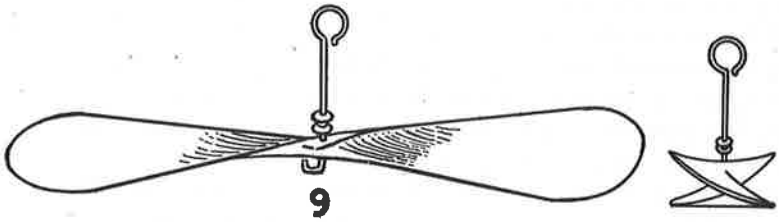
6



7



8



9

FIGURE 50. CARVED PROPELLERS, 2

Step 8 shows the sandpapering of the blades. This is an important step. On a speed propeller, the blades may be $\frac{1}{32}$" to $\frac{1}{16}$" thick, but for endurance models, they should be sandpapered so thin that light will show through them.

The propeller is now tested for proper balance. To insure even rotation of a propeller, the blades must be exactly the same weight. As it is obviously impossible to weigh each blade, the balance method is used.

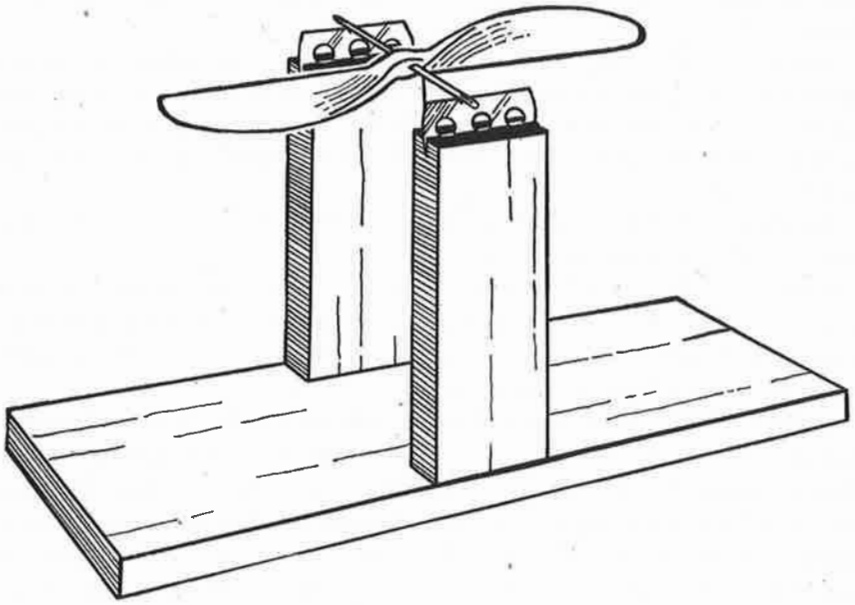


FIGURE 51. PROPELLER BALANCE BLOCK

BALANCE BLOCK. A simple balancing apparatus is shown in Fig. 51. It consists of a base board from which extend two arms. These are 2" wide and should be at least 6" high, so that a 12" long propeller, when mounted on them, will be able to rotate without striking the base board. Two safety razor blades are sunk into the ends of these arms, and in the exposed edges of the blades notches are filed.

The propeller shaft is now thrust through the center of the hub, removed, and a needle, slightly smaller in diameter than the shaft, inserted through the hole. The ends of the needle protruding from the hub are placed in the notches cut in the blades.

The propeller should now rotate easily on the needle when blown on. If the two blades are of the same weight, the propeller will stay at what-

ever angle it is stopped in. If not, the heavier of the two will drop down. If this is the case, the propeller must be removed, and the heavier of the blades sandpapered. It is then retested, and the process continued until perfect balance results.

The propeller shaft is now attached to the propeller. Insert the shaft through its hole in the hub. If the propeller is to be a tractor, fit the shaft so that it extends out from the concave side of the blades. If a pusher propeller is desired, the shaft must extend out from the convex side of the blades.

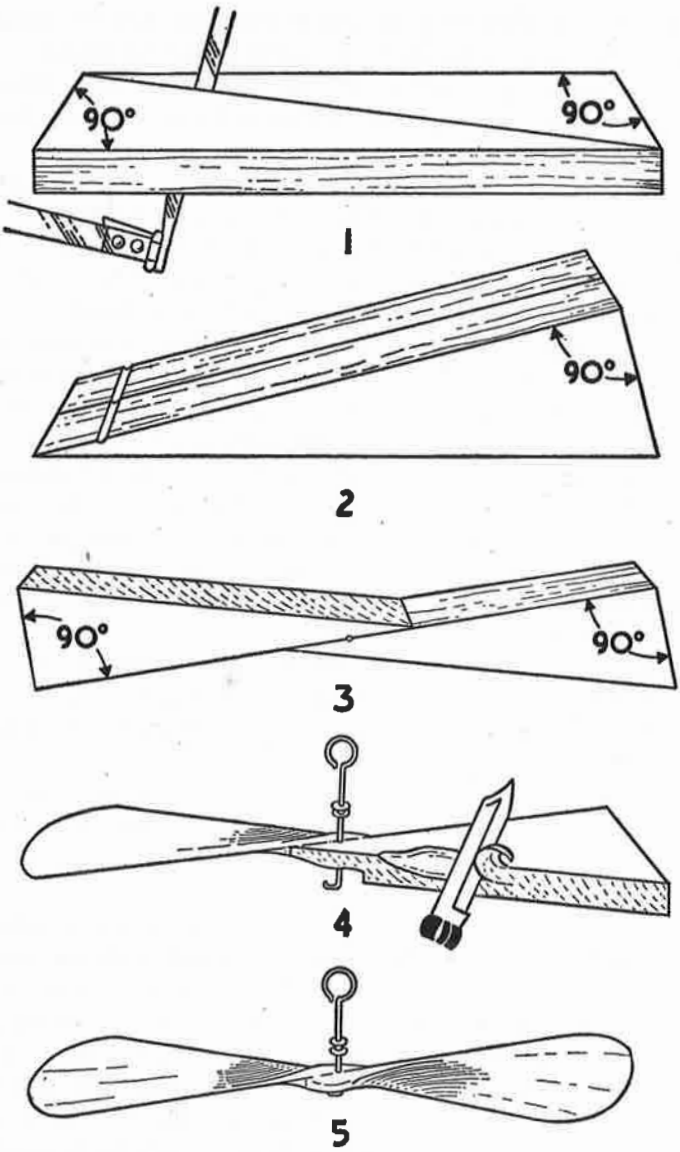
The end of the shaft is then bent around, so that when the shaft is pulled back, the point of the wire will bury itself in the wood of the hub. A drop of cement will hold it in place. Many cement a large washer against the hub, after threading it on the shaft. Two smaller washers are then assembled on the shaft.

Another method is to apply one washer, followed by a steel bead or dress spangle, and then a second washer.

If the propeller is for a light endurance model, it can be left in its natural state, but for scale, commercial, speed, and heavier models, it can be reënforced with a few coats of banana oil. After each coat, the propeller should be given a light sandpapering.

CARVED TRIANGULAR-BLOCK PROPELLER. For this type of carving, a block only about half as long as the desired length of the propeller is required. This has two advantages over the type just described. Balsa wood seldom maintains the same hardness and weight over any great length, with the result that propellers 10″ or 12″ long seldom have the same degree of hardness and weight in both blades. On this type of propeller, however, the cutting of the block into two triangles guarantees that the traits of one part will be those of the other. The second advantage is that costs are cut in half. Instead of purchasing a 12″ block for a 12″ propeller, the builder buys one only 6½″ to 7″ long, depending on the amount he wishes to use for the overlap joint.

Fig. 52 shows the various steps for carving a triangular-block propeller. Step No. 1 shows the block with one diagonal line drawn from corner to corner. Before deciding the length of block required, the exact amount of overlap at the hub must be determined. Some use only ¼″ for this center joint, but a ½″ lap is safer. For example, let us say that we must carve a 10″ long propeller, and that we have decided to overlap our triangular blocks ½″. We will then require a block half as long as the propeller's finished length plus ½″ for each half, or an extra 1″. In the case of this example,



CARVED TRIANGULAR-BLOCK PROPELLER

FIGURE 52

we must purchase a block 6″ long, which represents half the length of our finished propeller, or 5″, plus the 1″ for overlapping the blocks.

The block should be tested to see that each corner is a right angle as in Step 1. When this has been done, a diagonal line is drawn from corner to corner, and the block sawed through on this line.

The two triangular blocks are shown in Step 2. These are placed side by side with their sawed portions facing down. The small groove running across both of them is located half the length of the desired overlap from the ends. In other words, if our overlap is to be ½″, as in the above example, it would be ¼″ from the pointed ends of the blocks.

This groove represents the propeller shaft hole. The best method of making it is to heat a length of piano wire red hot and place it in position on the blocks. The wire must be the same diameter as that used for the shaft, but must not be the same wire. After the groove has been made half as deep as the diameter of the wire, the blocks are ready for joining.

Apply cement to the portions being joined, line up the two grooves together, and press the blocks tightly together until the cement dries as in 3. The same wire used for the grooves should be inserted in the shaft hole, worked through the cement, and moved around while it is drying. This prevents the cement from closing the hole.

The block is now a perfect propeller blank, and the carving is started, as in Step 4. All further work is a duplicate of that described for the ordinary carved block, which is given under "Carved Propellers." The finished propeller is shown in 5.

BENT WOOD PROPELLERS. Another method is the bending of propellers from sheet balsa wood. These are good for ordinary flying models, but not for contest work, as they have not the strength or accuracy of the carved propeller.

These can be made of a veener, but sheet balsa makes splendid bent wood propellers, weighs less, and can be worked with far greater ease. Obtain a piece of 1/64″ or 1/32″ sheet balsa. This is cut as wide as you wish your blades to be when finished, and as long as the overall length of the propeller. Square up the piece and draw two diagonal lines on one face from corner to corner, as in Fig. 53, No. 1. As considerable width must be left for the hub, a ¼″ wide section is left in the center for this, as in Fig. 53, No. 2. This form is now cut out, and the sheet is ready for bending.

BENDING AND DRYING PRESS. To bend such a propeller, a press is made, as shown in Fig. 54. Some merely soak their balsa, twist its blades, and hold them over a flame until dry, but hand twisting is seldom uniform, and holding the blades while drying is difficult.

Such a press as shown is not difficult to make, can be used for any size propeller, and gives perfectly uniform blades. Any available wood can be used. It should be made large enough to take at least a 12″ long propeller, and high enough to allow the flame of the alcohol lamp to be at least 6″ from the propeller when in place in the press.

Cut the base 1″ x 3″ x 14″, and the sides ½″ x 3″ x 12″. Directly in the center and 2″ from one end, bore one 1″ diameter hole through each of the

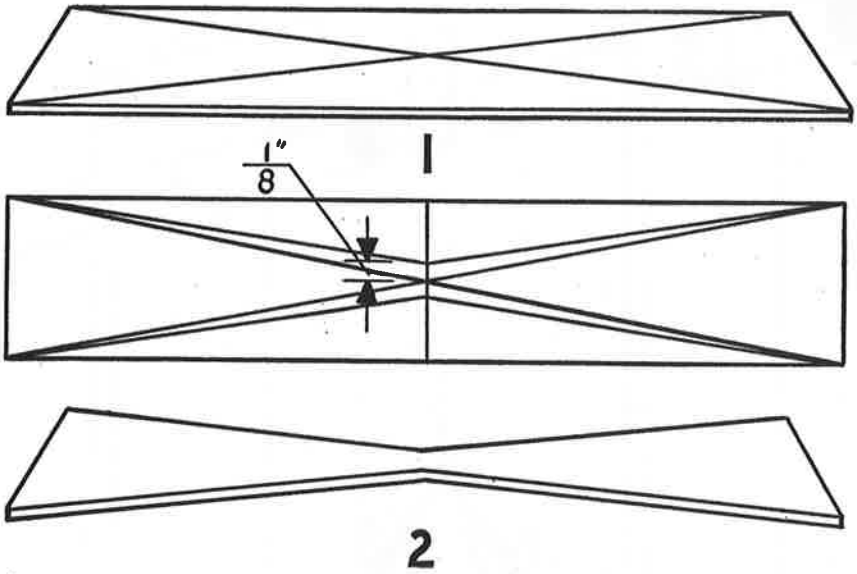


FIGURE 53. CUTTING BENT WOOD PROPELLER BLANK

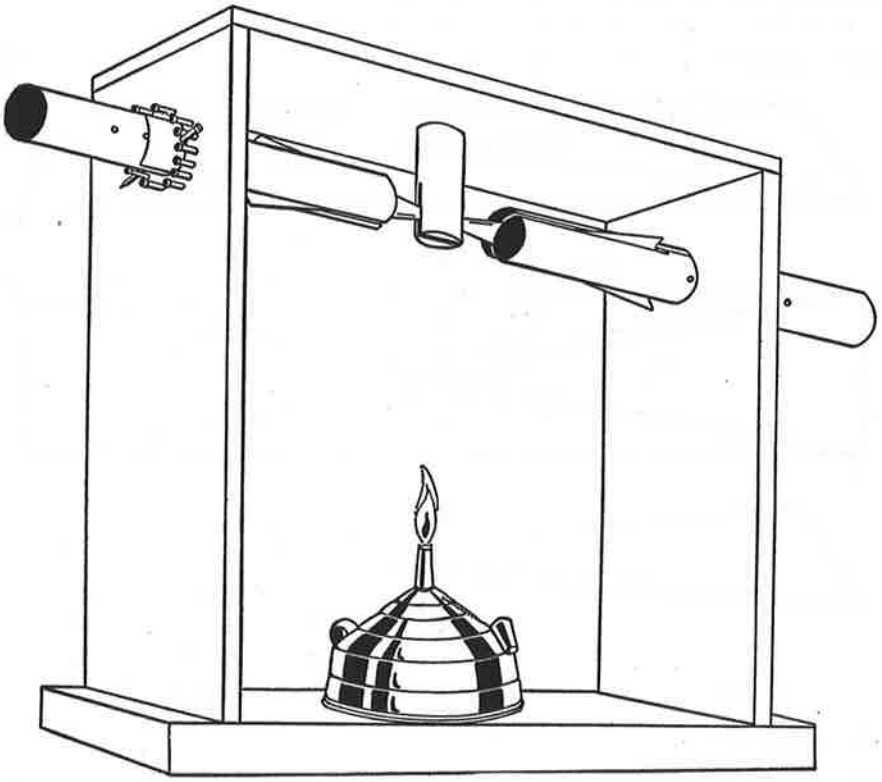
side pieces. Drive two-penny (1″) brads in a circle around each of these holes, as shown, but do not allow them to protrude through the wood. When doing this, make sure that the nails are on the outer side of these side pieces, which are now nailed to the base board ½″ in from its ends.

In one end of a 2½″ length of broomhandle, a saw slot is cut about 1″ deep. This is now centered on a ½″ x 3″ x 13″ top board, and nailed firmly in place. The top board is nailed across the ends of the side boards. The two grips are made so that the blades are not only twisted, but also given the necessary curves to produce concave and convex sides, when in them.

Study Fig. 55. The top is a 1″ diameter piece of stock as in Fig. 55, No. 1. This is cut 5″ long. The dotted lines shown in 2 represent the saw cuts. The straight portion of the cut is made ⅛″ off center and 4″ long. Another cut is made from the other end of the length through the dead

center of the stock and parallel with the first. The third cut joins the first and second, as shown in 3.

To complete the piece, the long cut edge is rounded to a convex form, as in 4 "Top." The bottom piece is the same diameter, but 7″ long. It is sawed



BENDING AND DRYING PRESS

FIGURE 54

through the center 5″ deep, while another cut severs the piece, as in Fig. 55, No. 2 "Bottom." The piece is now given a concave form for a distance of 4″ along its length, as in 3. Tests are now made to see that the convex portion of the top piece fits the concave portion of the bottom. These are completed and smoothed with sandpaper, so that when nailed together the slot between them is about $\frac{1}{32}$″, as in 5. A second grip is now made in the same manner. Place both grips through the holes in the sides of the press and

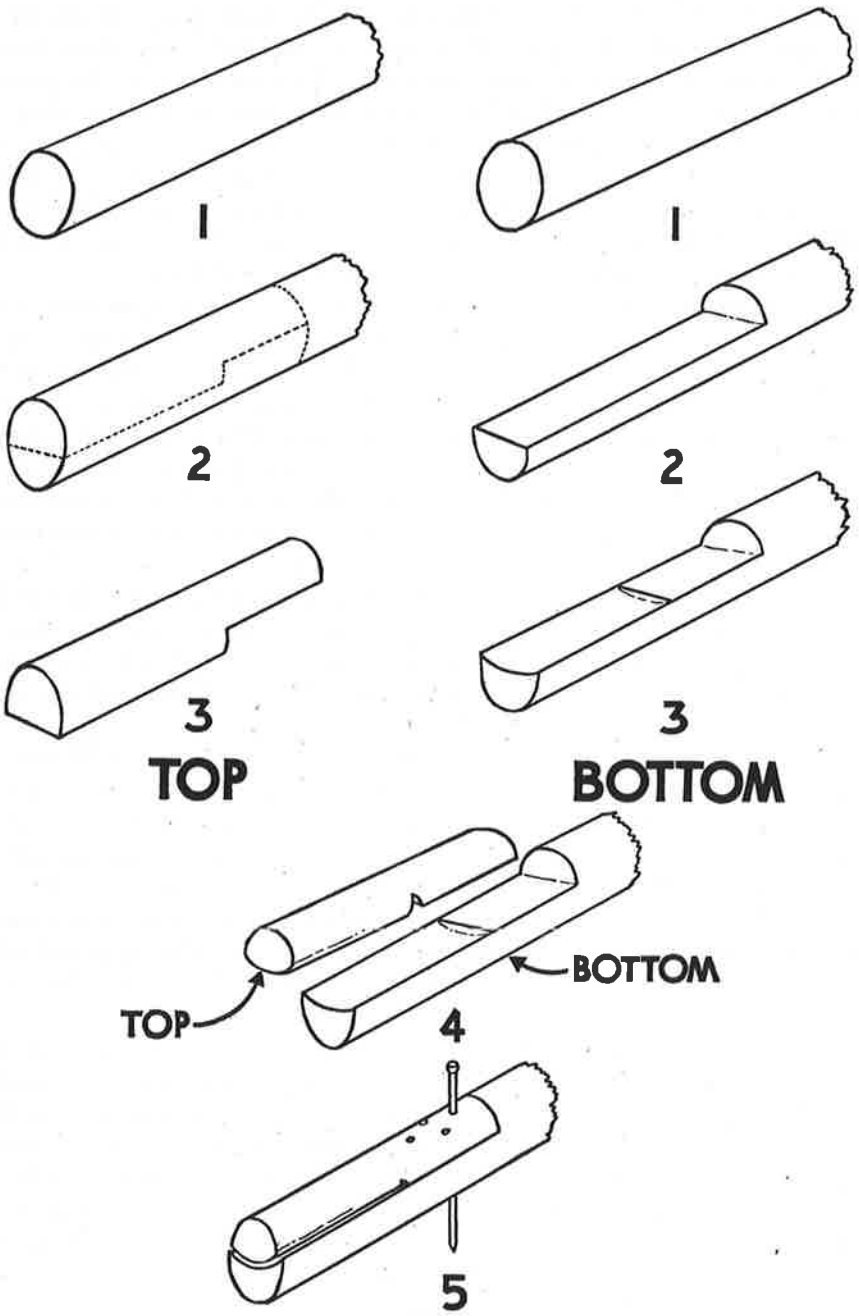


FIGURE 55. STEPS FOR MAKING, BENDING, AND DRYING PRESS GRIPS

work them back and forth until they turn in the holes easily. If the fit is too tight, sandpaper the grips. Place them in the holes with their inner ends 1″ from the center broomhandle piece. Mark on the grips the points of intersection between them and the outer side of the side boards when in this position. Remove the grips and drive a seven-penny (2¼″) brad through the center of each grip at these points. Make two or three more holes at ½″ intervals back of the first one through the centers of the grips with the brads. Remove all brads, and test six-penny (2″) brads in the holes to see that they slip in and out easily. This completes the press.

The sheet balsa blank shown in Fig. 53, No. 2, is thoroughly soaked in hot water, and then placed in the press. To do this, place the hub portion of the blank in the center grip. Thrust one side grip through its hole, slightly curve the blade of the blank with the fingers, and fit it into the slot of the grip, which is worked toward its hub. The second side grip is assembled on the second blade in the same manner. The first blade is then twisted as desired and the nail thrust through the hole between the nails in the side, which hold the grip and its blade in position. The second blade is then twisted and held in the same manner.

The propeller can be dried naturally, or an alcohol lamp may be placed on the base of the press, as in Fig. 54, so that its heat will create forced drying. The lamp should be moved from time to time to obtain even drying. When dry, the nails are removed, the grips pulled out, and the propeller released.

When the bending is completed, the form of the blades is drawn or traced on the balsa, as in Fig. 56, No. 4. The tips are now cut and the blades lightly sandpapered, as in 5. Test the propeller for balance. (See "Carved Propellers—Balance Block.") The usual propeller shaft of piano wire is inserted through the hub of the propeller and bent around. The point of the wire is not allowed to enter the wood at the hub, as in carved propellers, for this might split the wood. The last bend overlaps the hub and cement is applied, which will hold it firmly in place. The finished propeller is shown in 6.

LAMINATED PROPELLER. As far as flying models are concerned, the laminated propeller is seldom used. It has no advantages and is a complicated way to make a propeller blank. However, as an exhibition propeller on War models such as the S.E.5 and the Fokker, which are in this book, it cannot be surpassed. These planes had the old wood propellers of laminated construction, and, if great accuracy of detail is desired, models of these planes should be equipped with laminated propellers, which should be stained and then rubbed with pumice and oil.

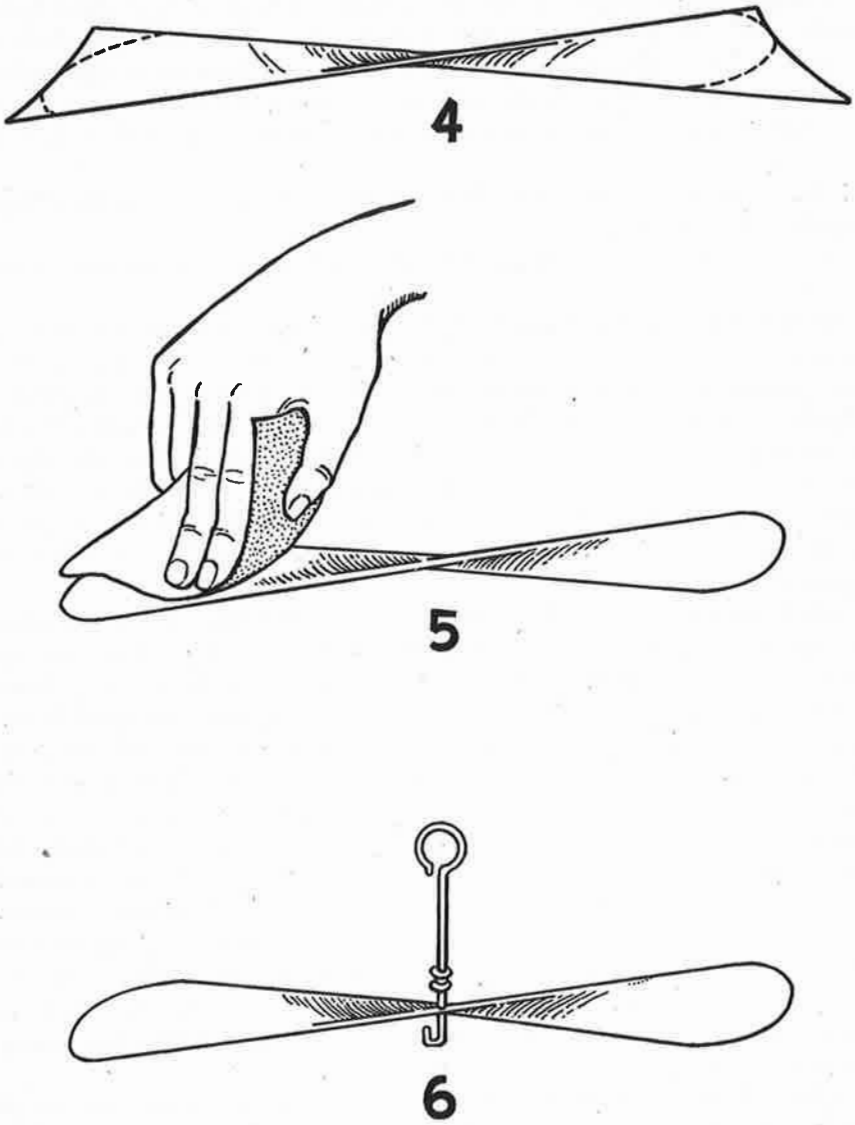


FIGURE 56. STEPS FOR COMPLETING BENT WOOD PROPELLER

A laminated propeller consists of a number of 1/64" or 1/32" sheet balsa lengths. They are assembled on top of each other and a long pin, such as an old hat pin, is forced through their exact center. Cement is applied between each face of these sheets, and as each is pressed to the under one, it is slightly pivoted on the pin, until the assembly is formed as in Fig. 57, No. 1.

This is allowed to dry. It is then carved the same as a regular carved propeller. This is shown in 2.

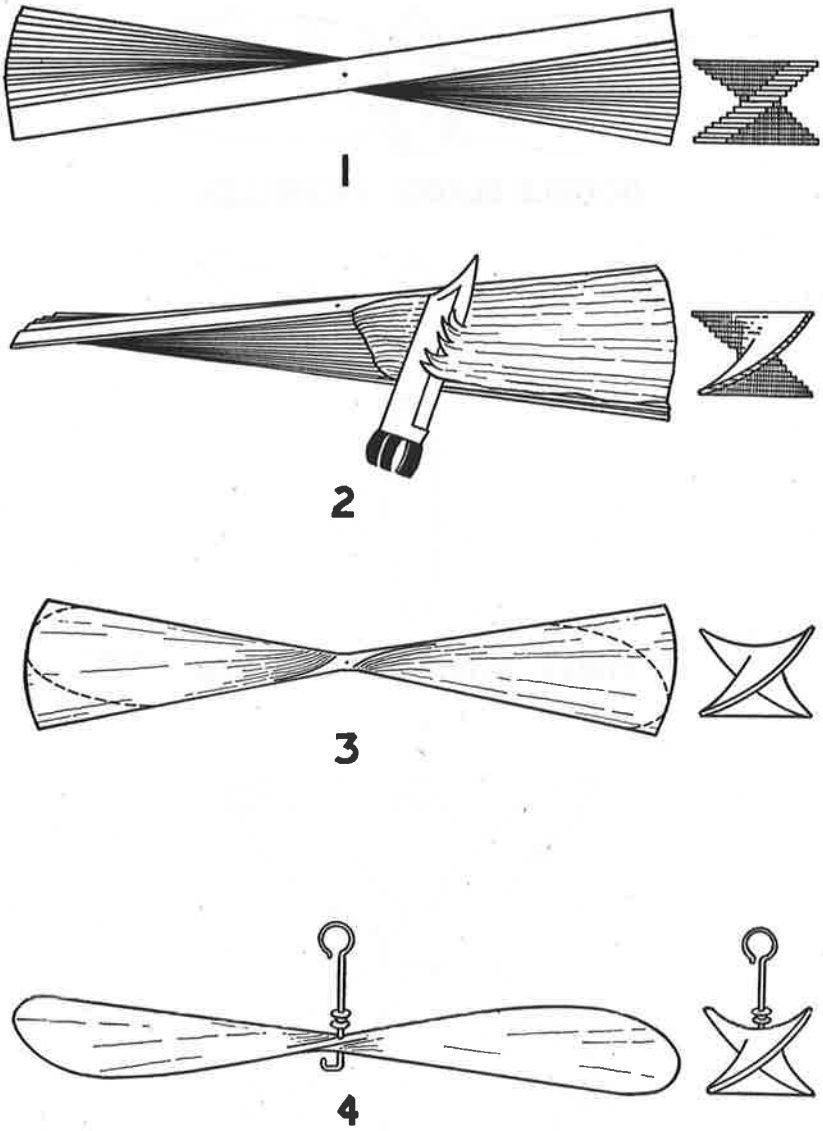
The propeller shaft is attached in the same manner as on any carved propeller.

BUILT-UP FLYING PROPELLER. Many flying scale models of modern design require this type of propeller, as they represent metal propellers with spinners. Fig. 58 shows three types of these propellers. The two-bladed propeller will be required on such flying models as the Autogiro PA-19, the Stearman Mailplane, and the Curtiss-Wright Sedan, while the three-bladed propeller is necessary for the Curtiss Shrike YA-8 Attack, all of which are in this book. While no four-bladed propellers will be required for the models in this book, such models as the Ford 8-A and others do require them.

These propellers are made of two, three, or four blades and a hub called the "spinner." All parts are of balsa. The blades are cut to shape and size from 1/32" or 1/16" sheet balsa. The most usual shape for these is shown in Fig. 58 under "Double Bladed Propeller." The spinner is carved from a square or round piece of balsa into the form of a cone. Slots are cut in the side of the spinner at an angle sufficient to produce the proper slant to the blades, as in the top views of Fig. 58. The blades are sandpapered smooth with a slight curve to produce a concave and convex side, and their ends tapered to fit deep into the spinner slots, where they are firmly cemented.

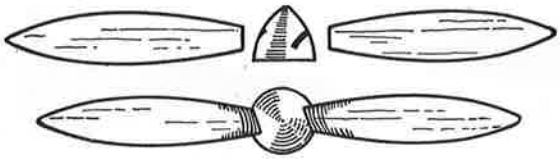
The propeller is then balanced. (See "Carved Propellers, Balance Block.") Care must be taken to see that each blade is directly opposite the other on two-bladed propellers, while three- and four-bladed propellers must have their slots so located in the spinner as to make the blades an equal distance apart when assembled. They are finished in the same manner as carved propellers.

TRUE-PITCH PROPELLER. Any discussion or instructions on the making of true-pitch propellers should rightly be placed after "Propeller Sizes" in this chapter, but it has been purposely placed after the various methods of cutting propellers, because few builders make true-pitch propellers. Others, novices in model airplane construction, might consider that every propeller must be a true-pitch one, which is not the case. It is true that

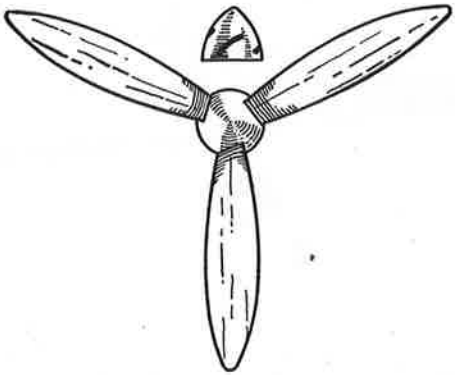


LAMINATED PROPELLER

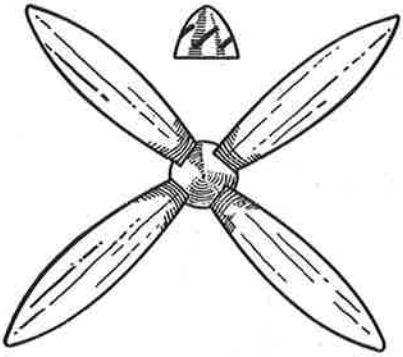
FIGURE 57



DOUBLE BLADED PROPELLER



THREE BLADED PROPELLER



FOUR BLADED PROPELLER

BUILT-UP FLYING PROPELLERS

FIGURE 58

if you wish a maximum of efficiency, your propellers should be true-pitch, but the beginner should not attempt designing these for his first models.

Even some experts are in the habit of thinking that the designing and cutting of true-pitch propellers is a most difficult task. This is due to a mistaken belief that no one but an aeronautical engineer can understand propeller mathematics. The author hopes the following information will abolish this belief, and that all builders of model aircraft will sooner or later make and use true-pitch propellers.

It must be understood that all the various methods so far described for carving propellers can be used for true-pitch propellers, and that the method used for carving or making the propeller is in no way affected by the fact that it is, or is not, to be a true-pitch propeller.

Three main factors must be considered in the shaping of such propellers:

(1) The theoretical pitch of the propeller.
(2) The desired width of the blade of the propeller.
(3) The necessary size of the propeller block.

The theoretical pitch of a propeller is the distance it would travel forward in one revolution if operating like a screw in solid material. We know that a certain amount of slippage prevents any propeller from boring through air as it would through a solid, so when we speak of the "theoretical pitch" we must speak in terms of theory. We likewise know that the slant of the propeller's blades forces the propeller through the air as the slant of the threads of a screw forces it through wood.

The theoretical pitch of a propeller is found by the following formula:

$$\text{Theoretical Pitch} = \frac{D \times \pi \times T}{W}$$

where D = the length of the propeller block, π = the constant 3.1416, T = the thickness of the propeller block, and W = the width of the propeller block.

For example, if a block measures 1" x 1½" x 11", the formula would read:

$$\frac{11 \times 3.1416 \times 1}{1\frac{1}{2}} = \frac{34.5576}{1\frac{1}{2}} = 23.03''$$, theoretical pitch.

On a sheet of paper – graph or cross section paper will be found best – draw a horizontal line which is as long as the circumference of the circle made by the tip of the propeller in one revolution, as in Fig. 59. In other words, it represents the length or diameter of the propeller multiplied by the constant 3.1416.

From the hub point and perpendicular to the circumference line, draw

another line, which must be as long as the theoretical pitch of the propeller being designed. These measurements must be exact, but can be drawn to scale if desired. Divide the circumference line into four equal parts and

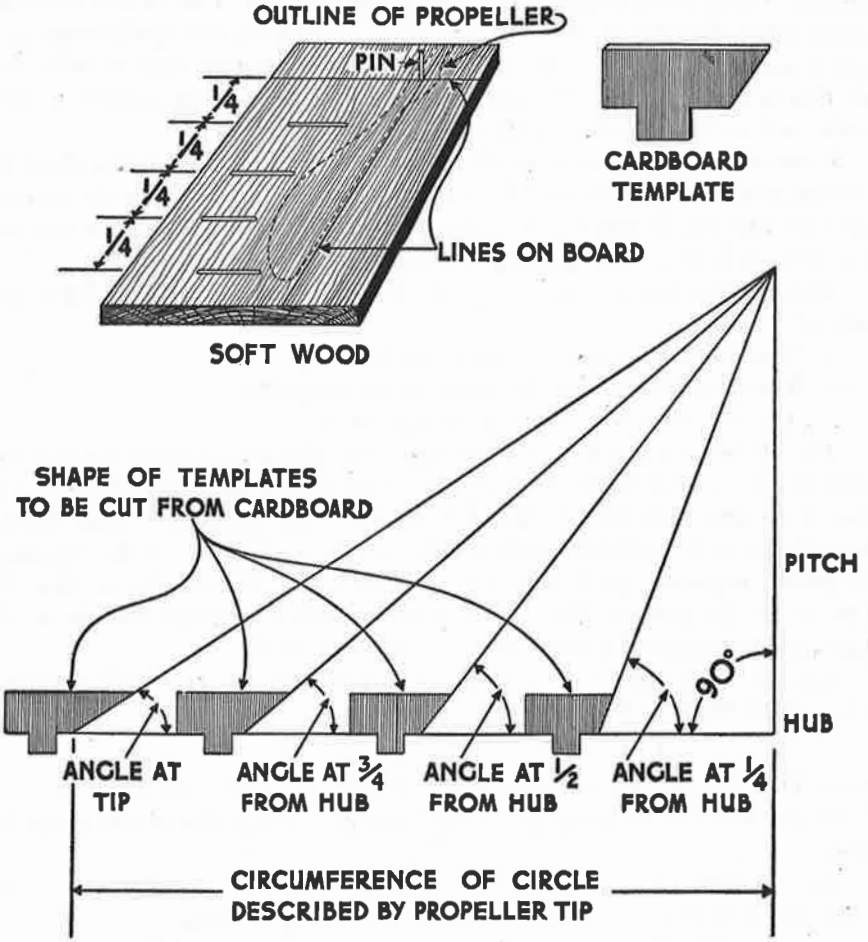


FIGURE 59. TRUE-PITCH PROPELLER LAYOUT

draw lines from these division points to the upper end of the pitch line, as in Fig. 59. These lines form with the base line the correct angle to be cut at each of their respective positions on each blade of the propeller. Block out the templates, as shown, and mark each according to its position along the propeller blade. Cut out each of them, trace the outline on tin or stiff cardboard, and cut the finished templates, which will appear as in Fig. 59

under "Cardboard Template." Note that these templates have small extensions on their bottom edges.

The next step is to prepare a soft wood platform. This should be slightly longer than the radius of the propeller, which includes one blade and half the hub. A line is drawn the length of the board and another line at right angles to it, as shown in Fig. 59.

A pin is thrust through the propeller shaft hole and into the board at the

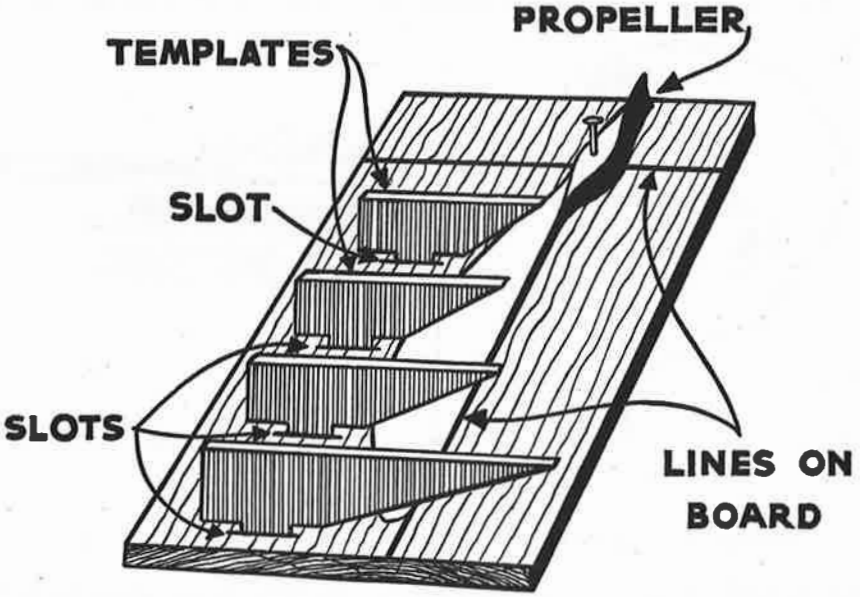


FIGURE 60. TRUE-PITCH PROPELLER PLATFORM ASSEMBLY

point where these two lines intersect. (Note pin location.) Shape the propeller as desired and carve the blades down until they are about ¼" thick. Place the propeller on the platform and trace its form with pencil on the board. Draw lines at right angles to the long line, as indicated by the short double lines on the platform, dividing the radius of the propeller into four equal lengths. Cut these lines through the board, but be sure that they are not longer than twice the width of the small extension pieces on the templates.

Again lay the propeller in place, slip the flap of each template into its respective slot, and push it up to the edge of the propeller blade, so that the angle of the template extends over the face of the propeller blade. Be sure that the bottom edge of each template is resting on, and is parallel to, the

top of the platform. Fig. 60 shows the finished platform, with each template in place, and the propeller ready to be tested. Fig. 61 shows the correct method of using the platform. As the blades are cut thinner, the templates must be pushed up, so that the angle at each point will remain correct. More templates can be used, if desired, simply by drawing more lines forming more angles and fitting the added templates into the platform at their respective positions.

Fig. 61 shows the platform placed on a surface level with the eyes, so

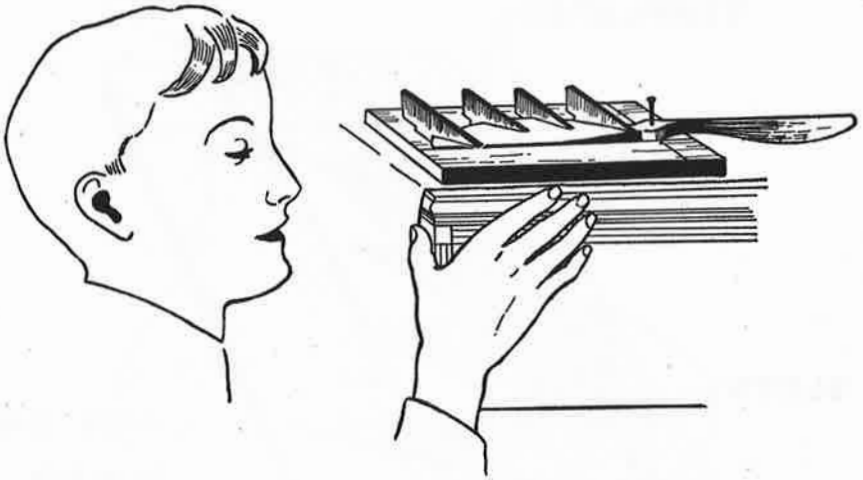


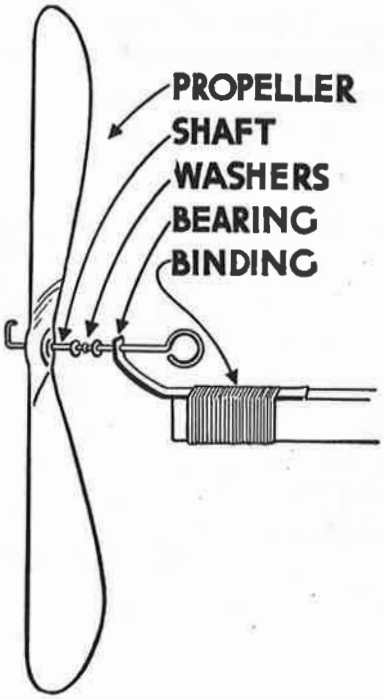
FIGURE 61. METHOD OF SIGHTING PROPELLER PLATFORM

that the builder can see at a glance whether the slant he has given his blade coincides with the angle of the template at each particular point. Of course, the blades must be sandpapered until the templates fit tightly against the blade at all points. When one blade has been perfected in this manner, the propeller is swung around and the other blade completed. Such templates and platform, as described here, may be kept for future use, but they can be used for one size of propeller block only. Others must be made to fit other sizes.

Great care should be taken to see that the platform is perfectly level at all points and that the bottom edge of each template is flat on the base.

PROPELLER ASSEMBLY. Fig. 62 shows the assembly of a propeller on a motor stick. Some fuselage models have no motor sticks, in which case a front plug is used for the propeller bearing, but aside from this difference, both assemblies are alike. The propeller shaft is of piano wire, shaped as

shown. (See Chapter 6, "Propeller Shafts.") The illustration shows the shaft before it has been cemented to the hub. When the shaft has been bent to this form, it is pulled back, as if to draw it back through its own hole. The point of the wire is guided into the wood of the hub, where it is pressed



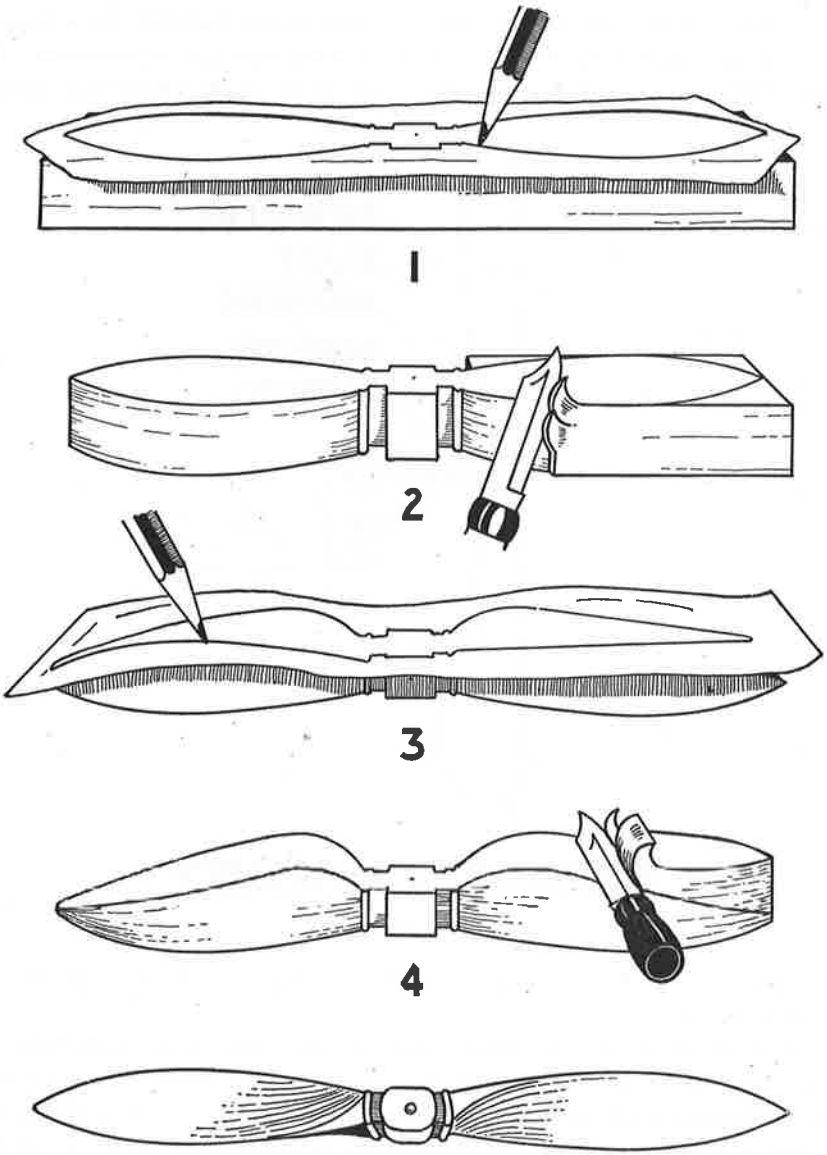
PROPELLER ASSEMBLY

FIGURE 62

into place, and cement is applied to the face of the hub over the bend of the shaft.

Many builders cement a large washer to the inside face of the hub, and then apply other washers to eliminate friction. The hub washer prevents the others from wearing into the face of the hub. Two small washers, with a bead of steel or an ordinary dress spangle between them, make a splendid assembly against friction, as shown.

For all small propeller bearings, it is best to cement the bearing to the stick, and further strengthen it with silk thread binding, as shown. When



EXHIBITION PROPELLER

FIGURE 63

fully wound, the thread is coated with cement or dope to tighten and hold it in place.

EXHIBITION PROPELLER. All non-flying models require exhibition propellers. Balsa wood is recommended for these because they require considerable carving. Fig. 63 shows the five steps for carving an exhibition propeller. Square up a block to the necessary length, width, and thickness. Make a full-size top and side pattern of the finished propeller. Trace the outline of the top on the block, as in Fig. 63, No. 1. This is then cut out, as in 2.

The side form of the propeller is traced on the side of the block, as in 3. This is then cut out, giving a perfect propeller blank, which is shown in 4. The propeller now has its blades carved as explained under "Carved Propellers." When completed, the propeller is given two coats of banana oil with a light sandpapering between coats. This is followed by three coats of aluminum paint. A model pin, thrust through the hub, is used to assemble the propeller to the nose of the fuselage or engine core. The finished propeller is shown in Fig. 63, No. 5.

THREE-BLADED EXHIBITION PROPELLER. There are two popular methods of making these. The first, shown in Fig. 64 is the more simple of the two. A pattern of the blade is made and traced on a block already cut to proper size, as in 1. This block is only half as long as the finished propeller.

It is then cut out, and the blade carved from the top back edge to the bottom front edge, as in 2. Half the hub shape is cut, plus a small triangular piece at the end, as shown. The blade is sanded smooth. Three of these blades are made. A circle is drawn to represent the circumference of the propeller, divided into three equally long arcs, and the blades placed in position on the drawing with their tips at the division points and their hubs together in the center.

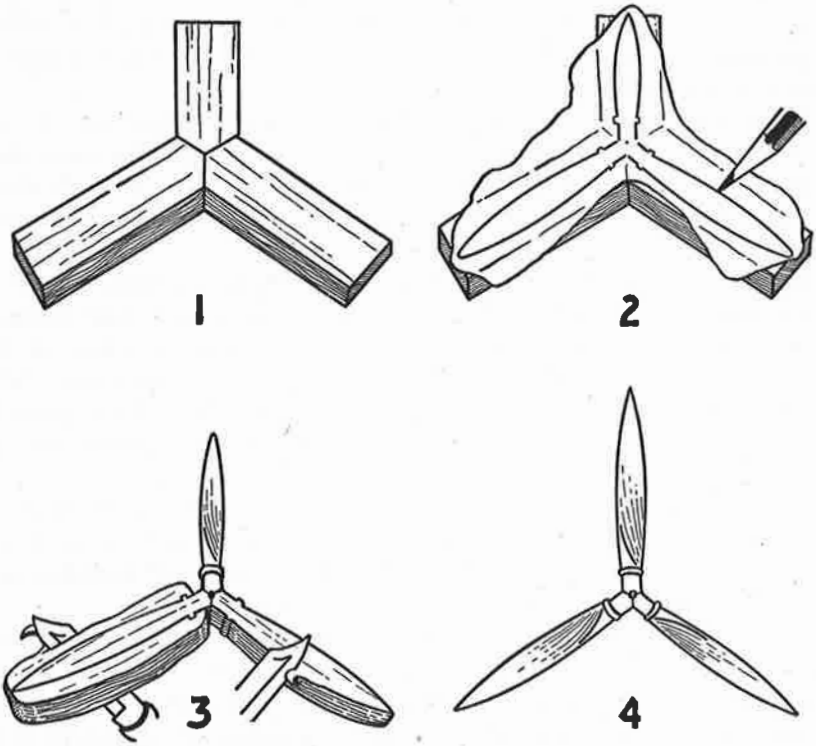
The triangular ends are now cut to fit each other, while the blades are in position. When completed, they are cemented together, as in Fig. 64, No. 4. The propeller is then finished as was the two-bladed propeller, and a pin is thrust through its hub for assembly on the model.

The second method consists of cementing the three original blade blocks together, as in Fig. 64, No. 1 under "Second Method." The outlines of the blades are then traced on this block, as in 2, and cut out. Each of the three blades is then carved. These two operations are shown in 3. The finished propeller is shown in 4.

FOUR-BLADED EXHIBITION PROPELLER. As shown in Fig. 65, No. 1, two exhibition propellers are carved as described in this chapter. See



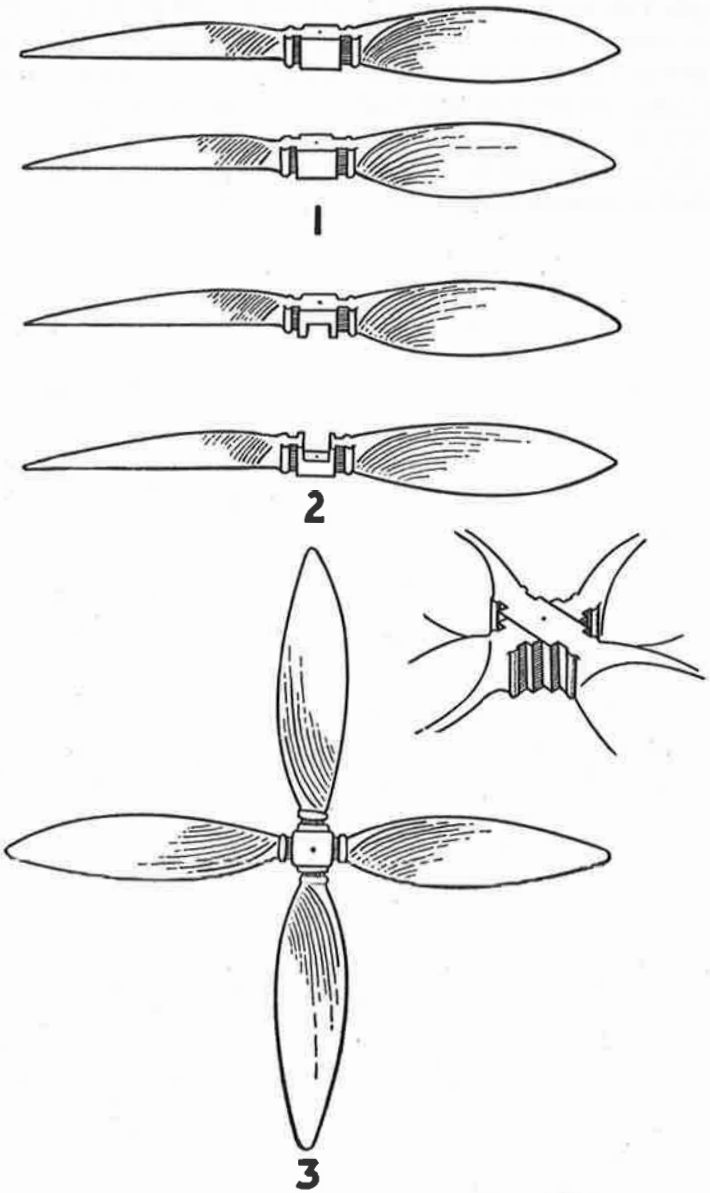
FIRST METHOD



SECOND METHOD

THREE-BLADED EXHIBITION PROPELLER

FIGURE 64



FOUR-BLADED EXHIBITION PROPELLER

FIGURE 65

Fig. 63. The thickness of their hubs is now notched halfway through, as in 2. To complete such a propeller, the notched portion of one is fitted into the notched portion of the other, and held with cement. Make sure that their hubs are notched only half their thickness, and that the walls of the notches are straight, so that when the propellers are fitted together, the tips of the blades will be an equal distance apart. This type of blade is also finished as were the other exhibition propellers.

CHAPTER 10

LANDING GEARS

SINGLE-STICK LANDING GEARS. Landing gears for these models serve only one purpose. This is to enable them to take off from or land on ground, water, or snow. They are not added for appearance, nor are they used particularly as a safeguard for the model upon landing.

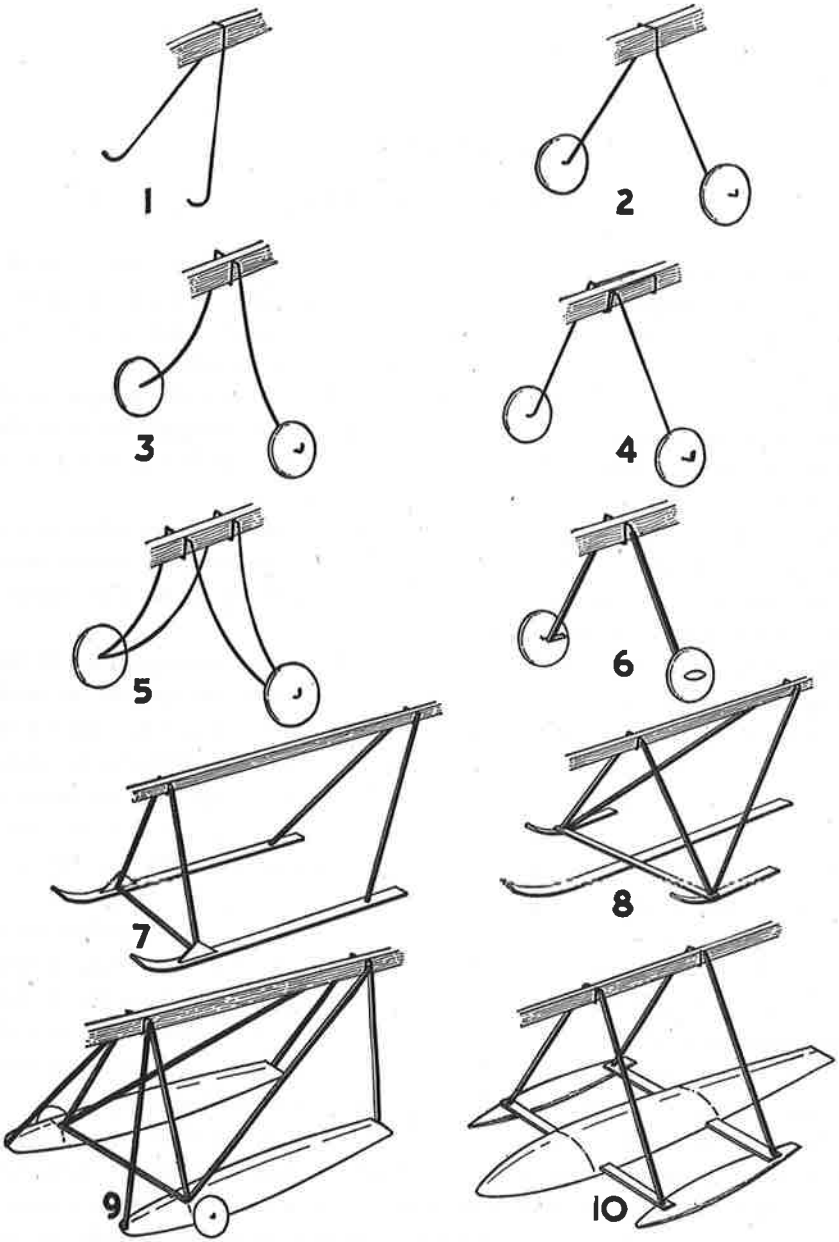
They should be as light as possible in order to keep the weight of the model at a minimum, but at the same time, strong enough to bear that weight, whatever it may be. In Fig. 66 ten popular landing gear types are shown.

No. 1 shows a skid gear used without wheels. At one time, when models weighed considerably, such skids were added to keep the model from breaking on landing. The skid consists of a single length of piano wire, bent to fit the motor stick, and having its ends turned up.

No. 2 shows the most popular type of landing gear used on light R.O.G. single-stick models. A length of piano wire is bent in the middle to fit the motor stick, from which it extends down on both sides. The ends of the wire gear are bent parallel to the ground to act as axles. Wheels are placed on the axles, and the tips of the axles are then bent up to keep them on. Another method of keeping the wheels in place is to apply a drop of cement to the ends of the axles after the wheels are in place. In this way, the ends do not require bending.

No. 3 illustrates another R.O.G. landing gear. This is attached to the under side of the motor stick, and the supporting wire struts have a slight bend. Such a gear has a certain amount of spring on touching the ground. The connection at the motor stick has no particular advantage over that of No. 2. On extremely light models builders prefer No. 2 stick connection, because it requires about ½″ to 1″ less wire, and saves that weight.

No. 4 landing gear is an exact copy of No. 2 except that its motor stick connection has been supplied with a saddle. Single wire connections sometimes allow the gear to fold against the stick when the model receives a sudden forward or backward shock on landing. With the saddle arrangement the gear has two points of contact with the motor stick, which prevent



SINGLE STICK LANDING GEARS

FIGURE 66

it from being folded forward or backward. Note how this saddle is bent, as shown at the right of the illustration.

No. 5 shows another method of obtaining the same effect as the saddle. Here two lengths of piano wire are bent as shown in No. 3 gear. Only one of these is thrust through the wheels, while the second is either twisted around the first one, soldered, or cemented to it. Notice, however, that such a gear requires about twice the amount of wire that is needed for the others. Because of this added weight it is seldom used on endurance models.

No. 6 is constructed of piano wire and balsa or bamboo. A wire clip fits under the motor stick, as in No. 3. Its ends extend down just far enough to be cemented into the ends of the landing gear struts, which are of balsa or bamboo. Short lengths of wire are cut and bent to form axles. These are thrust into the other ends of the upright struts and cemented. Wheels are then fitted on the axles. Small streamlined pieces of balsa wood are shaped and cemented over the ends of the wire.

No. 7 shows an R.O.S. (rise-off-snow) landing gear. It consists of two wire clips as shown for No. 6. These fit into balsa struts and are cemented in place. The distance between these clips on the stick should be great enough to hold the stick above the snow. The leading pair of balsa struts is at right angles to the stick, while the trailing pair extends back from the ends of the skis. Bamboo is usually used for skis, but to cut weight they can be made from $\frac{1}{32}$" sheet balsa, cut $\frac{1}{4}$" wide and sandpapered smooth. The ends of the skis should be bent up, as shown. Small triangular braces are used to strengthen the connection of the front struts, as these receive the greatest strain.

No. 8 shows another R.O.S. landing gear which has proved practical. Its motor stick connection is a duplicate of that of No. 7, but in this case only one long center ski is used, while two shorter ones act as balancers.

No. 9 illustrates an amphibian landing gear. It consists of the usual wire motor stick connection clip, balsa struts, and built-up floats. These are made of balsa formers with bamboo stringers forming their outline. This frame is then covered with tissue, water-sprayed, and doped. The latter makes it water-tight, which is of utmost importance. The general construction details of such a float are shown in Fig. 67, No. 1.

Small balsa wheels are used for R.O.G. purposes. These are attached with large-head pins, which are thrust into the sides of the float former. For landing on the water, these wheels need not be removed, as they will not interfere with the action of the floats.

No. 10 is an illustration of the R.O.W. (rise-off-water) type of landing gear. Its construction is much the same as the amphibian gear, except that

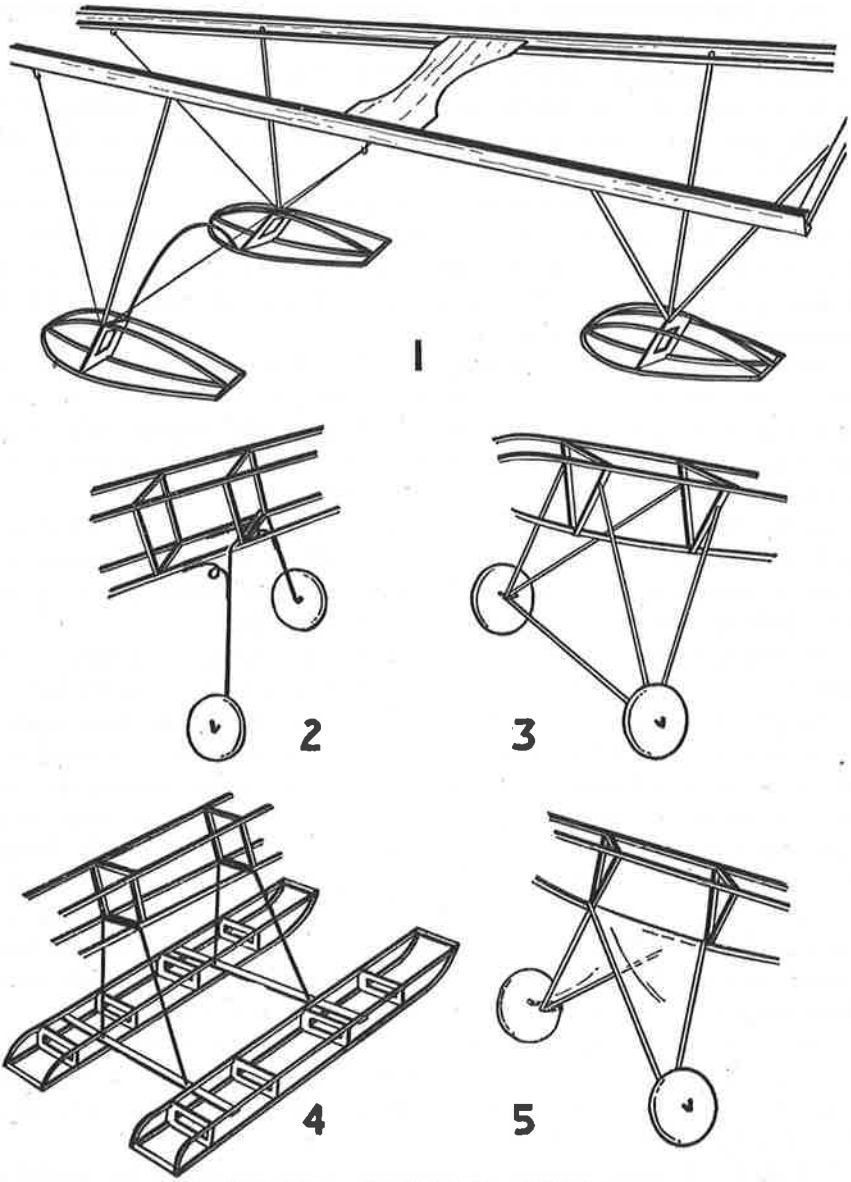
it has only one large float of the built-up type, while the two small side floats act as balancers. The small floats are of solid balsa, which has been well doped to make them water-tight. The large center float is constructed with two balsa formers and bamboo stringers. The small side floats are connected to the center built-up float by two lengths of balsa wood, which are cemented to the side bamboo stringers as well as to the two formers. Full instructions for making this gear will be found in Chapter 31. Either No. 9 or No. 10 can be made amphibian or just R.O.W. by adding or removing the side wheels.

TWIN-STICK AND COMMERCIAL LANDING GEARS. In Fig. 67, No. 1, is shown an R.O.W. (rise-off-water) landing gear, as applied to a twin-stick pusher. Full instructions for making such a gear will be found in Chapter 28.

No. 2 is designed for commercial models. A length of piano wire is bent in a "U" with its cross portion cemented to the under side of the fuselage and strengthened with silk thread binding. The upright portions are then spread apart about twice the width of the fuselage, and wheels are attached in the usual manner. Small lengths of piano wire are bent in loops, and attached between the fuselage and the upright strut sections of the landing gear. These are cemented in place and strengthened with silk thread binding, as shown. They function as springs, tending to absorb the shock of landing.

No. 3 is an R.O.G. gear especially adaptable to triangular fuselages. No wire is used on this gear, except very short lengths for axles. Bamboo is used in place of the wire, and balsa wood is not recommended, as any severe landing shocks will quickly break it, while bamboo is practically unbreakable.

No. 4 is an R.O.W. landing gear often found on commercial models. The form of the floats, shown in Fig. 66, Nos. 9 and 10, and in Fig. 67, No. 1, gives graceful streamlining, although it is a question as to which construction is the more simple. No. 4 is shown uncovered, so that all details can be seen. It consists of four formers, all square, with a bamboo stringer passing through each corner. These four stringers are united at both ends with a balsa cross brace. The float is covered with Japanese tissue, water-sprayed, and doped. Bent piano wire in the form of an inverted "U" makes the connection to the fuselage. The cross portion of the "U" is cemented and bound with silk thread to a bottom cross brace of the fuselage. The ends of the wire are bent and then cemented to the under side of the two connecting axles of the gear after they pass through each.



TWIN-STICK AND COMMERCIAL MODEL LANDING GEARS

FIGURE 67

No. 5 illustrates another R.O.G. landing gear for triangular fuselages. See building instructions in Chapter 35.

SCALE MODEL LANDING GEARS. In Fig. 68 and Fig. 69, fifteen of the most commonly seen landing gears are shown. These are replicas of the landing gears of various real airplanes, as of course they must be when attached to true scale models. As all of these are fully explained in the text covering the particular model to which each belongs, details will not be repeated here. No. 1 is the landing gear of the S.E.5 in Chapter 49. No. 2 is that of open cockpit Pitcairn Autogiro in Chapter 55. No. 3 is the landing gear of the Curtiss-Wright Sedan in Chapter 51, while No. 4 is the Stearman Mailplane in Chapter 54.

No. 5 shows the landing gear of the Waco Taper Wing in Chapter 47, and No. 6 is the Curtiss-Wright Junior in Chapter 46. In No. 7 we see a landing gear not given in this book. It belongs to the Stinson Monoplane. Such a gear is built up of bamboo lengths. No. 8 is the German Fokker D-7 in Chapter 53.

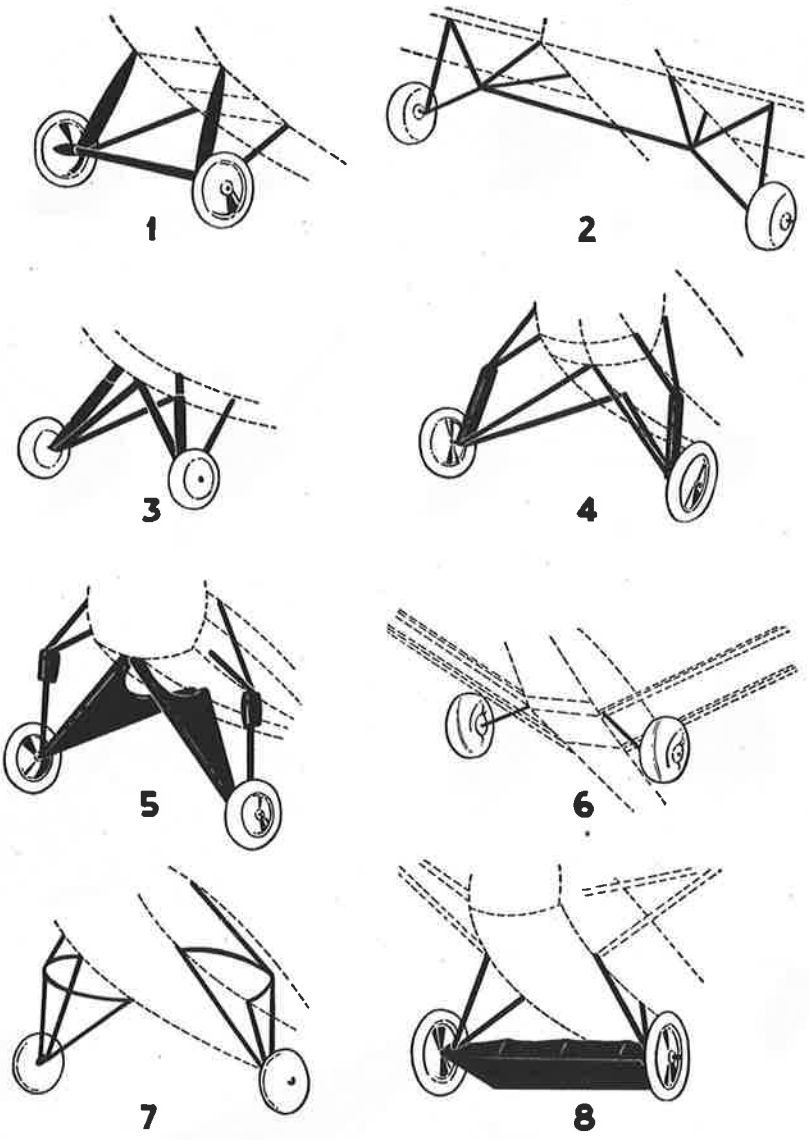
In Fig. 69, seven other popular landing gears are shown. No. 9 is that of the Gee Bee Super-Sportster in Chapter 40. No. 10 shows the landing gear of the Lockheed-Vega "Winnie Mae" in Chapter 42, while No. 11 is that of the Bellanca Pacemaker "Cape Cod" in Chapter 36.

No. 12 shows the landing gear of the Wedell Williams in Chapter 44, while No. 13 is the gear belonging to the Northrop Gamma in Chapter 48.

No. 14 has been added to this group to show the inside framework of the average scale model R.O.W. floats. These are built up of a number of balsa formers, with bamboo stringers connecting them and shaping the structure. While floats gain their forms from those of the real ships being copied, practically all are constructed in the same manner, so the builder can gain a general working knowledge of float construction through studying these. It has been found that bamboo is best for the stringers of such floats, as it is practically unbreakable, resists water splendidly, and has a certain amount of spring which balsa wood lacks. While the weight of the bamboo is slightly greater, the above factors offset this disadvantage.

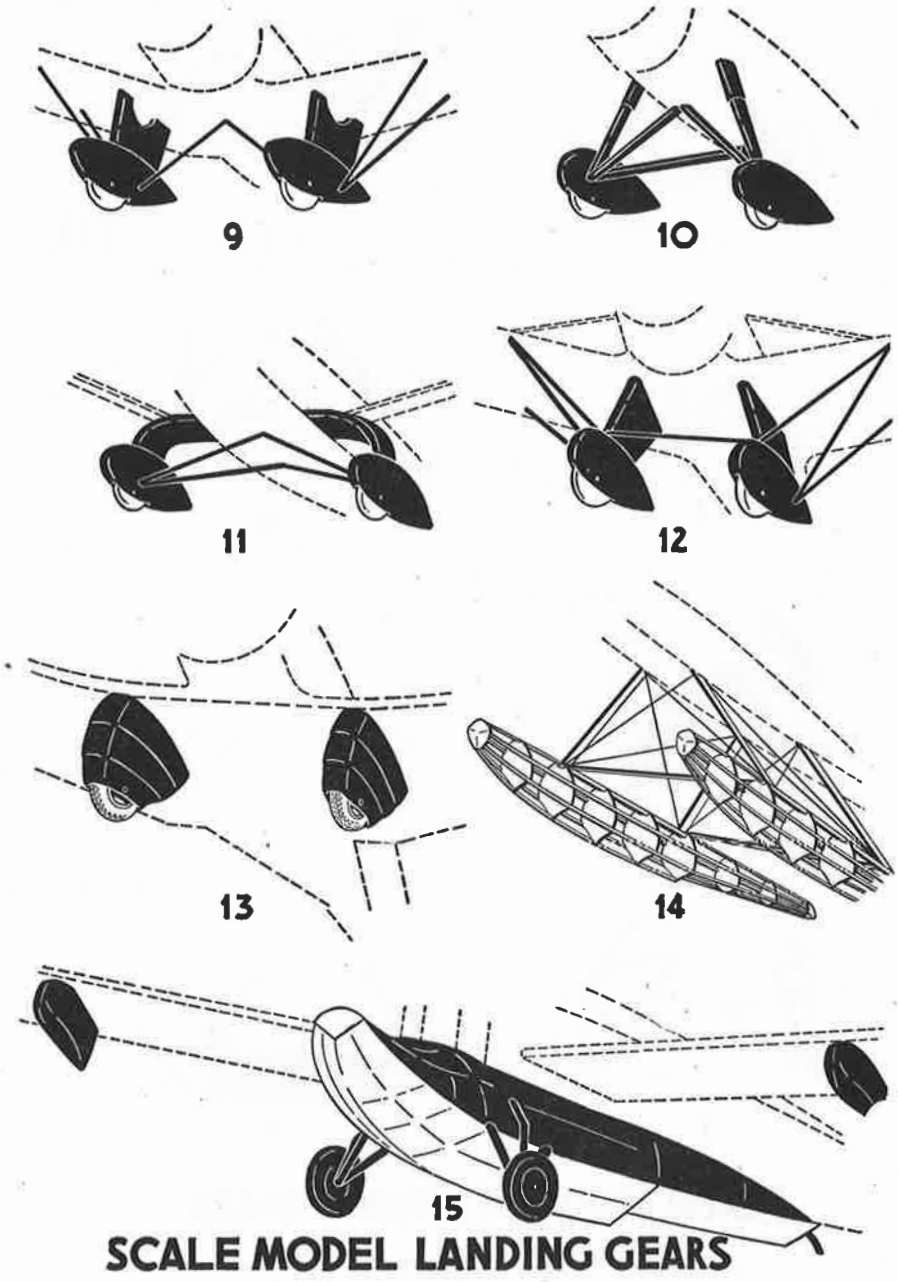
No. 15 shows the hull of the Loening Amphibian in Chapter 50. All of these gears are shown here to acquaint the reader with the various popular forms of landing gears, and a close study of each should prove of great aid when building scale models.

WHEELS. A great assortment of various types of wheels for model airplanes are carried by practically every model supply house. Some builders, when turning out a perfect scale model, prefer to buy the wheels, but for flying models they are usually made.



SCALE MODEL LANDING GEARS

FIGURE 68



SCALE MODEL LANDING GEARS

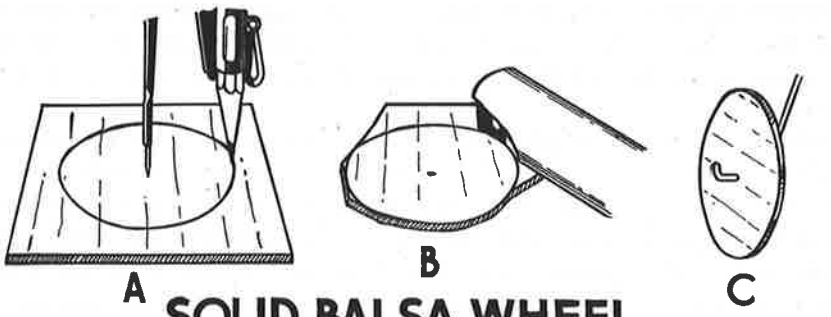
FIGURE 69

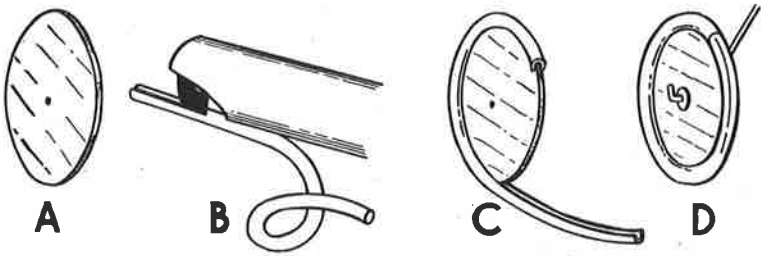
Several methods of building wheels are given here. These not only include flying model wheels, but those for scale models as well. If the builder will master these, he will be able to make wheels quite as good as those he can buy.

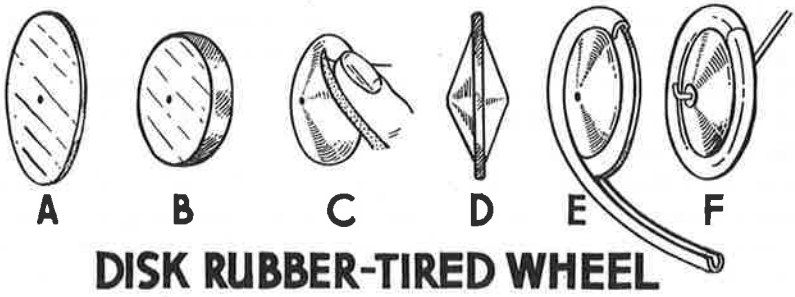
SOLID BALSA WHEELS. Fig. 70 shows the three steps in making a solid balsa wheel, the most popular wheel for flying stick models. A piece of 1/32", 1/16", or 1/8" sheet balsa, depending on the size and weight of the model, is cut out to form a disk. In A is shown the laying out of the wheel on the balsa with a pencil compass. B shows the cutting of the circle just drawn. (See Chapter 3, "Balsa Wood.") The edge of the disk is sandpapered perfectly round, and a hole slightly larger than the diameter of the axle wire is made in its center. It is then placed on the wire axle, which is bent up to prevent it from falling off, as shown in C.

SOLID BALSA RUBBER-TIRED WHEELS. These are exactly the same as the solid balsa wheels except for the addition of a rubber tire. Spectacle tubing is used for this purpose. It can be purchased at any optician's shop and most model supply companies now carry it. In A is shown the disk finished as shown in C for the solid balsa wheel. The tubing is split along one side, as shown in B. Cement is applied to the inner surface of the tubing and it is spread on the edge of the wheel, as in C. D shows the finished and mounted wheel. These make splendid wheels for large flying models or scale models. If the model is to be painted, the disk should be sandpapered, given two coats of dope, and painted any desired color. The rubber tubing is then mounted. If you wish to paint the tubing black, it should be done before the tubing is mounted, as the painting of the edge of the rubber will prove difficult if on the disk.

DISK RUBBER-TIRED WHEELS. This wheel should not be used on endurance models, as it is heavier than the others, but for flying scale and exhibition models it gives a splendid appearance. The usual disk of sheet balsa is finished as for the solid balsa wheel. In this case, however, the balsa should be cut from 1/32" stock. (Note A.) In B is shown a smaller disk cut in the same manner, but from 1/4" stock. The diameter of this second disk should be 1/8" less than that of the larger disk. Two of these smaller disks are required for each wheel. When cut out, they are sandpapered to a cone-like form, as in C, with their high point centering at the axle hole. These are then cemented on each side of the larger disk, after being carefully centered, as at D. Rubber tubing is split along one side and cemented in place around the edge of the large center disk, as in E. The finished wheel is shown in F. If the wheel is painted, as such wheels usually are, this is done before the tire is attached in place. (See "Solid Balsa Rubber-tired Wheels.")







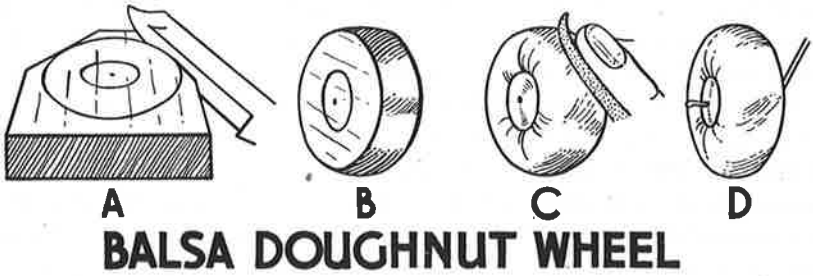


FIGURE 70. WHEELS, 1.

BALSA DOUGHNUT WHEELS. Balloon tires are often called "Doughnut" wheels, and they will be found on such planes as the Curtiss-Wright Junior and the Pitcairn Autogiro. (See Chapters 46 and 55.) For model work, these can be easily cut from a 1/2" or 5/8" thick balsa board. Trace the wheel outline on the balsa, and then cut it out, as in A. The disk is then finished perfectly round by sandpapering, as in B. The tire outline is made with sandpaper, making it round from side to side, and carrying out the shape of the tire to a 1/2" diameter circle at the hub of the wheel, as in C. The mounted and finished wheel is shown in D. Such wheels are usually painted black around the form of the tire, with another color for the hub circle.

PAPER WHEELS. These are very light, quite strong, and give a most realistic appearance. They are splendid for flying models. On fairly stiff paper, a circle is drawn with the compass slightly larger than you wish the finished wheel to be, as in Fig. 71 A. A small section of the circle is then ruled from its center to its edge, as shown. The circle is cut out and from this disk the ruled section is also removed, as in B. Two of these disks, exact copies of each other, are required for each wheel. They should be bent into the form of shallow cones by closing the edges of the cut sections and cementing them together, as in C. The edges of these disks, or cones, are now matched together and cemented.

At the center of each cone, a hole is cut, into which is fitted a small roll of paper, as in D. The length of this strip of paper, after it has been rolled, should be slightly longer than the thickness at the hub center of the joined cones. Cement is applied and the roll of paper is thrust through the holes made in the cones.

With scissors, trim off the ends of the roll until they extend out from both cones about 1/16", as in E. This small roll of paper forms an excellent wheel hub for the axle of the landing gear to turn in. The finished assembly requires two small washers, which should be cemented to the ends of the paper roll, as in F. The cement must not close up the ends of the roll, or the wire axle will not fit into it. Dope can be applied to such a wheel for weatherproofing and stiffening.

BUILT-UP BALSA WHEEL. This makes a light, serviceable, and strong wheel for any model. In A is shown the tracing of the wheel on sheet balsa with a compass, and in B is seen how the wheel is cut out. It is then sandpapered smooth, as in C. A small roll of paper is thrust through a hole made in the center of the disk, and allowed to extend out 1/4" from each side of the balsa disk, as in D. Japanese tissue or Japanese silk is then applied to each side of the disk, passing over the end of the roll, and being

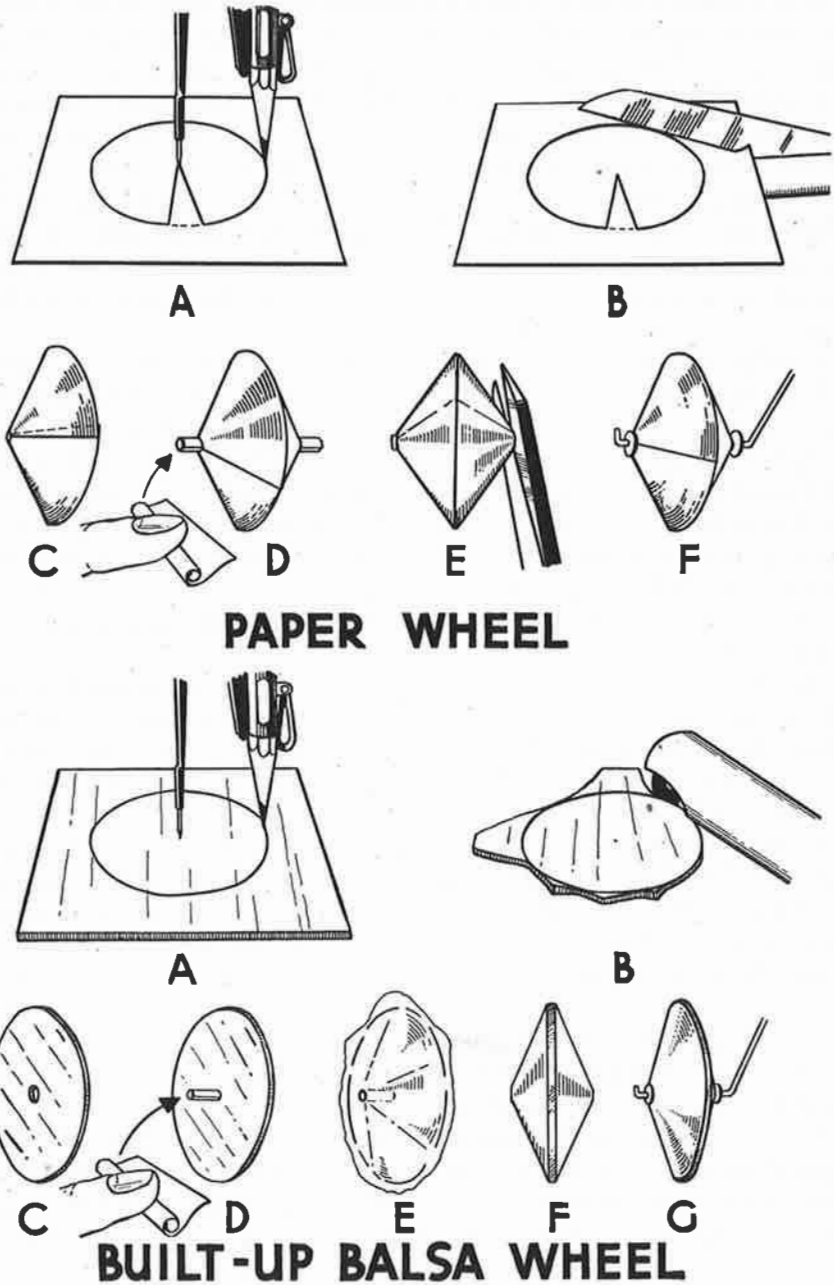
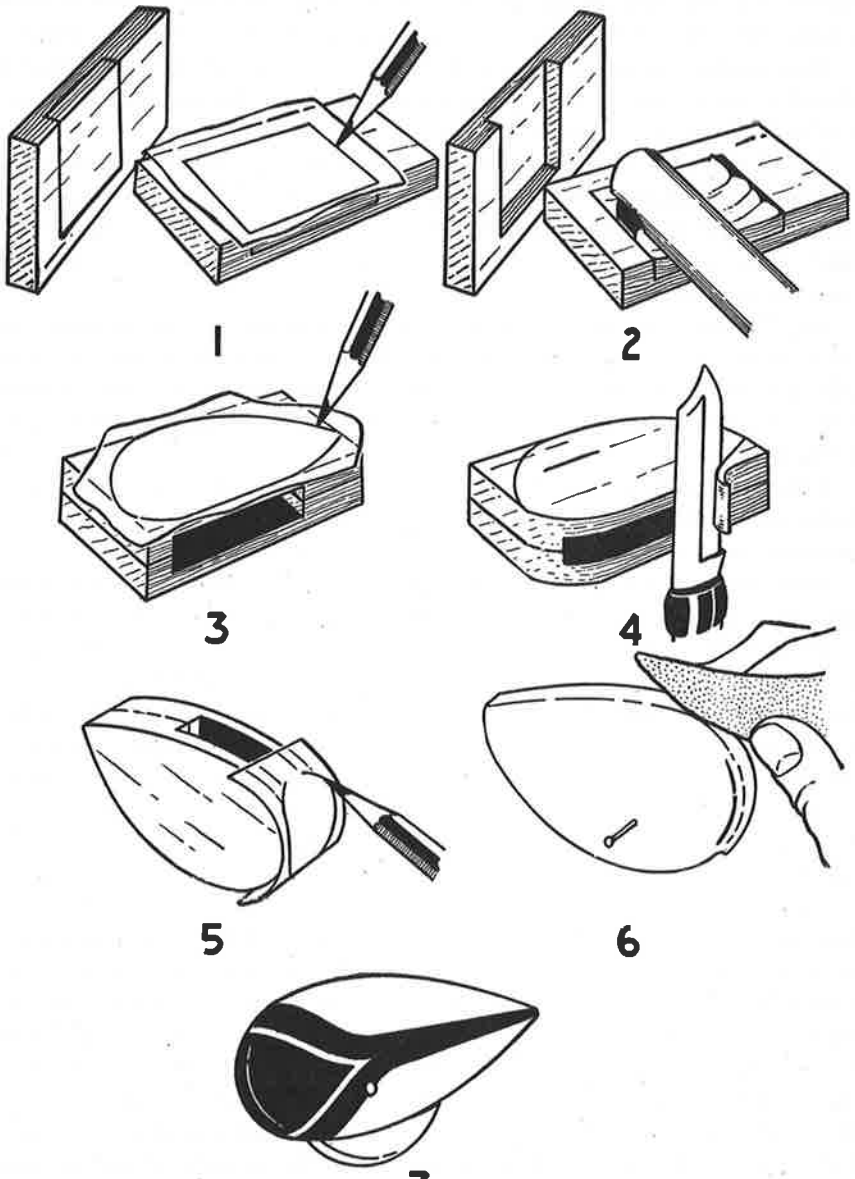


FIGURE 71. WHEELS, 2



WHEEL PANTS

FIGURE 72

cemented to the edge of the wood, as in E. The covering is then trimmed around the edge of the disk, and water-sprayed. The result is shown in F. Two washers are cemented to the ends of the paper roll, the covering pierced at both ends of the roll, and the axle fitted through the hub, as in G, which completes the wheel.

WHEEL PANTS. As the majority of modern airplanes have their wheels equipped with wheel pants, it will be necessary to add them to many solid scale and built-up, non-flying scale models. They are a form of wheel guard which serves to streamline the shape of the wheels, and by so doing to cut down air resistance.

Fig. 72 illustrates the seven steps necessary to make a wheel pant. Step No. 1 shows the laying out of the two blocks which make up one wheel pant. The necessary size of the material used depends on the size of wheels used, the type of pant, etc., all of which must be determined from the plans of the model.

Some pants also serve as landing gear struts, as in the case of the Curtiss Shrike in Chapter 52 and the Northrop Gamma in Chapter 48, but the majority are of the type shown in the illustration.

Sheet balsa of 1/8" or 1/4" thickness is used, depending on the thickness called for in the plans. Two duplicate pieces of this stock are squared up to the necessary length and width, as shown in Step 1. The inside cut for the wheel is then traced on each and cut out, as shown in Steps No. 1 and No. 2. These cuts must be large enough to allow the wheel to turn in them freely. Note that these cuts are located on the blocks slightly nearer one end than the other, and that they are made on opposite sides of the blocks, so that when the blocks are fitted together, the cuts in them will also fit, as shown in Step No. 3. The cuts must be a little deeper in each block than half the thickness of the wheel.

The two blocks are then cemented together, as shown in Step No. 3, and their outside shape traced on one face, as in No. 3. This outline is then cut out with a knife, as seen in Step No. 4. Step No. 5 shows the thickness being shaped by first tracing it on the blocks. This is then completed by sandpaper, as in No. 6. The wheel is mounted in the pant by means of a model pin, or a regular pin may be used. Test to see that the wheel moves freely when in place, and then cut off any excess length of the pin flush with the side of the pant. A drop of cement over the cut end will hold it firmly in place. The head of the pin should appear on the outside of the assembled pant, as shown in Step No. 7. It is then painted.

CHAPTER 11

ENGINES AND COWLINGS

ENGINES. All engines are made up of a number of cylinders, and the builder must determine beforehand how many cylinders the engine he is copying requires. On most of those given in this book, nine cylinders are required, with the two exceptions of the Curtiss-Wright Junior, which has only three cylinders, and the Northrop Gamma, which has fourteen.

The height of each cylinder depends on the size of the cowling into which it is to fit. As the cylinders are attached around a center core, they must be long enough to extend from this core to the inner face of the cowling, which fits around them. Some builders prefer to make their cylinders free of all contact with the cowling, which is the proper method of construction, as in real engines the cylinders do not touch the cowling, but if the engine is very small, the safest method is to attach one end of the cylinders to the core and the top of them to the cowling.

In Fig. 73 six steps in the construction of a cylinder are shown. In A is shown a square block of balsa wood cut to proper length. A circle of desired diameter is drawn on both ends, and the block is rounded, as in B. This is then tapered from its original diameter at one end to a slightly smaller one at the other, as in C. This shape should be that of a cork. The block is then shaped as shown in D. This consists of cutting a groove in the top of the block and then rounding the edges. Balsa is the best material for these blocks, although small corks or blocks of pine or other woods are sometimes used. Each block is painted black. A blue ink treatment gives the bluish tinge of steel which is desirable.

The block is wrapped with soft copper wire. No fastening is required, as it will stay in place on the block when it is wrapped. This is shown in E. The two illustrations in F show the final assembly of the cylinder on its core. On some models, this core may be a separate part of the model, but on most of them it is the nose of the fuselage. The cylinder is attached with cement and a pin thrust through its center into the core, as shown in F. The cylinders should be attached to the front portion of the core, so that when assembled in the cowling they will be just inside its front edge.

Two more pins are thrust into the core next to the front side of the

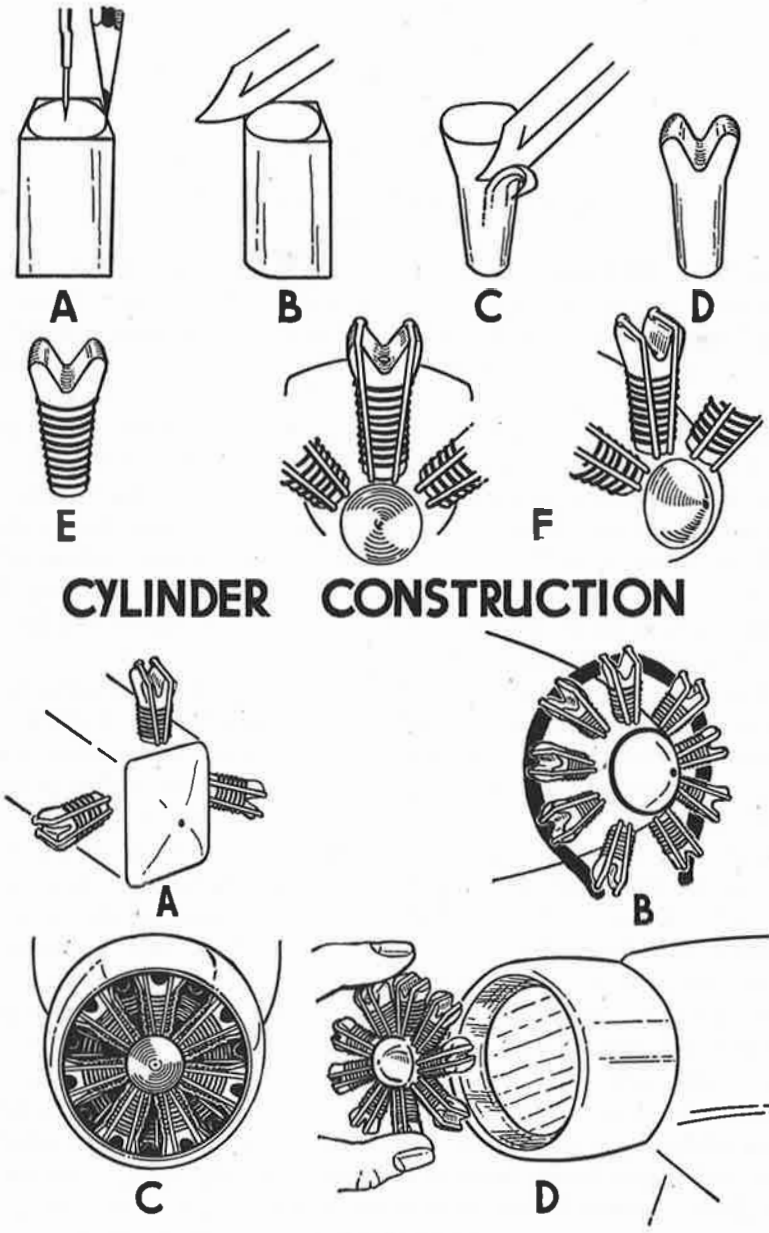


FIGURE 73

cylinder, after their stems have been bent at right angles to fit over the top of the cylinder. To finish the effect, the core of the engine should be colored in the same manner as each cylinder, after which the propeller is attached to the tip of the core with a pin.

The various assemblies of engines most commonly used in exhibition models are also shown in Fig. 73. A shows the assembly of the three-cylinder engine of the Curtiss-Wright Junior. B shows the assembly of an engine without a cowling, as in Chapter 47, while the fourteen-cylinder engine of the Northrop Gamma in Chapter 48 is shown in C.

The nine-cylinder Wright "Whirlwind" engine of the Waco, shown in B, has its pipe made of reed bent to shape and painted black. The fourteen-cylinder engine of the Northrop consists of two seven-cylinder assemblies around the same core, one behind the other, and so staggered that the rear cylinders will show between the front cylinders.

On most solid scale models, the cowling is not a separate part of the fuselage, as the front portion of the block from which the fuselage has been shaped is cut into the form of a cowling. When this is the case, the inside of the cowling must be hollowed out deep enough to accommodate the engine assembly.

When the cowling has been cut out, the cylinders are assembled on a separate core no longer than the cowling is deep. After the assembly has been completed, as in D, cement is applied to the end of the core and it is attached into the hollow of the cowling with its coated end against the inner wall of the cowling. A long pin can be thrust through the center of the core and into the back of the cowling to hold the assembly in place until the cement dries.

COWLINGS. There are only two types of cowlings the model builder will need to consider. These are the N.A.C.A. and ring cowlings.

SOLID N.A.C.A. COWLING. Fig. 74 under "Solid N.A.C.A. Cowling" shows the five steps for making this type of cowling from a solid block. As these cowlings are used on built-up, non-flying scale models, the inside diameter at their back should be just large enough to fit over the leading former of the fuselage, and their front diameter should be the same size.

A shows the first step of the work, after the block has been cut to proper size. A hard grade of balsa should be selected for these cowlings. After the outside diameter has been drawn on the face of the block, an inner circle is made to indicate the inside diameter of the cowling. This should be about ¼" smaller than the outside diameter, and the exact diameter of the front former.

The square block is now cut round, as in B, which is followed by scooping out the inside of the block, as in C.

The outer side of the block is now given a streamlined form, which is shown in D. The outer circle is tapered down to meet the inner circle at both leading and trailing edges of the block.

The block is now brought to a satin finish with No. 000 sandpaper, as in E. The completed cowling can be seen in F. The engine assembly for such a cowling should be made around a small center core of the same length as the cowling.

RING COWLING. Technically known as an "anti-drag ring," this so-called cowling aids in increasing the speed of the plane. It looks much like an enormous wedding ring. Slightly wider than the tops of the cylinders, it is streamlined in the same manner as the N.A.C.A. cowling.

In Fig. 74 under "Ring Cowling," the five steps for making this are shown, as were those of the N.A.C.A. cowling. Follow each step, as shown, when making this type of engine covering. These are used on engines assembled around the nose of solid fuselages, where they are fitted over the cylinders after these engine units have been attached in place. For this reason, such cowlings must have inside diameters equal to the diameter of the circle formed by the tops of the cylinders, when these are in position around the core.

BUILT-UP N.A.C.A. COWLING. For all flying models, the engine cowling must be of very light construction to keep weight at a minimum. For such models, having no engines, cowlings are used only to complete the general outline of the fuselage, and hold the front motor stick clip. The four necessary steps for building such cowlings are shown in Fig. 74 under "Built-up N.A.C.A. Cowling."

On $\frac{1}{32}$" sheet balsa, the two circular formers and six or eight former struts are traced with pencil, as seen in A. The next step, B, shows these after they have been cut out. The large former must have a diameter equal to that of the front fuselage former, while the small one need only be large enough to allow the motor stick and rubber motor to be removed through it. The width of these formers, or the distance from the inside to the outside diameters, should be about $\frac{3}{16}$". These are now assembled, as in C, and a piano wire motor stick clip is cemented to the inside face of the front, or small, former. When it is fully assembled and the cement has dried, the cowling framework is covered with Japanese tissue, silk, or whatever has been used on the fuselage. This can best be done by cutting the paper into strips wide enough to reach from one former strut to the next

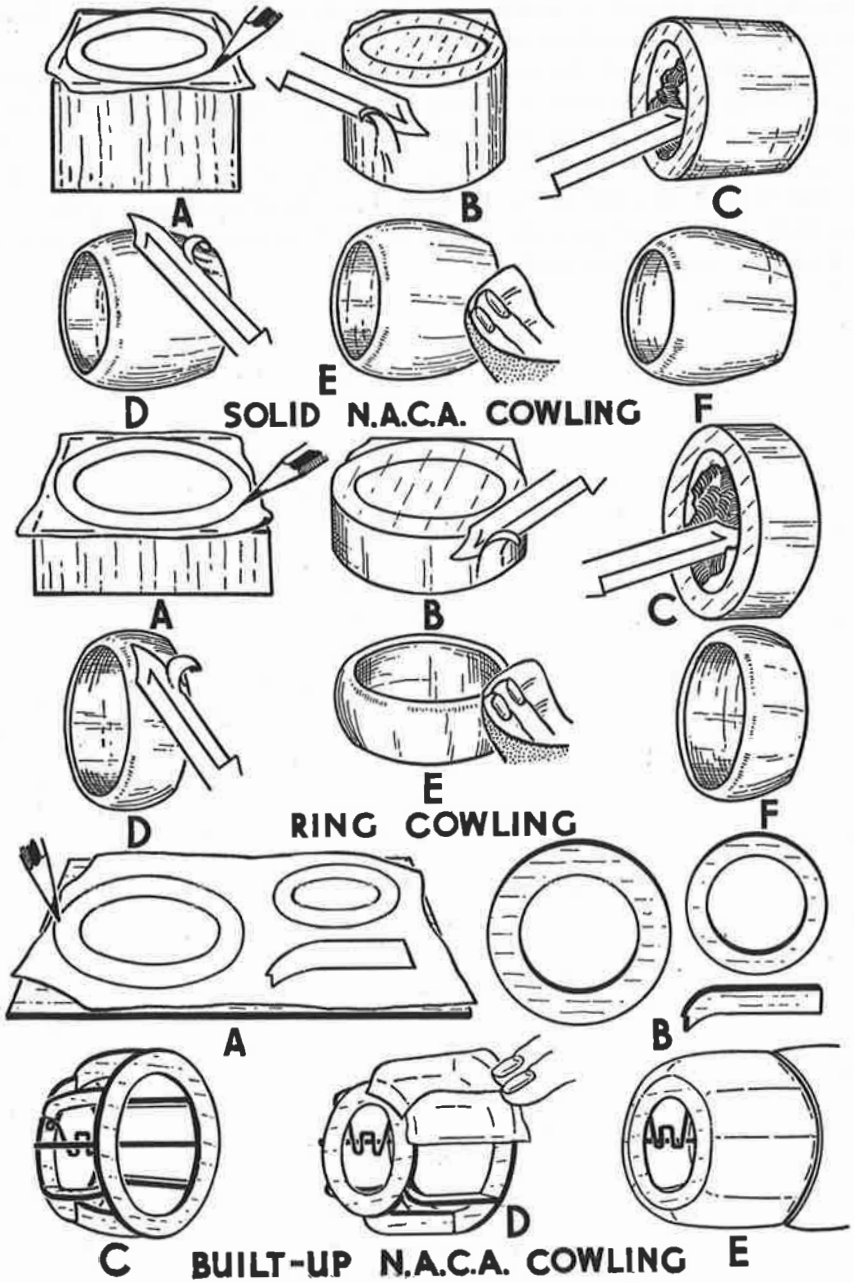


FIGURE 74. ENGINE COWLINGS

one, and long enough to reach from the front to the back former. Attach the covering with clear dope or banana oil, as in D.

When fully covered, the tissue or silk should be water-sprayed to tighten the covering. (See Chapter 7, "Wing Covering.") If the fuselage has been doped, the cowling should be finished in the same manner. When completed, all edges should be trimmed to remove any excess covering. The cowling is then attached to the fuselage. Coat the front former of the fuselage with cement, and press the large former of the cowling in place against it, holding it in position until dry.

CHAPTER 12

RUBBER MOTORS AND MOTOR STICKS

MANY different means of motive power have been suggested for model airplanes, but none has proved as efficient as rubber.

Every model enthusiast should understand a few of the basic facts concerning rubber and its action. In the first place, rubber has life. There is live rubber and dead rubber. The former allows more energy to be stored in it than in any other source of power of equal weight, while the latter is useless. Through constant use, rubber becomes tired, and it must be rested before it will regain its energy. Sunlight, oil, grease, certain metals, and the stretching of it beyond its elastic limit will quickly affect rubber, and it becomes hardened, cracked, and dead.

Every model supply house carries rubber for model airplanes. The finest is pure Para rubber. It comes in various sizes, the most common being $\frac{1}{32}$" and $\frac{3}{64}$" in the square, and $\frac{1}{8}$" and $\frac{3}{16}$" in the flat rubber.

The $\frac{1}{32}$" square rubber is best adaptable to very light indoor and R.O.G. flying models, while the $\frac{3}{64}$" square is suitable for heavier models of the same type. The $\frac{1}{8}$" flat rubber is by far the most popular size, being the best suited for indoor and outdoor endurance models. Such rubber is usually used on championship models found at most national meets. The $\frac{3}{16}$" flat rubber can be used on all outdoor models and is especially good for large high-speed ones.

The builder should make actual flying experiments, using various sizes of rubber, noting the performance of each, and then choosing the best size for the model being tested. The number of strands is governed chiefly by trial and error. Baby tractors and pushers usually give the best results on one or two strands; larger models require from four to twelve strands, depending on the strength of the motor stick, the size of the propeller, and the weight of the model. If the model is heavy, more rubber will be required.

Rubber always should be applied to a model with a certain amount of slack allowed. In other words, it should never be taut between the propeller shaft and the rear hook. Builders have their pet ideas on the amount of

this slack that is necessary, but for a beginner, here is a simple way of calculating it until definite decisions are reached through trials:

If using the average length propeller shaft and rear hook, each strand of the rubber should be just the length of the motor stick. When the rubber is attached, it will have a slack equal to the combined lengths of the rear hook and propeller shaft. For example, the motor stick of the model is 12″ long and is to be fitted with one strand of rubber for the motor. The rubber strand is then cut 12″ long, plus whatever surplus is necessary for binding the rubber in place to the end hook and propeller shaft. Further, let us assume that the end hook of this particular model extends from the end of the motor stick forward for a length of ¼″. On the other end, the propeller shaft extends over the motor stick for a distance of ¾″. The combined length of these hook extensions over the motor stick is 1″. In other words, the distance between them is 1″ less than the length of the 12″ motor stick, or 11″. By cutting the rubber 12″, a slack of 1″ is obtained.

Various kinds of rubber will stretch in different degrees, but good Para rubber will elongate about seven times its length. The purchaser can test the rubber by stretching a measured piece about seven times its original length, releasing it, and then measuring it again. If the rubber returns to its original length, it is "live" and good for use in a motor; if it remains longer than it was before the test, it is not first-class rubber. Any rubber, however, can be distorted by stretching it past its "live length," so care must be taken not to stretch it past this point.

Dr. William F. Tuley, of the research laboratories of a leading rubber company, gives this hint to model builders concerning the purchase of rubber: "Chemical substances known as 'antioxidants' have been discovered which greatly increase the life of rubber when compounded with it. These substances retard the destructive action of air and sunlight on rubber. They are being extensively used in tires, bathing caps, raincoats, and other rubber articles, and purchasers of rubber strands for model airplanes might find it advantageous to specify that they be included in the composition of the rubber. There are a number of good commercial antioxidants on the market."

Another point to watch when purchasing your rubber is that you specify and obtain pure Para rubber. This contains a minimum of nonrubber ingredients, making it the finest of all grades for model work. See that the rubber you purchase has been kept in a dark place. Do not buy rubber from an open shelf where the destructive elements of sunlight may harden and crack it. See that it has not been under tension.

The safest way to keep rubber when not in use is in a bottle which

has been painted black, so that sunlight and air cannot reach it. A Mason jar is excellent. Obtain one, pour a little black paint in it, shake it around until thoroughly covered, and then empty out the balance. When the paint is dry, rubber can be kept in the jar without fear of damage from light.

When more than one strand is used for a motor, the winding tends to cause the strands to stick together. Lubricants are used to prevent this on the theory that they make it easier for the strands to slip over each other when unwinding. Wound lubricated rubber contains a greater amount of energy than rubber not lubricated, and the author recommends it.

There are a number of commercial lubricants on the market, or plain glycerine will be found excellent for this purpose. Another splendid lubricant, but one requiring a little more attention, is made of soap, water, and glycerine. Cut Ivory soap into small shavings and boil it in a little water to make a thick liquid, then add a like amount of the glycerine, making a fifty percent glycerine and fifty percent soap and water solution.

The above lubricant is used by an expert model builder, who claims that he lubricates his rubber the day before it is to be used in a contest. He then packs it away in a dark receptacle well coated with talc. After it has been used, he replaces it in the same manner and keeps it this way.

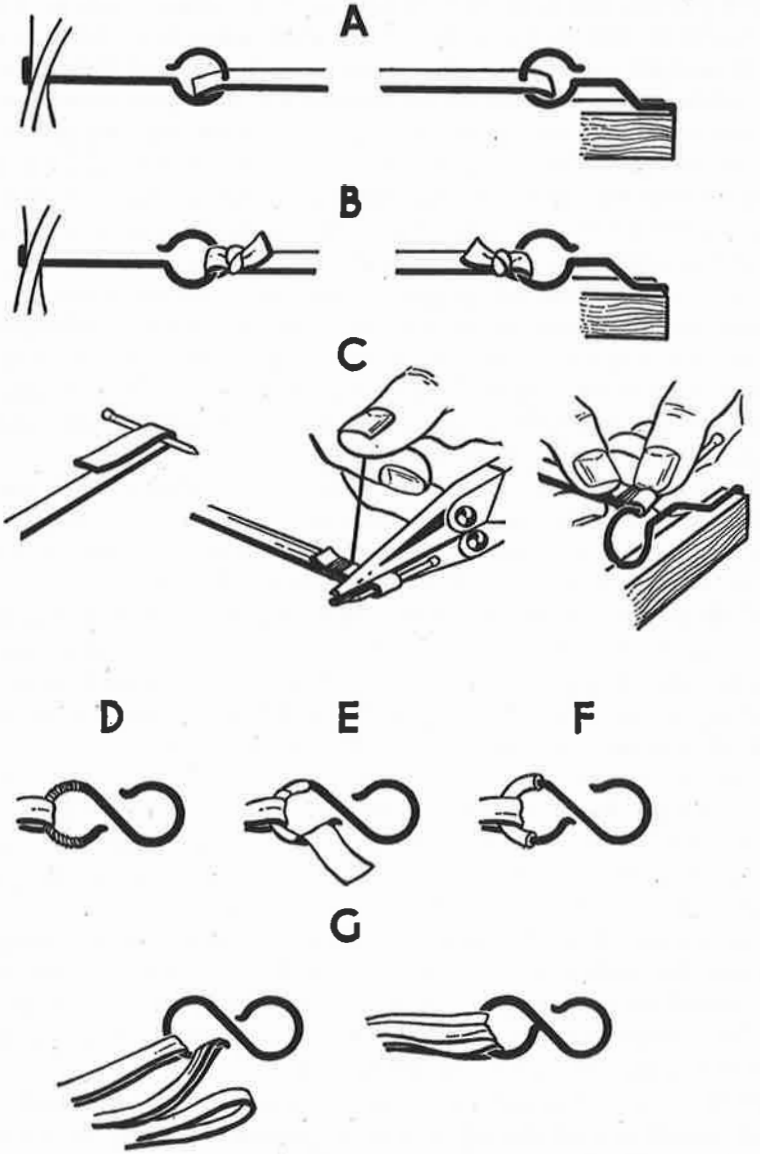
Others prefer to wash the rubber after it has been used. This is done in warm water with a pinch of soda added. After washing and removing all lubricant, the rubber is carefully dried before being packed away. When placed in the jar, it should be sprinkled with either common talc or cornstarch, after making sure that all strands are separated.

Never use oil or grease as lubricants, as these weaken and soften the finest of rubber. Tests should be made by the amateur with lubricated and unlubricated rubber. Various lubricants should be thoroughly tested to obtain the best, and the two methods of packing away and keeping rubber should be tried to determine which is preferred.

Experiments show that the best winding results can be obtained by stretching the rubber three or four times its length before starting to wind. Two should do this operation together, especially on large models: one holds the rubber while the other does the winding. Full instructions are given in Chapter 16 under "Winding."

There are several popular methods of connecting rubber to hooks. When a single strand is used, the rubber can be pierced, as in Fig. 75 A. However, the rubber will take many more turns if it is tied about the hook, as in Fig. 75 B.

As single strands are used only on small models with correspondingly small fittings, it is often difficult to make the knot. Fig. 75 C shows an easy



RUBBER MOTOR ATTACHMENTS

FIGURE 75

way to accomplish this. Fold the strand over a nail, hold the fold together with small-nose pliers, tightly wrap with silk thread, and tie. The nail is then held next to the hook, the rubber slipped off it on the hook, and the nail removed. The deterioration of rubber is accelerated by certain metals, the most common of which are copper and brass. If these should be used for propeller shafts, can hooks, "S" hooks, or end hooks, which come in contact with the motor, they should be wound with silk thread, Fig. 75 D, adhesive tape, E, or covered with spectacle tubing as shown in F.

When using "S" hooks, closing the hook, as shown in G, will keep the strands together on the hook. For motors having a number of strands, "election" bands are used on both ends to keep the strands of equal length. These are small rubber bands tied around the strands, just in front of the "S" hook or end hook at the rear of the motor stick, and just behind the propeller shaft hook at the front end of the stick.

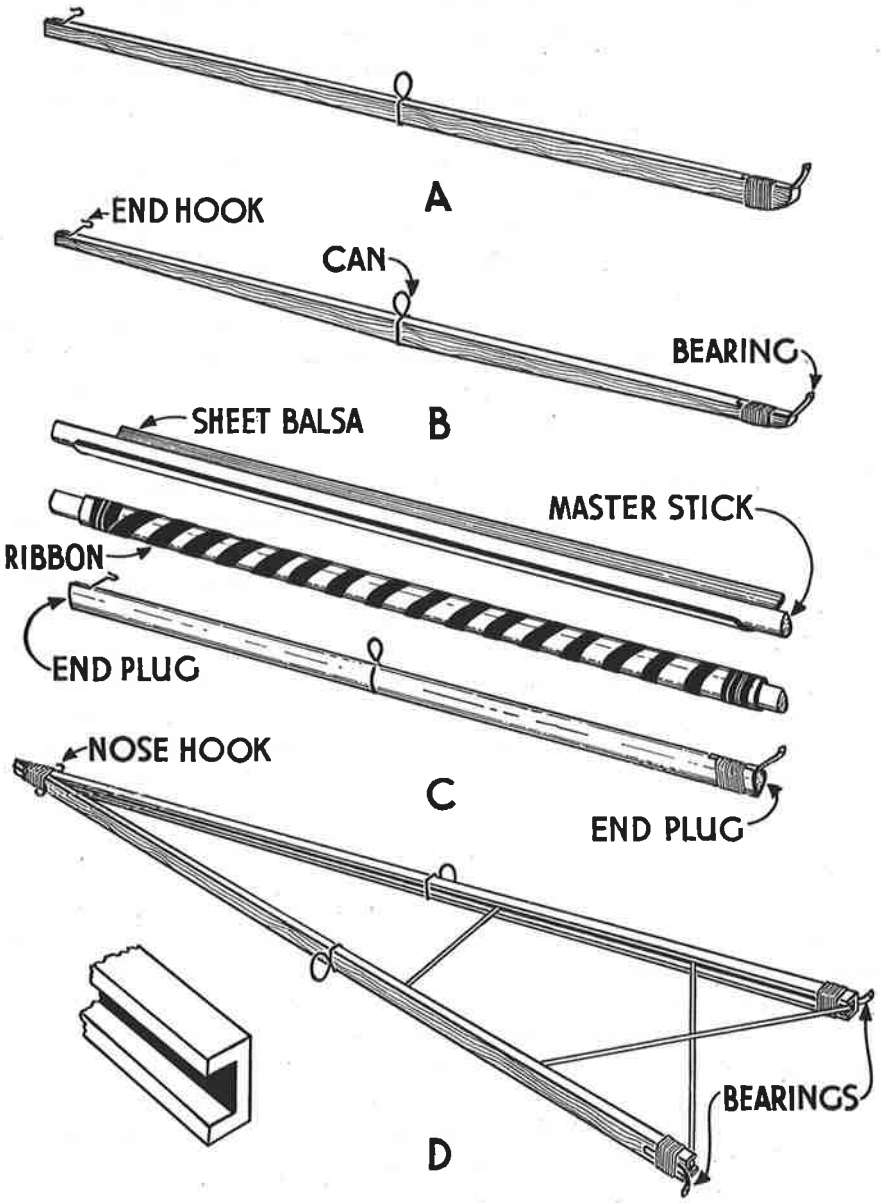
MOTOR STICKS. On stick models, the motor stick serves as a fuselage to which are attached the wing, elevator, rudder, propeller, motor, and landing gear if one is used. For this reason, these models are known as "stick models."

Flying fuselage models have the usual built-up fuselages with or without motor sticks. Some fuselages are so strengthened in their structural framework as to require no motor sticks, in which cases their rubbor motors are attached directly to the members of the fuselages. When this type of fuselage first became popular, it was considered a great asset to save the weight of a motor stick, but close study soon revealed the fact that such a fuselage required heavier construction, which often weighed more than the stick it eliminated. Another great disadvantage to this type of motor asbly was the danger of twisting the entire fuselage frame through winding.

For these reasons, the author recommends the use of a motor stick on all flying scale models. Such a stick allows the motor to be removed from the fuselage, so that the rubber can be stretched before winding. It permits more turns to be made in the rubber, which gives longer endurance, and allows motor repairs to be made easily.

While all scale models should be equipped with motor sticks, commercial models seldom need them. On such models, the construction can be so designed as to give the necessary strength with little added weight. They are usually left uncovered at the end hook, while the propeller bearing consists of a removable plug, which allows the rubber to be removed, as shown in Chapter 35.

Fig. 76 shows a number of the most important types and forms of motor sticks. In A is shown the most common form of motor stick, which is usually



MOTOR STICKS

FIGURE 76

twice as wide as it is thick. Such sticks usually are cut 1/16" x 1/8", 1/8" x 1/4", and 1/4" x 1/2". Occasionally we find a stick cut square, as on the tractor in Chapter 21, but these are unusual. The nose, or propeller end, of the stick is usually beveled, allowing the propeller free motion without danger of striking the stick.

B shows the tapered stick, which is the same as A except that it is slightly tapered toward both ends to eliminate excess weight. Such a stick is usually twice as wide as it is thick at its center and then tapers toward both ends until square. For example, a stick 1/8" x 1/4" at the center would taper to 1/8" x 1/8" at both ends.

C shows the three steps for making a hollow stick. On extremely light, endurance stick models, these sticks are very popular. Some builders make their sticks large enough to hold the rubber motor inside the stick, but weight tests made by the author seem to prove that such sticks weigh too much for any advantage gained.

For such hollow sticks, 1/64" or 1/32" sheet balsa is used. A master stick of pine is shaped as desired and cut about 1" longer than the required motor stick. Some make their motor sticks perfectly round, which can be done by forming the sheet balsa around a dowel stick. The shape given here is for the tractor in Chapter 33.

After the master stick has been prepared, the sheet balsa is cut to size. Its length must equal the required length of the finished stick, and its width must equal its desired circumference. A quick way to determine this is to tie a string around the master stick, remove the string while still knotted, cut it, and measure its length. This will represent the width required for the stick.

When the sheet balsa has been cut to size, it must be thoroughly soaked in hot water. Remove it from the water, place it on a flat table, and lay the master stick on it, so that the side of the stick and the edges of the sheet are parallel with each other. The balsa sheet is then bent up around the stick and tied in place with ribbon. Do not use string, rubber bands, or wire for this work, as any of these will quickly cut into the soft wood. Use a wide ribbon, and wrap it carefully around the entire length of the stick, as shown.

When the balsa has dried, the ribbon is removed and the edges of the sheet balsa cemented together. Some prefer to leave the master stick in position while doing this work. If this is done, it must be pulled back and forth while the cement is drying, so that the cement will not fasten it and the sheet balsa together.

The ribbon may be replaced until the cement has dried, but if this is

done, a thin coat of vaseline should be given the ribbon to keep it from adhering to the crack of the sheeting. After the cement has become thoroughly hard, two small end plugs are shaped to fit the inside form of the stick. These are cemented into the ends of the motor stick. When dry, the entire stick is sandpapered smooth and fitted with the usual end hook, can hook, if used, and propeller bearing.

On twin stick pusher models, the A-frame is often made of two U-beams, so named because they resemble a U in form. Note this type of construction in Fig. 76 D. The open side of the beam faces toward the inside of the A-frame, as shown. Such a beam is used on the model in Chapter 28. Note that the braces of the A-frame fit between the sides of the U-beams, where they are cemented into small holes cut for them. Such beams can be made by cementing three pieces of sheet balsa together, or they can usually be purchased from supply dealers.

CHAPTER 13

PAINTING

ENDURANCE CONTEST MODELS. Endurance models for contest purposes should never be painted. There are no exceptions to this rule, whether the model is a single-stick, twin-stick, commercial, or flying scale plane. All endurance models depend greatly on their lightness, and paint has weight. In fact, during tests to determine the effect of paint on models, one model so tested had its endurance cut in half. While this was not true with all the models so tested, each showed a decided drop in flying time when painted, which should give an idea of the harm paint can do to a flying model when its endurance is counted in seconds.

Many experts refuse even to give their wing surfaces a water-spray because of this danger and that of warping. When $\frac{1}{32}$" balsa is used on such parts as wing tips, it is not hard to realize the effect paint has on such models.

SPEED FLYING MODELS. Paint makes little difference on speed models, as they are of sturdy construction in which weight is not an important item. A close study of the speed twin pusher in Chapter 34 will prove this fact. With solid balsa wing and elevator, heavy balsa propellers, pine A-frame, and considerable weight from its two rubber motors alone, paint would have practically no effect on its flying ability.

The sole question of such a model is, "How fast will it cover the course?" Built to fly only a comparatively short distance, its action is more that of a bullet than the slow, steady, soaring flight of an endurance model. Such planes may safely be painted any color you wish. Give the A-frame, wing, elevator, and propellers two coats of banana oil, a careful sandpapering, and then apply any paint, lacquer, or enamel desired. However, few such models are ever painted, because their appearance counts nothing in a contest.

EXHIBITION FLYING MODELS. There are occasions when the appearance of flying models should be taken into consideration. If you intend to sell your model, give it as a present, or display it to a public which knows nothing about such models, its appearance will count for as much if not more than its flying ability. For such flying models, the author recommends the use of colored dope, which is now carried by practically all model sup-

ply houses. It comes in a number of bright colors and is applied with a soft camel hair brush. It requires no undercoating.

However, before applying any dope to wing sections, the builder should make sure that the construction of his model is strong enough to withstand the strain of shrinkage. Otherwise, he may find his wing sections warped beyond repair.

If the model is a stick type, sandpaper the wood parts and leave them without any finish, unless they are given a single coat of dope and finished with another sandpapering. The wing, rudder, and elevator covering can then be given a coat of colored dope, after each has been water-sprayed.

Models finished in this manner have a "professional" appearance, and while they will not be championship flyers, they seldom lose enough flying ability to be noticed.

SOLID SCALE MODELS. Solid scale models should always be painted. The sole purpose of such models is appearance. They are replicas of real planes and must therefore be finished like the planes they represent.

Such models usually require a certain amount of filling. This is done with a wood filler, of which various makes can be found in hardware stores or model supply houses. The author can recommend Plastic Wood as a splendid filler. This is used to fill all cracks, construction errors, wood defects, or to make streamline wings, cowlings, fuselages, etc. Wings are often tapered into fuselages, and for this purpose, a wood filler is excellent. After such a filler has become perfectly dry, it can be cut, planed, or sandpapered like wood, and will take paint splendidly.

Whether the model is of balsa, pine, or another wood, it should be given an undercoating to prevent the paint, enamel, or lacquer from seeping into the surface. For this purpose, use clear banana oil. The number of coats necessary depends on the hardness of the wood. For balsa, from four to seven coats of banana oil are usually necessary. The surface should be lightly sandpapered after each coat, which will give a splendid base for painting.

There are a number of paints, enamels, and lacquers for finishing work. Lacquer or enamel proves the best, although many builders use ordinary gloss paint. Model supply houses carry such finishers, and lacquer may be bought at the five-and-ten-cent store. Rogers lacquer has proved the best, but the beginner should try both lacquers and enamels to determine which give the best results.

After one or two coats of enamel or lacquer have been applied and allowed to dry thoroughly, a final coat of Valspar varnish will provide an

increased luster. After this finish, the proper insignia should be added to the model. (See Chapter 14.)

The wings are then given their proper numbers, which should be the same as those of the real plane being copied. If a manufacturer's plane is being made, any numbers you wish may be used. (See Chapter 3, "Emblems and License Numbers.")

Propellers are finished with aluminum paint if metal, or if they represent wood propellers, they should be stained oak or mahogany and then given two coats of varnish. All wires, cables, cockpit seats, steps, etc., should also be finished to represent metal.

Cockpits should be finished as shown in Chapter 15.

If the solid wood has been covered with tissue or silk, as shown in Chapter 8 under "Solid Fuselage Covering," this is doped and finished as explained under "Built-up, Non-flying Scale Models" in this chapter.

BUILT-UP, NON-FLYING SCALE MODELS. The object of these models is the same as that of solid scale models. Their framework construction, however, gives them a closer resemblance to real planes than solid models, because the methods employed to build them come very close to actual airplane construction.

If tissue has been used for covering, this should be given the usual water-spray. (See Chapter 7, "Wing Covering.") This is followed by clear dope slightly thinned with acetone. All wood parts, such as cowlings, cockpit formers, landing gears, etc., that have been left uncovered should be given two or more coats of clear dope and sandpapered between each.

Lacquer, enamel, or gloss paint is then applied as described under "Solid Scale Models." The tissue will take these coats quite as well as wood parts. When the last coat has dried, Valspar varnish should be applied. Propellers, wires, instrument boards, insignia, license numbers, seats, etc., are finished in the same way as solid scale models.

If the model has been covered with silk, the entire process is exactly the same, except that the undercoating should be clear banana oil without any thinner. This should be carefully applied with a camel hair brush. Use it sparingly, brush it well, and a perfect painting surface will result. If applied too thickly, the oil will penetrate the silk and deposit on its under side.

Silk covering treated in this manner will take enamel, lacquer, or paint splendidly. However, the silk must be water-sprayed before the banana oil is applied.

FLYING SCALE MODELS. Scale models entering endurance contests should not be painted, but as most flying scale model contests are judged by appearance alone, a perfect paint job is usually essential. If the contest

should be one judged on appearance and flying ability, the model should be water-sprayed and finished with colored dope, as this treatment will seldom harm the flying ability of the model. If, however, the model must merely prove that it can fly and then is judged on appearance alone, it should be finished completely. To paint a flying scale model, follow all the instructions given for built-up, non-flying scale models in this chapter. Proof of the flying ability of a scale model simply means it must fly on its own power a few feet, so the builder should test his model, as his finishing job progresses, for such flying ability. One builder known to the author finishes all insignia, license numbers, cockpits, etc., after giving his covering a color doping. The model is then tested. If it flies more than he thinks necessary to prove its ability at the meet, he gives his covering a coat of lacquer, and retests his model. In this way, he obtains a maximum of finish, and his successes at meets indicate the worth of his plan.

Some meets do not require flying scale models to prove their flying ability, and a close study of the rules governing the meet will show the builder such facts. If models are not required actually to fly, all that is necessary is to have the model carry a rubber motor. When this is the case, the model can be finished in the same way as any built-up, non-flying scale model.

Care of detail is most important when giving an exhibition model its final touches. Do not spoil an otherwise splendid building job by stinting work in finishing it. Remember that the paint on a model is the thing that is usually judged, as it has thoroughly covered all construction work.

CHAPTER 14

AIRPLANE INSIGNIA

WHEN building models for exhibition purposes, the painting of names, license numbers or insignia on them is of the utmost importance. Such models are usually judged solely for their resemblance to the real planes they represent, and such details often decide the success or failure of a model. The general painting of models has been covered in Chapter 13, and the painting of license numbers is explained in Chapter 3.

When building any model of a real plane, the builder should do so with the aid of photographs of the plane which show the proper positions of all insignia. As these locations often differ among planes, it would be impossible to give individual data on each one. Photographs can usually be found in aviation magazines or newspapers. Others can be obtained direct from the manufacturers.

Unfortunately, while such photographs show the location of the insignia, they seldom appear large enough to give detail. For this reason 120 of the most popular and interesting insignia are reproduced here. Each is an exact copy of the one appearing on the real plane, and they represent manufacturers, transport lines, individuals, and countries, as well as war and peace fighting squadrons.

It must be remembered that many planes carry insignia of the manufacturer as well as that of the transport company, squadron, or individual owner.

Two methods are used for transferring such designs to models. The experienced expert with a steady hand can paint them directly on the model, but the beginner should not attempt to do so, as he might ruin an otherwise perfect model. An easier method is to make an exact copy of the insignia on paper, using light pencil lines for its outline. This is then filled in and completed with colored inks or paints. When dry, cut out the design and glue it in position on the fuselage of the model. Its edges should then be touched up with paint the color of the surrounding area. As the majority of insignia are in black and white, much of the work can be done with black ink or paint.

The illustrations have been numbered, and are listed alphabetically under "Aircraft Manufacturers," "Transport Lines," "Miscellaneous" and "Military." Under the latter will be found such divisions as "Attack Groups," "Bombardment Groups," "Pursuit Groups," "Aero Squadrons," "Navy Squadrons," etc.

AIRCRAFT MANUFACTURERS

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FIGURE 77. AIRPLANE INSIGNIA, 1



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FIGURE 78. AIRPLANE INSIGNIA, 2



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FIGURE 79. AIRPLANE INSIGNIA, 3



FIGURE 80. AIRPLANE INSIGNIA, 4



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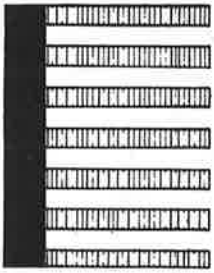
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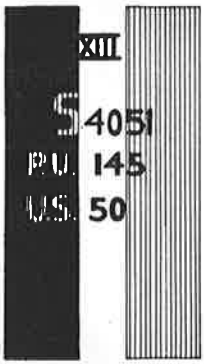
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LOCKHEED SIRIUS

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65

FIGURE 81. AIRPLANE INSIGNIA, 5



FIGURE 82. AIRPLANE INSIGNIA, 6

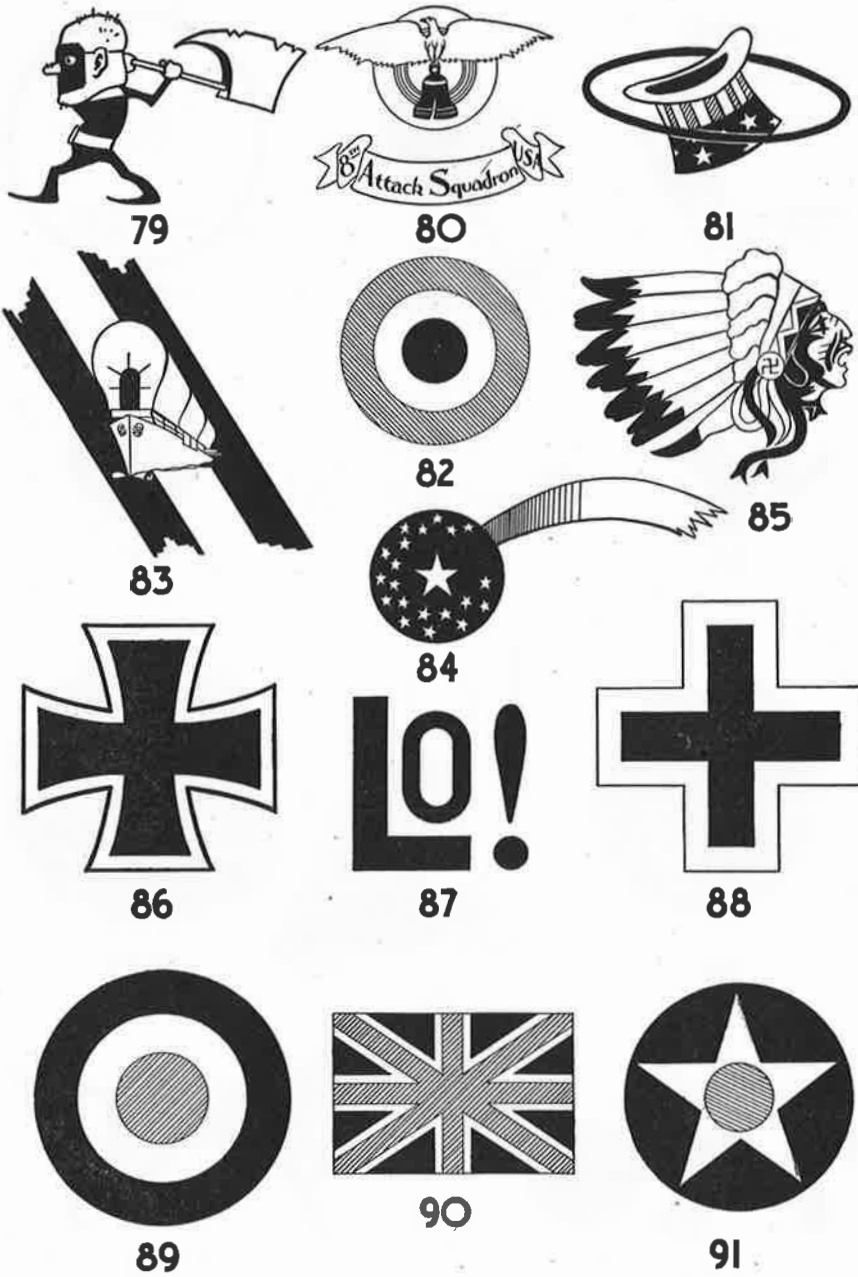


FIGURE 83. AIRPLANE INSIGNIA, 7

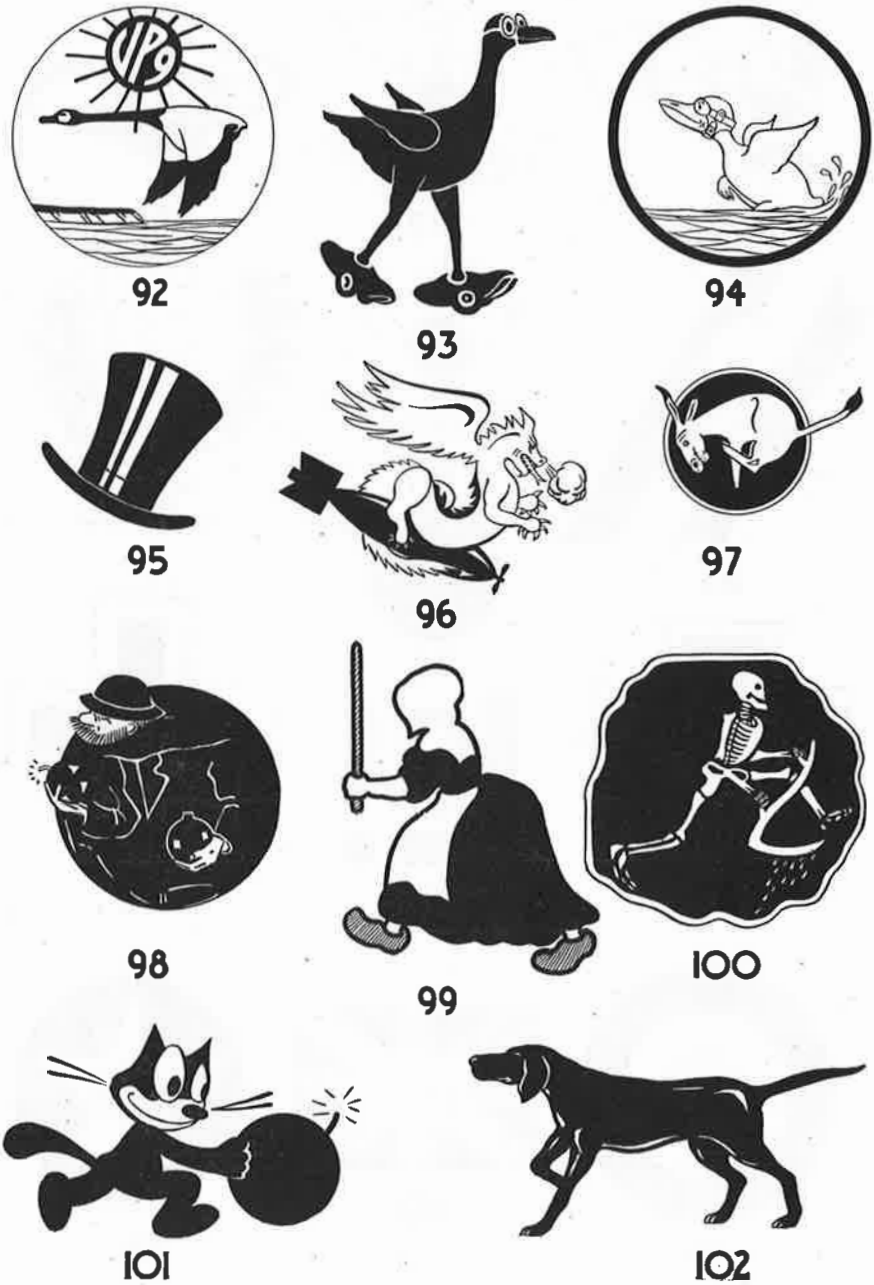


FIGURE 84. AIRPLANE INSIGNIA, 8

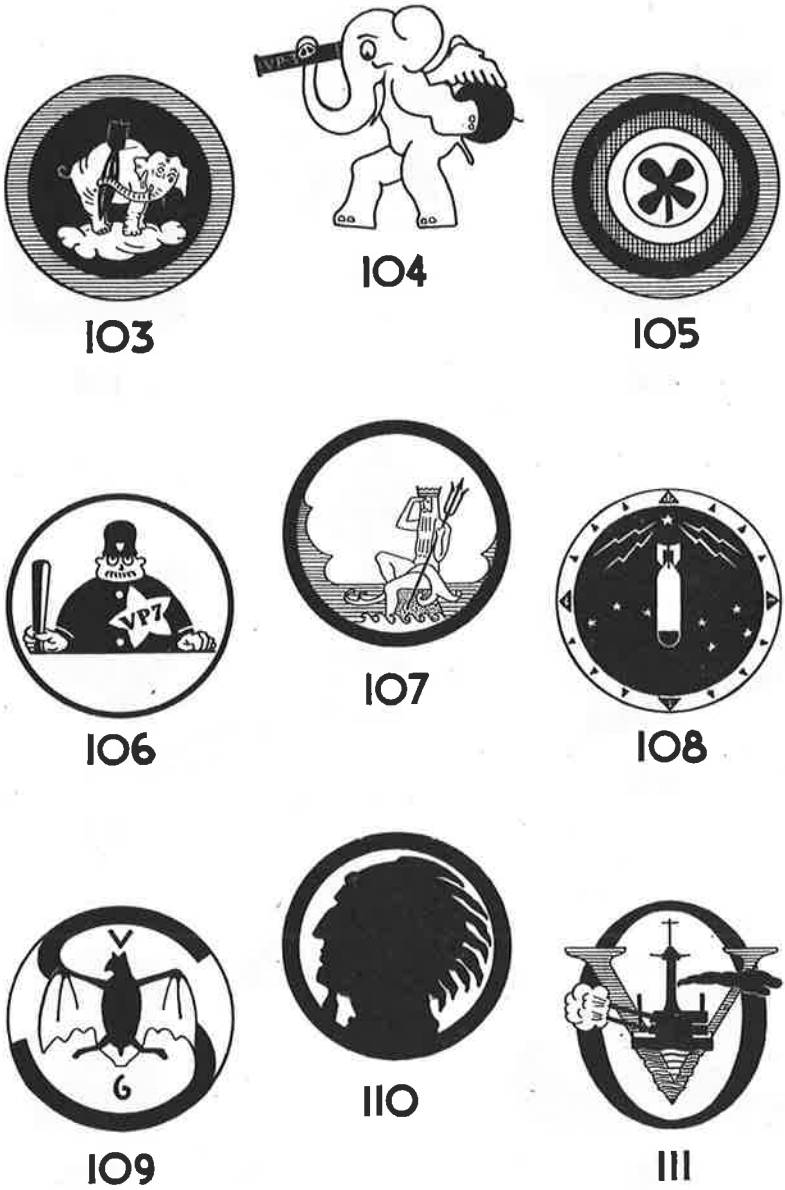


FIGURE 85. AIRPLANE INSIGNIA, 9



FIGURE 86. AIRPLANE INSIGNIA, 10

CHAPTER 15

MODEL ACCESSORIES

WHEN the painting of an exhibition model has been completed, many builders make the mistake of considering it a finished job. They forget the necessary accessories which often mean the difference between first and second honors. A fighting plane requires machine guns quite as much as a peace plane requires license numbers. Bombs hanging under a bombing plane are quite as important as the proper insignia painted on its wings and fuselage.

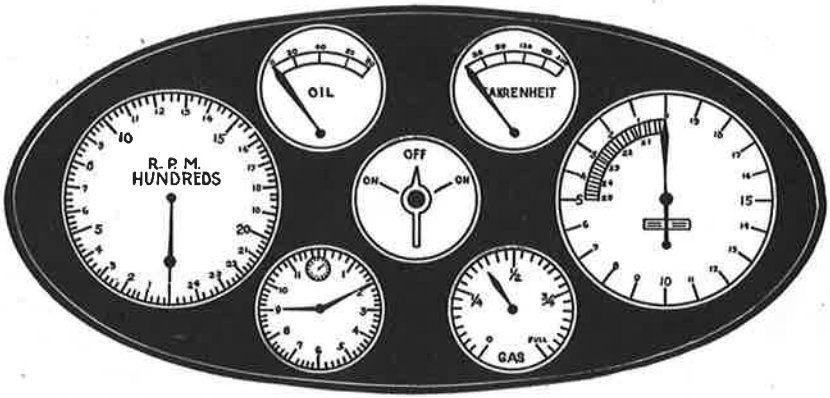
Many finely constructed models have failed to take first honors at meets because the builder failed to complete his job by adding details.

COCKPITS. On all exhibition models with cockpits cut out, an instrument board, windshield, rudder bar, joy stick, and seat should be added. If you do not intend to do this, leave the model without a cockpit.

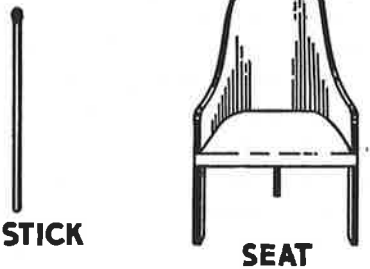
Fig. 87 shows four of these additions. Most of them can be purchased, but they are so simple to build that any model builder should make his own. The *instrument board* of a built-up model is usually located on the upper portion of the fuselage former situated directly in front of the cockpit. On solid scale models, it is located on the forward wall of the cut-out portion, which forms the cockpit. The dimensions of this should be taken and the instrument board drawn on paper to size. This is done by drawing circles on the paper, adding pointers, divisions, etc., and then filling in around the circles with black ink, as shown. This is then cut out and glued in place in the cockpit.

A *joy stick* can be sandpapered down from a match or balsa stick, and set in a small hole made in the floor of the cockpit. The *seat* is made of two pieces of $\frac{1}{16}$" or $\frac{1}{32}$" sheet balsa. Cut the seat out and bend a piece of balsa to fit its back curve. When dry, this is shaped and cemented in place. Three balsa sticks are cut for legs and cemented in position to the under side of the seat. The *rudder bar* is cut from sheet balsa, as shown.

When assembling these parts in the cockpit, the rudder bar should be attached first. This is placed in front of the instrument board and in the center of the floor board. It is pivoted on a model pin thrust through its



INSTRUMENT BOARD



JOY STICK

SEAT

RUDDER BAR



ASSEMBLED COCKPIT

FIGURE 87. COCKPIT ACCESSORIES

center, as shown. This is followed by the instrument board, which is glued into position.

The seat should be painted before it is placed in the cockpit. As the majority of these are made of aluminum, give it two coats of aluminum paint. When dry, apply cement to the ends of each leg and also to the back. Place in position, and press the back of the seat against the back wall of the cockpit. The joy stick is added last. This may be painted black, brown, or white, as you wish. It is then placed in a shallow hole cut for it halfway between the edge of the seat and the instrument board. Make this hole in the floor board in line with the pin of the rudder bar, coat the end of the stick with cement and hold in place until dry. *Cushion seats* can be added for passenger planes, if you wish, by cutting cloth and gluing it to the seat bottom.

Study the assembled cockpit, as shown in Fig. 87, so that no mistakes will be made when assembling is done. If an additional touch is desired, the sides and floor of the cockpit may be painted any natural wood finish, or if the plane is metal, a coat of aluminum paint will give a realistic effect.

Windshields of various designs can be made from isinglass or sheet celluloid. The former is recommended. Most windshields do not require an edging, but when this is necessary one should be shaped from $\frac{1}{64}$" split bamboo which can be glued to the edge of the isinglass or celluloid. (See Fig. 88, "Cockpit Edging.")

MISCELLANEOUS. In Fig. 88 will be seen a number of interesting model accessories. Ideal *head rests* may be made from an upholstery tack, as shown. *Exhaust pipes* are easily made from soda straws cut to length, or if they require painting, short lengths of brass, copper, or aluminum tubing may be used. With the advent of *corrugated* metal planes, many builders have experienced trouble obtaining realistic effects. If balsa wood has been used, a strong comb can be used to get the corrugated effect of metal. Place a straight block of wood against the fuselage, and using this as a guide for straight lines, press the teeth of the comb into the soft balsa as it is drawn over the surface. The model is then painted with aluminum paint.

The *edge of cockpits* can be given a finished appearance by adding spectacle tubing, which can be purchased at any optician's shop. Cut a straight line along its length severing the tubing on one side. Apply cement to the inside of the tubing and force it over the edge of the cockpit. (See Fig. 88.)

BOMBS. Bombs are cut from balsa blocks and small fins of paper are cemented to their ends, as shown. From No. 5 or 6 piano wire, bend a small hook and cement it to the bomb as its balancing point. This is then hung

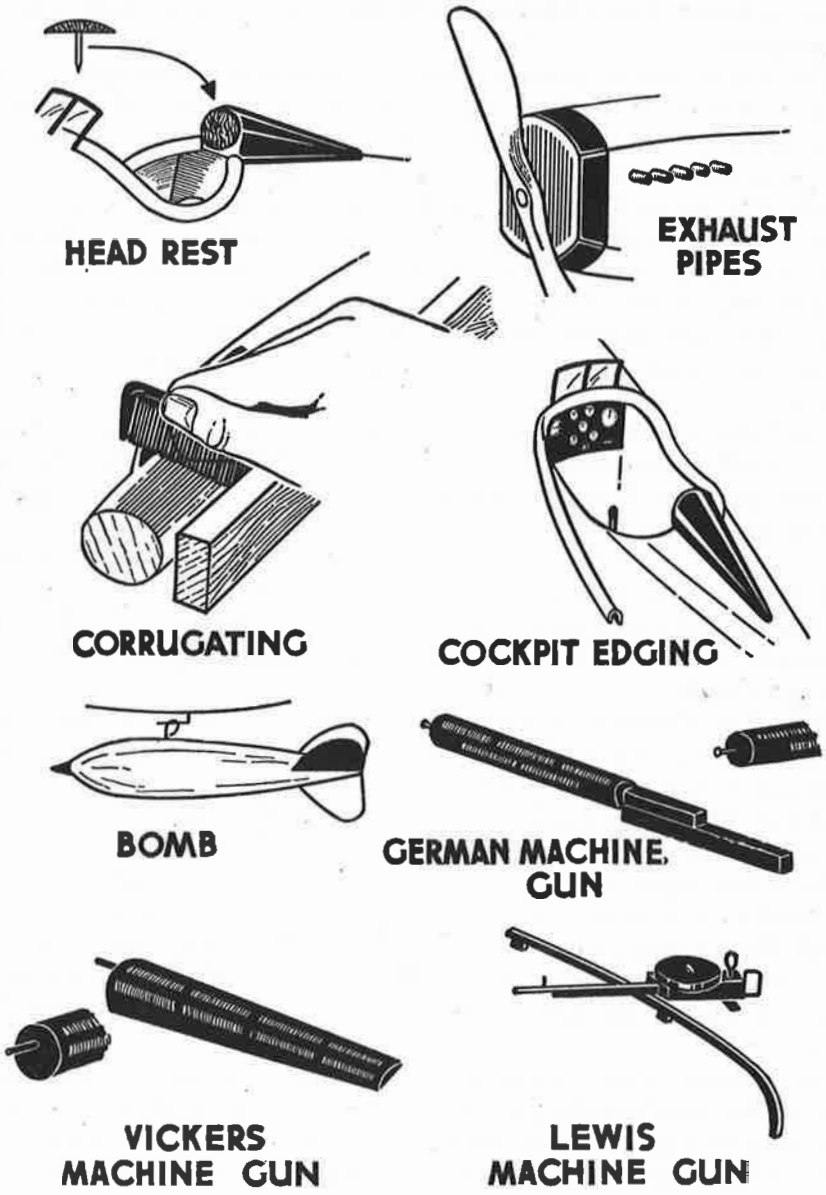


FIGURE 88. MISCELLANEOUS ACCESSORIES

on a small hook of the same wire cemented to the center bottom of the fuselage. When the plane climbs, the hook holds the bomb in place, but when it dives, the end of the holding hook points down and the bomb slides off. A model pin can be thrust into the nose of the bomb to act as a weight. The head is cut off, allowing the pin to protrude about ¼".

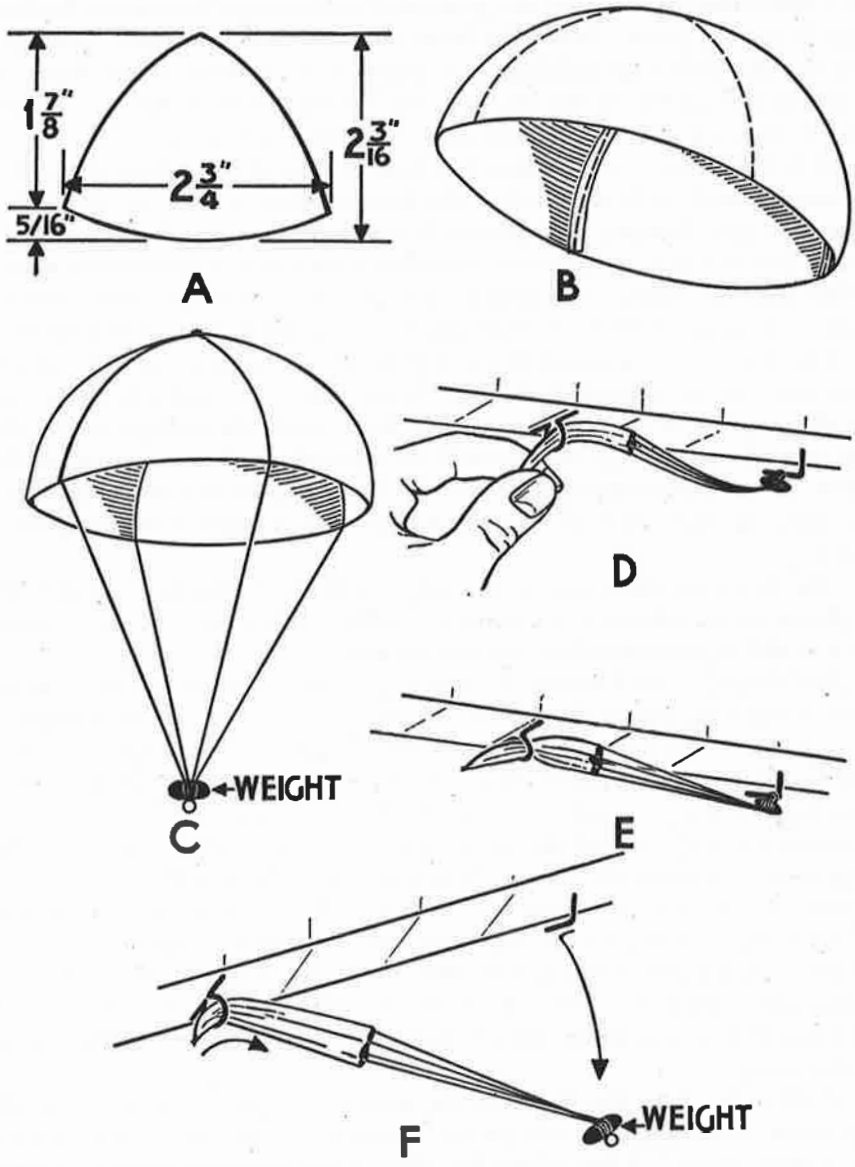
MACHINE GUNS. The three machine guns shown represent those most commonly used on War models. The German gun is used on all Fokker, Albatross, and Rumpler War planes. It is constructed of two pieces of balsa wood. The first piece is the barrel to which is cemented a standard to hold it off the fuselage. Small ventilation grooves are cut around the barrel, and the entire gun painted black. A small pin is used as the barrel, as in Fig. 88.

The Vickers gun consists of a round length of balsa wood with ventilation slots cut at intervals around it. A pin barrel protrudes from its end. As the majority of these guns extended from inside the cockpit to the outside top of the fuselage, they should be tapered, as shown, to obtain this effect. When cemented to the top of the fuselage just in front of the cockpit, they appear to pass through the top into the cockpit. They are painted black.

The Lewis machine gun is the father of them all. On some models this is placed in the observer's or gunner's cockpit. When used in this position on a model, it is mounted on a swivel mount.

For the S.E.5 in Chapter 49, the Lewis gun is mounted on a swivel mount extending from the top of the fuselage in front of the cockpit to the top of the upper wing. See the photographs of this model. A small square length of balsa wood represents the stock of the gun, while another cemented to it at an angle is the handle grip. A round piece of sheet balsa is cemented to the top of the stock to represent the bullet drum, and two large pins represent the barrel. A piano wire sight is added, and a wire handle on the end of the stock is used for directional handling. Another wire handle is added to the top center of the drum, completing the gun which is then painted black. The swivel is made of split bamboo, bent to form, and cemented to the top of the fuselage and the top of the wing with small elevation blocks placed under it to keep it raised off the surface of the wing.

PARACHUTES. Fig. 89 shows the making and attaching of a workable parachute. Four Japanese silk pieces, shown in A, are cut to shape. These are called "gores." Their edges are then sewed together with a running stitch, as shown in B. Silk thread should be used for the sewing as well as the shroud lines. The shroud lines are those running to the weight from the parachute.



MODEL PARACHUTE

FIGURE 89

These lines should be equal in length, meeting directly under the peak of the parachute, where they are tied to any weight sufficient to create a fall. BB shots, small dress weights, or any other type of weight can be used, as shown in C.

A unique method of assembling the parachute to the model is shown in D. A small length of piano wire is bent and attached to the under side of the fuselage or motor stick, so that its protruding portion will be parallel to the fuselage. Another piano wire part is then bent something on the order of a can hook, as shown. This should be just large enough to allow the parachute to be pulled through it, as shown in E, while the weight is attached over the first wire by means of a small wire loop made around the parachute weight.

While the model is flying level or while it is climbing, the apparatus will stay in the position as in E, but when the model glides down, the weight will slide off its hook and pull the silk through its hook, which will open the parachute, as shown in F. When assembling the model, hold it in the hand and point the nose down. If the assembly is correct, the weight will leave its hook, drag the silk through the forward hoop, and fall.

Every builder of exhibition models should have a number of dealers' catalogues handy, so that he can be familiar with the various accessories offered. These can then be copied and made by the builder or bought from dealers.

CHAPTER 16

THE ART OF FLYING MODELS

WHILE the builder may have designed and constructed an excellent flying model, there still remain four important steps to master before he can hope to make it fly to the best of its ability. These are proper wing adjustment, tail unit inspection, winding, and launching.

If the wing of a flying model is not correctly located on its fuselage, the model will stall or dive, either of which is disastrous to good flight. If the rudder and elevator are not perfectly straight and correctly located, the model may fly straight when circular flight is desired, or it may stall, dive, fly one wing low, side-slip, or do any number of undesirable things, any of which may ruin its flying possibilities.

If its motor is wound too much, the rubber will break, or if too few winds are given it, the motor will fail to give the propeller its maximum number of turns, which will cut down the model's endurance or speed in the air. The last of these four steps is one often given the least attention and yet it often proves to be the most important. If a model is poorly launched, its chances of a good flight are greatly lessened. As in real flying, the most ticklish and important part of any flight is the take-off, so do not handicap your model by a careless launching.

GLIDING METHOD OF WING ADJUSTMENT. The importance of proper wing location cannot be stressed too greatly. The wing location on a model can be found through an application of aerodynamics, as is done in real planes, but that would require such an amount of calculation for each model that the builder of today relies on the gliding method for obtaining this information. Its results are sure, while its method is simple.

When a model is being given this test, it must be complete with propeller and motor. If any accessories, such as bombs, parachutes, etc., are to be carried in flight, these, too, must be attached in place on the model before it is given the gliding test.

The model is then held between the fingers of the right hand at approximately its balancing point, with its nose pointing slightly down. It is launched with a slight forward motion of the forearm, and its performance

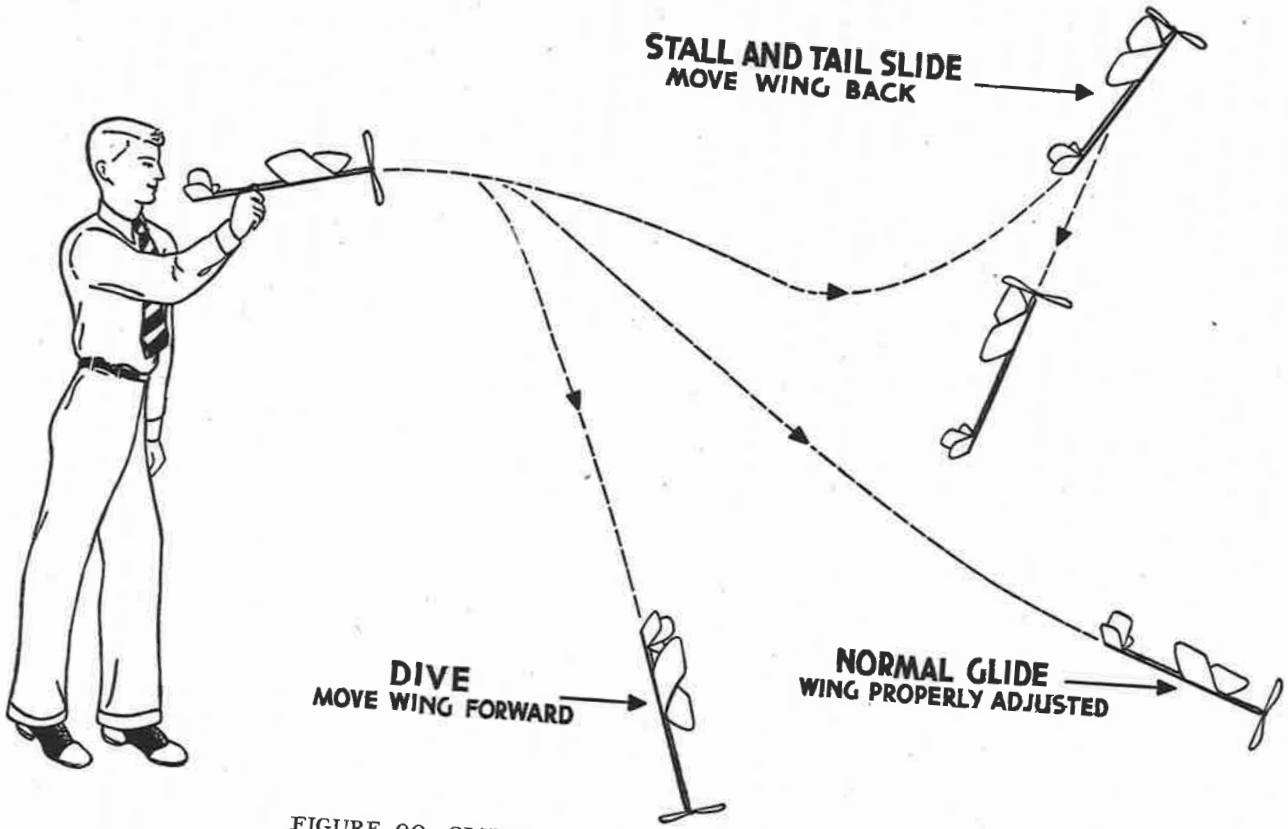


FIGURE 90. GLIDING METHOD OF WING ADJUSTMENT

carefully noted. In Fig. 90 are shown the three possible results of this test. If the model stalls, it indicates the wing is too far forward and must be brought back along the fuselage. After each adjustment, the model is again glided. If it should dive, the wing is too far back and must be brought forward along the fuselage. When a long, even, straight glide has been obtained, the wing location is correct. Mark the point on the fuselage. This mark will enable the builder to find the correct location quickly after the model has been dismantled, or in case it should strike an object in flight and its wing fly off. It is sometimes found that a new elevator or rudder, or a repair to a motor stick, will make a great difference in the location of the model's wing, so the model should be tested each time it is to be flown. Study Fig. 90 carefully and memorize its details, so that the adjusting of a wing becomes second nature.

TAIL UNIT INSPECTION. The elevator and rudder, which the author refers to as the model's tail unit, require attention before flight. On speed models, where straight, fast flights are required, inspect the rudder to see that it is perfectly straight in line with the motor stick, top stringer of the fuselage, or an imaginary line running fore-and-aft through the center of the fuselage. The elevator must be inspected to see that it forms right angles with the rudder, and that its main spars, if straight, are at right angles with the motor stick.

If the model is an indoor flyer, its rudder must be offset, as shown in Chapter 33, or, if a boom is not used and the rudder is attached directly on the motor stick, it must be slightly warped to one side, so that the model will fly in circles. Indoor models must be made to fly in circles, or they will travel the length or width of the room, strike a wall, and crash. As the rudder twist is increased, the circles of flight will become smaller.

If balsa and tissue construction has been used, breathing on the rudder will soften the structure enough to allow it to be bent a slight amount each time. If a heavy construction is used, the bend in the rudder must be built in.

WINDING. There are two methods of winding a motor. For models carrying light rubber, the hand method is used, but for all contest models, twin-stick pushers, and all others carrying heavy motors, a winder is used.

HAND WINDING. Hold the model in the left hand and with the right index finger twist the propeller around in the opposite direction from which it turns when in flight. The usual right-hand propeller turns clockwise when viewed from the rear, so it must be wound in the opposite direction, or counter-clockwise. Many methods have been propounded to calculate the breaking point of rubber motors, but none of these calculations can

be counted on at all times. For this reason, the author recommends the winding of rubber by feel alone. When the rubber feels as if it had no more elasticity left, cease winding. Do not be afraid of breaking a few rubber motors, as it is in this way only that the proper feel of rubber can be learned.

WINDERS. These may be purchased from any model supply house, or they can be easily made. If purchased, the handle of the winder can be improved by adding a pistol grip, as in Fig. 91. Two wood sides are cut

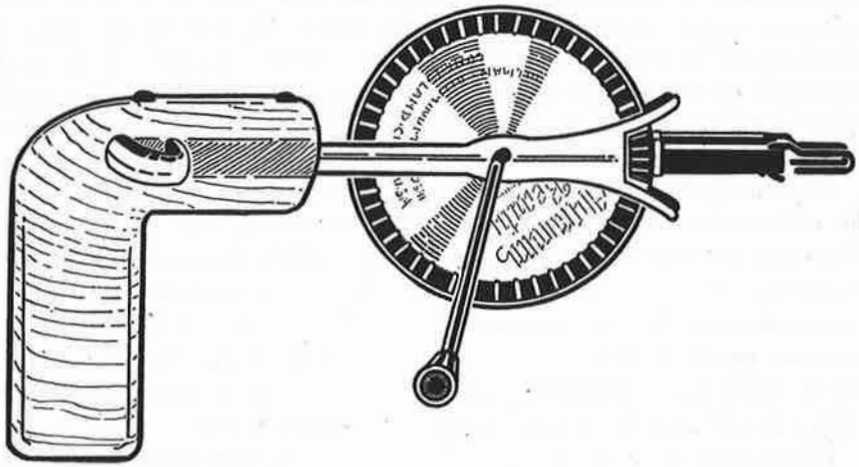


FIGURE 91. COMMERCIAL WINDER WITH HOMEMADE PISTOL GRIP

to shape and fitted to each side of the original handle. These are nailed or cemented together, and wood filler is used to fill in the wide space between the handle and the pistol grip. The assembly is then sandpapered until perfectly smooth. The handle can then be stained, painted, or left the natural shade of the wood.

The home-made winder, while not as strong as the manufactured article, is, nevertheless, strong enough for all average winding purposes. An egg-beater from your nearest five-and-ten-cent store can be quickly converted into a perfect winder, as in Fig. 92. With a hack saw, cut the extensions of the beater, as in A. The center core rod of each of these extensions is cut shorter than the stirring arms, as seen in B.

Two holes must now be drilled. These are drilled through the stirring arms close to their ends and must be the same diameter as the core rod, as in C. The ends of the stirring arms are bent over so that their holes fit over the end of the rod, as in D. The end of the rod is now flattened with a

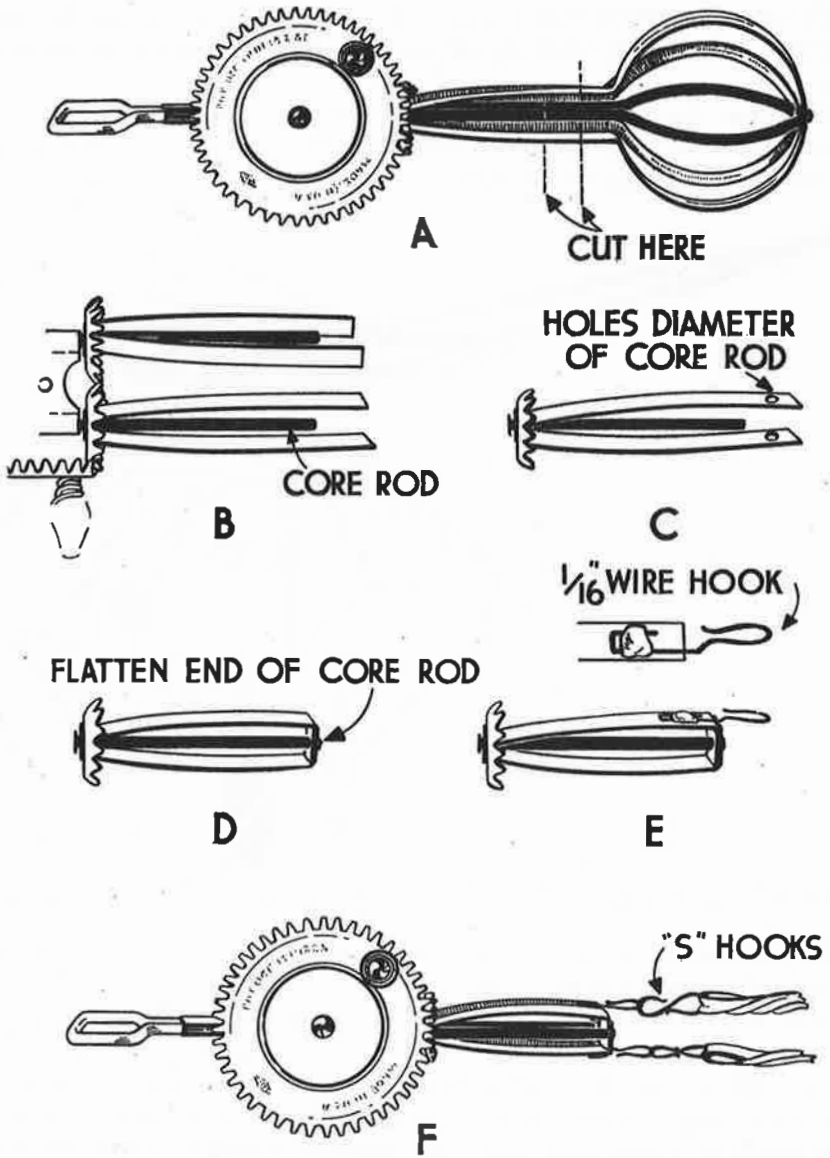
ball-pein hammer, or the arms are soldered in place on the rod. While C, D, and E show only one extension assembly, both of these extensions must be treated in the same way. Hooks are bent from 1/16" diameter wire, and soldered to the arms of the extension assemblies, as in E. Bend these two hooks, as shown in the enlarged illustration, and solder them in place, one on each extension arm. If you have no soldering outfit, your nearest carpenter, roofer, or hardware store will be able to do this for you.

The completed winder is shown in F. The great advantage of such a winder is that it can wind twin motors at one time, and insure both motors having an equal number of turns. It can also be used on single motors by attaching the hook of only one extension arm. As the two arms of the winder rotate in opposite directions, they are especially adaptable to twin pusher motors whose propellers turn in opposite directions. (See Chapter 9, "Right and Left Hand Propellers.")

To obtain the maximum number of turns possible in a rubber motor, the rubber should be stretched while being wound. For ordinary use, a motor can be stretched four times its own length. In other words, if the strands were 12" long, they could be stretched to 48" long and then wound. For contest work, where every second counts, this could be increased to 60" with the motor used here as an example, or five times the motor strand length. Stretching rubber beyond that point is not recommended, as the rubber quickly reaches a point where its elasticity is lost.

When using a winder, two people are required. One holds the propeller shaft while the other handles the winder. The process is simple. Measure the length of your rubber strands. Unhook the rubber from its end hook, while your friend holds the propeller shaft firmly in his hand. Walk away from him a distance of four or five times the length of the strands, stretching the rubber as you proceed. Attach the rubber to the winder with the usual "S" hook. When reaching the proper distance, start winding the rubber, slowly walking toward your friend as you wind. Some experts prefer to wind the motor tight, then take a step toward their holder, wind again, take another step, and so on until the motor is fully wound.

This is all right for the expert but is not recommended to the novice. When the motor feels as if it could not stand another turn, stop winding! The end of the motor is then transferred from the hook of the winder to the end hook, while the propeller is carefully held. The model is then ready for launching. Always wind a rubber motor just before flight, as wound rubber quickly becomes "dead" when left under strain. Rest the rubber at least ten minutes between flights, so that it will have a chance to



EGG-BEATER WINDER

FIGURE 92

regain its energy. Many builders favor the prewinding of a motor. By "prewinding" is meant the winding and running of a motor before actual flight tests.

It is true that second windings are usually the most efficient, but as a model should be tested by actual flight just before being used in contests, the necessary winding of the motor for this test will serve quite as well.



FIGURE 93. CORRECT LAUNCHING OF ENDURANCE TWIN-PUSHER

When prewinding a motor, never give it its full amount of turns. Save this for the judge's stop watch!

LAUNCHING. Every model requires individual launching. There can be no set rules governing all models. By this, we mean that each model will present different problems when being launched. Some models will prove best when facing a wind, others will give their best performance when no wind whatever is noticeable, while still others will show best with the wind on their tails. Some models must be launched slightly down, others with one wing slightly up, while still other models require other and different treatment.

The builder must determine the idiosyncrasies of his model by repeated

launching, but there are certain fundamental laws governing every model launching which he should learn.

CORRECT LAUNCHING OF ENDURANCE TWIN PUSHERS. In Fig. 93 is shown the most common position used for launching a twin-stick pusher. The thumb and index finger of each hand grasp the beams of the A-frame just in front of the propellers which rest in the palms of the hands, as shown. This keeps the propellers from moving, and allows the launcher to release his model by simply opening his fingers. The model is held with its nose slightly raised and the propellers parallel with the ground.

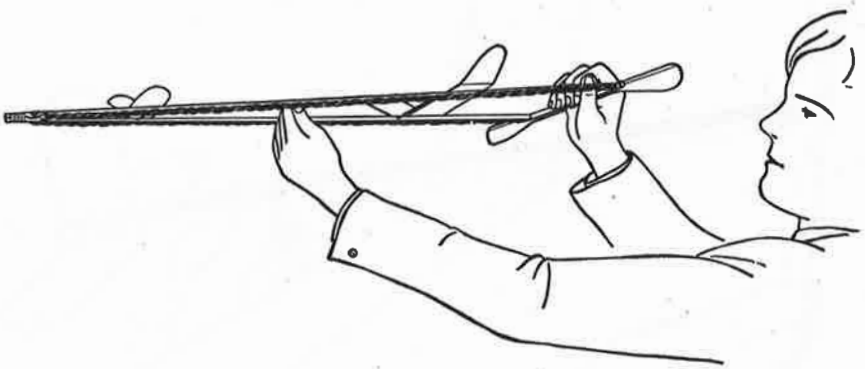


FIGURE 94. CORRECT LAUNCHING OF SPEED TWIN-PUSHER

The majority of builders launch their models from a position above their heads, but this is a question of choice. Some prefer to launch near the ground, getting down on one knee to do so, but this method is seldom used. The position shown in the illustration is the most popular today, but each builder should decide this question for himself from actual trials with his model.

The greatest consideration in launching a twin pusher is to be sure that both hands are released simultaneously, and that if any forward push is given the model, both hands are brought forward with equal strength, so that the model will not be launched with one propeller ahead of the other.

CORRECT LAUNCHING OF SPEED TWIN PUSHERS. Without a doubt, the most difficult model to launch properly is the speed twin pusher. In the first place, its propellers have been wound by such a strong motor that real strength is required to hold them before launching. In the second place, the action of a speed model is that of a bullet rather than an airplane, so that it will travel in a straight line in the direction in which it is

facing when launched. Nothing can change its course. Wind currents have no effect on such a model, so the secret of launching a speed plane is to be able to hold its propellers and at the same time launch it in a dead straight line. This requires a hold on the propellers that can be released without jarring or moving the model. Fig. 94 shows the proper way to launch such a model. The hand is doubled loosely around the rear brace

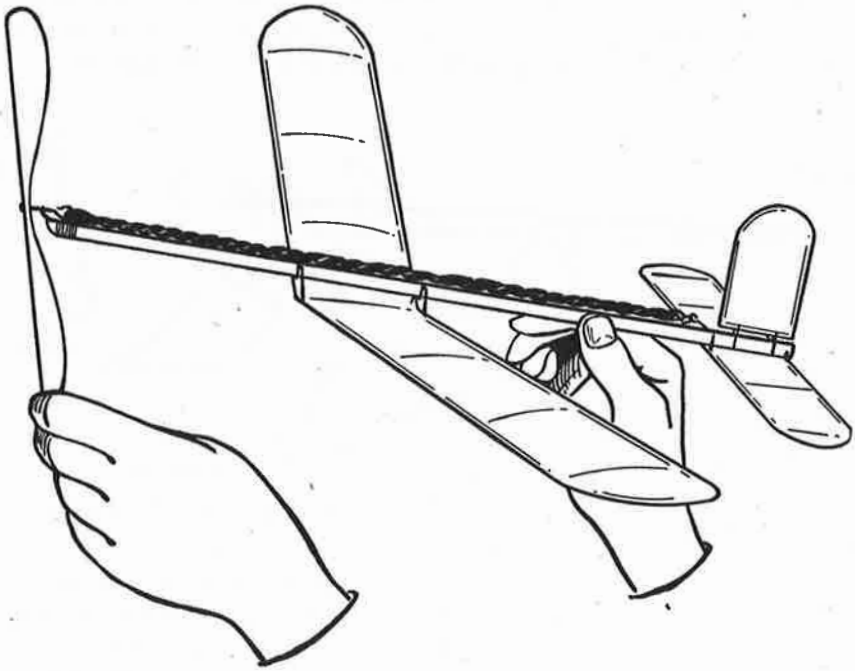


FIGURE 95. CORRECT LAUNCHING OF SINGLE STICK TRACTOR

of the A-frame, with the inner blades of the two propellers held in the palm of the hand, which is pushed against the brace. The other hand holds the model by its forward brace.

The model is then raised to eye level, so that the launcher can aim it at a distant point and at the same time see that the A-frame is perfectly parallel with the ground. When ready to release, the right hand is quickly opened wide, which releases the powerful propellers, and the left hand is dropped, sending the model on its arrow-like dash down the course. The builder must remember that he is holding in his hand a model capable of traveling a mile a minute, which is the speed that won the famous Barney Oldfield his reputation as a dare-devil automobile racer. You are not strapped into

a seat with a powerful motor in front of you and four great wheels to carry you along, but actually holding in your two hands a machine that is able to break half the world's records in the days of that famous racer.

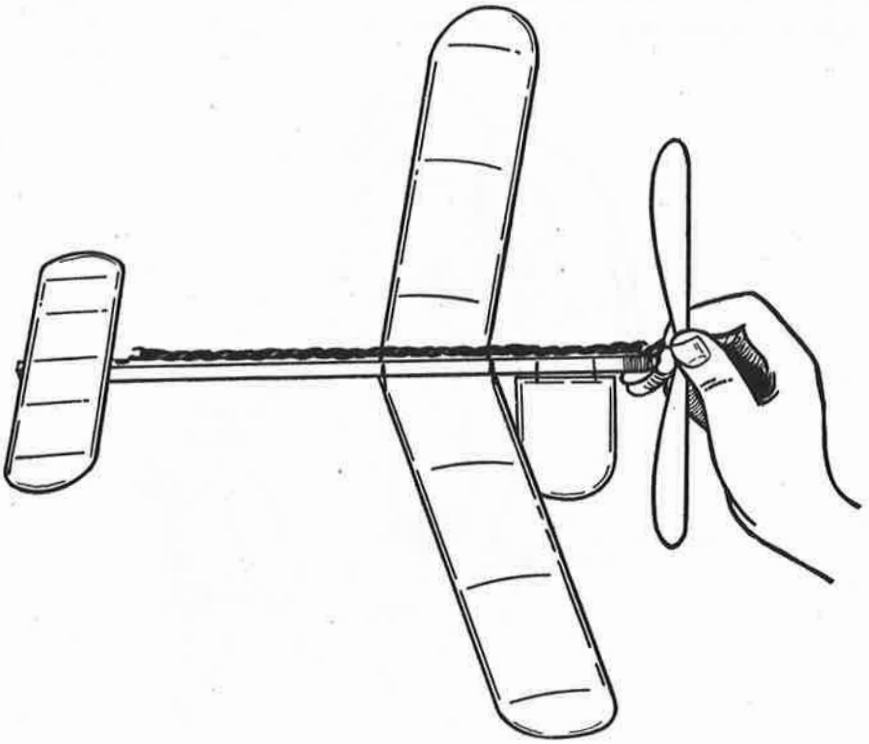


FIGURE 96. CORRECT LAUNCHING OF SINGLE STICK PUSHER

It is capable of producing a speed equal to the Twentieth Century Limited, so be careful!

CORRECT LAUNCHING OF SINGLE-STICK TRACTOR. When launching a single-stick tractor, the left hand holds the tip of one of the propeller blades, while the right hand holds the stick between the main wing and the elevator with finger and thumb. This is shown in Fig. 95. The model is given a slight forward push with the right hand, while the left releases the propeller. Such models may be launched with their nose slightly tilted up, or the entire motor stick can be held parallel with the ground.

CORRECT LAUNCHING OF SINGLE-STICK PUSHERS. Single-stick pushers, if small, can be easily launched with one hand. Hold the hub of the

propeller between the thumb and index finger, which should also extend over the propeller bearing, as shown in Fig. 96. The middle finger rests under the motor stick and supports it. The launching consists of bringing the forearm forward and releasing the model. If the model is a large one, the left hand should be used to steady and support it at the front. Place the



FIGURE 97. CORRECT LAUNCHING OF R.O.G. MODEL

thumb and forefinger under the motor stick between the main wing and the elevator, and drop the hand away as the model is released by the right hand.

CORRECT LAUNCHING OF R.O.G. MODEL. In Fig. 97 is shown the correct position for launching any rise-off-ground or rise-off-snow model, whether it is a stick or fuselage model. The launcher gets down on one knee, places his left thumb and index finger over the tip of one blade of the propeller to keep it from turning. The right hand holds the trailing edge of the rudder in the same manner. No forward motion should be applied to an R.O.G. or R.O.S. model. It should simply be released, whereupon it will race across the ground and rise on its own power. The danger of applying forward motion to such a model is that the force may not be perfectly centered, in which case the model will start with one wing low

or in another direction than that desired. Giving forward motion to such a model while on the ground causes more "ground loops" than anything else.

Another interesting method is shown in Fig. 98. This is especially good when racing with R.O.G. or R.O.S. models. Instead of holding the tip of



FIGURE 98. NOVEL METHOD OF LAUNCHING R.O.G. MODEL

the propeller, the tail of the model is raised sufficiently to allow the tip to touch the ground, which keeps it from turning. When ready to launch the model, simply drop the tail to the ground. This releases the propeller and the model is launched.

The reader must remember that these facts on the launching of models are gained through experimentation only, and that in this manner he, too, must learn and constantly improve until perfection has been gained.

GLIDERS

CHAPTER 17

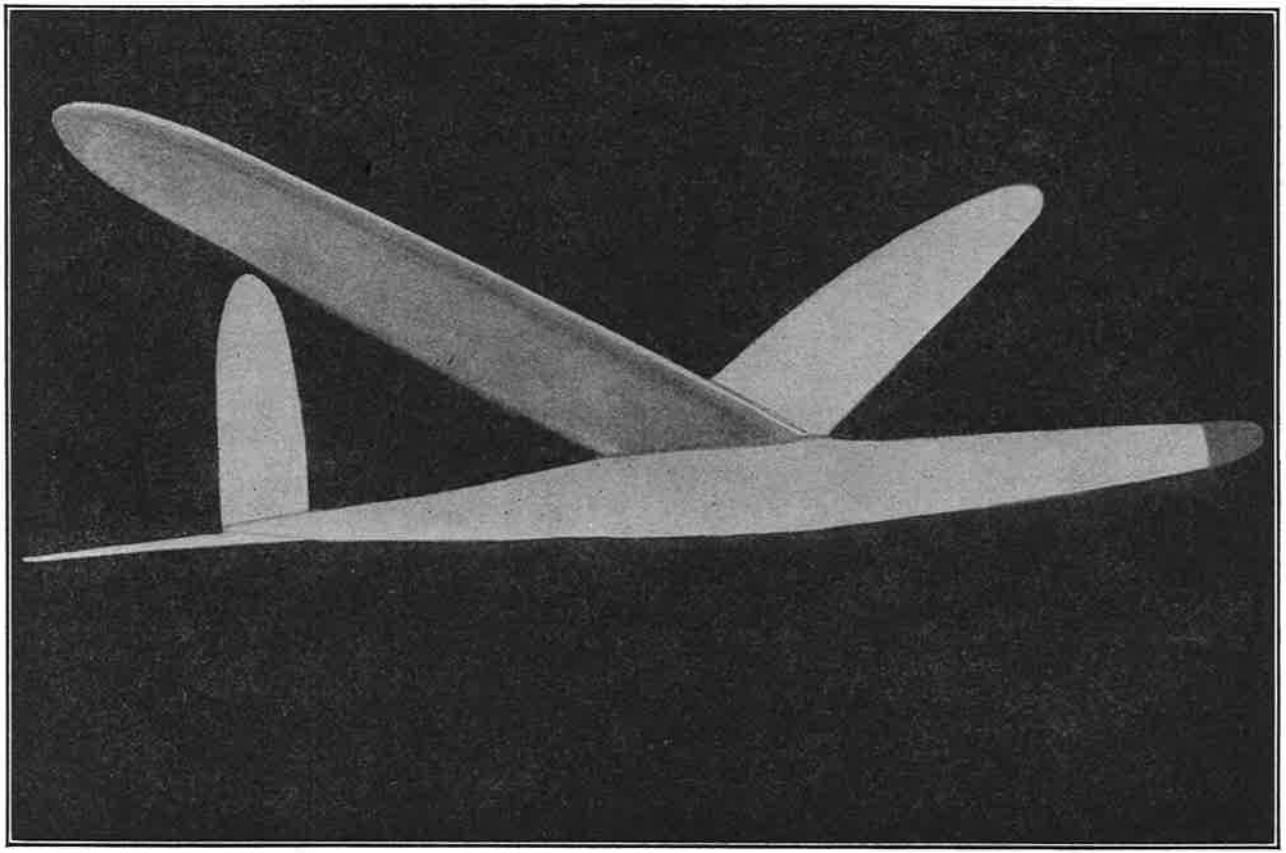
CHAMPIONSHIP SOLID BALSA GLIDER

IF records mean anything, here's the champion of champions in the all-balsa glider class. Designed and built by Louis Milowitz, it has made official and unofficial records surpassing anything of which the author has yet heard. The best performance it has been known to give took place in the Bronx, New York, where it was timed in the air for thirty minutes before flying over the Harlem River and out of sight. Official records show that it was clocked four minutes out of sight to win the 1935 Junior Birdmen Novice Contest, and that in a high wind under adverse conditions it flew for forty-seven seconds to win the New York City Park Department Contest. Later in the same contest it flew three minutes out of sight and was later found on the roof of one of New York's skyscraper hotels. Here is a glider you can't afford to miss, so get busy, build it, and when the next glider contest comes along you'll go home with the prize!

MATERIAL LIST

1 pc.—1/4" x 3/4" x 18" long—Sheet Balsa (Fuselage)
1 pc.—1/16" x 2" x 12" long—Sheet Balsa (Tail unit)
1 pc.—1/8" x 3" x 18" long—Sheet Balsa (Wing)
Banana oil
Colorless cement
Sandpaper

FUSELAGE. The fuselage is carved to shape from a single sheet of balsa 1/4" x 3/4" x 18" long. Study the accompanying plan. In the side view shown at the bottom of the plan are three cross-sectional views of the fuselage. These are "A-A," "B-B" and "C-C." It will be noted that at "B-B" the full width of the fuselage is kept, while it tapers off toward both ends. Square up the sheet balsa to 1/4" x 3/4" x 17 1/2" long. Make a full-size drawing of its outline on paper. The part that is kept 3/4" wide is the wing location. This begins 5 1/2" back from the nose and continues for 3". Start at this point, which is 8 1/2" back from the nose, to work out your drawing. Draw the slight dip just behind this point, as shown in the plan. Measure



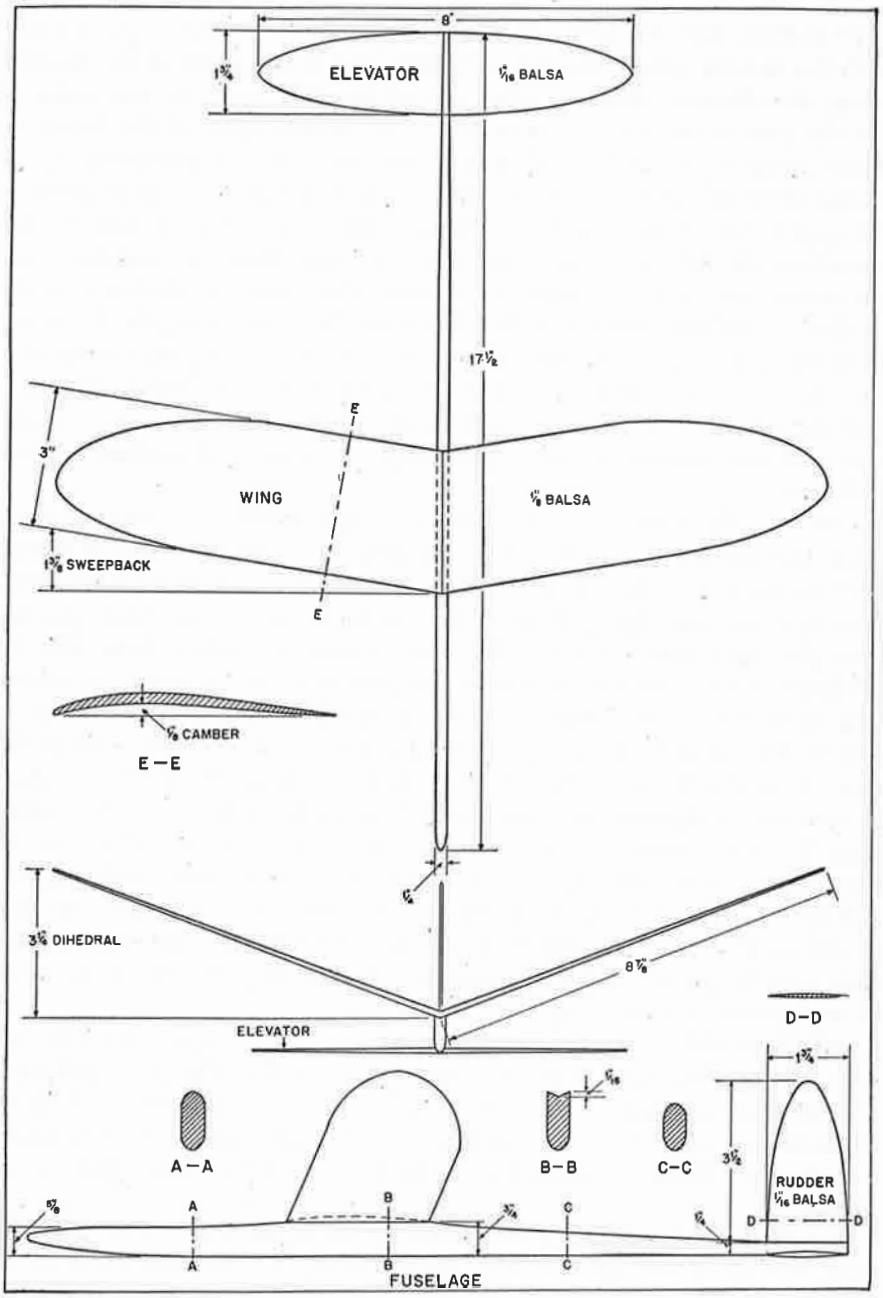
CHAMPIONSHIP SOLID BALSA GLIDER

1¾" in from the end of the fuselage. Draw a line ¼" above and parallel with the bottom edge of the layout board. This is the width of the fuselage along this distance. Join the front end of this line with the rear point of the dip just drawn by a straight line. The bottom edge of the board remains straight until within 3" of its front end, where it curves up ⅜" to form a blunt nose. Draw a slight dip from the front of the wing location on the upper edge of the drawing to the nose, which completes it. This is then traced on the ¼" sheet balsa and cut out. Note that the fuselage is cut out under the rudder location to accommodate half the thickness of the elevator. The cross-section "B-B" shows the "V" cut along the 3" of the wing location to accommodate it, and the top view of the plan shows how the fuselage tapers slightly in thickness toward the tail. When this taper and the other cuts have been made, bring the fuselage to a satin smoothness with fine sandpaper. Apply three coats of banana oil sanding between each coat.

WING. The wing is shaped from a ⅛" sheet of balsa 3" wide and 17¾" long. The tips are shaped first. The tip curves on both ends start at a point 3¼" in from the ends of the wing board along the leading edge. They start 4½" in from the ends along the trailing edge. Shape these tips and then give the entire length of the wing a natural camber. Note that the thickness of the wing tapers from its full thickness at the center to a knife edge at both tips. This taper must be given when the camber is being obtained. The camber forming an under-chamber is not given the wing at this time. Note this at "E-E." Cut the wing in half. Obtain the 1⅜" sweepback at each tip by tapering the inner end of each wing half ½" on its trailing edge. Bevel the inner ends and then obtain the necessary dihedral. Lay the wing halves in position flat on the bench. Hold their inner ends together and lift one tip 6½" off the bench. Cement the halves together and hold in this position until dry. Apply three coats of banana oil and sand between each coat for proper finish. Cement the wing in the "V" cut for it on top of the fuselage at zero degrees.

ELEVATOR. The elevator is shaped from 1/16" sheet balsa cut 1¾" wide and 8" long. Give it proper camber, as shown in the plan, and finish smooth with sandpaper. Apply three coats of banana oil and sand lightly between each coat. Cement it in place on the upper side of the fuselage at zero degrees. Test to see that it is perfectly level and at right angles to the fuselage.

RUDDER. The rudder is cut from 1/16" sheet balsa 1¾" wide and 3½" high. It is given the same form as one end of the elevator and then streamlined, as shown in the cross-sectional view "D-D." When finally sanded



CHAMPIONSHIP SOLID BALSA GLIDER PLAN

smooth, apply three coats of banana oil and sand between each coat with fine paper. Cement the rudder to the top-center of the fuselage just above the location of the elevator. Test to see that it is at right angles to the elevator.

ADJUSTING. The tips of the wing should be given a 1/8" under-chamber, as shown in the plan at "E-E." In adjusting the glider, clay is used on the nose to produce proper weight. The amount required to gain this longitudinal stability is determined by gliding it from the hand. For a right hand adjustment the glider should be made to turn to the left in a circle about thirty-five feet in diameter. This can be done by warping the trailing edge of the rudder to the left. When launching the model, it should be given an almost vertical thrust upward into the air with a slight right bank. The glider has a very slow glide which allows it to take full advantage of upward currents. Here's to hours of fun for future glider experts!

GLIDING. The secret of proper gliding is to have the weight of the model located just in front of the center of pressure. Then if the model stalls, this forward weight will pull the nose of the glider down and allow it to continue its glide. If the nose of the glider were not heavier than its tail, and the model should stall, it might drop into a tail slip which would carry it to the ground.

To prevent this a piece of sheet lead, or any other appropriate weight, is added to the nose of the model, and the builder must determine the exact amount of this weight necessary to give the best results. This is not difficult, but requires careful tests of the gliding ability of the model. If the model stalls, the weight must be increased, and if it dives, too much weight has been applied.

The builder will find that the sheet of lead called for in the material list is larger than necessary for such a model, but this has been done purposely. Adding weight to a model is far more difficult than removing it. This is true because a single piece of lead is easier to attach to the upper edge of a fuselage than two or more small pieces. So we start our trial glides with too much weight, and then slowly cut away the excess material until a single piece of the correct weight remains, which is then cemented in place.

Bend the sheet of lead so that it will fit over the top edge of the fuselage, as shown. When launching the model, do not thrust it from you with force, but allow it to leave the hand lightly. When the model dives, cut a small amount of the lead away, replace it in position on the fuselage, and relaunch. Continue these tests until the model continues in a straight path with its nose pointing slightly down in a rather fast glide.

When a long, smooth glide of this type has been obtained, give the model more force by swinging the arm forward and releasing it. If it stalls, you have cut off too much weight, which must be corrected by additional lead. If, however, the model tends to sail up, stall slightly, drop its nose into a dive, and then straighten into another glide, its action is correct, and long glides should result. When such flights have been obtained, the lead should be cemented in place.

If the glide is not straight, the builder must examine his rudder, as this is usually the cause of any turning in flight. Make sure it is perfectly straight up and down. If this does not correct the fault, the wing should be removed and given the balance test. (See Chapter 7, "Wing Assembly.")

The builder wishing a larger glider can easily build one by doubling all dimensions given in the plan, and following building instructions given in the text.

CHAPTER 18

PRIMARY GLIDER

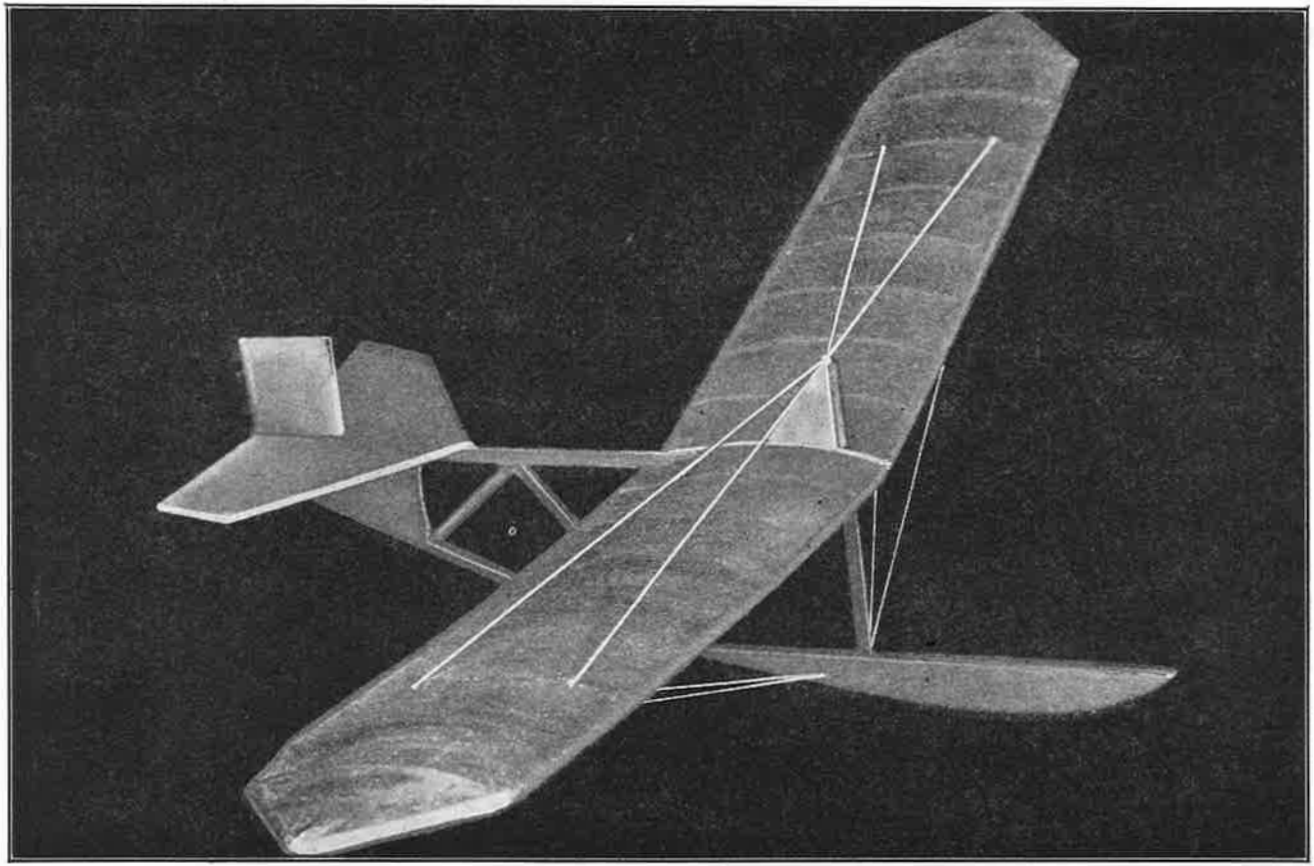
PRIMARY gliders obtain their name through the fact that they are the first on which new students learn the fundamentals behind soaring, or motorless, flight. From these, they graduate to secondary gliders and then to soaring gliders. This model is a true design of the best known primary glider. It adapts itself to the necessary small dimensions in a remarkable way, and its builder will find it a splendid performer in the air.

MATERIAL LIST

1 pc. —1/16" x 3" x 36"	—Sheet balsa for wing ribs and gusset plates
2 pcs.—1/4" x 1/4" x 18"	—Balsa for inner wing spar
2 pcs.—1/4" x 1/4" x 18"	—Balsa for leading edge spar
2 pcs.—1/8" x 1/8" x 18"	—Balsa for trailing edge spar
1 pc. —3/8" x 1 1/8" x 10 1/8"	—Balsa wood for skid of fuselage
1 pc. —1/4" x 1/4" x 36"	—Balsa for fuselage, wing tips, and fin
1 pc. —1/8" x 1/8" x 30"	—Balsa for rudder and elevator
1 1/2 sheets	—Japanese tissue paper for covering
1/2 oz.	—Colorless cement
1/2 oz.	—Dope
1 yard	—White cotton thread
Sheet lead weight	

FUSELAGE. On this type of model, the fuselage can be divided into two parts, the skid and the frame. On the 3/8" x 1 1/8" x 10 1/8" piece of balsa, trace with pencil the shape of the skid, as shown in Plan 1. This consists of the solid piece located along the bottom of the fuselage. When the shape has been traced, the piece is cut out and its edges sandpapered smooth. An edge view of the fuselage skid is shown in Plan 2. It is 3/8" thick at the front end and tapers to 1/4" thick at the end. This is also shown in the edge view, and is called for in Plan 1. Sandpaper both faces of this balsa piece until it tapers from its original thickness at the nose to 1/4" thickness at its rear end.

The frame of the fuselage is built up on the skid with 1/4" square balsa lengths. Cut your 1/4" x 1/4" x 36" length of balsa wood into the required nine pieces, which will leave enough wood to make the necessary wing tips.



PRIMARY GLIDER

Assemble these pieces to the skid, and cement each in place. Cement the four uprights to the skid, follow with the long cross piece, and then cut and cement in the diagonal cross braces. The gusset plates are added to strengthen the frame. The plates A are cut first. Draw a 1½" diameter circle in pencil on the 1/16" sheet balsa. This circle is cut out, and split into two halves. Along the straight edge of each half circle, the form of the fuselage is cut, so that it will fit perfectly in place, as shown in the plan. One of these gusset plates is cemented on each side of skid and frame upright.

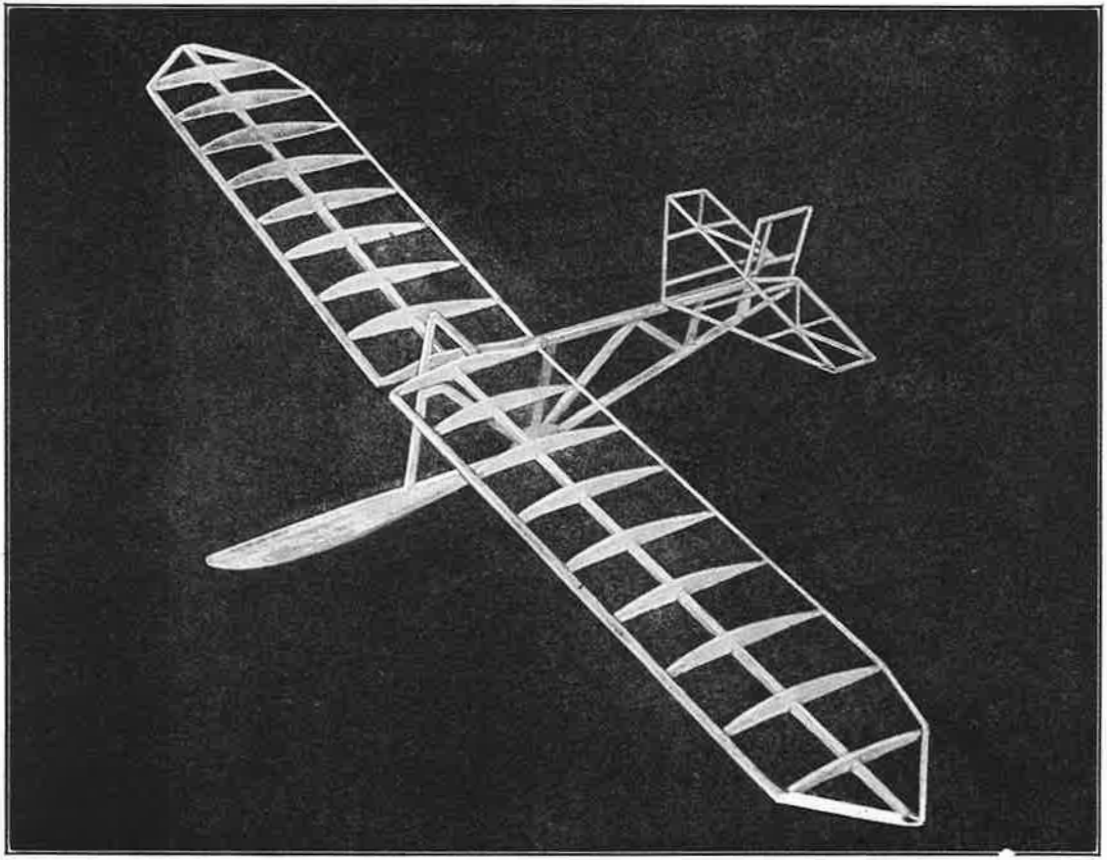
The smaller plates B are also cut from the 1/16" sheet balsa. These are ¾" wide and 1" long. Cut them out and cement one on each side of the front upright and the long top member of the frame. The assembly should dry for an hour, after which it is lightly sandpapered to remove all traces of cement.

RUDDER. As the rudder is built on the fuselage and is therefore a part of it, this should be cut and assembled at this time. It requires seven pieces of 1/8" x 1/8" balsa. Cut these pieces and assemble them in position to the end of the fuselage, as shown. Each should be carefully cemented in place, and when dry, given a light sandpapering for a smooth finish and to remove excess cement.

When assembled and sandpapered, the rudder is covered on both sides. At the same time, the frame section next to the rudder is also covered on both sides. This can be seen in the photograph of the finished model. Cut the Japanese tissue to proper shape, coat all parts the paper will cover with dope, or clear banana oil, and press the tissue in place on them. When dry, water-spray the paper, and give it a coat of dope. (See Chapter 7, "Wing Covering.")

ELEVATOR. The elevator is constructed of 1/8" square balsa lengths. As it is fully assembled before being attached to the fuselage, the builder should make a full-size working drawing of the elevator. (See Plan 2.)

Cut one balsa length 8", which forms the longest member of its frame. This is the inner spar. Place it in position on your drawing. Cut two leading edge spars long enough to extend from the ends of the inner spar to a point 3" in front of it, where the ends of the leading edge spars meet. Cement these three pieces together. A center rib 3" long is cemented in place from the center of the inner spar to the point where the leading edge spars meet. Two more ribs are cemented between the leading edge spars and the inner spar ½" on each side of this center rib. The remaining two ribs, which complete the front of the elevator, are cemented between the lead-



PRIMARY GLIDER SKELETON

ing edge spars and the inner spar. These are located 1¾″ out from the last attached ribs, and complete the front section of the elevator.

The trailing edge spars are both 3½″ long and are located 1½″ behind the inner spar. Note that each of the 1½″ ribs used on this part of the elevator are so placed as to look like continuations of the forward ribs, but that they are further strengthened by diagonally placed spars. Lay each piece in its proper position on the plan, and when complete, cement each in place.

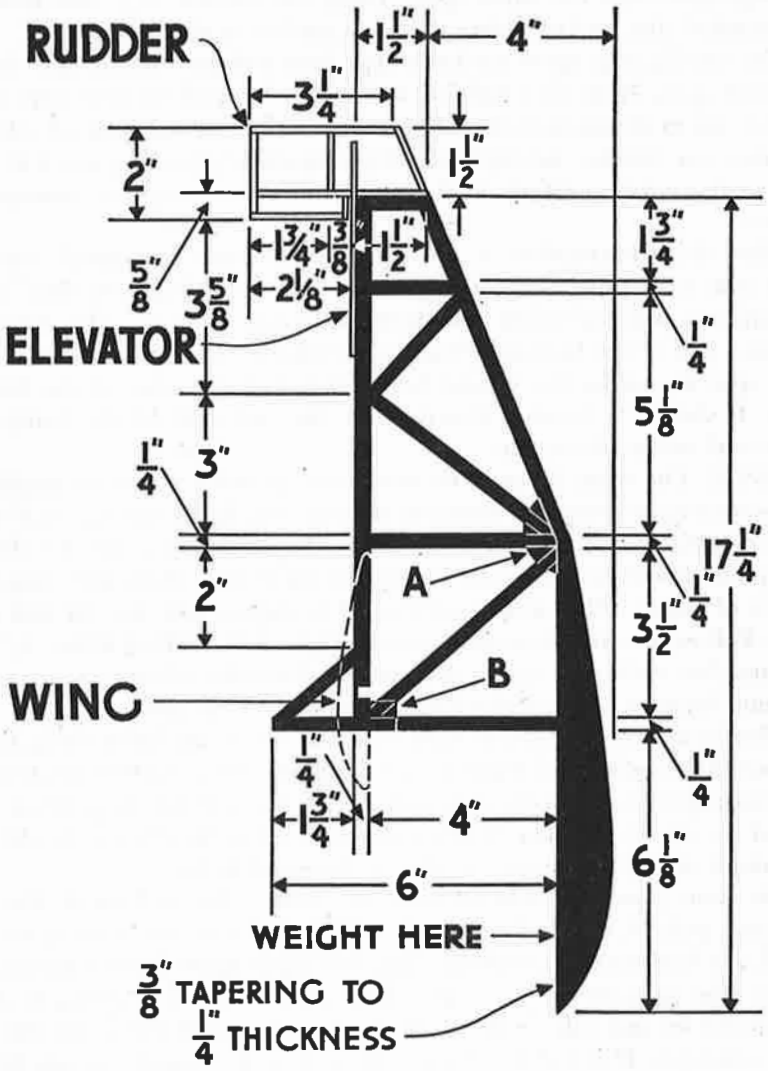
When the construction of the elevator has been completed, cover its upper side with Japanese tissue. (See Chapter 7, "Wing Covering.") Give the surface a water-spraying and then a thin coat of dope. The elevator is now attached to the fuselage. Note its position in Plan 1 and Plan 2. The inner spar fits under the rudder between it and the edge of the fuselage frame. It should be located directly over the end strut of the frame, with its covered surface facing up.

WING. The wing is made in two parts. As both are exact duplicates, these instructions cover the building of only one. From the 1/16″ x 3″ x 36″ sheet of balsa wood, cut eight A ribs, as shown in the plan. To do this, a template should be cut to the full size of these ribs. Draw ½″ squares on a sheet of paper. The outline of the rib is drawn full size on this ruled paper. Follow the outline as shown in the plan under "Wing Ribs—A," making sure that each part of the line passes through each square in exactly the same location it takes through the squares of the plan.

When completed, trace the outline of the rib on the balsa sheet, by cutting out the drawing and using it as a template. After one rib has been cut out, sandpaper its edges smooth, and test to see that its shape is an exact copy of the one in the plan. When completed, all other ribs can be cut from this master one by tracing its outline on the sheet balsa.

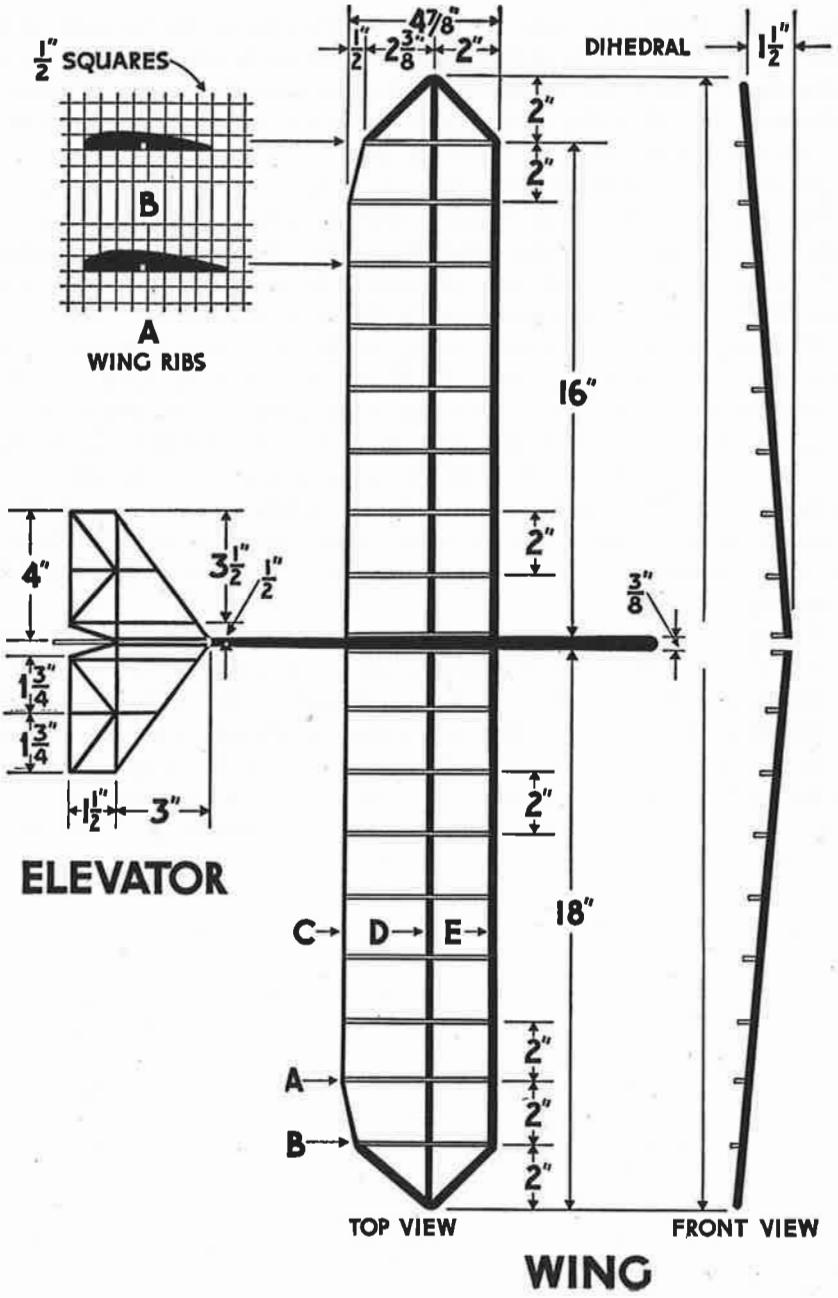
The same process should be used for cutting the end rib B. For each half wing, eight A ribs and one B rib will be required. When these are completed, the leading edge, trailing edge, and inner spars should be cut. The leading edge spar, shown in the plan by E, is ¼″ x ¼″ x 16″ long. It should be rounded on one side to carry out the front curve of the wing ribs. The inner wing spar D is ¼″ x ¼″ x 18″ long. It is left square, as can be seen from the side view of the ribs under "Wing Ribs." Each rib is notched on its straight under edge to accommodate this spar.

The trailing edge spar is cut from a balsa piece ⅛″ x ⅛″ x 16″ long. It is shown in the plan by C. Cement the eight ribs 2″ apart along the inner wing spar D. Cement the leading edge spar E to the front ends of each of these ribs. The short rib B is cemented 2″ from the last A rib on the inner



FUSELAGE

PRIMARY GLIDER PLAN 1



PRIMARY GLIDER PLAN 2

spar. The trailing edge spar is attached with cement to the ends of the eight A ribs. Note that it will require bending to be cemented to the end of the short B rib. Crack it slightly at this point, fill the crack with cement, and cement its end to the trailing end of B rib, at the same time cementing the other end of B rib to the end of E spar.

The wing tip is formed of two lengths of 1/4" x 1/4" balsa. These are cut and cemented in place. The wing is covered on both sides with Japanese tissue. (See Chapter 7, "Wing Covering.") Give the tissue a water-spraying and then finish with a thin coat of dope. This completes one half of the wing. The second half is constructed in the same manner.

The wing is now assembled on the model. Each half is fitted to each side of the fuselage frame, as shown in Plan 1. Note that the wing has a 1½" dihedral angle. To obtain this, each half of the wing must be attached to the fuselage with its tip 1½" higher than the point of attachment at the fuselage. When doing this work, hold the wing in place on the side of the fuselage frame with model pins until the exact dihedral is obtained. When in proper position, fill the crack between the inner rib and the fuselage side with cement and allow to dry for one hour. The model pins can then be removed.

To complete the model, the small forward fin just above the wing is covered on both sides with Japanese tissue, as shown in the photograph of the finished model, and then water-sprayed and given a thin coat of dope.

The landing and flying wires are added, as shown in the photograph. These are of white cotton thread. For determining the proper amount of weight, its location, and the flying of glider models, see Chapter 17. If you wish a larger model than the one given here, all measurements should be increased in the same proportions.

CHAPTER 19

GERMAN "HANGWIND" SECONDARY GLIDER

SECONDARY gliders of the "Hangwind" type are extensively used throughout Germany for instruction purposes in their many schools. After students have mastered primary gliders, they graduate to this type, which prepares them for the greatest of all gliders, the soaring sailplanes.

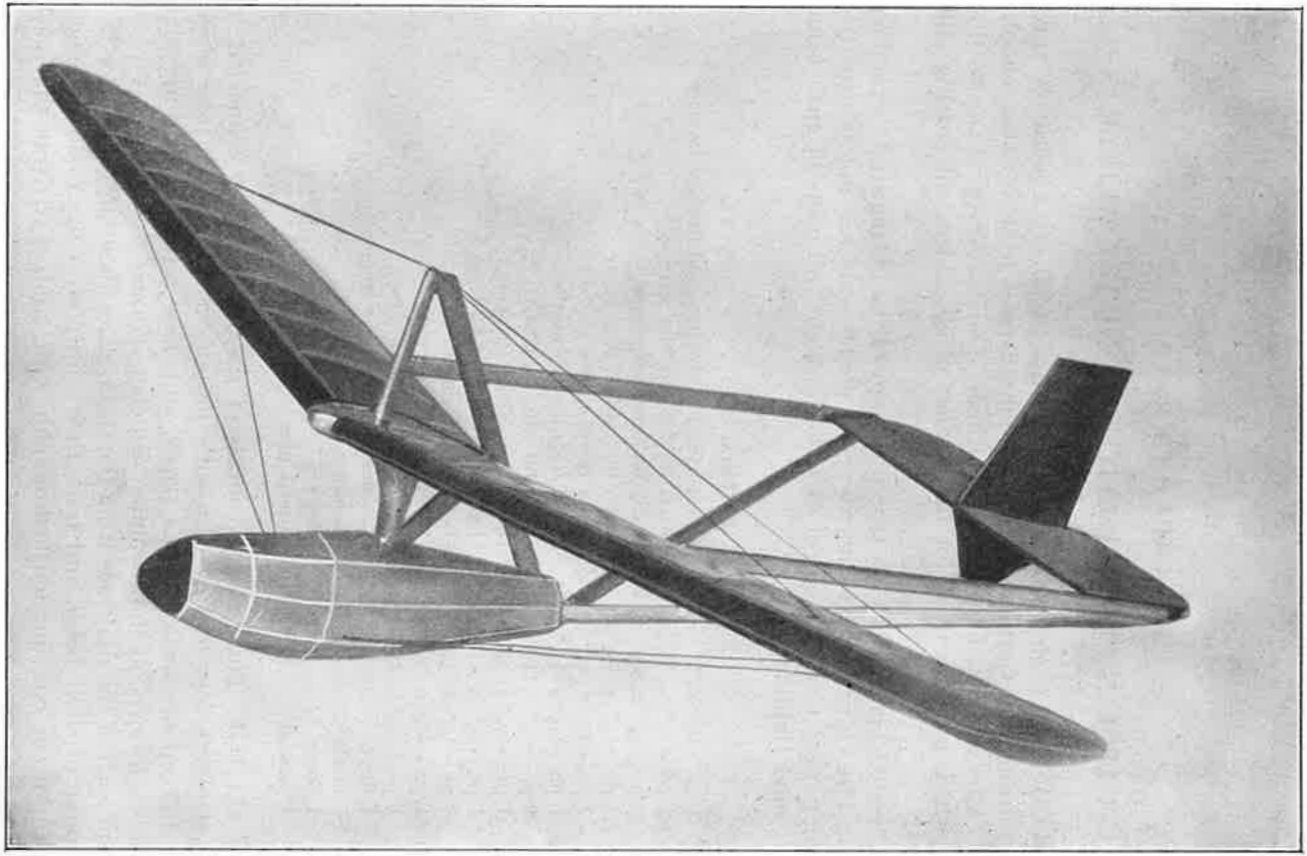
The model given here is a true scale copy of the "Hangwind" secondary glider. The cutting of its dimensions to model scale has not lessened its gliding powers. Careful study of its action in flight will prove of great value to any model builder.

MATERIAL LIST

1 pc.	1/16"	x 3"	x 28"	—Sheet balsa for wing ribs and fuselage formers
2 pcs.	1/4"	x 5/16"	x 9 5/8"	—Balsa for leading edge spars
2 pcs.	1/8"	x 1/8"	x 9"	—Balsa for inner wing spars
2 pcs.	1/8"	x 3/32"	x 8 1/8"	—Balsa for trailing edge spars
2 pcs.	5/16"	x 5/8"	x 1 5/8"	—Balsa for wing tips
1 pc.	1/16"	x 1/16"	x 24"	—Balsa for wing bracing
1 pc.	1/2"	x 1 1/4"	x 1 3/8"	—Balsa for wing support
1 pc.	1/16"	x 1/16"	x 28"	—Balsa for fuselage stringers
1 pc.	1/2"	x 5/8"	x 7/8"	—Balsa for fuselage nose block
1 pc.	1/8"	x 1/4"	x 36"	—Balsa for outriggers and struts
1 pc.	1/16"	x 1/16"	x 24"	—Balsa for elevator and rudder
1 pc.	1/32"	x 1/32"	x 8"	—Split bamboo for elevator
1 sheet				—Japanese tissue for covering
1 bottle				—Colorless cement
1 bottle				—Dope
1 package				—Model pins

FUSELAGE. The fuselage consists of six balsa formers connected by balsa stringers, four outriggers, a wing support, a mast, and a nose block. Rule 1/8" squares on a sheet of paper, and draw a full-size working plan of the six formers, as shown under "Fuselage Formers."

Cut each of the drawings from the sheet, place them on the 1/16" x 3" x 28" piece of sheet balsa, and trace their outlines on the wood in pencil. These are cut out and finished smooth with sandpaper. Note that each



GERMAN "HANGWIND" SECONDARY GLIDER

of these formers has small notches cut in them to fit the 1/16" square stringers. When cut and sandpapered, mark each with its proper number, as shown in the plan. This is done to aid the builder in locating their position in the fuselage framework. The side view of the model, shown at the top of the plan page, shows each of these formers by number.

When building any fuselage of formers and stringers, all stringers running in a straight line should be attached first, so that those requiring bending can be easily given the necessary curve by following the notches cut for them in the formers, after the formers have been given their position through the location of straight stringers.

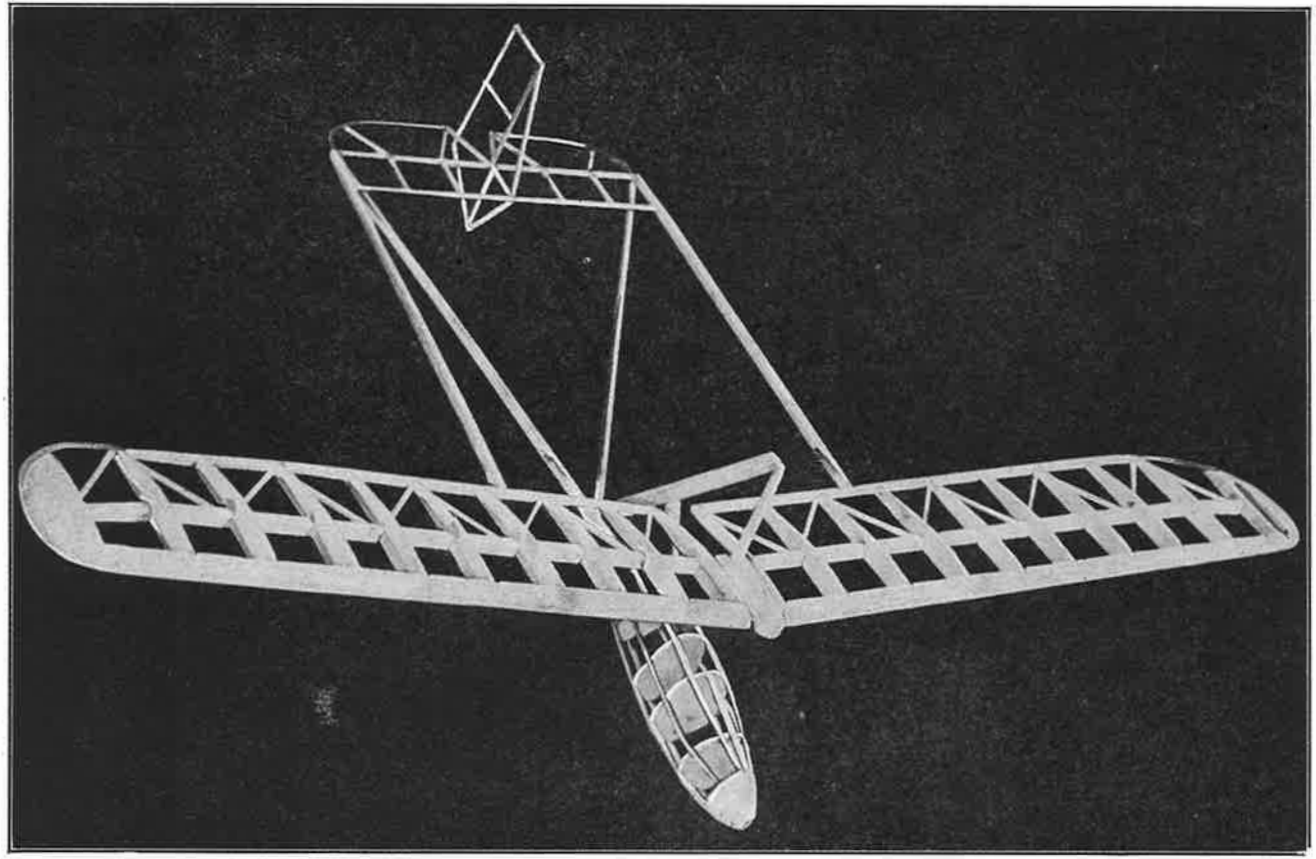
On this fuselage, only two stringers extend in a straight line. These are shown in the plan by the letter K. On the top and side view, these have been clearly marked, while the notches they fit into on the first two formers are designated on the graph plan of the fuselage formers. To start these stringers, cement the ends of two lengths of the 1/16" x 1/16" balsa into the side notches of former No. 1 shown by letter K. They are then cemented into the corresponding notches of former No. 2, which is placed 1/2" behind former No. 1. Continue cementing each of these stringers into the same notches on the remaining formers, making sure to space the formers, as shown in the side view of the fuselage.

From the balsa block measuring 1/2" x 5/8" x 7/8", shape the nose piece of the fuselage, as shown in the side and top view of the plan. This is cemented to former No. 1. The wing support is shaped and attached to the fuselage. This is cut from the 1/2" x 1 1/4" x 1 3/8" balsa block. Note its front, side, and top shape, as shown under "Wing Support." Cut out this shape, and finish smooth with sandpaper.

The top center stringer is cut just behind former No. 4 to allow the end of this support to be sunk into the fuselage 1/4". It is cemented to former No. 4 and the end of the center stringer just cut to accommodate it. The straight back of this support should be parallel to the formers of the fuselage. The mast L is 1/8" x 3/16" x 1 1/2" long and is made of balsa wood. It should be streamlined, being 1/8" at the front and tapering to an edge at the rear. This is cemented to the top of the wing support, as shown in the side view. It should form a right angle with the top of the wing support.

The brace J extends from the top, rear end of the fuselage to the top of the upright mast piece L. It is 1/8" x 1/4" x 4" long, and should be streamlined in the same manner as piece L. Cement this brace in position, as shown in the side view of the fuselage.

The brace J is further strengthened by a shorter brace running from the top center stringer, just in front of former No. 5, to a point 1 1/2" from



GERMAN "HANGWIND" SECONDARY GLIDER SKELETON

the lower end of brace J. This is 1/8" x 1/4" x 15/16" long, and should also be streamlined. Cement this piece in place, after cutting its ends at an angle to fit.

Four outriggers are cut from the 1/8" x 1/4" x 36" long piece of balsa. The two D pieces, as shown in the plan, are cut 7" long and then sandpapered to a streamline, while the outriggers E are cut 6 5/8" long and finished in the same manner. These are not assembled at this time.

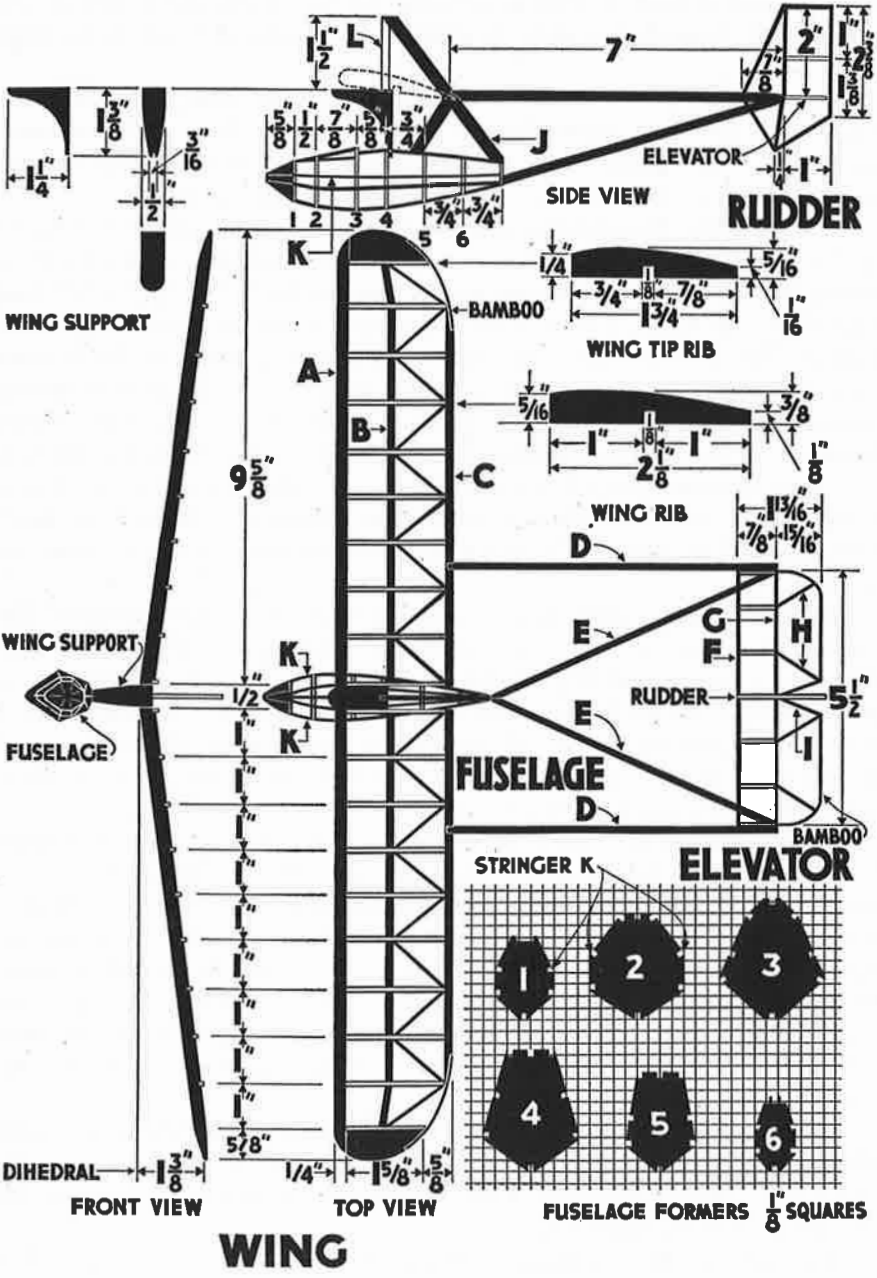
ELEVATOR. The elevator consists of a leading edge spar F cut 1/16" x 1/16" x 5 1/2" long. An inner elevator spar of the same dimensions is cut, as shown by G. These two spars are joined together by 1/16" x 1/16" x 3/4" long balsa ribs. Cut seven of these ribs and cement them in place between the leading edge spar and the inner spar G. The rear portion of the elevator is constructed of 1/16" x 1/16" x 1 1/8" balsa braces, each of which should be cemented in place and then cut to exact length. These braces are shown by letters H and I. The trailing edge of the elevator is formed from bent 1/32" split bamboo. (See Chapter 3, "Bamboo.") The elevator is covered on its upper side only with Japanese tissue. (See Chapter 7, "Wing Covering.") Give the surface a spraying with water and finish with a coat of banana oil or dope.

RUDDER. The rudder is also made of 1/16" x 1/16" balsa lengths. The trailing edge piece is 2 3/8" long, while the inner spar upright is 2" long above the elevator and 1 1/8" below it. When all pieces have been cut to proper length, assemble the rudder on the elevator with cement. This is done before covering because the rudder fits over the elevator and extends up and down from it. Cover the rudder on both sides with Japanese tissue, water-spray, and coat with banana oil or dope.

WING. The wing is made in two halves, but all parts for both should be cut and shaped before assembling takes place. Cut a pattern of the wing rib, as shown in the plan, out of tin or paper. On the 1/16" x 3" x 28" sheet of balsa wood, trace the outlines of eighteen of these ribs. These are cut out and notched to accommodate the inner wing spar B, as shown under "Wing Rib." Finish each with sandpaper. Both leading edges are now shaped from the two 1/4" x 5/16" x 9 5/8" balsa pieces. These should be made half round to carry out the curvature of the wing ribs at their front. Do this work with sandpaper.

The inner wing spar is 1/8" x 1/8" x 9" long for each half of the wing. These require no shaping. The trailing edge spars are shaped from 1/8" x 3/32" x 8 1/8" long balsa pieces. They are shaped half round to conform with the ribs at their trailing ends.

Two wing tip ribs are required, which should be cut from the 1/16" sheet



GERMAN "HANGWIND" SECONDARY GLIDER PLAN

balsa to the size and shape shown in the plan under "Wing Tip Ribs." To complete the preparation of the wing material, two sheet balsa wing tips should be cut from the two 5/16" x 5/8" x 1 5/8" balsa blocks. These are cut to the shape shown in the top view of the wing. Their inner edge, which rests against the wing tip rib, is left 5/16" thick, but from this point they taper off to an edge at the extreme end of the wing.

Each half of the wing is now assembled, and as both are done in the same manner, these instructions cover one half only. The ribs are spaced 1" apart along the inner wing spar B, which is cemented into the notches cut in the ribs for this purpose. The leading edge spar A is cemented in place along the leading end of the ribs, and this is followed by the cementing of the trailing edge spar C to the trailing ends of the ribs. At the point where the outer wing rib contacts the inner wing spar, this spar is cracked to give it the necessary bend to fit into the notch of the wing tip rib, which is cemented to the leading edge spar at its end. The inner spar is cemented into the notch cut for it in the wing tip rib at the same time.

The solid balsa wing tip is cemented to the outer side of the wing tip rib. To complete the trailing edge of the wing, a short length of 1/32" split bamboo is bent to shape and cemented to the trailing edge of the tip and to the trailing edge spar, both of which are grooved to accommodate this bamboo piece.

To strengthen the wing structure, bracing is cut from 1/16" x 1/16" balsa wood. Nine 1½" long pieces of this bracing are required for each wing half. Cut these and cement them in place to the trailing edge spar and the inner wing spar, as shown in the top view of the wing.

The second half of the wing is assembled in the same manner. Both halves are covered on both sides with Japanese tissue. (See Chapter 7, "Wing Covering.") Water-spray the wing and finish it with a single coat of dope.

ASSEMBLY. Both halves of the wing are attached to the sides of the wing support. Study the front view of the wing. Note that each half is located on the side of the wing support so that the upper surface of the wing is just above the top of the support. It should also be noted that the wing has a 1⅜" dihedral and a 1/8" angle of incidence. This latter measurement means that the leading edge of the wing must be 1/8" higher than the trailing edge. Do not confuse this wing location with the wing outline shown in the side view of the plan. The part of the wing shown in that view is connected to the outriggers, and as the wing has a dihedral angle, it necessarily is higher than the part which connects with the wing support.

Attach the wing halves to the support with model pins until the proper

angles of incidence and dihedral have been obtained, and then apply cement between the inner end of the wing and the side of the support. Allow one hour for drying.

The outriggers are now attached to the wing. Note the location of D outriggers. These extend from the trailing edge spar of the wing straight out and parallel to the top of the wing support. The inside measurement between these two outriggers is 5½". Measure 2½" from the inner end of the wing halves toward both wing tips, mark, and cement the ends of the outriggers at these points. The tail assembly, which includes the rudder and elevator, is cemented between the other ends of these outriggers, as shown in the top view of the plans. The elevator must be parallel to the outriggers when this connection is made. The two outriggers E are cemented between the end of the fuselage and the trailing ends of outriggers D. This completes construction with the exception of the landing and flying wires, which can be added to the model by studying the photograph. These are of white cotton thread cemented at points of contact. Small model pins should be used to hold the outriggers in place until the cement has dried, when the pins can be removed.

A small cockpit can be cut into the top of the fuselage by removing the top stringer between formers No. 3 and No. 4, as shown in the side view of the plans. This will aid in attaching the necessary weight to the nose of the model. (See Chapter 17.) After the weight has been determined, the lead, or other metal, should be cemented inside the fuselage. The model can be painted any desired colors.

As this type of model closely resembles soaring flight when in the air, choose a hilly locality with a fair wind blowing, and launch the model into the wind. These dimensions may be doubled if the builder wishes a large glider model.

CHAPTER 20

BOWLUS SAILPLANE

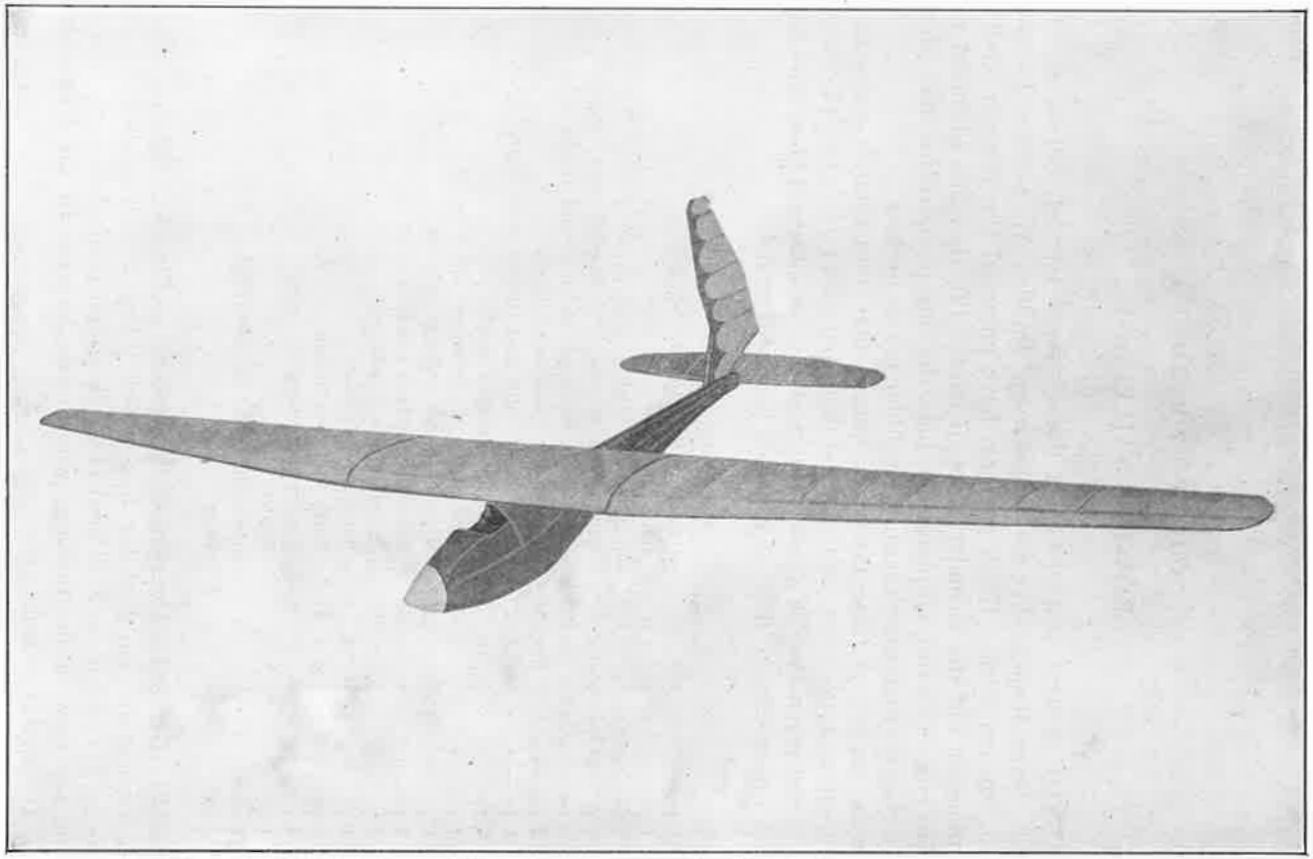
THE Bowlus sailplane is of the advanced type of soaring glider, being named after its designer and builder, W. Hawley Bowlus of San Diego. When students have mastered the primary glider (Chapter 18) and the secondary type (Chapter 19), they are advanced to this last type of soaring sailplane. On these, they are prepared for their final tests through which they obtain their glider pilot's licenses.

It was on one of these Bowlus sailplanes that both Charles and Anne Lindbergh took their tests and received their first-class glider pilot's licenses. The model given here is a true replica of this famous sailplane, and has proved a most efficient flyer, as well as a beautiful model.

MATERIAL LIST

1 pc. —1/4" x 3/8" x 36"	—Balsa for leading edge spars
1 pc. —1/8" x 1/4" x 36"	—Balsa for inner wing spars
2 pcs.—1/16" x 1/16" x 15"	—Bamboo for trailing edge spars
1 pc. —1/16" x 1/16" x 7"	—Bamboo for trailing edge spar of center section
1 pc. —1/16" x 2" x 40"	—Sheet balsa for wing, elevator, and rudder ribs
2 pcs.—1/16" x 1/16" x 15"	—Bamboo for elevator and rudder
1 pc. —1/16" x 1/16" x 12"	—Balsa for elevator and rudder inner spars
2 pcs.—1/8" x 3/8" x 3/4"	—Balsa for elevator tips
1 pc. —1/32" x 1" x 27/16"	—Sheet balsa for center section of wing
1 pc. —1/16" x 2" x 12"	—Sheet balsa for fuselage formers
3 pcs.—1/16" x 1/16" x 36"	—Balsa for fuselage stringers
1 pc. —5/8" x 3/4" x 1"	—Balsa for nose block
1 pc. —7/16" x 7/16" x 3/8"	—Balsa for tail block
1 pc. —5/16" x 7/16" x 2 1/2"	—Balsa for wing mount
4 pcs.—1/8" diam., 2 1/2" long	—Aluminum tubing for wing
1 oz.	—Cement
1 sheet	—Japanese tissue for covering
1 oz.	—Dope

FUSELAGE. Study the plan of the fuselage in Plan 1. Nine 1/16" sheet balsa formers are required for this model. These are designated by the letters A, B, C, C, D, E, F, G, and H in the graph plan of each, as well as on the top view of the fuselage, where their location in the framework of the fuselage is shown.



BOWLUS SAILPLANE

Rule 1/8" squares on paper, and draw a full-size working plan of each of these formers. They should then be traced on the sheet balsa, cut out, and the necessary notches made in each.

Each of the stringers is shown in the plan by number. Note that all duplicate stringers are shown by the same number. For example, stringer No. 1 is shown as No. 1 on both sides of the top view of the fuselage. This is done because these are exact duplicates and are located in the same positions on both sides of the fuselage. It will also be seen in the side view of the fuselage on the right of the plan. It appears only once here, because its duplicate is hidden behind it. All these stringers are 1/16" x 1/16" balsa wood cut to proper lengths.

The nose block is of solid balsa measuring 5/8" x 3/4" x 1", being cut to the shape shown on both views of the fuselage. Its inner face should be shaped to conform to the outline of former A, as it is cemented to this former, and should carry out the general streamline of the fuselage.

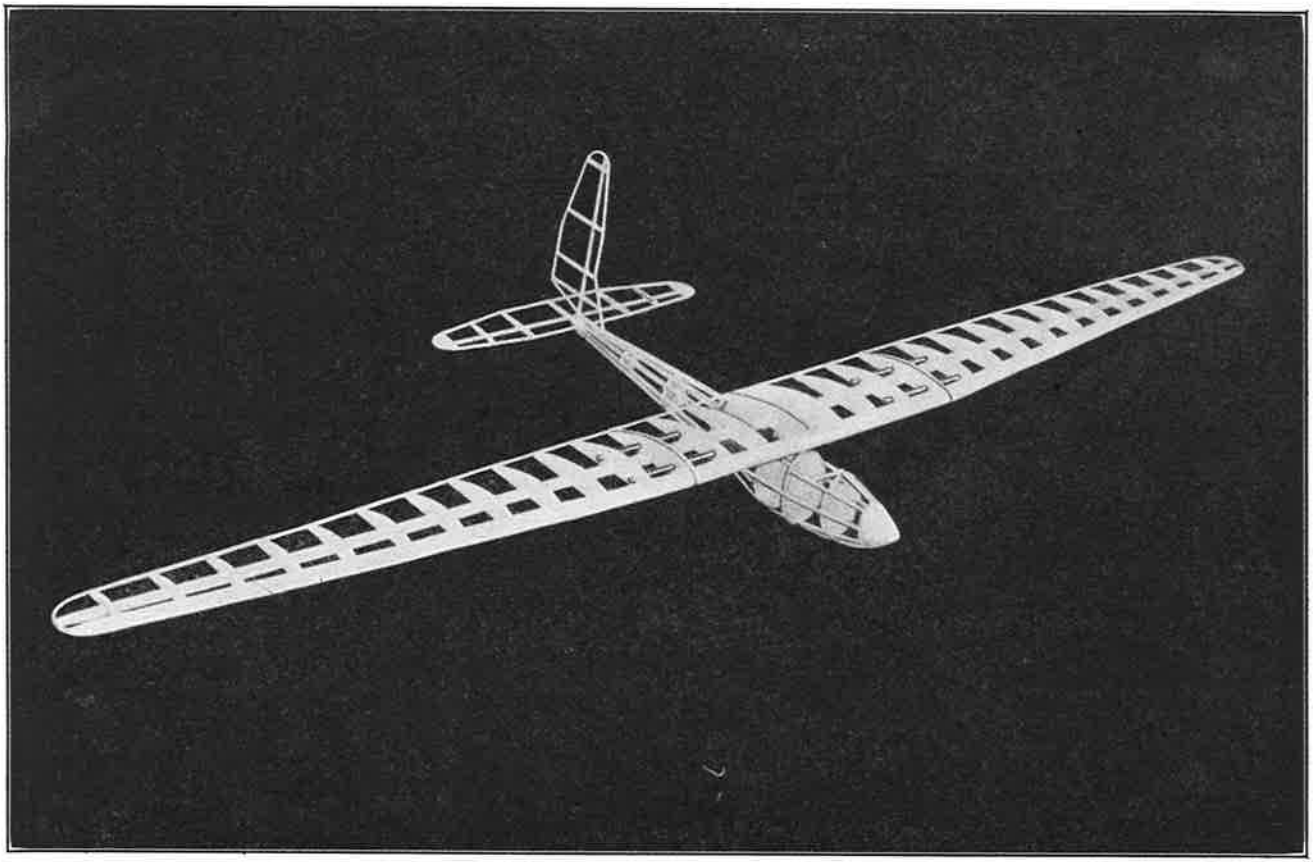
The tail block is also solid balsa. It should be given the form of fuselage former H, as it is cemented against the outside face of this piece. It is 7/16" x 7/16" x 3/8".

When these pieces have all been cut to proper shape and size, they should be carefully sandpapered smooth and then assembled. Cement stringers No. 6 into the notches cut for them in formers C, C, D, E, F, G, and H. Each of the other stringers is then attached in the same manner, making sure that each of the formers is properly spaced, as shown in the side view of the plan.

The formers B and A are added, and the nose and tail blocks cemented to formers A and H respectively. The main wing support block is shaped from a balsa block measuring 5/16" x 7/16" x 2 1/2" long. This wing mount is shown in the top and side views of the fuselage in solid black. Cut it to shape, and cement it to the tops of stringers No. 6, locating it at the front on former C. The fuselage is covered with Japanese tissue, as explained for round fuselages in Chapter 8. Water-spray the tissue and finish it with a single coat of dope.

RUDDER. The rudder is made of five balsa ribs, a balsa inner spar, and a bamboo outline piece. Study the rudder plan in Plan 2. From the 1/16" sheet balsa, cut the five ribs M, N, O, P, and Q, making them 1/8" wide at their widest point, tapering to 1/16" at each end.

The inner spar R is 1/16" x 1/16" x 3 7/8" long balsa wood. Thrust this spar through the holes cut for it in each rib, space the ribs on it, as shown, and cement each in position, making sure that they are on a line with each other. The edge of the rudder is made of 1/16" square split bamboo. Heat



BOWLUS SAILPLANE SKELETON

the length (see Chapter 3, "Bamboo"), and bend it to shape. Cement it in place to the ends of the ribs and the two ends of the inner spar.

Cover the rudder on both sides with Japanese tissue. (See Chapter 7, "Wing Covering.") Water-spray the tissue, and when dry, give it a coat of dope. It is now mounted on the fuselage. This connection is made with rib M. Coat the rib with cement and attach it to the fuselage on the top-center of the tail block. The end of the inner spar of the rudder should come at the very end of the tail block, while the front of rib M extends forward between formers H and G, as well as between stringers No. 6.

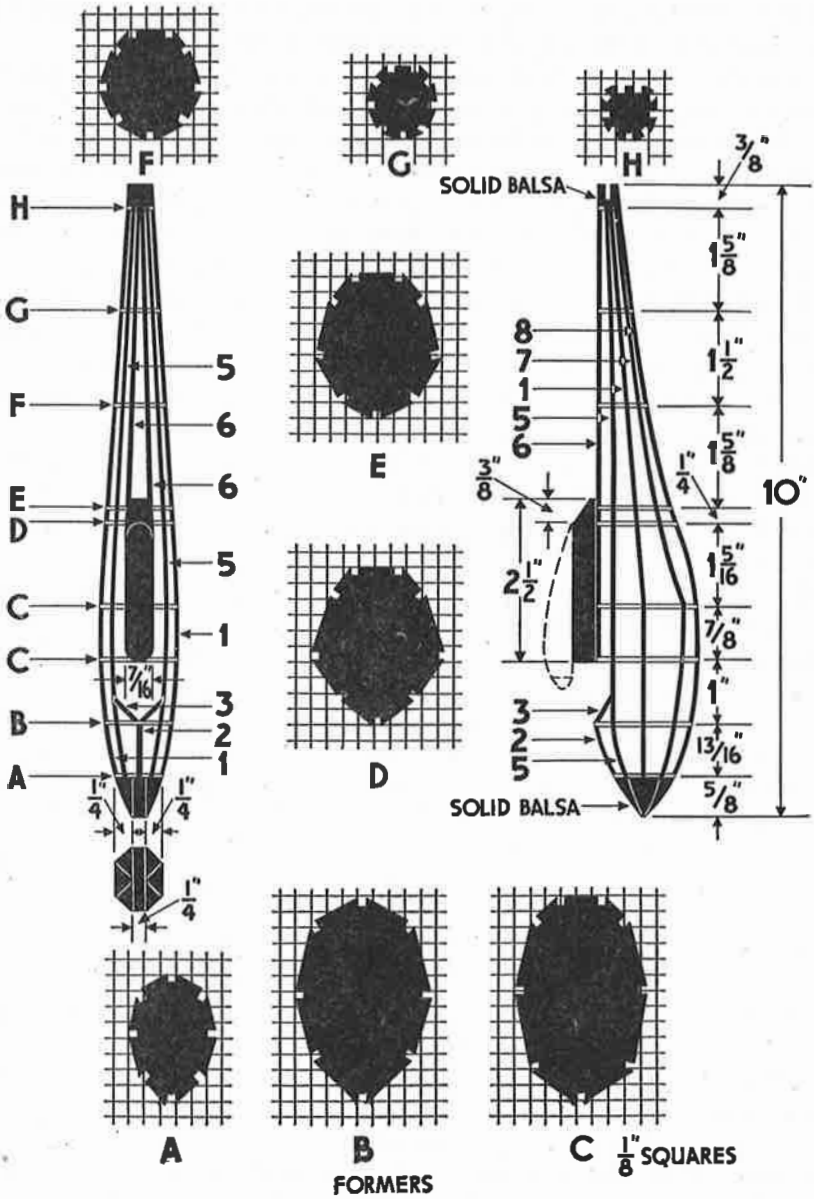
ELEVATOR. The elevator requires seven 1/16" sheet balsa ribs. These are shown in Plan 2 under "Elevator" as S, T, and U. Follow the same method used in cutting the ribs of the rudder, when cutting these ribs, making two S, two T, and three U ribs. These are also 1/8" at their widest part, tapering to 1/16" at both ends.

The inner elevator spar 2 is 1/16" square balsa. Make it 7" long. Solid balsa tips are used on this elevator, being cut to shape from 1/8" x 3/8" x 3/4" blocks. These are tapered to match the taper of ribs S and narrow toward their ends to match the 1/16" square bamboo outline.

Space the seven ribs on the inner spar, and cement each in place, making sure it forms right angles with the spar. Small 1/8" deep holes are cut in the solid wing tips to accommodate the ends of this spar. Cement the tips in place against the ribs S. The leading and trailing edge spars are made from 1/16" square split bamboo. The leading edge spar 1 should be heated, bent to conform to the ends of the ribs, and then cemented in place. The trailing edge spar 3 is attached in the same manner. As this elevator has no dihedral, it should be covered on both sides with Japanese tissue. Water-spray and give one coat of dope to stretch the covering.

In Plan 1 will be seen a notch in the tail block. (Note side view of the fuselage.) This is cut to accommodate the elevator, which is cemented into it. Make it 1/4" deep and 1/16" thick. The leading edge is thrust into this notch and cemented in place. The center rib U is the one placed into this slot. When doing this, care should be taken to see that it is centered perfectly, and forms right angles with the rudder.

WING. The wing is made in three sections, which for instruction purposes will be called the left, right, and center sections. As the left and right sections of the wing are exact duplicates, building instructions will cover only one of these. Twelve ribs of 1/16" sheet balsa are required for the left or right sections. The usual 1/8" squares should be ruled on paper, and full-size working plans of each rib made, as shown under "Wing Ribs" in Plan 2. For the entire wing, two of each of these ribs are necessary, except



FUSELAGE

BOWLUS SAILPLANE PLAN 1

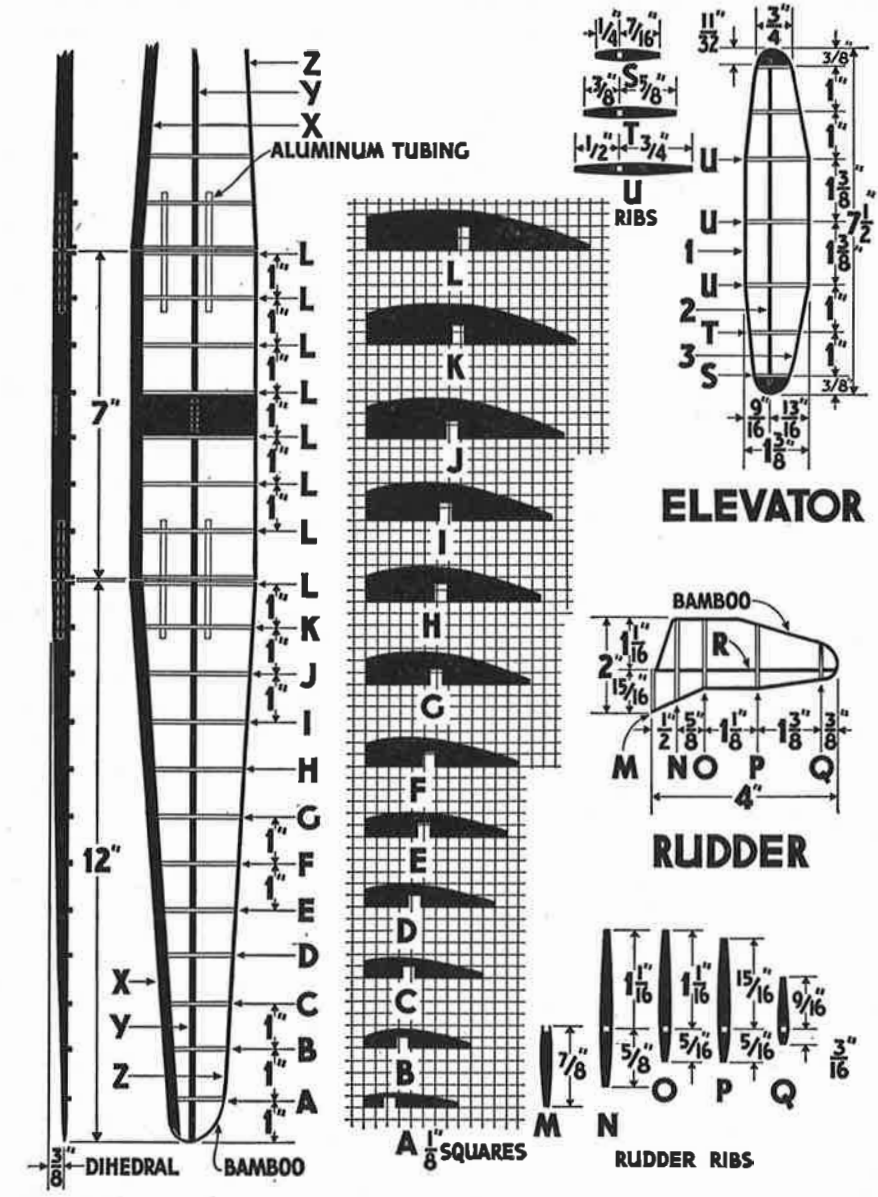
rib L, which is used on the inner end of each side section and for the entire center section, making ten necessary in all. Trace the rib outline on the 1/16" sheet balsa, and then cut them out. Make the necessary inner spar notch in each, as shown.

The leading edge spar X of one side section is 1/4" x 3/8" x 12" long. The inner wing spar Y for the same section is 1/8" x 1/4" x 12" long, while the trailing edge spar Z is 1/16" square bamboo. The leading edge spar is tapered from 3/8" thick at rib L to 1/16" at the wing tip. The inner wing spar is tapered from 1/4" at rib L to 1/16" at the wing tip, while the trailing edge remains the same along the entire length of the wing. Space the ribs along the inner wing spar Y, as shown in the top view of the wing in Plan 2, and then cement them in place, each at right angles to the spar. The leading edge spar is cemented to the ends of the ribs, after it has been sandpapered to a half-round form to fit the contour of the ribs. When completed, the bamboo trailing edge spar should be bent to form the wing tip at one end, and then cemented in place. A piece about 13" long will be needed for this spar.

The three sections of the wing are held together by four 2 1/2" lengths of 1/8" diameter aluminum tubing, which can be purchased at any model airplane supply house. In each side section, two lengths of this tubing extend through holes cut in ribs L and K. These holes should now be made. Note their position in Plan 2, showing the top view of the wing. One is located halfway between the leading edge spar and the inner wing spar, while the second one is 1/4" behind the inner wing spar. Two 1/8" diameter holes must be made in each of these two ribs to accommodate this tubing.

The section is covered on both sides with Japanese tissue. (See Chapter 7, "Wing Covering.") Water-spray the wing, and when dry, give it a coat of dope to shrink the tissue. The other side section of the wing is made and assembled in the same manner.

The center section of the wing is made with eight L ribs, which are cut from the 1/16" balsa sheeting. A 1/8" x 1/4" notch is cut in each of these to take the inner wing spar. The leading edge spar is 1/4" x 3/8" along the entire length, while the inner wing spar is 1/8" x 1/4". Both of these spars are balsa. The leading edge spar should be given a half-round form to match the other leading edge spars, but the inner wing spar is left without any forming. The trailing edge spar is 1/16" split bamboo. Each of these three spars is 7" long. Assemble this section in the same manner as the side sections. The section between the fourth ribs from each end has a solid 1/32" sheet balsa piece, fitted between the ribs and the leading and trailing edge spars. It is cemented to the under side of the inner wing spar, and to the sides of the



BOWLUS SAILPLANE PLAN 2

adjoining ribs, as well as the leading and trailing edge spars. Being fitted on the under surface of the wing, it forms a wing base.

The necessary holes for the aluminum tubing are made in the two outer ribs on each end of this center section. Care must be taken when doing this, as the wing dihedral is obtained through the position of these holes. Place the center section flat on a table. Insert two of the tubes into the holes of one side section. Line this section up with the center section so that the ends of the tubes just touch the sides of the end rib of the center section. Lift the tip of the side section 3/8" off the table. Mark the exact spots where the tubes rest against the outer side of the center section end rib. Cut 1/8" diameter holes at these points. With the wing tip still off the table 3/8" insert the ends of the tubes into these holes. Continue pushing them through until they rest against the second end rib of the center section. Again check the side section and center section to see that they have their inner spars forming a straight line, and that the tip of the side section is off the table 3/8". When in this position, mark the points where the ends of the tubes rest against the rib. Cut 1/8" diameter holes at these two points. The tubes are now removed from the side sections, placed in position in the center section and firmly cemented. This allows the tubes to be slipped into the holes of each side section, or removed from them, without being moved from the center section, where they are permanently attached. The tubes are attached to the other end of the center section in the same manner after like tests.

The center section is covered on both sides with Japanese tissue, water-sprayed, and doped. The wing is mounted on the fuselage. Note its position in Plan 1 showing the side view of the fuselage.

Coat the balsa wing base with cement and press it in position on the wing mount of the fuselage. Note that the trailing edge of the wing crosses the mount at a point 3/8" from its trailing end, and that the forward portion of the wing extends beyond the mount. Care must be taken to see that the wing forms right angles with a center line drawn through the center of the fuselage from nose to tail. Another test for this is to see that the edge of the wing is parallel with all fuselage formers.

A cockpit, into which weights may be inserted, is cut in the top of the fuselage. It extends from stringer 5 on one side to the same stringer on the other, and from former C at the back to stringers 3 at the front, which give it a V-shape at the front. For flying instructions, proper determining of weights and launching, see Chapter 17.

STICK MODELS

CHAPTER 21

GRANT "MINUTE MAN" TRACTOR

BECAUSE of its simplicity of construction, an all-balsa tractor should be the logical model for the beginner, but as few of them prove exceptional flyers, they are seldom used to introduce model building.

Through the courtesy of Charles Hampson Grant, Editor of "Universal Model Airplane News" and a model designer of national reputation, the author is able to present here an unusually fine all-balsa tractor. Its simplicity of construction, exceptional flying ability, and almost unbreakable sturdiness, have given it a country-wide popularity.

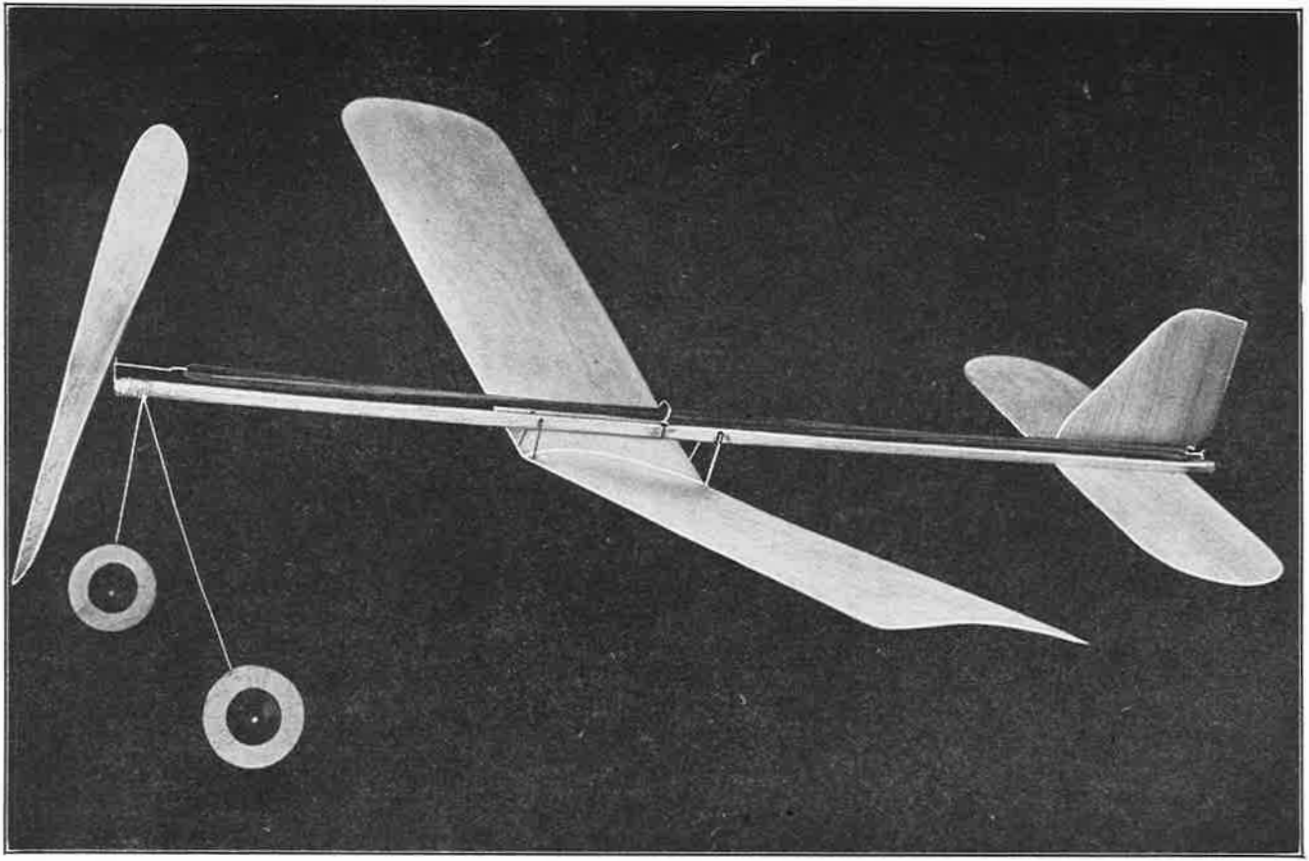
The fact that it has only five balsa parts speaks for its simplicity, while such flights as that made by Thomas W. MacLean of Charlotte, N. C., who flew his "Minute Man" over 1,500 feet for a duration of six minutes and a height of 300 feet, prove its flying ability. Here is a model any beginner can build with ease, and at the same time be assured of many hours of excellent flights and happy landings.

MATERIAL LIST

2 pcs.	1/32" x 3" x 10½"	—Sheet balsa for wing
1 pc.	1/32" x 2¾" x 3"	—Sheet balsa for rudder
1 pc.	1/32" x 2⅜" x 7¾"	—Sheet balsa for elevator
1 pc.	3/16" x 3/16" x 18"	—Balsa for motor stick
1 pc.	5/8" x 1⅜" x 8"	—Balsa propeller block
1 pc.	1/16" x 2" x 3½"	—Sheet balsa for wing ribs
1 pc.	3/16" x ¾" x 3½"	—Balsa for center wing ribs
1 pc.	1/8" x 1½" x 3"	—Sheet balsa for wheels
1 pc.	1/32" x ⅛" x 64"	—Pure Para rubber for motor
1 pc.	—12" long	—No. 7 piano wire for wing clips and can hook
1 pc.	—24" long	—No. 12 piano wire for landing gear, "S" hook, shaft, etc.

Washers
Propeller bearing
Cement

MOTOR STICK. The motor stick consists of a 3/16" x 3/16" x 18" long balsa stick. Its front end is beveled, as shown. Sandpaper the stick until perfectly smooth. On the beveled end, the usual propeller bearing is ce-



GRANT "MINUTE MAN" TRACTOR

mented, but is not bound with silk thread until the landing gear is in place. (See Chapter 6, "Propeller Bearings.") In the center of the stick, a can hook is attached. This is bent from No. 7 piano wire, as shown in the plan under "Can Hook," and cemented in place on the stick with the loop on the same side as the bearing. The trailing end of the stick is equipped with a combination end hook and tail skid, as seen in the plans. Follow the dimensions given for this in the plan, and then cement it over the end of the stick, with the hook on the same side of the stick as the hook of the can. It should then be tightly bound with silk thread over which a thin coat of cement is applied to bind it in place.

RUDDER. Make a full-size drawing of the rudder, as shown. This is then placed on the 2¾" x 3" piece of 1/32" sheet balsa and carefully traced. Place the tracing on the wood, so that when the rudder is attached on the motor stick, its grain will run up and down. Cut the rudder out and finish all edges and both faces with sandpaper. It is now cemented to the side of the motor stick, as shown. Note that when looking at the stick held in flying position from the front, the rudder is cemented to its left side. The bottom edge of the rudder and the bottom edge of the motor stick should be flush, while the back, or trailing edge of the rudder, forms right angles with the stick.

ELEVATOR. The elevator is made of a single piece of 1/32" sheet balsa. Cut the stock 2⅜" wide and 7¾" long, making sure that all corners are square. The rounded tips are formed from a half circle with a radius of 1 3/16", as shown under "Elevator."

Lay these out with a compass, and then cut them with a razor blade. Finish the elevator with a careful sandpapering. It can be attached to the stick with cement, which gives a permanent connection, or a single rubber band may be used. Note the position of the elevator on the motor stick. If the former method is used, apply cement along the under side of the stick, and press the elevator tightly against it, making sure that it extends out from the stick evenly on both sides, that its leading and trailing edges form right angles with the stick, and that its trailing edge is ¾" in from the end of the stick.

If the rubber is used, pass one end of the rubber over the stick. Place the elevator in position and bring the band under the elevator, and its loop up and over the end of the stick, which will hold it in position.

LANDING GEAR. This is bent from a single length of No. 12 piano wire. The front view of the landing gear, shown in the plan, illustrates how the wire looks after it is bent. Above this illustration is a top view of the

wire. The small U-shaped section is bent down at right angles with the other sections of the wire.

When bent as shown, apply cement and press the "U" of the wire to the under side of the motor stick on top of the propeller bearing. Both the bearing and this portion of the landing gear wire are now bound with silk thread, which is given a thin coat of cement to strengthen it. As the "U" of the gear was bent at right angles to the rest of the wire, or the wire struts of the landing gear, these will extend straight down and out from the stick. Note in the plans that these struts not only extend out on each side of the stick, but also 1¼" back from the wire "U."

When completed, the wire gear is equipped with two ⅛" sheet balsa wheels. (See Chapter 10, "Solid Balsa Wheels.") When these are finished, slip them on the axles of the gear, and bend the wires up to prevent them from falling off.

PROPELLER. The propeller is carved from a ⅝" x 1⅜" x 8" long balsa propeller block. (See Chapter 9, "Carved Propellers.") A propeller shaft is bent from No. 12 piano wire. (See Chapter 6, "Propeller Shafts.")

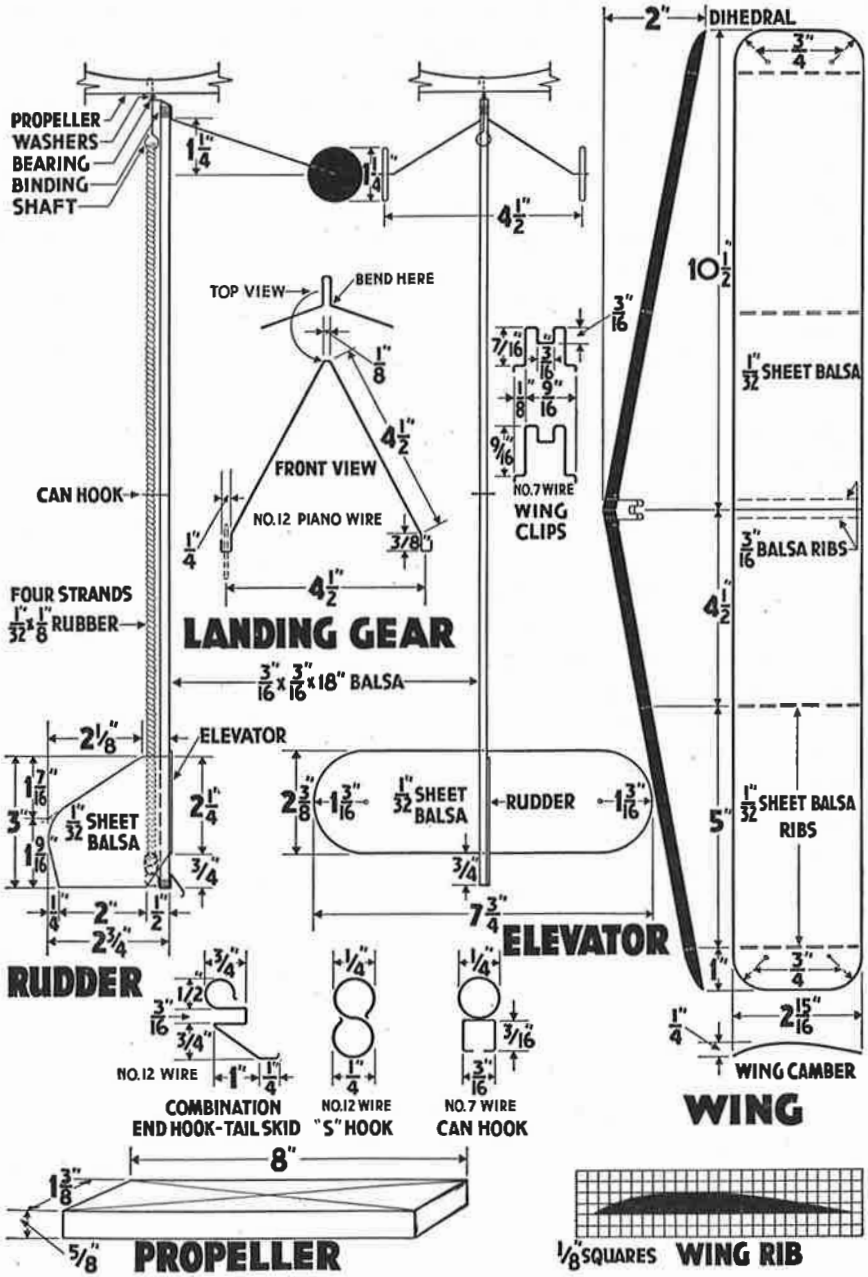
Thread the shaft through the hub, bend it around, and pull it back, allowing its point to bury itself in the hub, and apply cement to the bend.

MOTOR. This consists of a 64" length of 1/32" x ⅛" pure Para rubber, tied, and looped four times. An "S" hook is bent from No. 12 piano wire, as shown in the plans, and one of its hooks is fastened through the end hook. The rubber strands are then looped around the other end of the "S" hook, threaded through the can hook, and looped over the hook of the propeller shaft, after two washers have been applied to it and it has been passed through the propeller bearing hole.

WING. The wing is made in two parts, each half being 2 15/16" wide and 10½" long. It is made of 1/32" sheet balsa. Cut these to size, rounding two corners of each half, as shown in the plans, with the arc of a circle having a ¾" radius. Sandpaper all edges and both faces until smooth.

Four 1/16" sheet balsa ribs are used to give the wing its necessary camber. Note the size of these in the plans under "Wing Rib." Draw a full-size plan of the rib on ⅛" squared paper, as shown. Trace this on the 1/16" sheet balsa piece, and cut out each rib. Sandpaper them smooth. To make sure they are alike, the ribs should be placed together with all sides flush, and then sandpapered as a whole.

They are now cemented to the under side of the wing, which must be bent to their top curve. Paper clips can be used to hold the sheet balsa to the ribs until the cement is dry. Slip one clip over the wing and rib at the leading edge and another at the trailing edge. When all four ribs are in



GRANT "MINUTE MAN" TRACTOR PLAN

place and firmly cemented, the wing halves are joined together. Note that the wing has a 2″ dihedral. Lay the two halves with their inner ends together on a flat table. Holding one half flat on the table, lift the tip of the other 4″ off the surface. Apply cement along their center joint while in this position, and allow the cement to become hard before freeing the wing. (See Chapter 7, "Wing Assembly.")

To give the wing the same camber along its center section and to strengthen its joint, two $\frac{3}{16}$″ thick heavy-duty ribs are used. These are cut from balsa wood, after being traced on it. Use the same tracing as used for the outer ribs. The tops of these ribs must be beveled to fit the angle made by both halves of the wing when they were joined and given the dihedral.

Cement these two ribs together side by side, and then bevel the top in the form of a shallow V to fit the angle of the wing. Cement them in place, so that the cemented crack of the ribs fits directly under the cemented crack of the wing.

Two wing clips are bent from No. 7 piano wire, as shown in the plan. The small clip fits on the leading edge of the wing, while the large one is cemented to the trailing edge. The small prongs of these clips are pressed into the surface of the wing, while cement is added to give further strength to the connection. Both clips are located on the upper side of the wing directly over its center joint.

FLYING. Slip the clips of the wing over the under side of the motor stick to attach the wing to the model. Give the model the gliding test. (See Chapter 16, "Gliding Method of Wing Adjustment.")

If hand winding, the motor may be safely wound about 325 turns, while a winder allows it to be wound 575 turns. Before launching your model, make sure that its wing, elevator, and rudder are perfectly straight and not warped in any manner. For the proper method of launching, see Chapter 16, "Correct Launching of R.O.G. Model."

CHAPTER 22

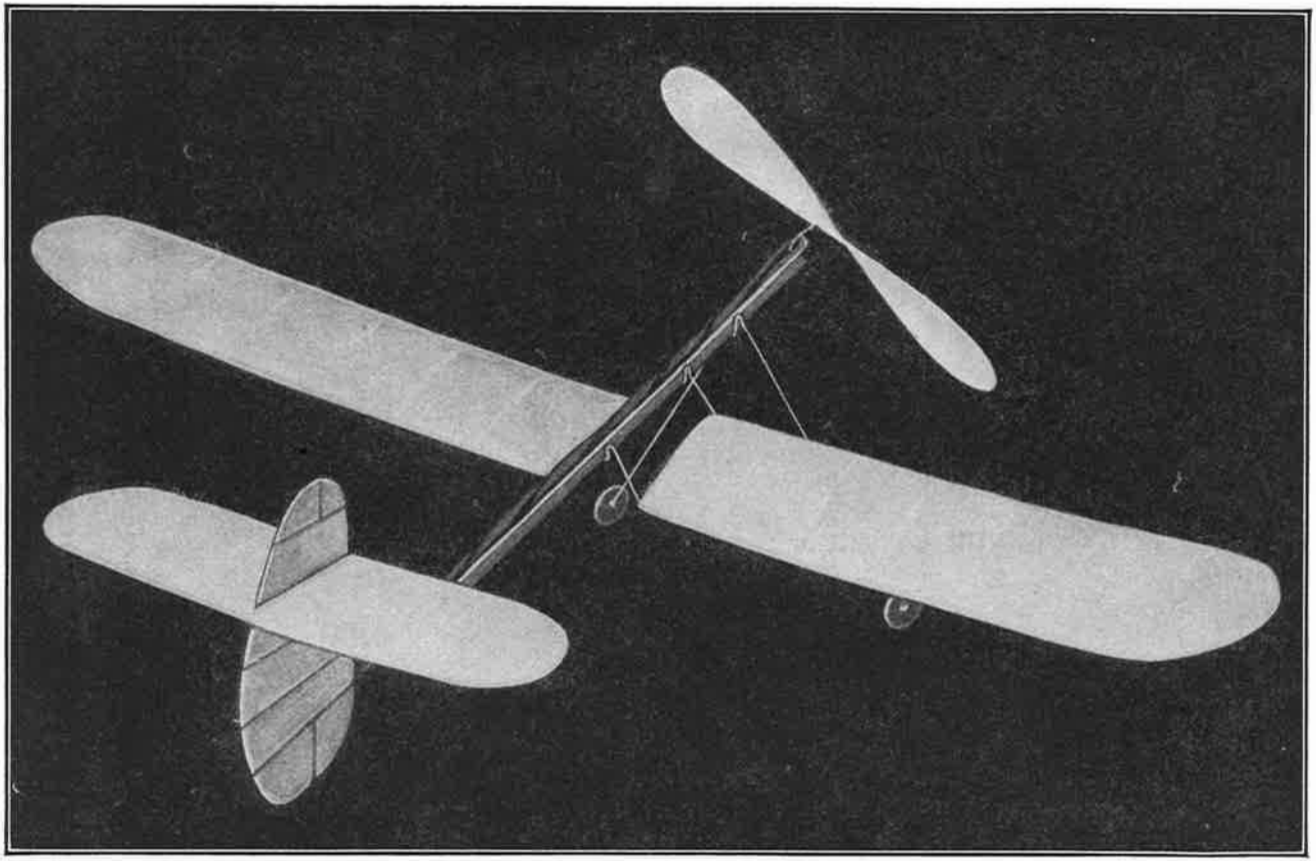
CONDOR TRACTOR

HERE is a splendid model with which the beginner can experiment to his heart's content. When Nick Limber designs and builds a model, he does so for a specific reason and with such great success that today he is considered among the finest designers and builders in this country. The author greatly appreciates the opportunity given him by Mr. Limber to present such a fine example of tractor type model in these pages. The specific reason behind the designing of the "Condor" was a curiosity to discover the effect a high set tail would have on a light model. Results in the air proved that such a tail was a distinct success. Many German light planes have such tails and it was from them that Mr. Limber took his example. The model not only gave a fine endurance and stability performance, but also proved a graceful and smooth flier. When the builder saw this, he immediately called it the "Condor" after that most graceful bird. So get busy and build your own "Condor."

MATERIAL LIST

1 pc. — 1/8" x 3/8" x 13" —Balsa (Motor Stick)
2 pcs.— 1/16" x 1/8" x 10" —Balsa (Leading Edges of Wings)
1 pc. — 1/16" x 3/8" x 15" —Bamboo (Trailing Edge, Tail, etc.)
1 pc. — 1/16" x 2" x 12" —Balsa (Wing and Tail Ribs)
1 pc. — 1/16" diameter —Aluminum Tubing (Bearing)
1 pc. —.020 x 15" long —Music Wire (All Metal Parts)
1 pc. — 1/8" x 26" long —Flat Rubber (Motor)
1 pc. — 3/4" x 1 1/8" x 8" —Balsa Block (Propeller)
Japanese Tissue
Banana Oil
Copper Washers
Sandpaper

MOTOR STICK. The fuselage on a stick model is known as the "Motor Stick." It is shown in detail under "Motor Stick" in the plans. It is cut from a 1/8" x 3/8" x 13" long piece of hard balsa. It is tapered along its bottom edge to 1/4" width at the nose and 3/16" at the tail. The thickness



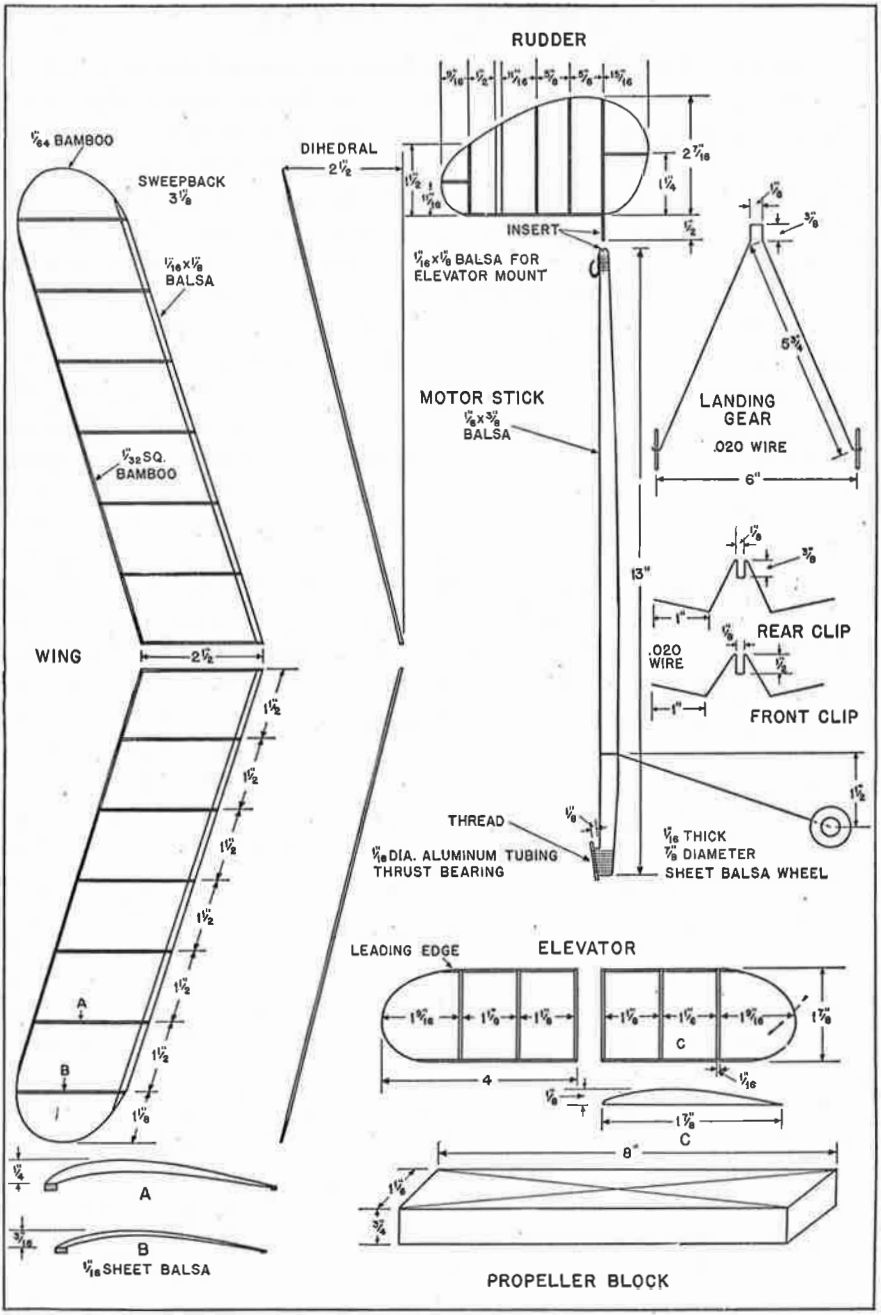
CONDOR TRACTOR

is also tapered along its entire length from its original thickness of 1/8" along the top to 1/16" along the bottom. Note that the upper edge of the fuselage remains perfectly straight. Carve the stick in this manner and finish smooth with sandpaper. A strip of 1/8" square balsa is cemented to the top-front of the stick, which is then shaved at a slant so that it is only 1/16" wide at the front, as shown. A 3/4" long aluminum tube is then cemented along this strip and bound with silk thread, as shown in the plan. A rear hook is bent from .020 music wire, cemented in place on top of the stick, and then bound with the thread, as shown.

RUDDER. The rudder has a strip of hard balsa measuring 1/32" square and 4" long. The trailing edge is made up of a single length of split bamboo making the rounded form of this part. All cross pieces are of 1/32" square balsa. Cement the lower brace, which extends out 1/2" and is of 1/32" square bamboo, in place across the leading edge. Cement the top 1 1/2" long cross piece in place against the leading edge. The bamboo is then shaped from the leading edge, around these two braces, and then back to the leading edge piece. Cement the other braces in place as shown. The elevator mount is a length of 1/16" sheet balsa 1/8" wide located 1 1/16" down from the top of the rudder, as shown. This should be sanded down to match the leading and trailing edges. Cover the rudder with Japanese tissue on one side only using banana oil as an adhesive. When completed, insert the 1/2" of projecting bamboo into the end of the stick by making a small hole to take it. Line the rudder up with the motor stick and cement it in place.

LANDING GEAR. This is made of a single length of .020 music wire. Note it in the plan. It is first bent around the stick for a tight fit. Each "leg" is 5 3/4" long, as shown, and the axles should be 1/8" long. In the side view of the motor stick is shown the forward thrust of the landing gear. Bend yours in this manner. The "track," or distance between the wheels, must be 6" long. Two 1/16" sheet balsa wheels are cut to 7/8" diameter and threaded on the axles which are turned up to hold them in place. The landing gear is now attached in place on the fuselage stick 2 1/2" back from its nose, as shown.

ELEVATOR. The elevator is made in two halves, as shown in the plan. The leading edge is 1/32" strip bamboo 2 3/4" long. The trailing edge is 1/32" strip bamboo cut 3" long. The three ribs are shaped from 1/16" sheet balsa, as shown at "C." Each one is 1/8" wide at its widest point and all are cut 1 7/8" long. Cement the ribs in place between the leading and trailing edge spars, and then make the tip of thin bamboo. When complete, make the other half in the same manner. Both halves are covered on the top side only with Japanese tissue using banana oil as an adhesive. If the



CONDOR TRACTOR PLAN

rudder was properly made, the sheet balsa mounting on it should be exactly 1⅞" long, which is just the width of the elevator halves. Cement each half on a side of this mount, and check to see that they are in line with each other, perfectly level, and at right angles to the rudder.

WING. The wing is also made in two halves, as shown in the plan. The leading edge spar is 1/16" x 1/8" x 9½" long, and is of strip balsa. Note its shape in the plan under "A" and "B." The trailing edge spar is 1/32" square bamboo cut 8½" long. For one half of the wing, you will require seven ribs. These are cut from 1/16" sheet balsa. Six "A" ribs are 2½" long, and the one "B" rib is 2 5/16" long. The "A" ribs are ⅛" at their widest point and the "B" rib is only 1/16" at its widest point. Trace these on 1/16" sheet balsa and cut them out. Finish with sandpaper. Draw a straight line on paper and place the leading edge spar directly over it. Hold the inner end to the line and move its outer end back 3⅛". Mark this location on the paper. The ribs are now cemented in place to the leading edge while that spar is held on the second line. Each rib, however, must be at right angles to the first line drawn. In this manner the correct sweepback is obtained. The trailing edge spar is then cemented in place. Note that the leading edge spar fits under the entering end of the ribs. A split bamboo wing tip completes the half. The opposite half is made in the same way except that the leading edge is moved back along the other half of the straight line, as it would be when in flying position. While the frame is drying, make the two wing clips of .020 music wire, as shown in the plan under "Front Clip" and "Rear Clip." The wing halves are now covered on their top sides only with Japanese tissue. Use banana oil as an adhesive and stretch the paper as tightly as possible without tearing it. Cement the wing clips to the leading and trailing edge spars, as shown in the photograph. Slip the wings in place under the stick, test each for proper sweepback and bend their clips up to obtain a 2½" dihedral at each tip. See that both tips are level with each other.

PROPELLER. Carve the propeller from the block shown in the plans as explained on page 91 under "Carved Propellers." Use hard balsa for this, and when finished apply three coats of dope and sand between each coat. Make a shaft from .020 music wire and cement it to the propeller hub. It is then passed through the aluminum tubing and its hook bent properly. Bend two "S" hooks of the same wire, as explained on page 139, attach the rubber motor, and the model is ready for its maiden voyage. Glide without power to obtain the best wing location. When a long even glide has been obtained, wind the motor and let her go.

CHAPTER 23

BABY R.O.G. TRACTOR

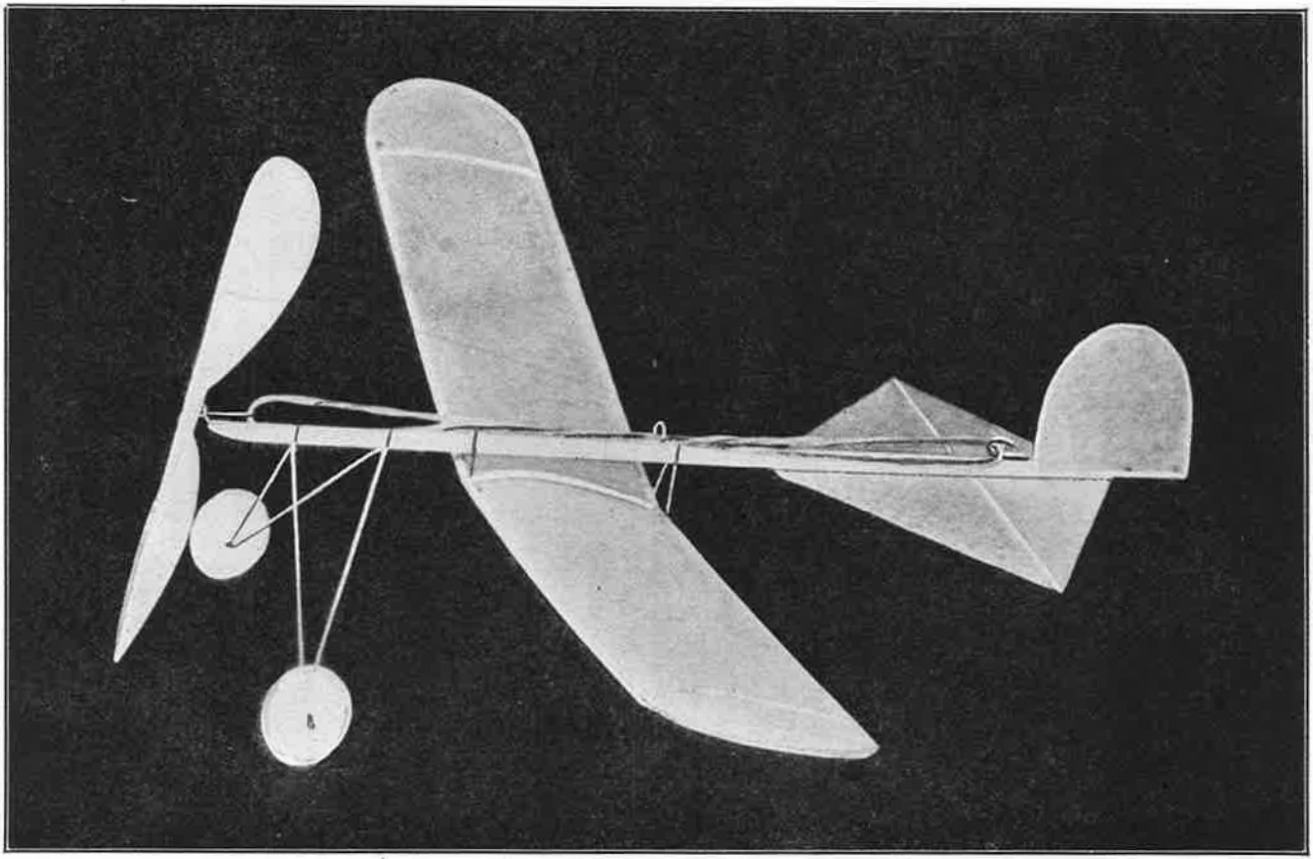
THIS rise-off-ground (R.O.G.) tractor is practically the same size as the indoor tractor of the preceding chapter. Its construction is much the same, except that it is equipped with a landing gear and has a thread outline for the elevator in place of the usual balsa spars and ribs. This model has proved an excellent flyer.

MOTOR STICK. From balsa wood, cut a piece measuring 1/16" x 1/8" x 8" long. A regulation propeller bearing is cemented to the top edge of the stick at its front end. This can be purchased or made. (See Chapter 6, "Propeller Bearings.") On the rear end of the stick and in the same position, a rear or end hook is cemented in place. This is bent from No. 6 piano wire. (See Chapter 6, "End Hooks.") Note in the plans that the propeller bearing is shown with thread wound around it, which acts as an extra binding for the bearing. On models of this size, such treatment is optional with the builder, but on large models carrying a great amount of rubber, all bearings should be reënforced in this manner.

RUDDER. This is made of two lengths of 1/32" x 1/32" split bamboo. The base of the rudder is made of one length of this bamboo 1¾" long. The 1/4" at the front of this length is allowed to protrude out from the rudder to act as a cementing surface to hold it in position on the motor stick, as shown in the plans. The second length of bamboo is bent over heat to form the outline of the rudder, as shown. (See Chapter 3, "Bamboo.")

Cement the horizontal piece to the under side of the motor stick by applying cement to its forward 1/4" portion, and then press it in position. The bent outline length of bamboo is now cemented in place. Apply cement to the end of the motor stick, the front of the horizontal piece and also to its trailing end, and then press the outline piece in position. Make sure that the straight sides of this length are at right angles to the motor stick and that it is also straight up and down.

The rudder is covered with Japanese tissue. Cut the tissue to the exact size and shape of the rudder, coat the outline bamboo with clear dope or banana oil, and press the paper to it. When dry, the paper may be water-



BABY R.Q.G. TRACTOR

sprayed to tighten it on the frame. Hold under weights until the paper covering becomes dry.

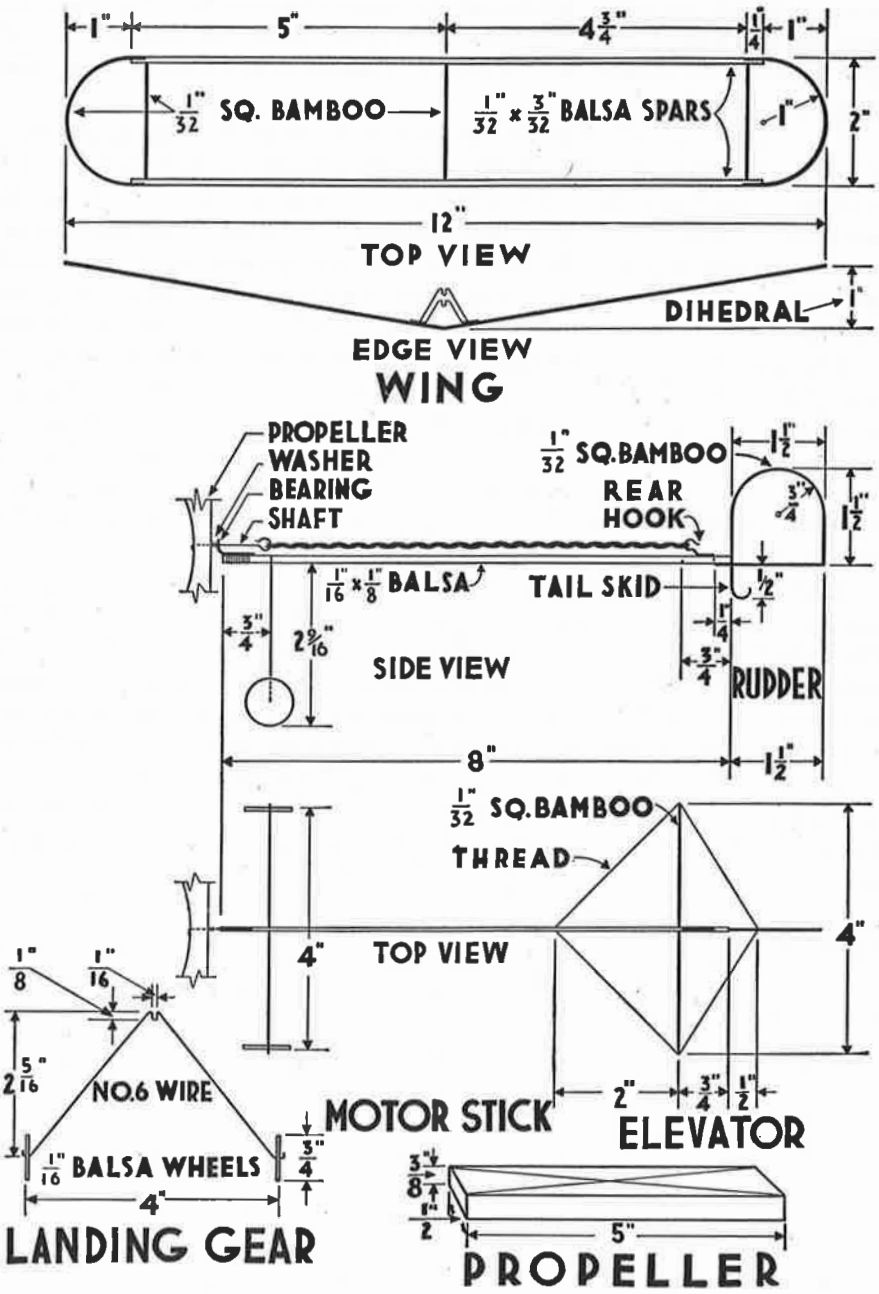
ELEVATOR. The elevator consists of one length of 1/32" x 1/32" split bamboo and a thread outline. Cut the bamboo piece 4" long, notch the under side of the motor stick 3/4" in from its rear end, and fasten the bamboo spar in place in it. When doing this, make sure that the spar is at right angles to the motor stick and that it extends out from both its sides an equal distance. A length of silk thread completes the framework of the elevator. Cement the end of the thread to the under side of the motor stick 2 3/4" in from its rear end, or 2" in front of the elevator spar. Pass the thread to one end of the spar, and then to a point on the horizontal spar of the rudder 1/2" from the rear end of the motor stick. Both these points of contact should be held with cement. The thread is continued to the opposite end of the elevator spar, cemented, and then back to the original point of starting on the motor stick, where it is cemented in place.

When completed, the elevator outline is covered with Japanese tissue. Cut the paper to the exact size and shape of the elevator, coat the elevator spar, under side of the motor stick and rudder spar, and press the paper in place. When hard, the outline thread should be coated in the same manner with clear dope or banana oil, and the edging of the paper pressed on it. The paper should be trimmed if any excess has been left. Water-spraying should not be done on the elevator, because of the delicate framework, so that the paper should be carefully ironed before being applied.

PROPELLER. This is hand carved from a 3/8" x 1/2" x 5" balsa propeller block. Sandpaper until light will show through the blades. (See Chapter 9, "Carved Propellers.") The propeller is completed by bending a propeller shaft from No. 6 piano wire, as shown. (See Chapter 6, "Propeller Shafts.") Force the end of the shaft through the center of the propeller hub, bend it around, and pull the shaft back until the point buries itself in the wood of the hub. A drop of cement at the bend will hold it securely in place.

MOTOR. Two strands of 1/8" flat rubber are used for motive power. Obtain a 15" length of this rubber and tie its ends together to form a loop. Assemble the motor at this time. Place two washers on the propeller shaft and pass it through the hole in the propeller bearing. Loop one end of the rubber over the hook of the propeller bearing and the other end over the end hook, which completes the motor assembly.

WING. Cut two 1/32" x 3/32" x 10" long balsa pieces for the leading and trailing edge spars. Cut three 1/32" x 1/32" split bamboo ribs 2" long. Bend these slightly over heat to give the wing a small curve or camber. Lay the spars on a table parallel to each other and 2" apart, and then proceed to



BABY R.O.G. TRACTOR PLAN

cement the ribs in place. Complete the wing structure by cementing two bent bamboo wing tips to the ends of the spars. These are also 1/32" x 1/32" split bamboo, and should be bent in a 1" diameter circle over a flame. (See Chapter 3, "Bamboo.")

The wing is now given its 1" dihedral angle. Snap the leading and trailing edge spars between the thumb and index finger in their exact center, or at the point where the center rib has been cemented in place. Place the two halves in position on a flat table, with the convex side of the wing facing up, and while holding the broken joints together, lift the tip of one half off the table 2". While in this position, apply cement to the broken joints, and hold until dry. This will give each wing tip the necessary 1" dihedral angle.

The wing is covered with Japanese tissue on its upper side only. Coat all spars, ribs, and wing tips with clear dope or banana oil, and press the paper in place. Trim all edges and give the wing a water-spray treatment to tighten it. Two wing clips are bent from No. 6 piano wire. (See Chapter 6, "Clips.") The large one is cemented to the upper side of the trailing edge, while the small one is located on the leading edge. Note the position of these in the plans.

LANDING GEAR. This is bent from a single length of No. 6 piano wire, as shown in the plans. Two wheels are cut from 1/16" sheet balsa. They should be 3/4" in diameter. (See Chapter 10, "Wheels.") Thrust the ends of the landing gear wire through the centers of the wheels and bend them up to keep them in place. The small notch at the top of the landing gear wire has been made the same size as the motor stick, so that it can be slipped over the stick. See that this fit is snug enough to hold the landing gear without the aid of cement. Locate it 3/4" from the front end of the motor stick. Give the model the usual gliding tests to determine proper location of the wing, which is clipped to the under side of the motor stick. For the proper method of launching, see Chapter 16, "Correct Launching of R.O.G. Model."

CHAPTER 24

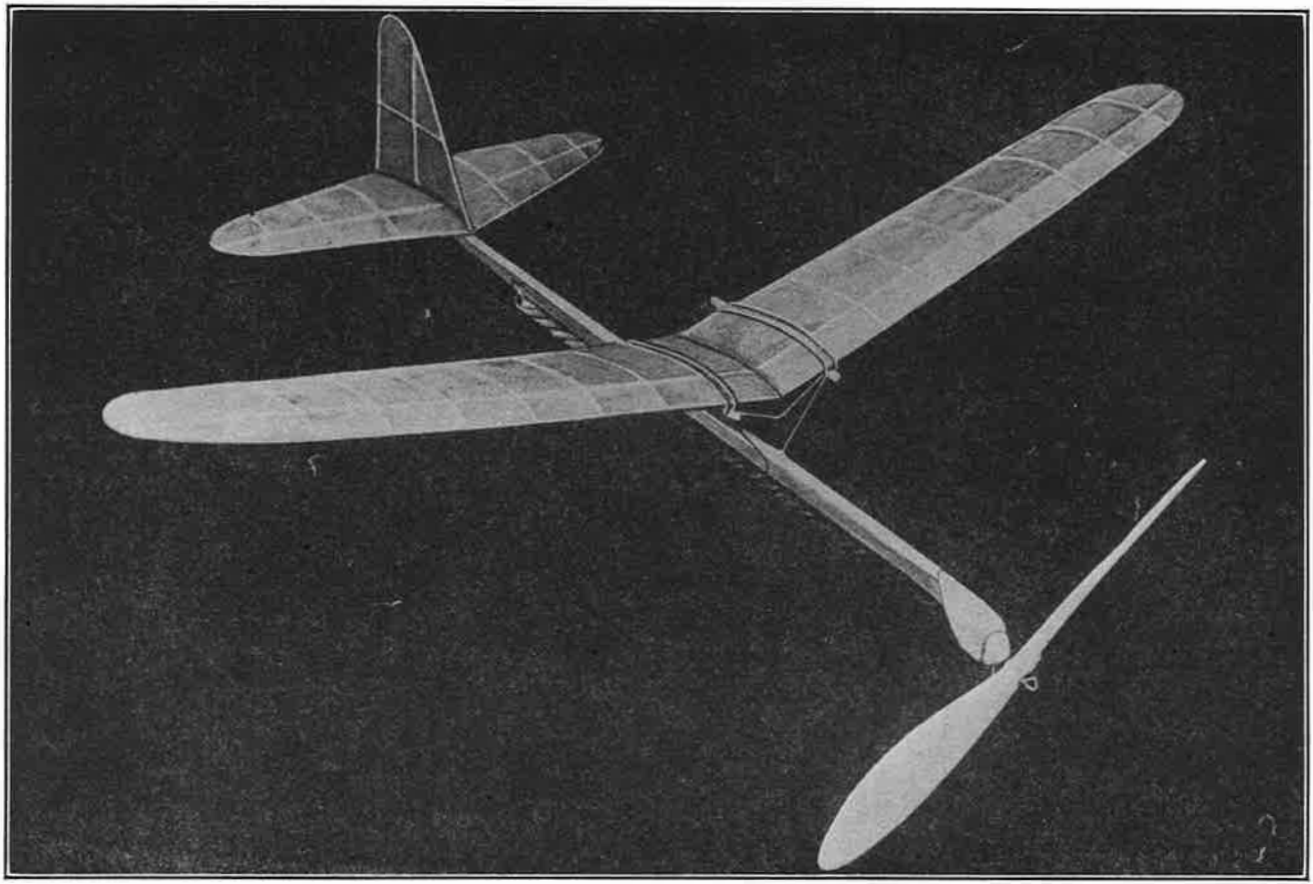
CHAMPION OUTDOOR TRACTOR

AMONG the various winners that made their appearance in 1936, this remarkable outdoor tractor, designed and built by Henry Struck, turned in some of the best endurance flights ever recorded. The author appreciates the permission given him by Mr. Struck to bring it to these pages. At the 1936 Junior Birdmen Outdoor Air Races this model demonstrated its worth by turning in an official winning time of 12 minutes and 47 seconds, when unfortunately it flew out of sight while still at a great height. Interesting to note is the fact that the shortest flight it made that day was over four minutes. In the calm air of the evening, this model has often flown for over three minutes, and flights of over two minutes are made consistently. It was designed to conform with the new rules governing stick models as drafted by the Junior Birdmen, which allows no landing gears and nothing but solid motor sticks. When the model is built, use nothing but strong balsa of medium hardness throughout.

MATERIAL LIST

1 pc. —	1/8" x 1/8" x 36"	—Balsa (Leading edge spar)
2 pcs.—	1/16" x 3/16" x 36"	—Balsa (Wing spars)
1 pc. —	1/18" x 1/2" x 36"	—Balsa (Trailing edge spar)
1 pc. —	1/2" x 3/4" x 30"	—Balsa (Motor Stick)
1 pc. —	1/16" x 3" x 36"	—Sheet Balsa (Ribs and Wing tips)
2 pcs.—	3/16" x 3/16" x 6"	—Balsa (Wing Mount)
1 pc. —	1" x 1" x 1"	—Balsa (Nose Plug)
1 pc. —	1/8" x 1 1/2" x 1 1/2"	—Sheet Balsa (Thrust bearing sides)
1 pc. —	.034 x 12" long	—Music Wire (Wing clips)
1 pc. —	.040 x 6" long	—Music Wire (Shaft and Hook)
1 pc. —	1 1/8" x 1 3/4" x 14"	—Balsa (Propeller)
2 sheets		—Japanese tissue
Cement		
Banana Oil		
Sandpaper		

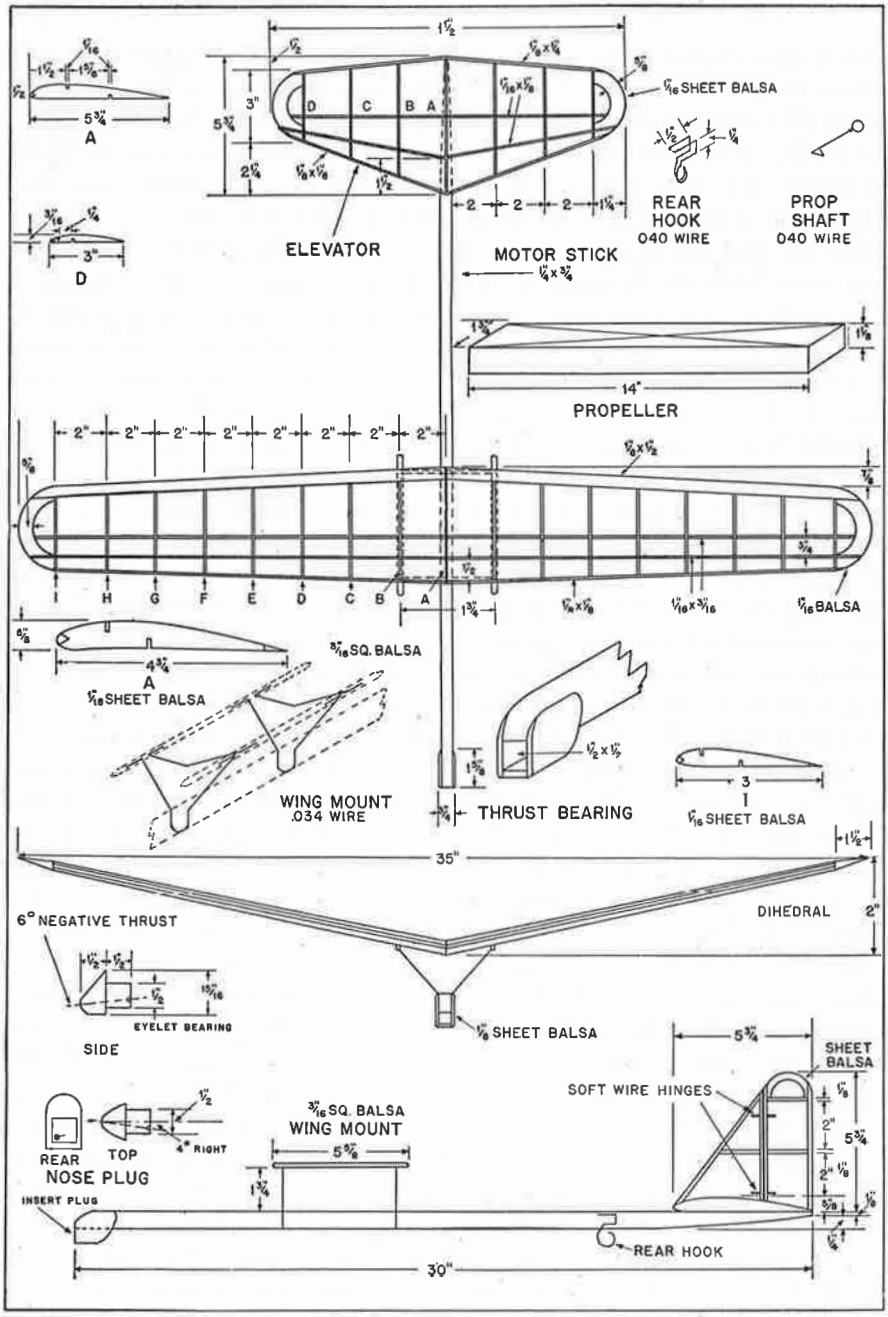
MOTOR STICK. The motor stick is shaped from a 1/2" x 3/4" x 30" long piece of straight-grained, unwarped balsa. Its thickness is tapered from the leading edge of the elevator to its rear end, as shown in the top view. The



CHAMPION OUTDOOR TRACTOR

width is also tapered from a point 8" in from its rear end, which decreases from its original width of 3/4" to 1/8" at the rear, as shown in the side view. Round all corners of the stick with sandpaper. The thrust bearing consists of a small pocket into which fits a nose plug. Note this pocket at the front end of the stick. It is made up of three pieces of 1/8" sheet balsa. Note this construction under "Thrust Bearing." When assembling the sides of this pocket, see that the grain in these pieces runs at right angles to the grain in the stick. Make the opening of this pocket 1/2" square. Cement it in place on the leading end of the motor stick. The top of the stick is then rounded, as shown, and a nose plug made to fit the pocket. This is cut to shape from the 1" x 1" x 1" balsa block. Carve it as shown in the plan under "Nose Plug." Test constantly during this work for a snug fit in the pocket. This removable nose plug eliminates the necessity of the usual "S" hook that is so troublesome to fit on when the motor is wound. When the plug is finished, washers with bushings at front and rear are added for bearings. Note that the thrust line is tilted down six degrees and two degrees to the right. When completed, give it a single coat of cement to toughen it. The rear hook is bent from .040 music wire, as shown in the plan under "Rear Hook." It is then cemented with its end prongs buried into the sides of the stick, as shown in the side view. Three or four coats of cement should be applied around the stick and over the hook to form a strong binding.

ELEVATOR. The elevator is made in one piece. The ribs "A" and "D" are cut from 1/16" sheet balsa. Cut out one "A" rib, locate its notches, and cut these 1/16" wide and 1/8" high. Cut out two "D" ribs without their notches. Cut two elevator tips from 1/16" sheet balsa. These have outside diameters of 3" and are 5/8" wide. Cement the two "D" ribs against the opening side of these half-round tips, as shown in the plan. Cut the straight inner spar 1/16" x 1/8" x 13 3/4" long. Cement this spar in its notch in the "A" rib. Test to see that it is at right angles to the rib. Shape the trailing edge spar from 1/8" x 1/4" x 14 1/2" long balsa. Rule a straight line on paper and place this spar on it. Snap the spar in its exact center and bring its ends forward of the line 1/2". While in this position, cement the trailing end of "A" rib to the center of this trailing edge spar. See that "A" is at right angles to the drawn line. The inner spar already cemented on "A" should be parallel to it. Place a tip with its inner circle against the end of the spar on "A" and its trailing edge against the trailing edge spar. When in this position mark the point where the spar on "A" passes over "D" rib. Cut a notch for the inner spar at this point. The notch location on the other "D" rib is located in the same way. Cement the inner spar in these notches and against the inner circle of each tip. The trailing



CHAMPION OUTDOOR TRACTOR PLAN

edge spar is now trimmed to proper length, the tip notched to receive it, and the two joined with cement. Cement the other tip in the same manner to the opposite end of the trailing edge spar. Cut a leading edge spar of 1/8" square balsa, snap it in its center, and cement it in place against the tips and the three ribs. Cut ribs "B" and "C" from 1/16" sheet balsa, shape them exactly as the others, cut them to proper length and cement in place. The leading inner spar, which fits in the upper edge of the ribs, is now cut from 1/16" x 1/8" balsa. Notch each rib to receive it, snap the spar in its center, cement it in each rib notch and to the tips, and then trim to proper length at both ends. Cover the elevator on both sides with tissue, water spray, and dope.

RUDDER. The rudder is made in two parts, which form the fin (forward) and the rudder (rear). Note its construction in the plan showing the side view. Draw the upper curve of elevator rib "A" on paper. Cut the trailing edge spar of the rudder 1/16" x 1/4" balsa. Cut its leading edge of the same material and size. The tip of the rudder is of 1/16" sheet balsa. This consists of a half-circle 2" in diameter. Trim its ends on its outer-sides so that the trailing and leading edge spars fit it 2" apart from each other. Place these spars in position on the "A" elevator rib and cement the tip in place between these spars so that its highest point is 5 3/4" above the lower end of the trailing spar. The two rudder ribs are cut of 1/16" x 1/8" balsa. Cement them in place as shown. Build up the fin in the same manner. The rudder is joined to the fin by two soft wire hinges cemented in place. Cover on both sides, water spray, and dope.

WING. The wing is made and assembled exactly as was the elevator. When covering it, dope the tissue to the under side of the ribs to hold their contour. Water spray and dope when held in position to the bench.

PROPELLER. Carve the propeller from the 1 1/8" x 1 3/4" x 14" long balsa block. When finished, sand smooth, and then cement a washer with a small bushing inserted on each side of the hub. Dope and sand between coats. Bend the shaft from .040 wire, pass it through the nose plug, and cement in place. Attach 14 strands of rubber.

ASSEMBLY. Bend the two wing mounts to shape and cement them to two 3/16" square balsa wing tracks cut 5 1/4" long, which are set at an angle of three degrees incidence. Cement the elevator to the stick at a zero degree incidence. Cement just the fin of the rudder in place at right angles to the elevator directly over its center. Locate the center of gravity by balancing the stick when the elevator and rudder are in place, and cement the mounts so that this point comes directly halfway between them. Attach the wing with rubber bands, as shown in the photograph.

CHAPTER 25

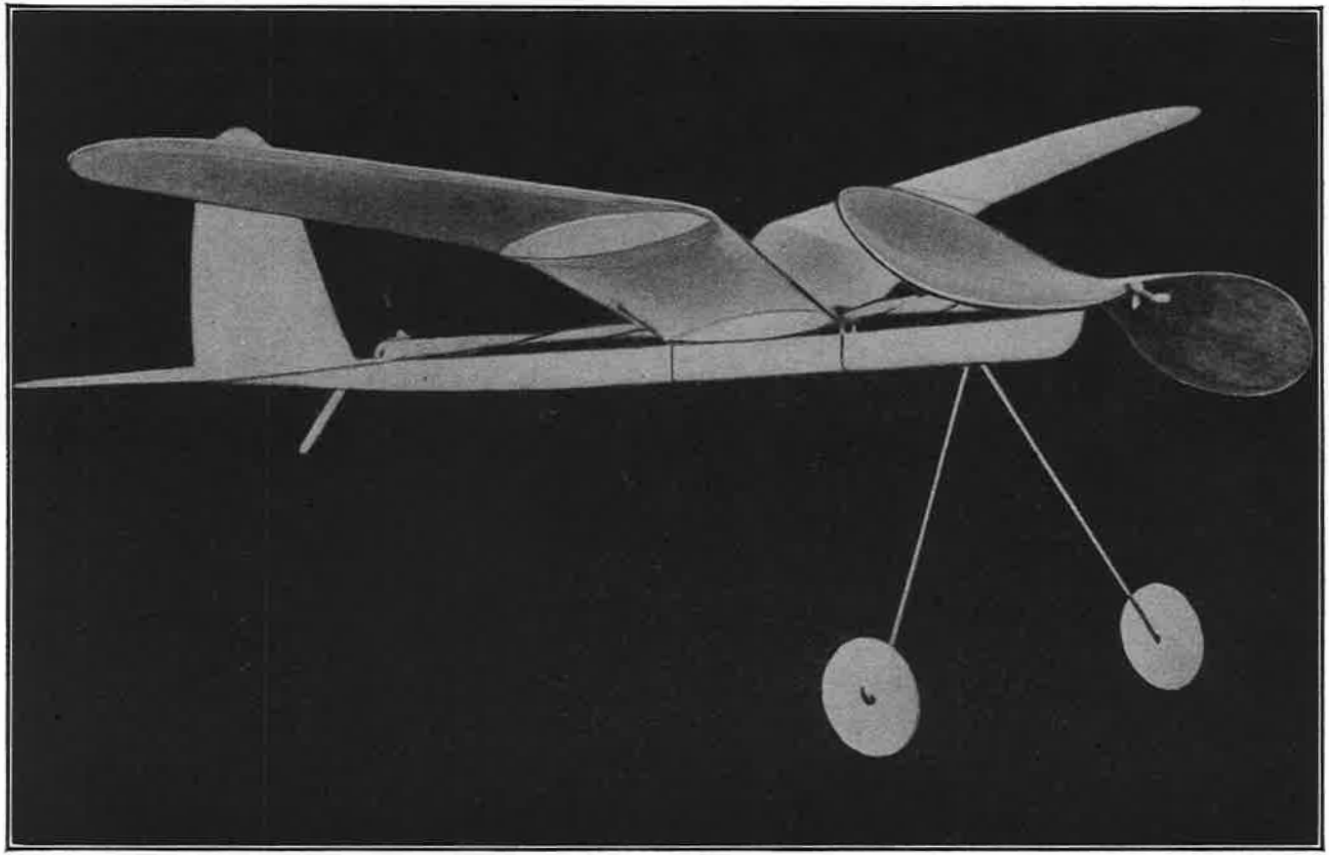
GULL WING

IF you have ever seen a gull pointed for flight on a sandy beach, you will know the incentive that prompted Louis Garami to design and build this all-balsa tractor model. Not only has he incorporated into it the grace and beauty of the gull, but he has also designed a model having considerable of the flying and soaring ability of that well-known bird. The author wishes to thank Mr. Garami for permission to reproduce his successful effort here.

MATERIAL LIST

2 pcs.—1/32" x 2¾" x 5½" —Sheet Balsa (Wings)
2 pcs.—1/32" x 2¾" x 2" —Sheet Balsa (Center-section)
1 pc. —1/32" x 2½" x 2½" —Sheet Balsa (Rudder)
1 pc. —1/32" x 2½" x 6" —Sheet Balsa (Elevator)
1 pc. —1/8" x 3/8" x 12" —Hard Balsa (Motor stick)
1 pc. —1/16" x 3" x 6" —Sheet Balsa (Ribs and Wheels)
1 pc. —¾" x 1⅛" x 6" —Balsa (Propeller)
1 pc. —1/16" x 1/16" x 1 3/16" —Bamboo (Tail skid)
1 pc. —.028 x 18" long —Music Wire (Metal fittings)
1 pc. —1/16" O.D. x 3/8" —Aluminum Tubing (Bearing)
2 pcs.—1/16" O.D. x 1/16" —Aluminum Tubing (Wheel Hubs)
6 —1/8" diameter —Washers (Shaft and Hubs)
1 pc. —1/8" x 17" long —Flat Rubber (Motor)
Cement
Sandpaper (00)
Clear Dope

MOTOR STICK. The motor stick is shaped from a 1/8" x 3/8" x 12" long piece of hard balsa. It remains this size with the exception of the taper given it along its under side. Note this in the side view in the plan. This starts 4½" from the rear end and tapers to 1/8" wide at the end. Round all edges, as shown in the "A-A" and "B-B" cross-sectional views, and then cut the small thrust bearing mount shown on top of the stick at its entering end. This is 1/8" thick, ¼" wide, and 7/16" long. It is of balsa and should be grooved along the top to take the tubing. Note that the stick is notched out to accommodate it. Cut this notch now and cement the block in place.



GULL WING

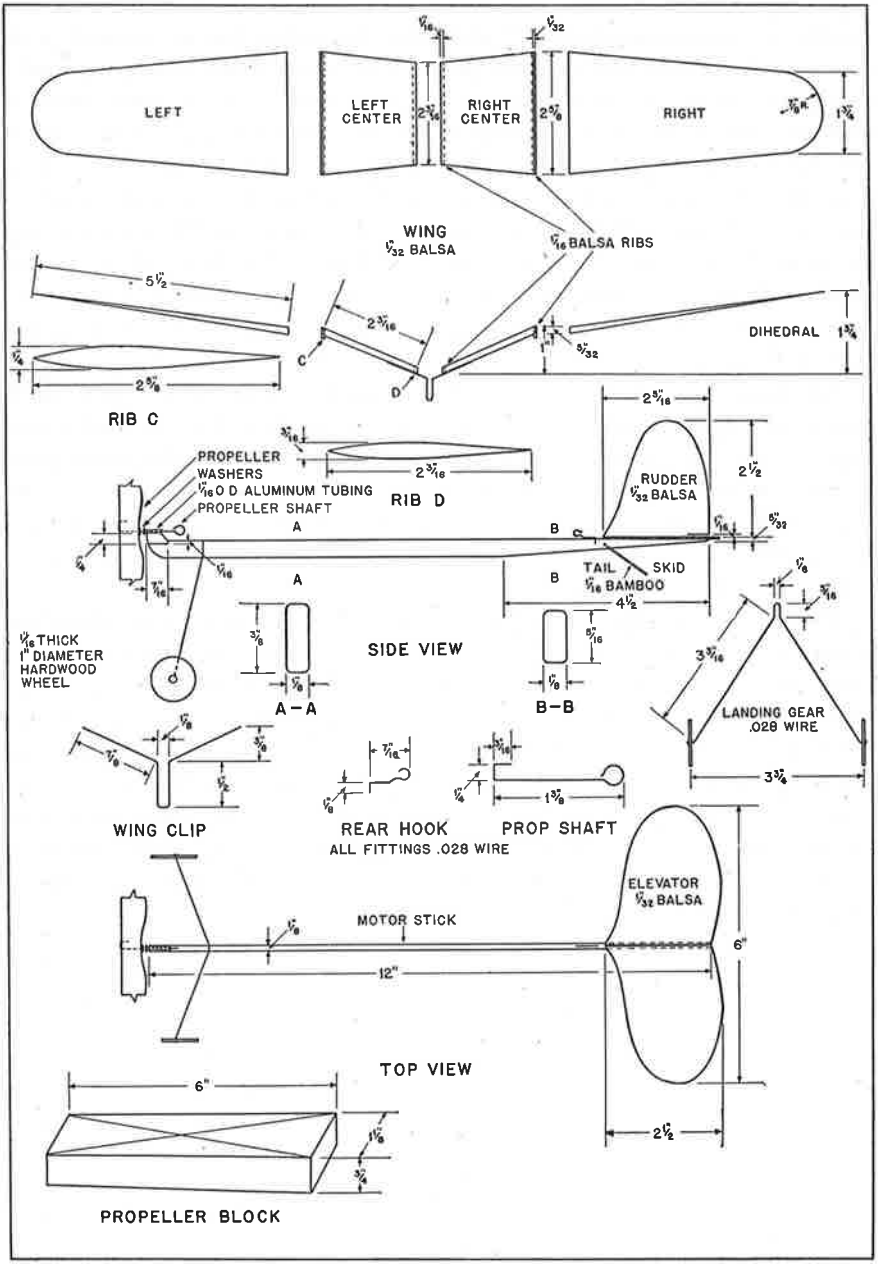
The under edge of the stick is then rounded directly under this mount. Cement the 3/8" long aluminum tubing in place on the thrust bearing mount, as shown in the side view. Use plenty of cement for this joint. Bend the rear hook of .028 music wire, as shown under "Rear Hook," and after thrusting its end into the top of the stick 2 3/8" in from the trailing end of the stick, cement is applied to hold it firmly in place. The tail skid is a length of 1/16" split bamboo inserted in the under side of the stick 2 5/16" in from the stick's rear end, as shown in the plan. Apply two coats of dope to the stick rubbing down between coats with fine sandpaper.

LANDING GEAR. The landing gear details are shown in the plan. This is bent from a single length of .028 music wire. Two solid balsa wheels are cut of 1/16" sheet balsa to diameters of 1" each. Use hard balsa for these. Cement the 1/16" lengths of aluminum tubing in their hubs, thread on the wire axles, and bend the axles up to prevent them from falling off. A washer can be cemented on each side of the wheels over the aluminum tubing's ends if desired. Cement the landing gear 1 1/4" in from the nose of the stick, as shown. The legs of the landing gear are bent forward so that the lower ends of the legs extend 1/4" in front of their upper ends connecting with the stick. The wheels must be in line with each other and 3 3/4" apart.

ELEVATOR. The elevator is shaped from a single piece of 1/32" sheet balsa. It is 2 1/2" wide and 6" long. Cut it to the shape shown in the plan and then sand it to streamlined form. Apply two coats of dope and sand between coats. Cement the elevator on top of the motor stick at its trailing end. Make sure that it is perfectly level and that it is at right angles to the sides of the stick.

RUDDER. The rudder is shaped from a single piece of 1/32" sheet balsa. It is 2 5/16" wide and 2 1/2" long. Shape it as shown in the side view and then streamline it with sandpaper. Apply two coats of clear dope and sand between the coats. A short groove is cut out of the lower edge from the trailing edge of the rudder to permit the rudder being adjusted either way without fear of cracking the wood. When completed the rudder is cemented to the top-center of the elevator at right angles to it. Note that the leading edge of the rudder fits flush with the leading edge of the elevator, which extends out beyond the rear end of the motor stick.

WING. The wing is made in four parts consisting of two center-sections and two outer panels. All four pieces are cut from 1/32" sheet balsa. Start by squaring up two pieces 2 5/8" wide and 2 3/16" long. Taper their sides from this width to 2 3/16" wide at their opposite ends. Sand carefully. The outer panels are cut from original pieces squared up to measure 2 5/8" wide and



GULL WING PLAN

5½" long. Rule a straight line along their lengths directly through their centers. Set your compass at ⅞" and using this center line as a center, scribe a half circle at one end of each piece. This circle must touch the end of each piece with the center line as a pivot. Rule straight lines from the opposite end of the piece to connect the sides of the drawn circles and the sides of the piece at the other end. Cut out these forms and sand smooth. Note that the piece tapers from the wide end to the tip end. Sand this taper in each piece. All four pieces are doped and sanded between coats. Cut two "D" and two "C" ribs from 1/16" sheet balsa. Bevel their tops and cement the two "D" ribs under the short ends of the center-sections. The long ribs "C" are cemented halfway under their wide ends. Use pins to hold the sheeting to the curve of the ribs until dry. Bend two wing clips of .028 music wire, as shown in the plan under "Wing Clip." Cement the clips to the under sides of the center-sections at their leading and trailing edges. Test each clip for alignment and proper dihedral. The outer panels are then cemented in place against the outer ends of the center-section pieces and over the exposed half of the "C" rib in each case. Check for required dihedral and proper alignment, and make any corrections required by bending the wing clips.

PROPELLER. The propeller is carved from a block of medium balsa measuring ¾" x 1⅛" x 6" long. Full instructions covering this work will be found on page 91 under "Carved Propellers." Sand the blades to 1/16" thickness at their tips. A large copper washer and a small eyelet cemented in its hub hole completes it. Apply a single coat of dope to the propeller and sand. Bend a propeller shaft of .028 music wire. Cement it in the hub, thread a washer over the protruding shaft, insert it through the aluminum tubing bearing, and bend the hook. A single loop of ⅛" flat rubber forms the motive power. Tie it in a loop and place it over the shaft and the end hook. The model is now ready for flight.

CHAPTER 26

SINGLE-STICK OUTDOOR PUSHER

THE pusher airplane is so called because the propeller, being in the rear, pushes the model through the air, instead of pulling it as in the case of tractor models. Many pusher models have proved successful at national meets recently, and it would be difficult to say which type of model airplane is more popular.

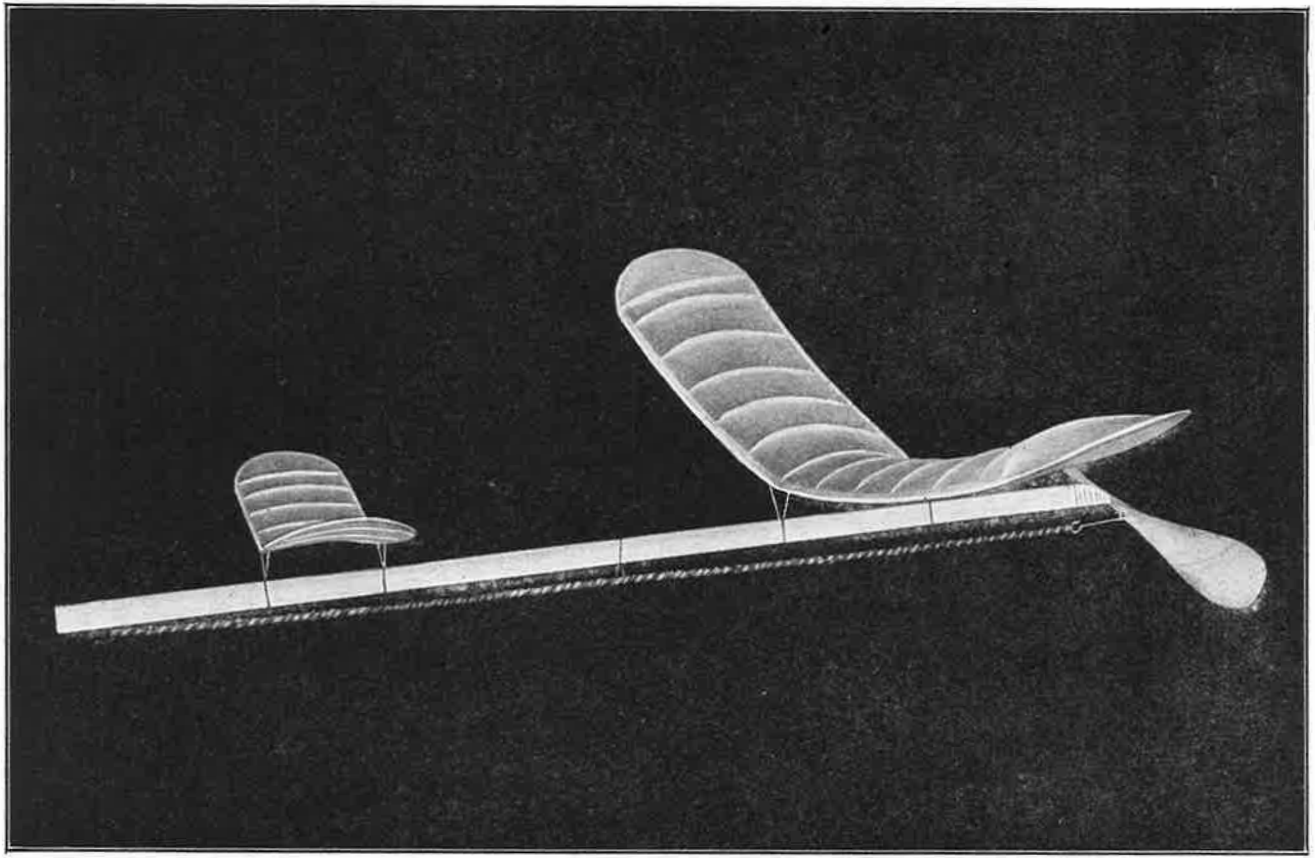
The model given here, while rather complicated in design and construction, embodies practically every detail found in pusher models, and has been chosen to represent this type of model because of this fact, plus its superb flying qualities. Each step in its construction should be carefully followed by the beginner, as many seemingly unimportant details in its design prove of utmost importance when the model is launched.

MOTOR STICK. The motor stick of this model consists of a 1/8" x 1/4" x 24" balsa piece. Study the plan of this stick. Note that its direction of flight is opposite to that of the tractor models. The regulation propeller bearing can be purchased or made. (See Chapter 6, "Propeller Bearings.") This is cemented and bound with silk thread to the end of the motor stick on its under surface. When in position, this end becomes the rear of the model.

At the opposite or front end, a nose hook is cemented over the end of the stick, which becomes the nose or forward end of the motor stick. This nose hook is similar to the regulation rear or end hook of the tractor model, except that it is attached differently. Its function, however, is the same as a rear hook. This nose hook can be bent from No. 9 piano wire, as shown in the plans. (See Chapter 6, "Nose Hooks.")

A can hook is provided to hold the rubber motor in place on the stick. It can be bent from No. 8 piano wire, as shown. (See Chapter 6, "Can Hooks.") The nose hook is cemented in place on the end of the motor stick, while the can hook is fastened in the same manner to the center of the stick.

WING. The wing requires two spars, two wing tips, and thirteen wing ribs. The leading and trailing edge spars are duplicates, both being 1/8" x 1/4" x 24" long. They are cut to size from balsa wood, and tapered as shown in the plans under "Camber of Wing Rib." The thirteen wing ribs are 1/16"



SINGLE-STICK OUTDOOR PUSHER

x 1/16" x 4" balsa wood. While the distance from the inside of the leading edge spar to the inside of the trailing edge spar is only 3½", the ribs should be cut 4" long to allow for their necessary wing camber. This is shown in the plans under "Camber of Wing Rib." A single piece of 1/16" sheet balsa wood 1" wide should be soaked and bent to proper shape, and the ribs are cut 1/16" wide from this piece. Each rib will then have the same bend as all the others. (See Chapter 3, "Balsa Wood.")

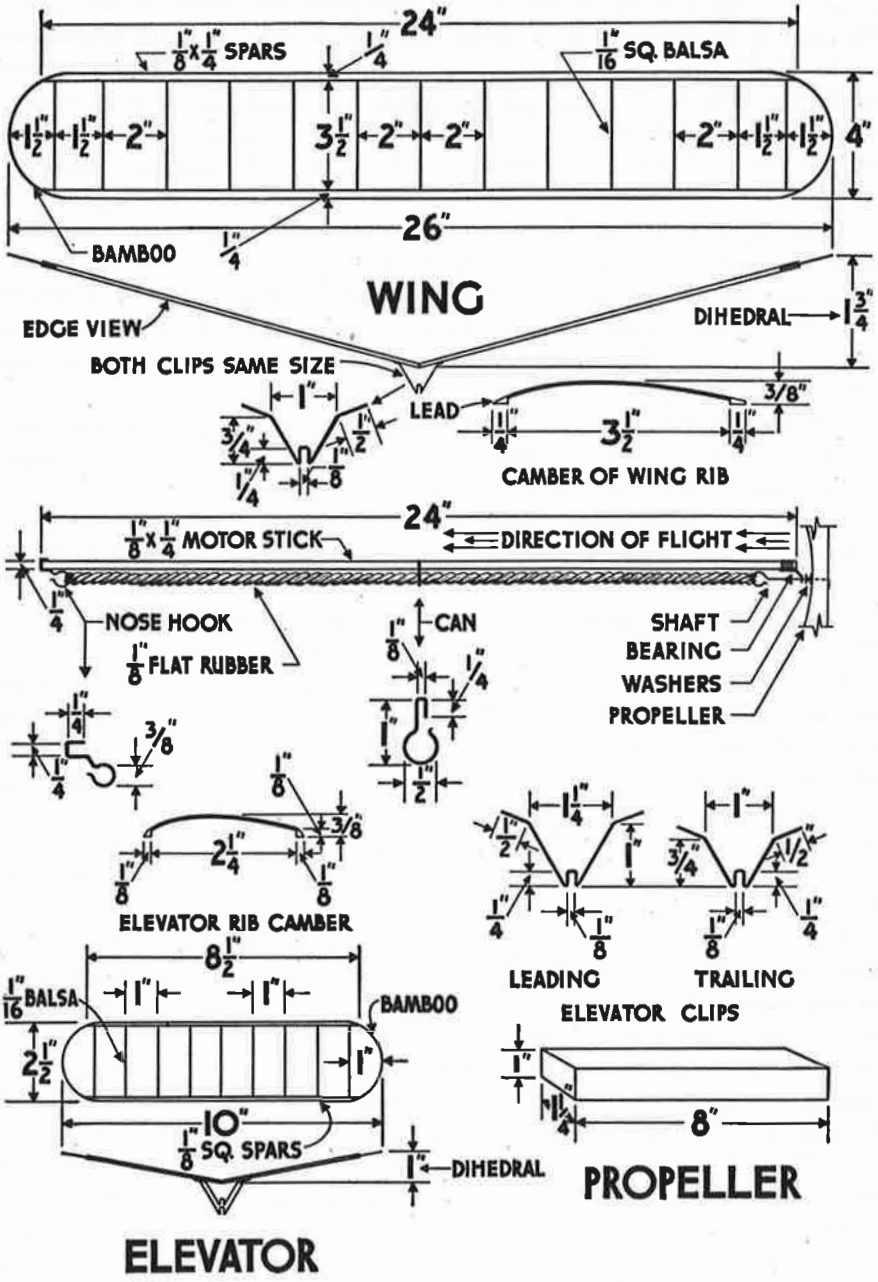
Place the leading and trailing edge spars parallel to each other and 3½" apart. Proceed to cement each of the thirteen ribs in place. Do not cement the center rib at this time, as this can best be done after the necessary wing dihedral has been obtained. Two 1/16" x 1/16" split bamboo wing tips are bent to proper form, and cemented in place to the ends of the wing spars. (See Chapter 3, "Bamboo.")

The wing dihedral on this model is more than average models require, being 1¾". This is now obtained. Snap the leading and trailing edge spars between the thumb and index finger in their centers, or at the location of the center rib. Place both halves in line with each other on a flat table. Holding them at the point of their broken joints, lift the tip of one half 3½" off the table. While in this position, cement the leading and trailing edge spars together again. Hold in position until dry. (See Chapter 7, "Wing Assembly.") The center rib is now cemented in place.

The wing is covered with Japanese tissue. Coat both wing tips, all spars, and ribs on their upper side, and then press the paper on them, making sure it adheres at all points. Use clear dope or banana oil for this work. After the dope has dried, trim all edges of the paper, and give the wing a thorough water-spraying. (See Chapter 7, "Wing Covering.") Two wing clips of the same size are bent from No. 9 piano wire, as shown in the plan. These are cemented over the center wing rib to the under side of the leading and trailing edge spars.

ELEVATOR. The elevator is built up in much the same manner as the wing. Two 1/8" x 1/8" x 8½" long balsa wood spars form the leading and trailing edges. These are streamlined, as were those of the wing. Note their form in the plans under "Elevator Rib Camber." Nine 1/16" x 1/16" x 2½" long balsa elevator ribs are now cut and bent, as shown under "Elevator Rib Camber." These should be made in the same manner as those of the wing. Assemble the elevator ribs between the spars as already instructed for the wing. Bend two bamboo elevator tips from 1/32" x 1/32" split bamboo, and cement them in place at the ends of the leading and trailing edge spars.

Give the elevator a 1" dihedral, by the same method used in obtaining the wing dihedral. Two elevator wing clips are bent from No. 9 piano wire,



SINGLE-STICK OUTDOOR PUSHER PLAN

as shown under "Elevator Clips." The larger of these is cemented to the leading edge spar on its under side, while the smaller one is located on the trailing edge spar. Note their location in the plan of the elevator.

The elevator is covered on its top side with Japanese tissue, which is held with clear dope or banana oil. Do this in the same manner as in covering the wing.

PROPELLER. This is cut from a 1″ x 1¼″ x 8″ balsa propeller block, and should have its blades sandpapered until light will show through them. The regulation propeller shaft is bent from No. 9 piano wire. (See Chapter 6, "Propeller Shafts.") Thrust the end of the shaft through the center of the propeller hub, bend it around, and pull the shaft back until the point buries itself in the wood of the hub. A drop of cement at this bend will hold the shaft firmly in place. The builder must keep in mind that the propeller is to be a pusher propeller, and while it is carved in exactly the same manner as a tractor propeller, the shaft must be inserted through the hub from the opposite side to that of a tractor propeller. In other words, the hook of the propeller must be on the convex side of the blade on a pusher propeller, while it is on the concave side for tractor models. (See Chapter 9, Fig. 47.)

MOTOR. This consists of four strands of ⅛″ flat rubber. Obtain a 92″ length of this rubber, tie its ends together, and loop it into four strands. The propeller and motor assembly is now mounted on the stick. To do this, apply two washers to the propeller shaft and then pass the shaft through the hole in the propeller bearing. One end of the two loops of the rubber motor is looped over the hook of the propeller shaft, passed through the can hook in the center of the motor stick, and the other end of the loops is passed over the nose hook, which completes the motor assembly.

ASSEMBLY. Clip the elevator to the top of the motor stick about 3″ back of the nose hook. The location of the wing should be determined by gliding tests. Change the wing back and forth on the motor stick until a long, even glide is obtained. It may be found that the elevator will also need adjusting, which can be determined by the same gliding tests. When launching the model, remember that the wing trails the elevator with the propeller pushing the model from the end of the motor stick. For the proper method of launching, see Chapter 16, "Correct Launching of Single-Stick Pushers."

CHAPTER 27

HAND-LAUNCHED TWIN PUSHER

PRACTICALLY every endurance record made at outdoor meets has been won by this popular type of model airplane. The twin pusher has become the standard for endurance competition throughout the world and at every meet it wins the greatest amount of awards.

The model given here is a record breaker for endurance flights, being an improved composite of various championship models of the past three years. With a forty-inch A-frame and a thirty-four-inch wing, it lends itself to speed as well as endurance flying. The wing camber and dihedral given in the plans are the result of over a hundred flying tests. The builder should take every precaution to make these as perfect as possible, for the flying ability of the model depends on these main dimensions.

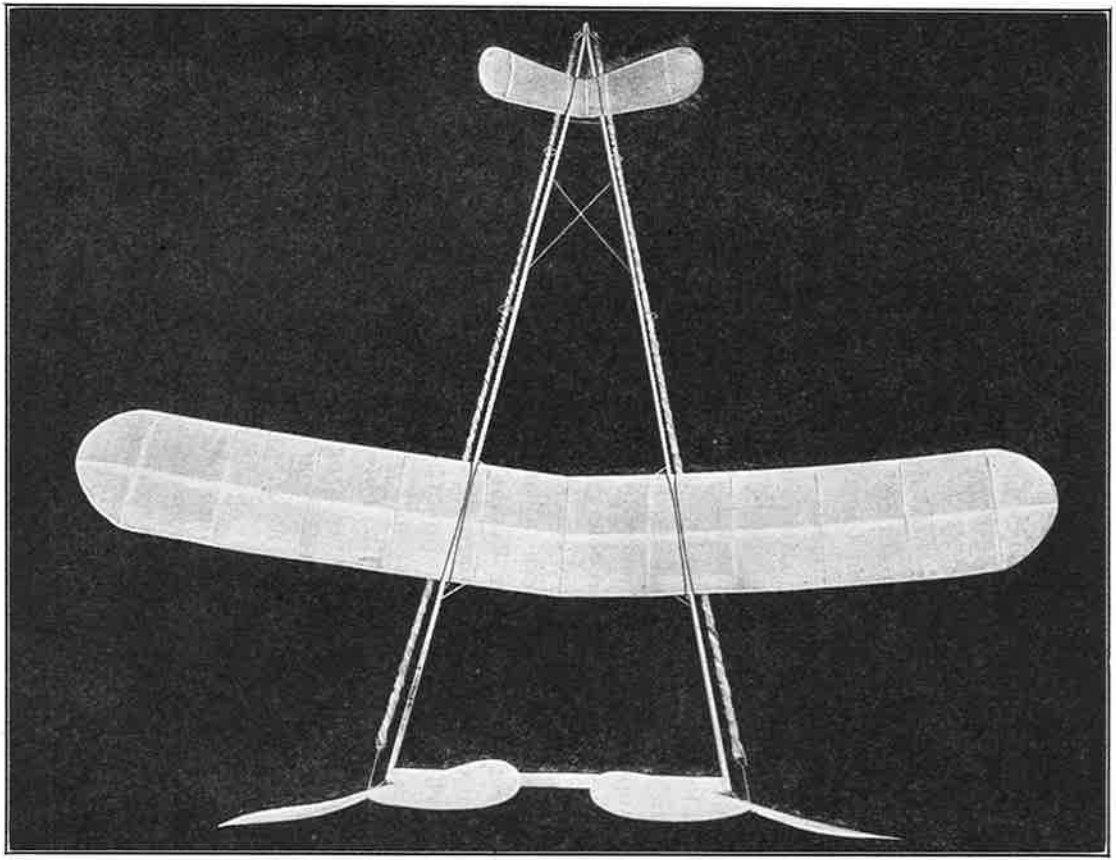
FUSELAGE. The fuselage of such a model is known as the "A-frame," and consists of two long sticks strengthened by various cross bracing. For this model, the following material will be needed:

2 pcs.—3/16" x 3/8" x 40" —Balsa
1 pc. —3/16" x 3/8" x 9 3/8"—Balsa
4 pcs.—1/32" —Split bamboo

If balsa cannot be obtained long enough for the long twin sticks, two pieces should be spliced together, firmly cemented, and bound with silk thread, to make the necessary 40" length. If this is necessary, the splices should be made as near to the front end as possible. As this model is a pusher, the front end is the one equipped with the nose hook, as shown in the plans.

After these pieces have been cut to proper size and sandpapered smooth, they should be equipped with all metal parts before being assembled. A standard propeller bearing is attached to the outer side of each stick at the rear, as shown in the plans. (See Chapter 6, "Propeller Bearings.")

When these are cemented in place, silk thread should be wound around them for added strength. Six can hooks are shaped from No. 12 piano wire. These are used to hold the rubber in position along the fuselage. Each stick is equipped with three of these hooks. They should be placed 10"



HAND-LAUNCHED TWIN PUSHER

apart on the outer side of the sticks and held with cement and thread bindings. (See Chapter 6, "Can Hooks.")

The sticks are now joined together. Taper the front ends of the sticks on their inner sides so that when matched together the propeller bearing holes will be spread 11" apart, as shown in the plan. From No. 12 piano wire, a nose hook is formed, as shown. (See Chapter 6, "Nose Hooks.") This hook not only serves to hold the "S" hooks, but also forms a strong binding for the joint at the front end of the fuselage.

The front joint is cemented together, the nose hook cemented over it, and the entire joint bound tightly with silk thread, as shown in the plan. The 3/16" x 3/8" x 9 3/8" long balsa rear brace is cut and sandpapered smooth. Its ends are notched and the ends of the fuselage sticks are also cut to form a half lap joint. When completed, the brace is cemented in place. This is followed by the inner bamboo bracing. Small holes are cut on the inner side of the sticks to hold this bracing. From 1/32" split bamboo, the braces are cut to proper length and cemented in place. At their intersection, a drop of cement should be applied to hold them together.

WING. From the plan of the wing rib, cut a paper template to exact size. The rounded part, shown in white at the front, is left off the template as this form is gained by the leading edge spar. From 1/16" sheet balsa, cut out eleven of these ribs. Remove their inner excess material by cutting the small circles in them, as shown. Give them a careful sandpapering for smoothness. The leading edge spar is now cut to length and then shaped, as shown by the plan of the rib. This is made from 5/16" square balsa and should be 30 1/2" long. The inner wing spar is made from 1/16" x 1/4" x 34" long balsa, while the trailing edge spar is 1/32" x 1/16" x 30" long balsa.

The small holes in the ribs for the inner wing spar are now cut, and the ribs are properly spaced on this spar and held with cement. Allow this assembly to dry thoroughly. To the blunt front end of each rib, the leading edge spar is cemented. Note that this spar extends only 1/4" beyond the outer rib on each end. The trailing edge spar is cemented in place, and the structure set aside to dry.

The wing tip can be bent to shape while the wing structure is drying. When completed, the ends of the leading and trailing edge spars are tapered to accommodate the 1/32" split bamboo wing tips, which are cemented in place.

To obtain the 1 7/8" dihedral angle, carefully snap the leading and trailing edge spars between the thumb and finger. Lay one side of the wing flat on a table and lift the other end up until it is 3 3/4" above the table top. A drop of cement at the joint of these spars will hold the wing in this posi-

tion. The wing is covered on both sides with Japanese tissue, and steamed or water-sprayed to tighten the covering. (See Chapter 7, "Wing Covering.") The wing of this model is held to the A-frame with rubber bands, so no clips will be needed.

ELEVATOR. On twin-stick pushers, the elevator is often called the "nose wing," because of its position on the fuselage. This elevator is constructed of 1/32" x 1/16" split bamboo throughout. Cut five ribs, slightly camber them, and then attach them between the leading and trailing edge spars, which are constructed of one length of bamboo. When the cement is thoroughly dry, snap the leading and trailing edge spars in their centers to obtain the necessary dihedral. Note that both these spars have different dihedral angles. The leading edge has a 1½" dihedral, while the trailing edge has one only ¾" high, as shown in the plan. Obtain these dihedrals in the same manner as for the main wing and hold with cement. (See Chapter 7, "Wing Assembly.")

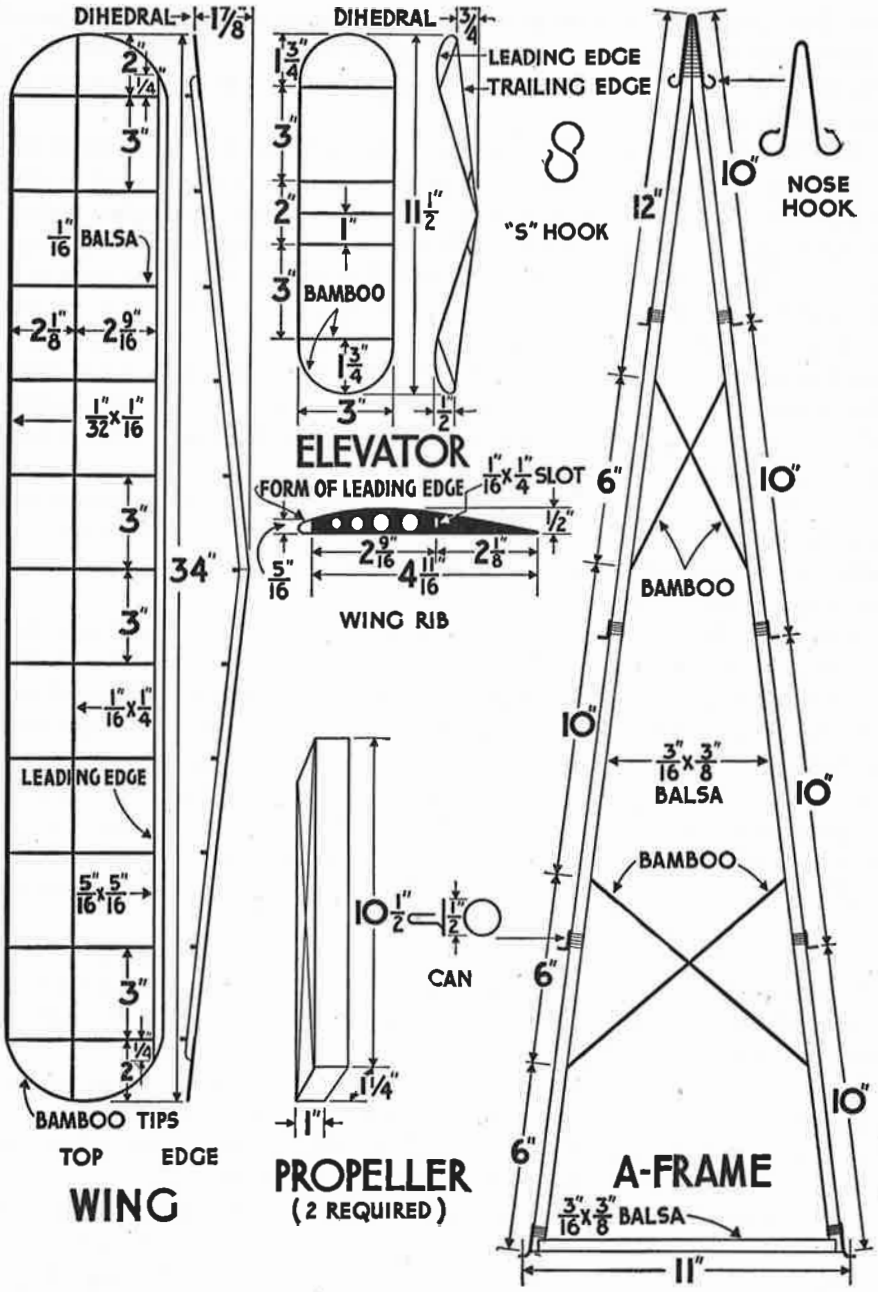
The elevator is covered on one side only with Japanese tissue, which can then be water-sprayed or steamed to tighten the paper. (See Chapter 7, "Wing Covering.") This part is also held on with rubber bands, and therefore requires no metal clips.

PROPELLERS. Twin-pushers obtain their name through the fact that they have two or "twin" pusher propellers. These are cut from 1" x 1¼" x 10½" balsa propeller blocks. Remember that they must be left hand and right hand propellers, so carving must start on opposite edges. (See Chapter 9, "Right and Left Hand Propellers.") As they are pusher propellers, their shafts must be inserted so that their hooks are on the convex side of the propellers. Bend two propeller shafts from No. 12 piano wire, insert them through the hubs of the propellers, bend their ends over, and cement in place. Two washers should be provided for each shaft. When complete, thread them through the holes in the propeller bearings.

MOTIVE POWER. The motor of this model consists of eight strands of 1/8" flat pure Para rubber for each propeller. Obtain a fifty-four-foot length of this rubber, cut it into two twenty-seven-foot lengths, and tie the ends of each piece together to form two loops.

These are then ready for assembly. Form two "S" hooks from No. 12 piano wire, as shown. (See Chapter 6, " 'S' Hooks.") Attach these hooks to the nose hook, and then make eight equally long strands of the rubber by looping it between the propeller hooks and the "S" hooks.

ASSEMBLY. To attach the wing and elevator, strong rubber bands will be required. (See Chapter 28, "Assembly.") After these parts have been assembled, the model must be glided to test for their proper location. If the



HAND-LAUNCHED TWIN PUSHER PLAN

model dives, the wing should be pushed forward on the fuselage. If it stalls, the wing should be brought back. The nose wing, or elevator, should be attached about 3″ to 5″ from the nose hook. After the location of the wing has been determined, an egg-beater winder should be used to wind the motors. For the proper method of launching, see Chapter 16, "Correct Launching of Endurance Twin Pushers."

CHAPTER 28

R.O.W. TWIN-STICK PUSHER

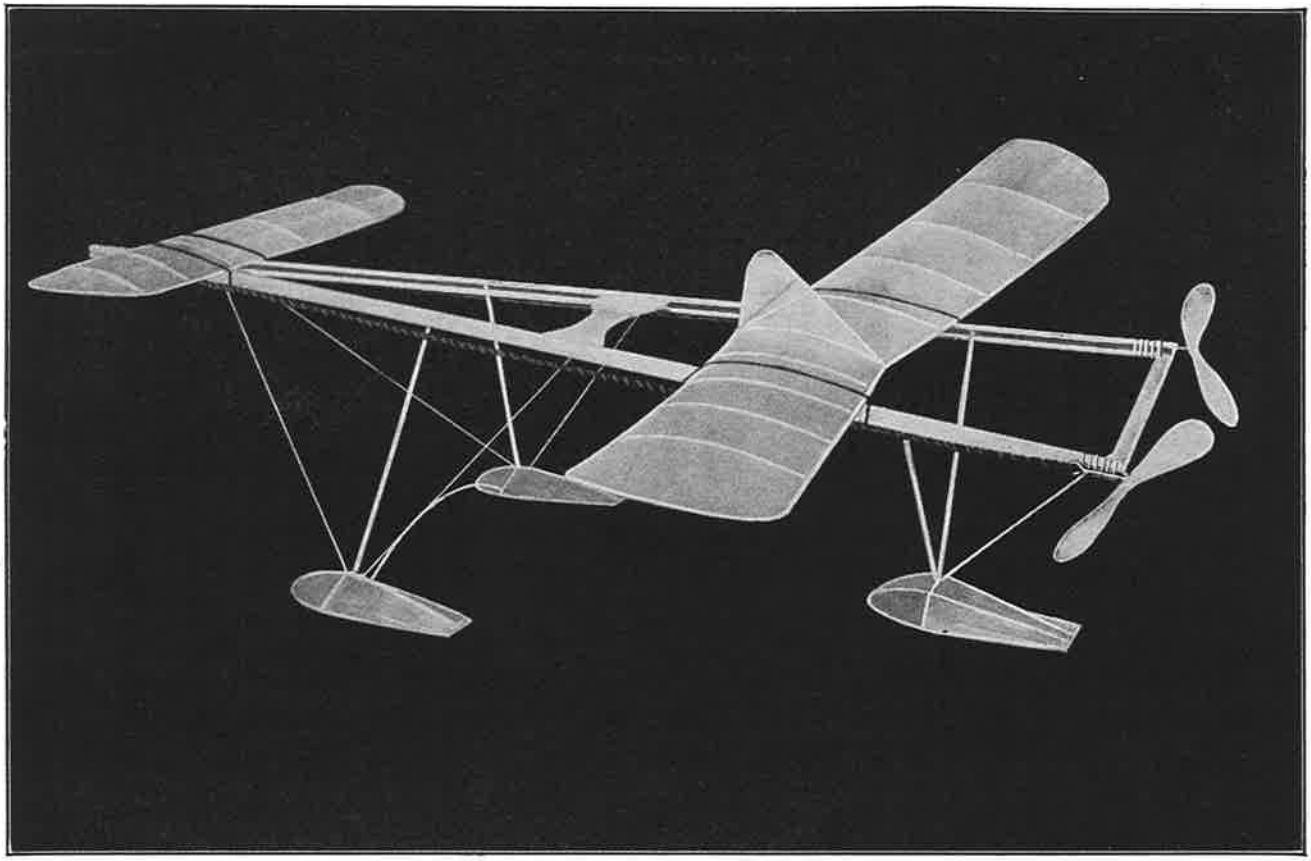
ONE of the most interesting performers of all the stick model group is the rise-off-water (R.O.W.) twin-stick pusher. It is a splendid endurance flyer and possesses a natural grace seldom found in model airplanes. Its ability to take off from the water and its attractive flying qualities make it a model well worth building.

It is a model for the advanced builder rather than for the beginner, as its construction is considerably more difficult than ordinary stick airplanes. However, if the amateur will carefully follow the plans and instructions, doing the work step by step, he should experience little trouble.

FUSELAGE. The fuselage of a twin-stick pusher is known as the "A-frame" because its general form often resembles a large letter "A." Two lengths of 1/4" x 3/8" balsa wood "U" beam are used for our fuselage, with the opening of the "U" on the inside. In case "U" beam cannot be obtained, solid pieces of balsa wood may be used. These should be 30" long. At one end the "U" beams are held apart by a 1/16" x 5/16" x 8 3/4" balsa length, known as a "spreader." The ends of the two beams are notched to allow the ends of the spreader to fit into them, as shown in Plan 1.

A piece of 1/16" sheet balsa wood is used as a center brace between the two beams. It is 2" wide and is cut out as shown to eliminate weight. As the openings of the "U" beams are wider than the thickness of this center brace, small wedges are placed between the sides of the beams and the brace. Cement the brace and these wedges in place between the beams, after the front ends of the beams have been tapered and brought together to fit. Note that the ends of the center brace must be tapered to fit the slant of the "U" beams. When this is in place, cement the ends of the beams together.

A nose hook is bent from No. 11 piano wire. This is sometimes called the "yoke," as it serves a double purpose by holding the front end of the frame together and also as a means for fastening the front ends of the rubber motor. (See Chapter 6, "Nose Hooks.") This is attached over the ends of the beams with cement and silk thread, as shown. Two propeller bearings are purchased or made. (See Chapter 6, "Propeller Bearings.") These are



R.O.W. TWIN-STICK PUSHER

cemented and bound with silk thread to the outer side of the "U" beams at their rear ends.

Two small elevator blocks are now cut from balsa wood as shown in Plan 1. These are cemented to the upper side of the beams 2" from their front ends. The thick part of these blocks should be facing toward the nose of the frame.

ELEVATOR. As the elevator has a sweepback of 1¾", it must be built in two parts, or halves. The leading edge spar is ⅛" x ⅛" x 15" long, and is cut from balsa wood. When this piece has been shaped, as shown under "Elevator Rib," it must be cut into two 7½" lengths. The trailing edge of the elevator consists of two lengths of balsa wood. Cut these two pieces 1/16" x ⅛" x 6" long. Five sheet balsa ribs are now provided. Cut these from 1/32" sheet balsa in the form shown in Plan 1 under "Elevator Rib."

The inner elevator spar is 1/16" x ⅛" x 15" long balsa. As the wing must be built by halves, this spar must be cut into two equal lengths of 7½" each. Make a full-size drawing of the elevator, and place each part in its proper location on your plan. Cement the inner elevator spar of one half to its two ribs, leaving the center rib until later. Notch the front end of the ribs and cement the leading edge spar to them, which should be followed by cementing the trailing edge spar. Bend two 1/32" split bamboo elevator tips over a flame, as shown in the plans. Complete one half of the elevator by cementing one of the tips to the ends of the spars.

The second half of the elevator is assembled in the same manner. The elevator is given its 1" dihedral angle. Place the two halves together on a flat table. Holding them to the table at their joints, lift the tip of one of the halves off the table 2", and while in this position, cement the joints together. (See Chapter 7, "Wing Assembly.") The center rib is now attached.

The elevator is covered on both sides with Japanese tissue. Coat the under side of all ribs, spars, and wing tips with clear dope or banana oil, and press the paper in place. Follow this by covering the top in the same manner. (See Chapter 7, "Wing Covering.") The elevator should be water-sprayed or steamed to tighten the paper.

WING. The wing is constructed much in the same manner as the elevator. As it, too, has a sweepback, it must be built one half at a time. Cut the leading edge spar from balsa wood measuring ⅛" x ⅛" x 30½" long. An inner wing spar is cut from the same wood 1/16" x ⅛" x 30½" long. Cut these into two equal lengths of 15¼". Shape the leading edge spar, as shown in Plan 1 under "Wing Section." From 1/16" sheet balsa, cut the nine wing ribs to proper shape and size, as shown under "Wing Rib." Remove excess

material from the center of each to reduce weight. Notch their front ends to fit the form of the leading edge spar.

Draw a full-size copy of the top view of the wing, as shown in Plan 1. Lay each piece in its proper place on the drawing. Building one half at a time, the various pieces are now assembled. Space the ribs on the inner wing spar at their correct positions and cement in place. Do not cement the center rib at this time.

The leading edge spar is attached to the front ends of the ribs with cement. A $\frac{1}{16}$" x $\frac{1}{8}$" x 25" long balsa trailing edge spar is now cut. While this requires no shaping, it must be cut into two equal lengths of $11\frac{1}{2}$" each. When completed, cement one half to the trailing ends of the ribs of the half wing on which you are now working.

Two $\frac{1}{32}$" x $\frac{1}{32}$" split bamboo wing tips are formed by heating over a flame. (See Chapter 3, "Bamboo.") When completed, one of these tips should be cemented in place on the wing half you are assembling by cementing its ends to the ends of the leading and trailing edge spars.

When one half of the wing has been completed, the other half should be assembled in the same manner. The structure should now fit the full-size drawing of the plan when placed on it. When in this position, the necessary wing dihedral is obtained. (See Chapter 7, "Wing Assembly.") The center rib is now cemented in place. Cover the wing on both sides with Japanese tissue. Spray the covering with water and when dry, give it a thin coat of dope or banana oil. A wing stabilizer is bent from $\frac{1}{16}$" split bamboo and attached to the center rib of the wing. Cement one end to the trailing edge spar at the trailing end of the center rib. Bring the bamboo forward and up to a point 2" above the leading edge spar, bend it sharply, and bring it down to this spar at the leading end of the center rib, where it is cemented in place.

A small $\frac{1}{16}$" split bamboo brace is inserted with cement between the bamboo outline and the leading edge spar, as shown in Plan 1. Cover the stabilizer with Japanese tissue on one side only. Note this in the plans under "Stabilizer." This completes the wing, which requires no clips as it is held with rubber bands. (See "Assembly.")

PROPELLERS. Two propellers are necessary for this model. They are carved from 1" x $1\frac{1}{4}$" x 9" propeller blocks of balsa wood, as shown under "Propeller." One of these is a right hand, while the other is a left hand propeller. (See Chapter 9, "Right and Left Hand Propellers.")

When viewed from the rear, as shown in Fig. 48 in Chapter 9, the right hand propeller turns clockwise, while the left hand turns counter-clockwise.

In other words, both propellers turn up and out, when viewed from the rear of the model.

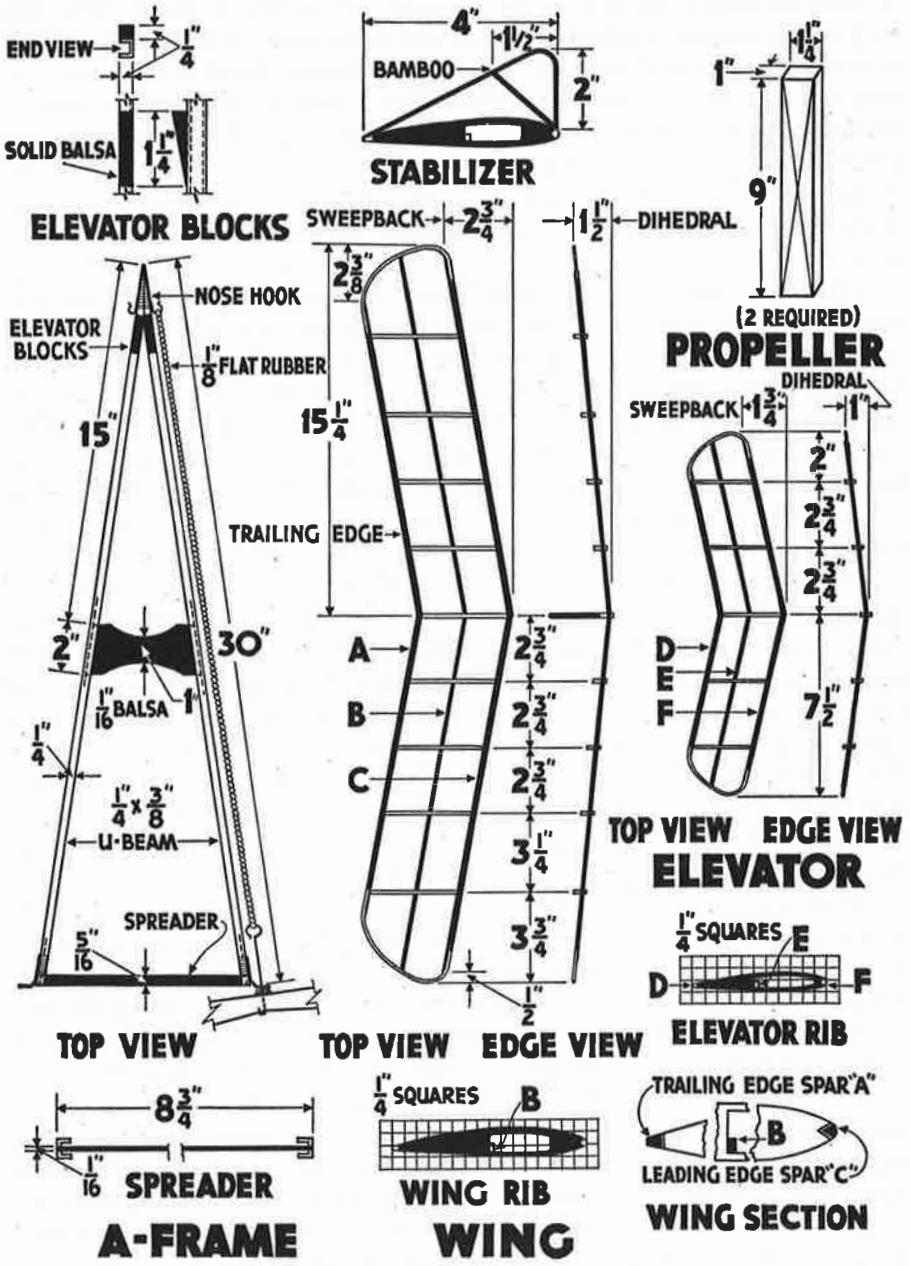
When the carving has been completed, propeller shafts are bent from No. 14 piano wire. (See Chapter 6, "Propeller Shafts.") As these are pusher propellers, the shafts should be inserted through the hubs of the propellers so that the hooks of the shafts are on the convex side of the blades. Remember that the convex side of the blade always leads on both tractor and pusher models.

LANDING GEAR. The floats are extremely important on any rise-off-water model. Those shown for this model have been designed to give the least resistance in the water, a minimum of weight, and quick rising. Floats should be large enough to displace water weighing at least three times the weight of the model, when they are fully submerged. When this is done, they will carry the model while riding high on the water. If the floats are smaller, the weight of the model will sink them deeper into the water, which will retard forward motion, making the take-off difficult if not impossible. The "V" bottom form also assists the floats to cut through the water much in the manner of a boat, giving rapid rising, keeping the course of the model in a straight line, and assisting in landing.

Their construction is simple, but the beginner should carefully follow these directions when making his first floats. The trailing end of the model has a single float, while the leading end is equipped with a duplicate pair. The single float is necessarily larger than the front floats, but the construction is practically the same.

The rear float is made first. For this the builder will require one 1/16" sheet balsa former, one balsa rear brace, and three lengths of 1/16" square bamboo. Draw a full-size plan of the former on a sheet of paper, which has been ruled with 1/4" squares. See Plan 2. Trace this drawing on a piece of 1/16" thick sheet balsa. Cut the former from the balsa sheet, remove excess material from its center, and cut the five necessary 1/16" x 1/16" notches to accommodate the split bamboo lengths. The second balsa piece required in the construction is 1/16" x 1/4" x 1 3/4" long. Four notches should be cut on the top of this length to accommodate the top bamboo stringers, while one is cut on the bottom to fit the bottom, center, bamboo stringer.

Study the plan of the rear float. Three bamboo lengths, marked 1, 2, and 3, are required to complete the necessary materials for this job. The longest stringer (2) starts at one end of the rear balsa brace, where it is cemented into the notch cut for it. From this point it extends 3 1/4" forward to the side of the balsa former, where it is cemented into the side notch of the former. It is then bent in a wide curve 1 3/4" in front of the former,



R.O.W. TWIN-STICK PUSHER PLAN 1

brought around, cemented to the opposite side notch of the former, and back to the opposite end notch of the rear balsa brace. The second stringer is attached in the same manner, although its forward bend is a sharper one than the first stringer. When in place, this second stringer is cemented to the first at the point of their curves where they meet. Note that while the first stringer attached (2) remains straight, as shown in the side view, the second stringer (1) must be bent in a curve from the rear brace to the top of the former, and then down again to meet the first stringer at its forward point.

The third stringer (3) is a single length running in a curve from the forward point of contact of the first two stringers, through the bottom notch of the former, and on back to the bottom notch of the rear brace. When fully assembled, the float is covered with Japanese tissue, water-sprayed, and then given a single coat of dope. The struts used to attach this float to the model are of $\frac{1}{16}$" square bamboo. Three are used. These struts can be cemented to the float and the A-frame, or they can be attached by using $\frac{1}{16}$" diameter bushing eyelets, which can be purchased at any model supply house.

For builders carrying their models some distance the latter is recommended, as the floats can then be removed and the entire model carried as easily as any hand-launched type. If bushings are used, care must be taken when cementing them to the former of the float. Small notches are cut in the top of the former, directly over the stringer 3. These three notches are then coated with cement and the three eyelets set in them at their required angles. The middle one points to the spreader of the A-frame, while the two outer ones point toward the A-frame beams. When these are set in position and the first cement has dried, additional cement should be applied to bind them in one coating of cement. Allow an hour for drying.

Three eyelets are also used on the A-frame into which fit the other ends of the struts. One of these is located in the center of the spreader, while the two others fit into the beams of the A-frame 5" from their trailing ends. To do this, make holes in the under side of the "U" beams, insert the eyelets into them, and apply cement. The ends of the struts should be tapered to allow them to enter the eyelets, but only enough to give a tight fit.

The duplicate pair of floats for the front of the model are made in the same manner as the rear one. Only two lengths of bamboo are necessary for each of these. The former and trailing edge have the same dimensions as the large rear float. Note, however, that the dimensions of these floats are smaller than the overall dimensions of the rear float. When completed, they are joined together by a $\frac{1}{16}$" square split bamboo length, as shown in

the front view of the model in Plan 2. This piece is bent with a 1″ arch and is cut long enough to spread the floats 9¼″ apart. Each of these floats has one 1/16″ square bamboo strut running from the float former directly over the No. 1 stringer to a point on the "U" beam 12″ from the nose of the A-frame. They can be cemented or fitted with bushing eyelets, in the manner already described. A length of silk thread is used to strengthen this assembly on each side. Small hooks are bent from No. 6 piano wire and tied to each end of the thread, as shown. Before this is done, however, the thread should be passed through the tissue, around the top portion of the former, and out the other side. This can be done with a bent pin. At the points where the thread comes through the tissue, cement is applied to hold the thread in position. The hooks are then tied in place. One end of the thread is attached to the A-frame 5″ from the nose, while its other end is attached 16″ from the nose, as shown. The connection at the A-frame is made by similar hooks cemented in place on the beams. Both sides are connected in the same manner.

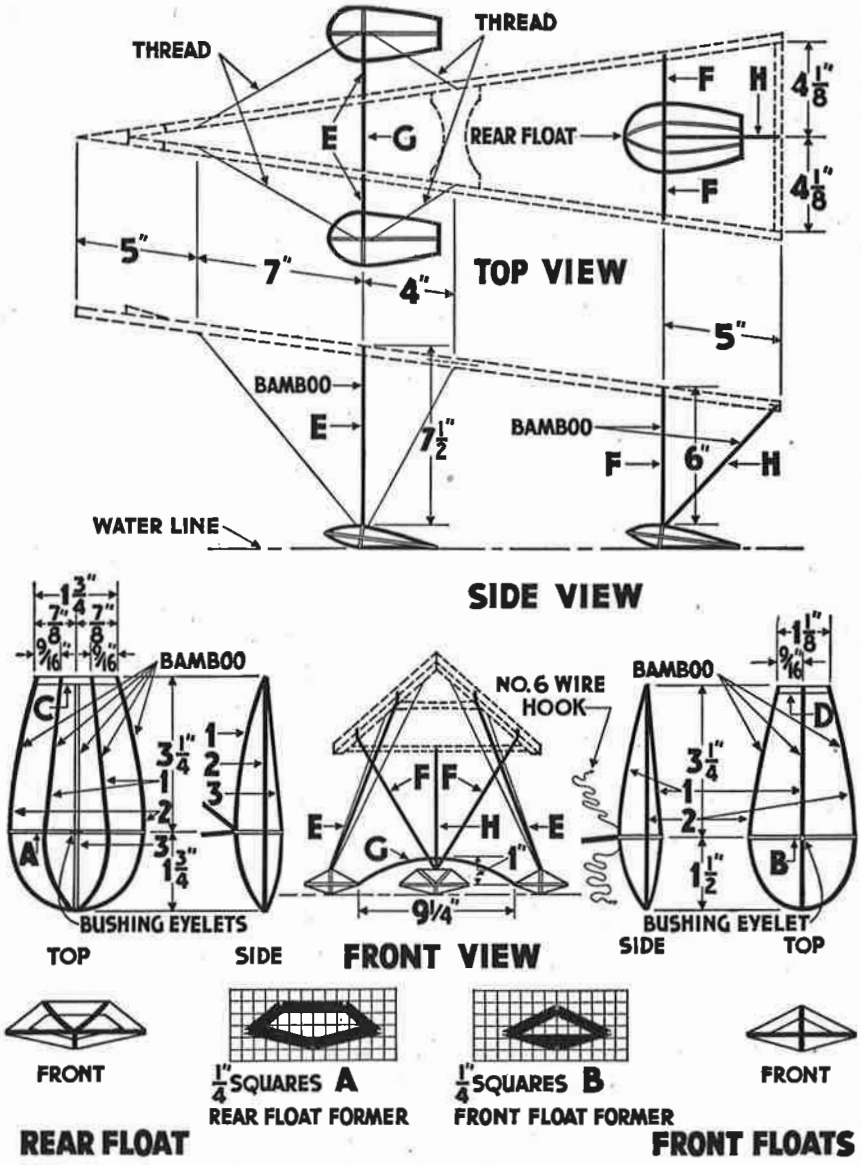
WATERPROOFING. As such models are bound to get wet, they should be thoroughly waterproofed before being flown. As the average dope is too thin for good waterproofing, a small quantity of cement should be mixed with the dope to give it thickness. The propellers should be given five coats of this mixture. After each coat has become thoroughly dry, the propellers should be carefully sandpapered, leaving the last coat untouched.

The entire A-frame should be treated in the same manner. The wing and elevator should not be treated with this mixture, as sandpaper cannot be used on these parts. Give each from three to five coats of clear banana oil to make them watertight. The floats should be given the same treatment, and tests must be made to see that these are especially waterproof.

ASSEMBLY. The wing and elevator are held with rubber bands. The leading edge of the elevator fits on the top of the small triangular blocks attached to the "U" beams near the nose, while the wing is located near the propellers. The elevator adjustment is practically stationary, but the wing must be adjusted by gliding tests before the motors are used.

One rubber band holds the elevator in place. Slip the band over the nose of the model and work the loop along the "U" beams to the point where the trailing edge of the elevator crosses them. Place the elevator in position on the "U" beams, bring the rubber band loop over the top of the elevator, and then slip the loop under the nose of the model. This will hold the elevator in place and at the same time allow it to be moved forward or backward as the flyer adjusts his model.

The main wing requires two rubber bands, both of which must be



R.O.W. LANDING GEAR

R.O.W. TWIN-STICK PUSHER PLAN 2

broken inasmuch as the closed ends of the A-frame prevent the bands from being passed over each beam. Break one of the bands, pass one end under the "U" beam, and bring the ends of the band together over the frame. Place the wing on the A-frame, bring the band strands over the top of the wing and under the "U" beam, where they are tied together. The other band is attached in the same manner.

The propellers are now assembled. Two small washers, which can be purchased at any model supply store, are placed on each propeller shaft. They are then passed through the holes in the propeller bearings, and the rubber motors are attached. For this model, six strands of 1/8" flat rubber are used on each propeller. As considerable slack is desirable, 180" of rubber should be applied in six strands for each motor. From No. 14 piano wire, bend two "S" hooks. (See Chapter 6, " 'S' Hooks.") One end of these hooks is attached to the nose hook, while the loops of the rubber motor are passed over the other.

FLYING. Before winding the motors, glide the model to determine the best wing location. As the floats are delicate, this should be done over shallow water or deep grass, so that the landing will not harm them.

If the model stalls, the wing should be moved back on the A-frame, or if its glide takes the form of a dive, move the wing forward. Continue these gliding tests until a long, smooth, and gradual glide has been obtained. On the "U" beams, mark the wing location, so that when the model has been taken apart, it can be assembled again without the necessity of tests.

The motor should be wound with an egg-beater winder to about four hundred turns. Remember that each propeller must be wound in opposite directions, or down, out, and up, when viewed from the rear of the model. For the proper method of launching, see Chapter 16, "Correct Launching of R.O.G. Model," as this method also applies to R.O.W. types.

CHAPTER 29

TAILLESS TRACTOR

ALL experienced model airplane builders enjoy attempting the construction of new types of aircraft. The "tailless" tractor is presented here—not so much to show how it can be done as to prove it possible, and in the hope that the reader will experiment with it in an effort to develop this type of model. Simplicity is the main advantage of the model, as it is a single-stick tractor without the usual elevator, the lack of which is corrected through the specially designed wing.

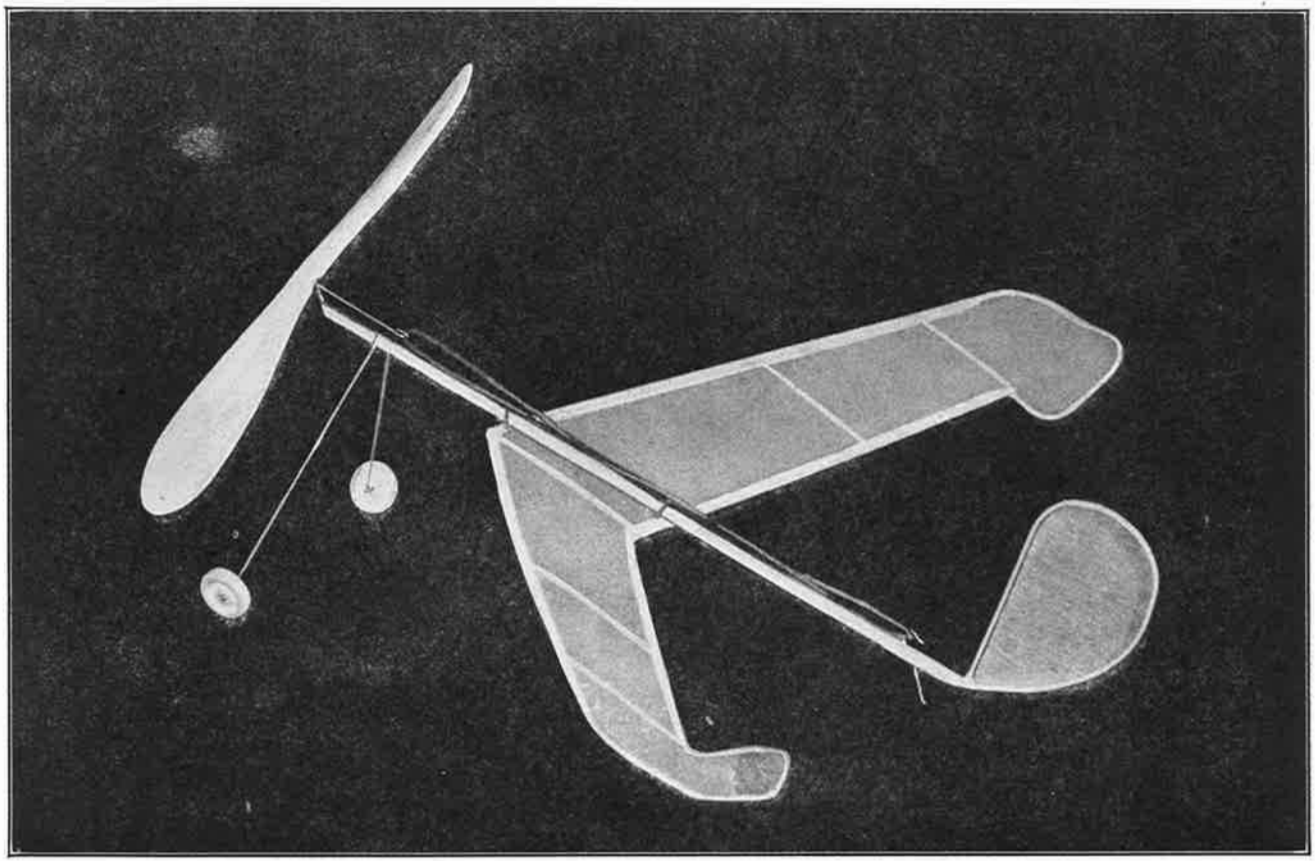
MOTOR STICK. This consists of a balsa stick 1/16" x 1/8" x 8" long. Its rear end is left square, while the front or nose of the stick has a 1/8" bevel, as shown. A lightweight propeller bearing is cemented on the 1/16" top edge of the motor stick at its front end, while a rear or end hook is attached in the same way at the rear end. These fittings may be bent from No. 8 piano wire. (See Chapter 6, "End Hooks" and "Propeller Bearings.")

RUDDER. One piece of 1/32" split bamboo forms the outline edge of the rudder. This is bent to proper shape by heating. (See Chapter 3, "Bamboo.") Cement the ends together. Cover the structure with Japanese tissue on one side only, holding it tightly with dope. (See Chapter 7, "Wing Covering.")

LANDING GEAR. This consists of one length of No. 8 piano wire bent to shape, as shown in the plans under "Landing Gear." Two wheels are cut from 1/32" sheet balsa. These should be 3/4" in diameter. After they are threaded on the axles, the axles are bent up to keep them in place.

PROPELLER. The propeller is carved from a 1/2" x 3/4" x 6" balsa propeller blank. (See Chapter 9, "Carved Propellers.") A propeller shaft of No. 8 piano wire is bent to form and inserted through the center of the hub. It should then be bent over, and a drop of cement applied on the bend to hold the shaft in position.

MOTOR. The motive power is obtained through a length of 3/16" flat rubber. This should be long enough to allow a slack of 1/2" between the hook of the propeller shaft and the rear hook. The rubber is held in place by piercing the ends with the hooks.



TAILLESS TRACTOR

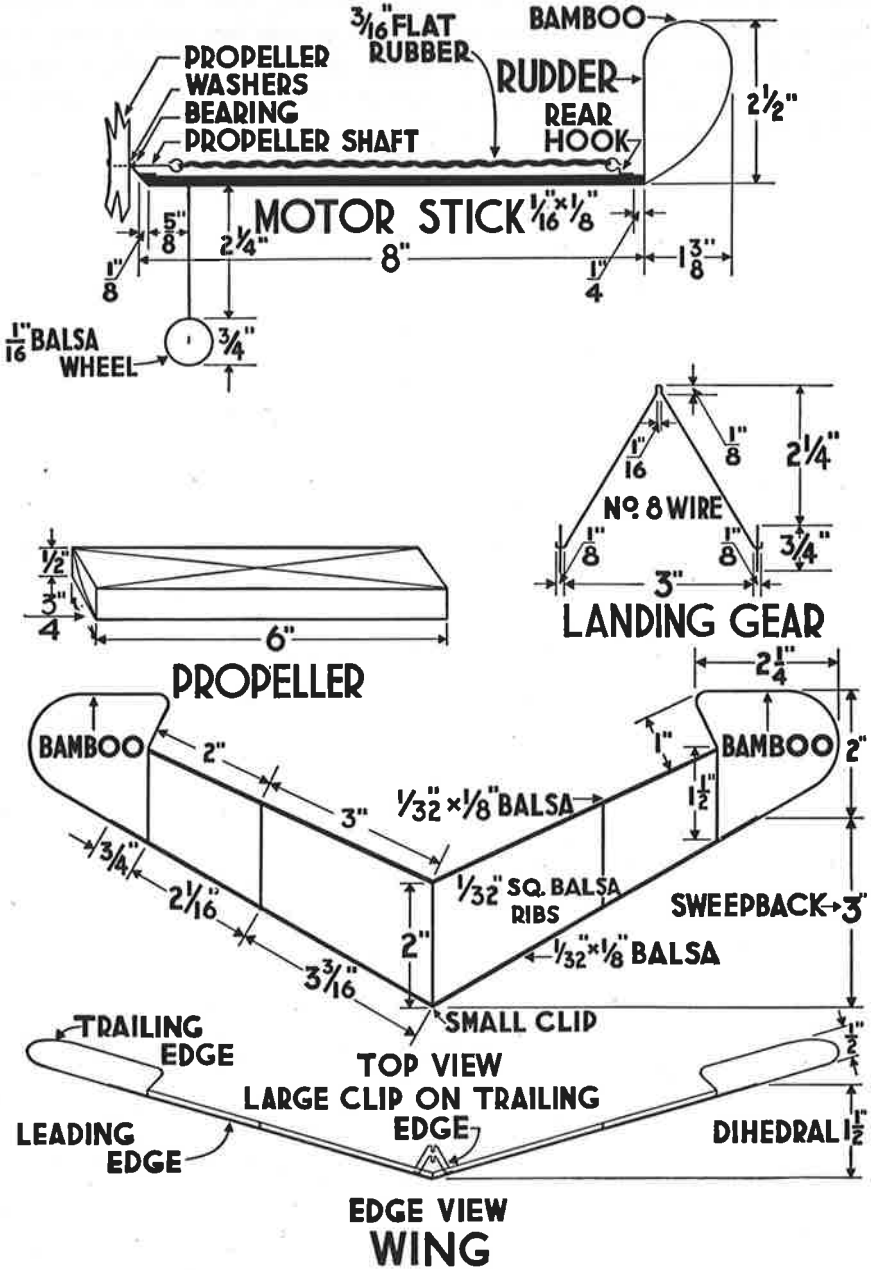
WING. The leading edge spar of each half of the wing is constructed from a 1/32" x 1/8" x 6" long piece of balsa, while the trailing edge spars are 1/32" x 1/8" x 5" long. The five ribs are of 1/32" square balsa wood and are given a slight curve, as shown.

Draw a full-size working layout of one half of the wing exactly as given in the plans. Bend a length of 1/32" split bamboo over a flame to the form shown for the tip. Cut out the leading and trailing edge spars and the ribs. This half of the wing is now assembled on the layout drawing by placing each part of it in its proper position.

Cement the ribs and tip to the balsa spars. When attaching the tip, see that the bamboo length, which is attached to the trailing spar, is at right angles to it. At this point, construct the other half of the wing by following the same directions and using the same full-size layout drawing.

The sweepback of the wing is gained through the difference in length of the leading and trailing edge spars, so that when the two halves of the wing are cemented together, they give the desired shape. The wing has a 1½" dihedral angle, which is obtained by cementing the two halves together. (See Chapter 7, "Wing Assembly.") The structure is now covered. Cut out a pattern of the wing from Japanese tissue, allowing about ¼" surplus material around all sides in order that the paper can be wrapped over the edges of the wing structure. Cover the wing on one side only—the top—and hold the covering in place with dope or banana oil. A close study of the plan, as well as the photograph, will show that the tips of the wing are turned up. This is now done. As shown in the plan, the trailing edges of the tips are ½" higher than the leading edges. This is done by heating the bamboo framework, but be careful not to burn the paper. When completed, the wing is fitted with the usual wing clips, as shown in the plans. These are bent from No. 8 piano wire. The large clip is cemented to the center top of the wing on the trailing edge spar, while the small one is fastened to the leading edge spar. (See Chapter 6, "Clips.") The wing can now be water-sprayed or steamed. As it is of delicate construction, spray one half at a time, allowing it to dry thoroughly under weight before proceeding with the other half.

ASSEMBLY. Cement the rudder to the end of the motor stick, as shown in the plans. The landing gear is cemented or pressed in position on the motor stick ¾" from the front end of the stick, as shown. Slip the propeller shaft through the propeller bearing, and attach the rubber motor, as already instructed. The wing is attached in position to the under side of the motor stick, as shown in the photograph. Glide the model to obtain the correct



TAILLESS TRACTOR PLAN

position of the wing. If the glide results in a stall, move the wing slightly back, or if the model dives, move the wing forward. Test until a long even glide is obtained, and then wind the motor and send your "tailless" model on its maiden voyage. For the proper method of launching, see Chapter 16, "Correct Launching of R.O.G. Model."

CHAPTER 30

UMBRELLA-TAIL TRACTOR

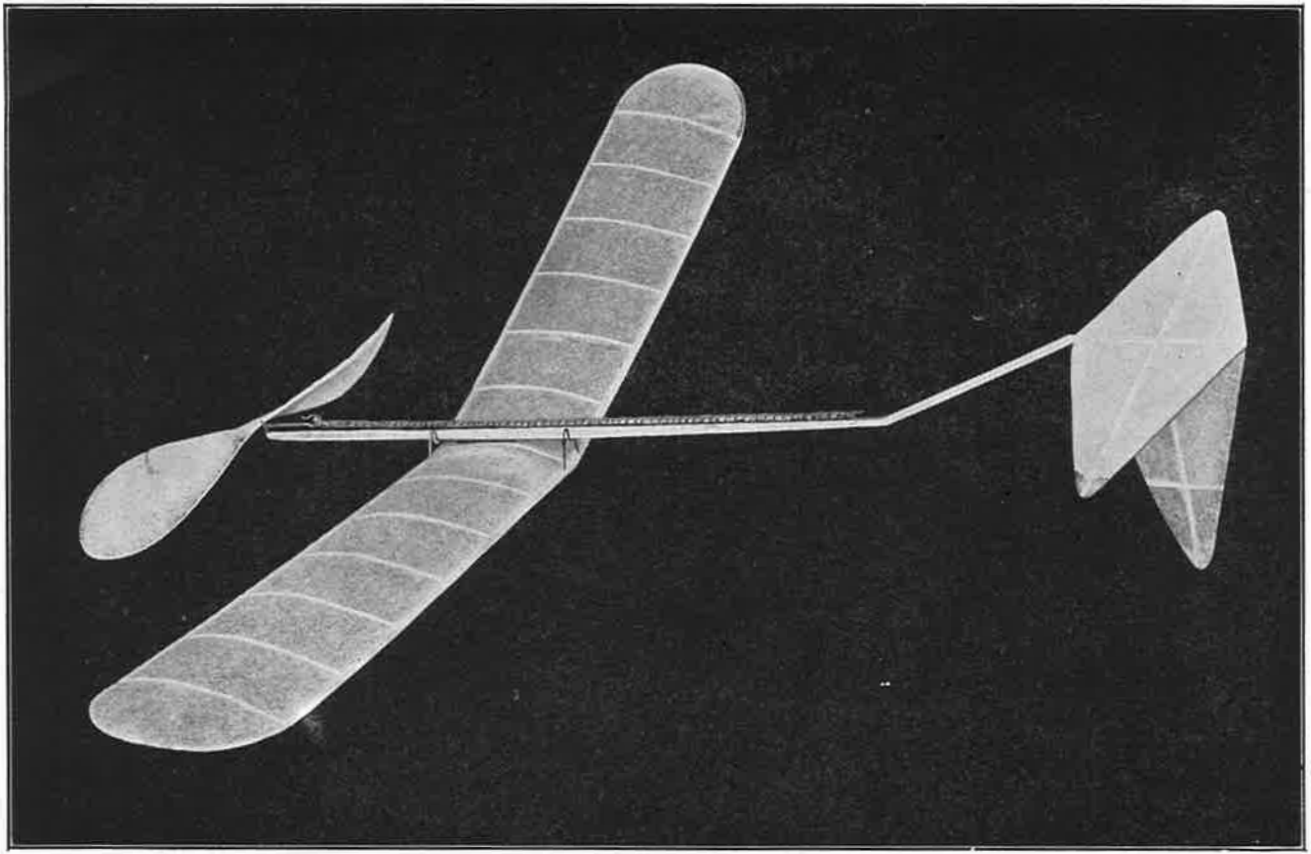
THIS type of model is a splendid endurance flyer. It is similar to other stick tractors, except for the peculiar form of its tail. As can be seen in the plans and photograph, the tail unit is connected to the motor stick by means of a tail boom, which extends up from and slightly to one side of the motor stick. As with all light endurance models, its construction is most delicate, requiring careful adjusting and handling for proper flight results.

FUSELAGE. This model has its length made up of three different parts, the motor stick, the tail boom, and the center spar of the elevator. The motor stick on such models can be hollow, if extreme lightness is desired, or it can be cut from a solid length of balsa. (See Chapter 12, "Motor Sticks.") The latter form of motor stick is used on the model given here. It consists of a 15″ length of balsa 1/8″ x 1/4″ at its center and tapering off to 1/8″ x 1/8″ at both ends. Note this in the side view of the plans. From No. 6 piano wire, the usual rear or end hook and can hook are bent and then cemented in place, as shown in the plans. A regulation propeller bearing is made or purchased, and cemented to the front end of the stick. (See Chapter 6, "Propeller Bearings.")

The tail boom consists of a 5″ length of 1/8″ x 1/8″ balsa. Note this in the plan shown by F. Do not cement this in place on the motor stick at this time.

ELEVATOR. The elevator consists of two lengths of balsa wood. The short piece C is 1/8″ x 1/8″ at the forward end and tapers to 1/8″ x 1/16″ at the rear end. It is 3 1/2″ long, and not only forms the center cross brace of the elevator, but also the top brace of the rudder. The second length of balsa used for the elevator is shown in the plan by E. It is 1/32″ x 1/16″ x 9 1/2″ long. This second piece is cemented over the first length at right angles to it, and exactly over its center point. Japanese tissue is cut to the proper elevator shape, as shown in the plans, and attached to these spars with clear dope or banana oil. Only the top side of these is covered, and no edging is used for the elevator.

RUDDER. The rudder extends down from the short spar of the ele-



UMBRELLA-TAIL TRACTOR

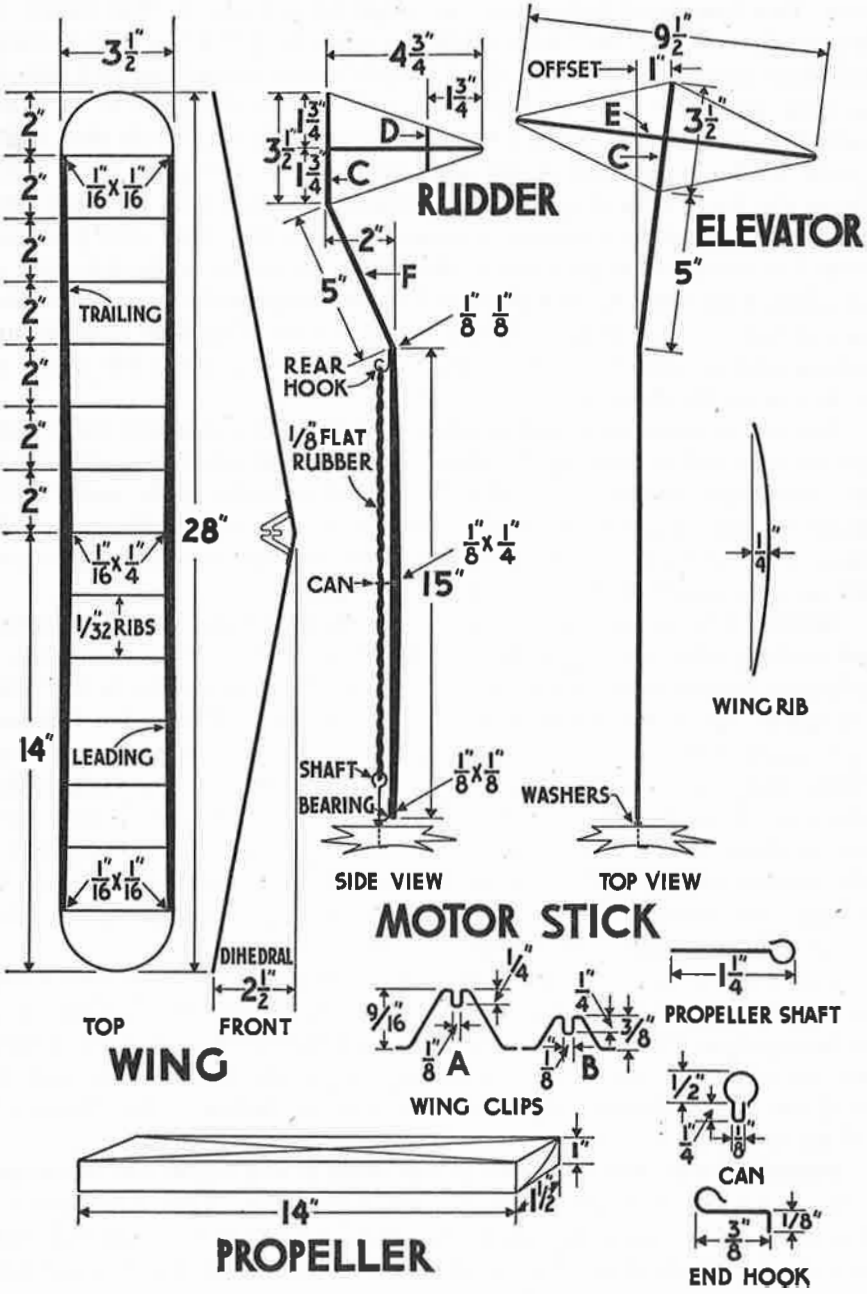
vator. Two lengths of balsa wood are required to make it. The longer of these is 1/32" x 1/16" x 4 3/4" long, while the other is 1/32" x 1/16" x 1 1/2" long. This short spar is cut into two equal lengths and cemented on each side of the long spar 1 3/4" from its lower end, as shown in the plan by D. This assembly is cemented to the spar C in its center, as shown. To do this, apply cement to the upper end of the long rudder spar and press it in place against the lower edge of spar C. This rudder spar should be perpendicular to spar C. The rudder structure is covered on one side only with Japanese tissue. Cut the tissue to the form of the rudder, as shown in the side view of the plans. Coat spars C and D, as well as the long rudder spar with clear dope or banana oil, and press the paper in place on them. Note that no supporting edge around the rudder is used, but that the paper is left as cut, as in the case of the elevator.

The tail boom is cemented in place to the end of the motor stick. Note that its rear end extends up 2" above its front end, which is cemented to the motor stick, and that it is offset 1" toward the right of the motor stick. When dry, the elevator and rudder assembly is cemented to the end of the boom. The 1/8" x 1/8" end of spar C is cemented to the boom F. When doing this, see that spar C is parallel to the motor stick.

WING. The wing is made in two duplicate halves. Cut the leading and trailing edge spars from balsa. These are 1/16" x 1/4" at their centers and taper toward both their ends to 1/16" x 1/16". They should be 24" long and when completed should be cut in half to give 12" lengths. Thirteen 1/32" square balsa ribs are cut and cambered, as shown in the plans under "Wing Rib." Cement the ribs in place between the leading and trailing edge spars. Complete the assembly by bending two 1/32" split bamboo wing tips, as shown, and then cement them in place. (See Chapter 3, "Bamboo.") The wing is now ready to have its halves assembled together. Cement the leading and trailing edge spars together, at the same time giving the wing a 2 1/2" dihedral angle. (See Chapter 7, "Wing Assembly.")

Cover the wing on its upper side only with Japanese tissue. (See Chapter 7, "Wing Covering.") Two wing clips are bent from No. 6 piano wire, as shown under "Wing Clips." These are cemented to the top of the leading and trailing edge spars. Place the large clip on the trailing edge and the small one on the leading edge. Test the wing for balance. (See Chapter 7, "Wing Assembly.")

PROPELLER. The propeller is cut from a 1" x 1 1/2" x 14" balsa propeller blank in the standard manner. (See Chapter 9, "Carved Propellers.") The blades of this propeller should be sandpapered until so thin that light will show through them. A propeller shaft is bent from No. 8 piano wire,



UMBRELLA-TAIL TRACTOR PLAN

as shown under "Propeller Shaft." Thrust it through the hub of the propeller, bend it around, and pull the end of the shaft into the face of the hub. A drop of cement at this point will hold it in place. Two light brass washers should be used on the shaft between the propeller hub and the propeller bearing.

MOTOR. This consists of two strands of 1/8" flat rubber, and should be cut long enough to allow about 1" of slack when in place. Obtain a 30" length of this rubber, and tie its ends together. Assemble the propeller by slipping its shaft through the hole in the propeller bearing, and loop the rubber motor over the hook. The other end of the rubber is placed over the end hook, after being placed through the can hook.

ASSEMBLY. As all parts of the model with the exception of the wing have been assembled as made, we have only to place the wing on the model to complete it. When in place and before attempting motored flight, test for correct wing position by gliding the model. Keep adjusting the wing forward or backward until a long, even glide is obtained. When the model glides properly, wind up the motor for its first flight. Do not wind the motor to capacity until short flights have been made, so that all wing, elevator, or rudder adjustments may be made before endurance flights are attempted. For the proper method of launching, see Chapter 16, "Correct Launching of Single-Stick Tractor."