


WhitewingsTM

ASSEMBLY INSTRUCTIONS

FLIGHT INSTRUCTIONS

INTRODUCTION TO
PAPER PLANE DESIGN

HOW TO BUILD "WHITE WINGS"



Send a white bird soaring through the sky

WhitewingsTM

Flight through the sky has long captivated men's imaginations. Today, air travel has become as simple for the average person as boarding a jumbo commercial airliner. If, however, we really want to experience, at first hand, the "joy of flight", I believe it's far more exciting to fly a miniature plane that you've made by your own efforts or to soar through the air on a hang glider. So that as many people as possible may readily get a taste of this fascinating experience, I would like to highly recommend that they make and fly their own paper airplanes.

The "WHITE WINGS" models are planes which can be built easily, by beginners as well as experienced paper plane enthusiasts, using a minimum of tools (scissors, glue, etc.). The parts are printed on excellent quality drawing paper to ensure good performance capability. The completed White Wings will fly better than most people probably ever imagined a paper plane could fly. In order to maximize the White Wings flying performance, you must follow the points listed below.

- Read the instructions thoroughly.
- After the plane is assembled, make sure that the glue is completely dry. (Allow at least one day.)

Learning how to fly your paper plane is of primary importance. Sufficient practice is necessary, as it is in learning to ski or ride a bicycle. To succeed you must follow the instructions, make adjustments by test flying so your plane will fly smoothly and in a straight line, and then practice how to make it fly to high altitudes.

Also, when you fly your plane, it will be important to remember the following:

- **Fly your planes in a big, open space, away from people who might get hit.**
- **Make sure you are in an area where there are no passing cars.**

DON'T FORGET THESE PRECAUTIONS!

So now you're ready to give it a try.
Take-off, WHITE WINGS!

Yasuaki Ninomiya

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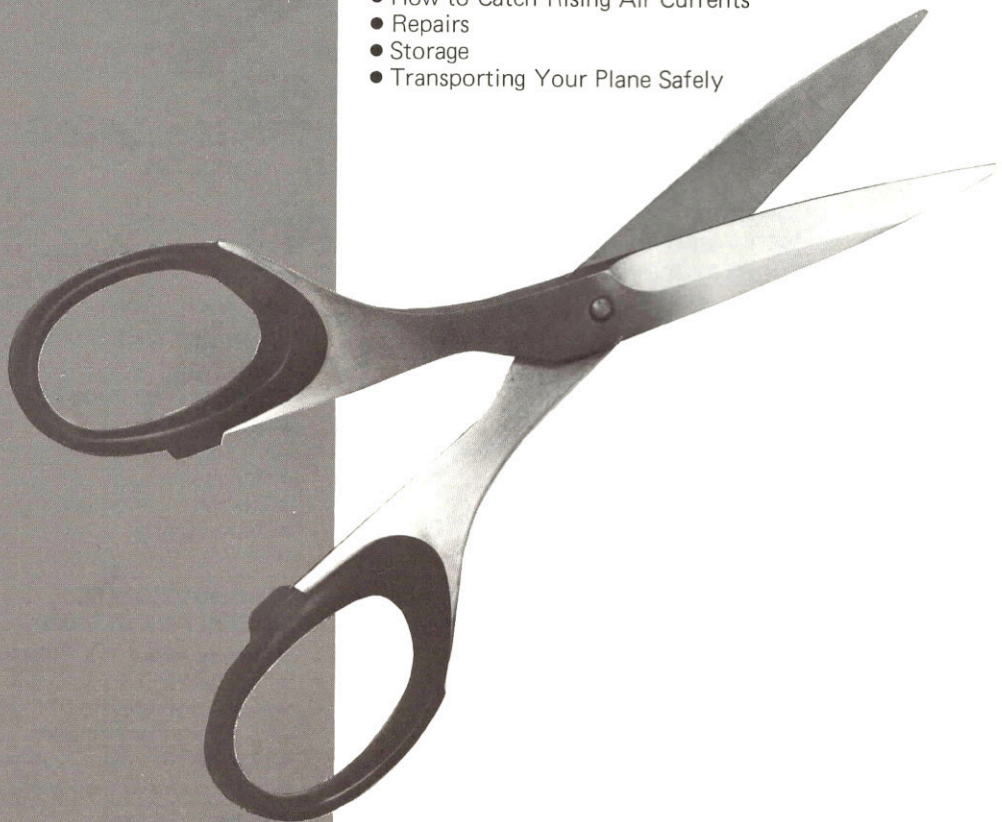
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ASSEMBLY INSTRUCTIONS

- Tools
- Materials
- Airplane Parts
- Cutting Out the Parts
- Gluing
- Finishing Touches

FLIGHT INSTRUCTIONS

- Test Flight
- Achieving Altitude
- How to Catch Rising Air Currents
- Repairs
- Storage
- Transporting Your Plane Safely



TOOLS

- **SCISSORS:** You will need a pair of scissors that cut well (Dressmaker's or tailor's are excellent).
- **CUTTER (X-ACTO KNIFE):** This is used for cutting out the weight hole. Any small knife that can cut with its tip is suitable.
- **RULER:** This is used to fold the pieces and make creases accurately.
- **TWEEZERS:** These are used for checking the center of gravity and assembling the smaller pieces such as the propeller.

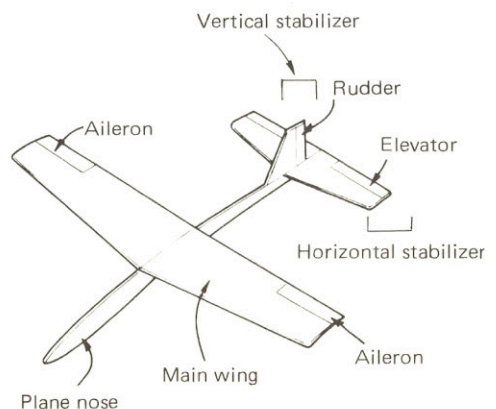
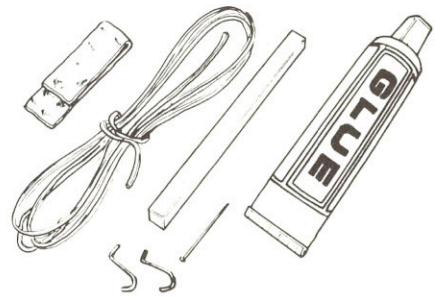
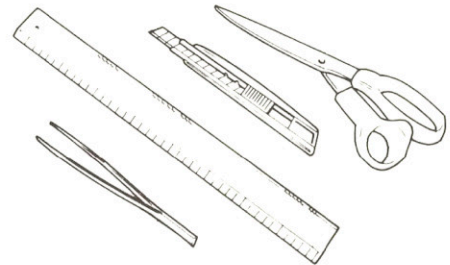
MATERIALS

Materials marked with ★ are included in this kit.

- **GLUE:** A clear, fast drying glue is most suitable; for instance, Dupont's "Duco Cement" or Allen Products Corporation's "Seal All." These can be bought at your local drugstore or stationery store.
- ★ **LEAD FOIL:** This is used for weight and is inserted inside the nose.
- ★ **HOOK:** This is used when plane is launched by catapult.
- ★ **RUBBER BAND AND ROD:** These are used for making a rubber band catapult.
- ★ **PIN:** This is used for the propeller shaft on the Flying Boat Model.

AIRPLANE PARTS

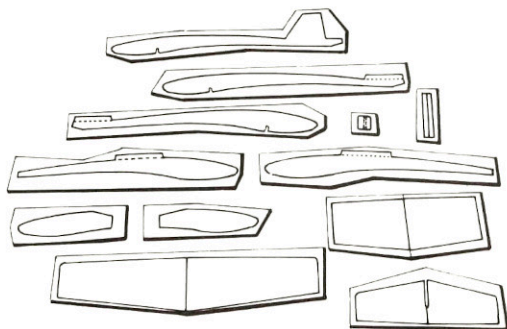
Figure shows a plane's parts and what they are called.



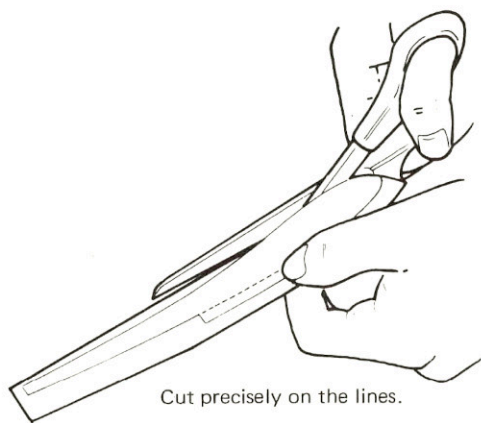
ASSEMBLY INSTRUCTIONS

CUTTING OUT THE PARTS

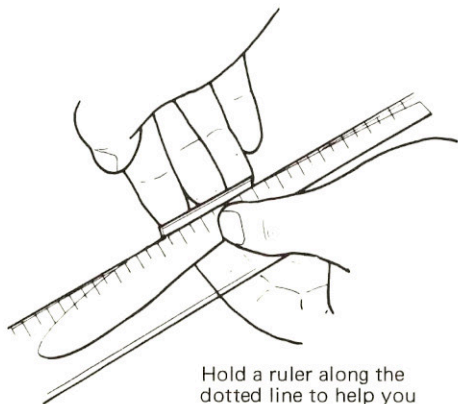
Roughly cut out each piece taking care not to cut into adjacent pieces.



First roughly cut out all the pieces.



Cut precisely on the lines.



Hold a ruler along the dotted line to help you fold accurately.

Trim each piece to size by cutting precisely on the line. However, don't cut on the lines of the front and back of the main wing backing. Leave a 2–3 mm margin on these edges, as described in the gluing instructions.

Bend the tabs for the main wing and stabilizer before gluing the fuselage (plane body) together. Bend the tabs along the dotted lines using a ruler to make sure that tabs are neatly folded.

GLUING

Try putting the pieces together before gluing, according to the gluing instructions and explanatory figures for each model, to make sure everything is ready and in order.

After all the details have been satisfactorily worked out, you are now ready for the actual gluing. Following the gluing instructions precisely, glue the pieces together in the proper order.

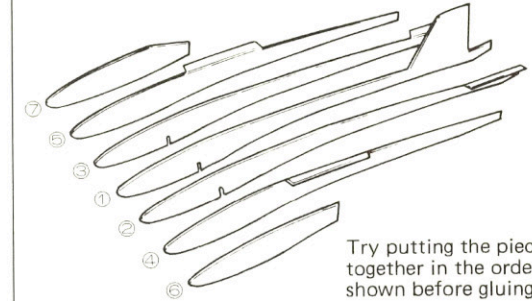
(Note: To build a straight solid body, first glue ①, ② and ③ together and let dry on a flat surface. Then glue the rest of the body parts, in order, to this center section.)

Apply the glue evenly and quickly, making sure that the assembled pieces do not slip out of position.

If the glue is insufficient, the pieces will not be firmly glued together, resulting in weak construction and poor flying performance.

In order to assemble a sturdy fuselage, after gluing on each piece, place the assembled pieces inside a folded piece of scrap paper and press out the excess glue with your fingers. Gradually assemble the fuselage piece by piece in this fashion, taking care that none of the pieces have slipped out of place, and that each one is in its proper position.

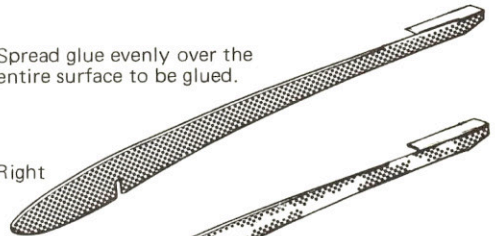
Use a blank piece of scrap paper and make sure that no print on the paper comes into contact with the glued parts. Since glue has the power to dissolve printing ink, the ink could smear onto the assembled plane.



Try putting the pieces together in the order shown before gluing.

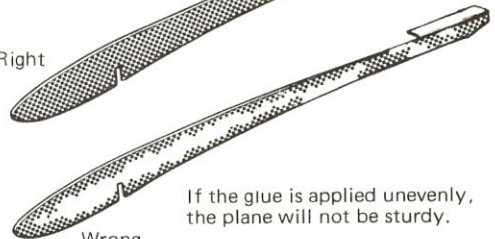
Spread glue evenly over the entire surface to be glued.

Right

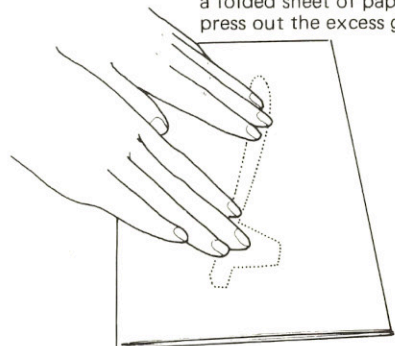


If the glue is applied unevenly, the plane will not be sturdy.

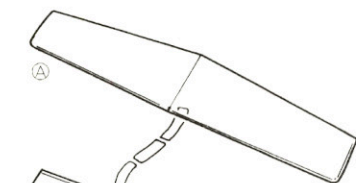
Wrong



Place the glued parts inside a folded sheet of paper to press out the excess glue.

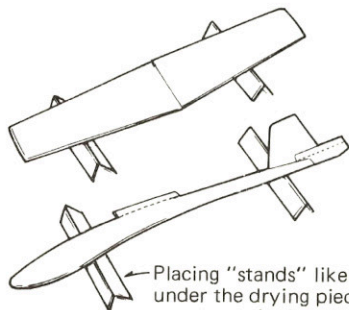


ASSEMBLY INSTRUCTIONS



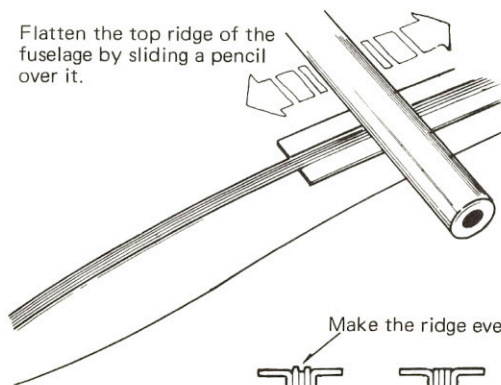
Piece (B) (the backing of the main wing) is cut out with an extra 2–3 mm margin along the front and back lines. Coat the upside of (B) with glue and apply it to the underside of the main wing (A), as shown, so that their center lines coincide.

2–3 mm

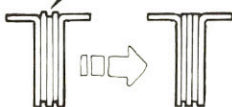


Placing "stands" like these under the drying pieces promotes air circulation.

Flatten the top ridge of the fuselage by sliding a pencil over it.



Make the ridge even.



Cross section of fuselage

When "assembling the main wing" is mentioned, we are referring to gluing the reinforcement piece (B) to the main wing (A).

In every model in this kit, the center line for piece (B) extends about 3 mm in front and in back of the cutting lines. When cutting out piece (B), you will notice in the figure that the left and right edges are cut right on the lines, but the front and back edges extend 2–3 mm outside the lines. Apply glue evenly to the upper surface of piece (B), and gently fit piece (A) on top of piece (B). Because piece (B)'s center line extends out from the front and back of piece (A), it is easy to line up the center lines of pieces (A) and (B) accurately. After the glue is dry, you can cut off the protruding portions of piece (B).

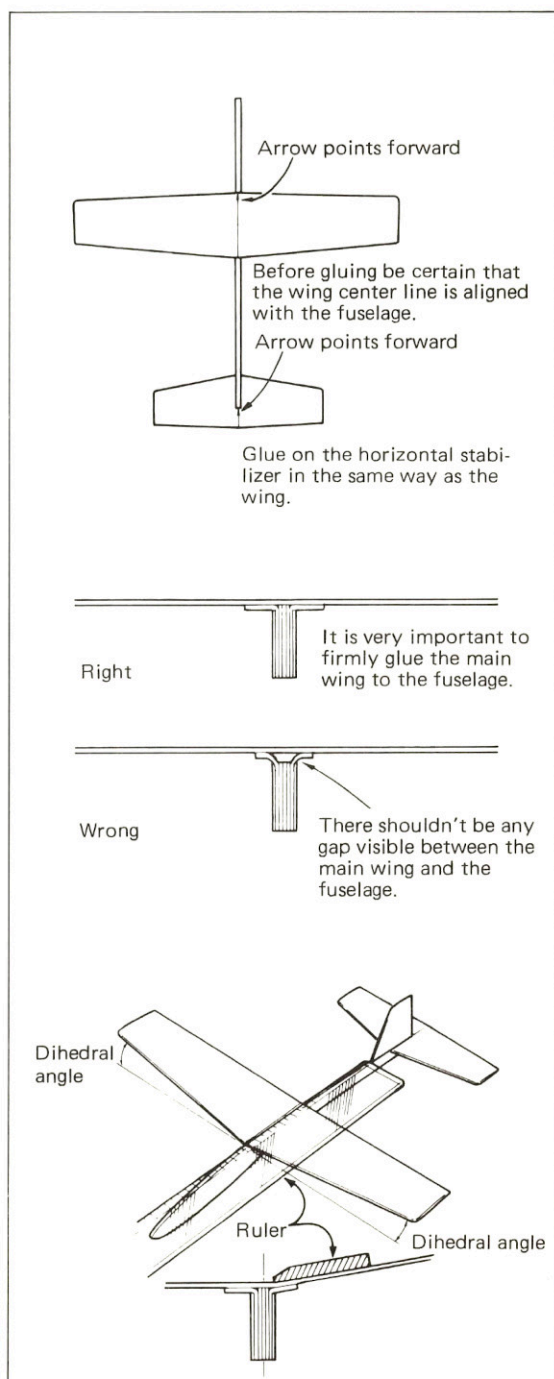
Spread several layers of large scrap paper over a desk or other flat surface for protection. Set the newly glued main wing and fuselage on the papers to dry for at least 5–6 hours.

Or, for speedier drying, place "stands" of folded paper under the glued parts as shown in the figure. This permits improved air circulation to the underside of the glued parts.

After the fuselage has thoroughly dried, cut the weight hole out of the nose with a knife before attaching the wings. (You may cut the weight hole out before gluing the fuselage pieces if you prefer.)

In order to glue the main wing precisely and securely to the body, the part of the fuselage to which it will be glued must be smoothed flat with a pencil, before applying the glue, as shown in the figure.

When gluing the main wing and horizontal stabilizer to the fuselage, make sure that the center line is properly aligned lengthwise with the center of the fuselage. You will find that if you glue the stabilizer onto the fuselage before gluing on the main wing, assembly will be much easier.



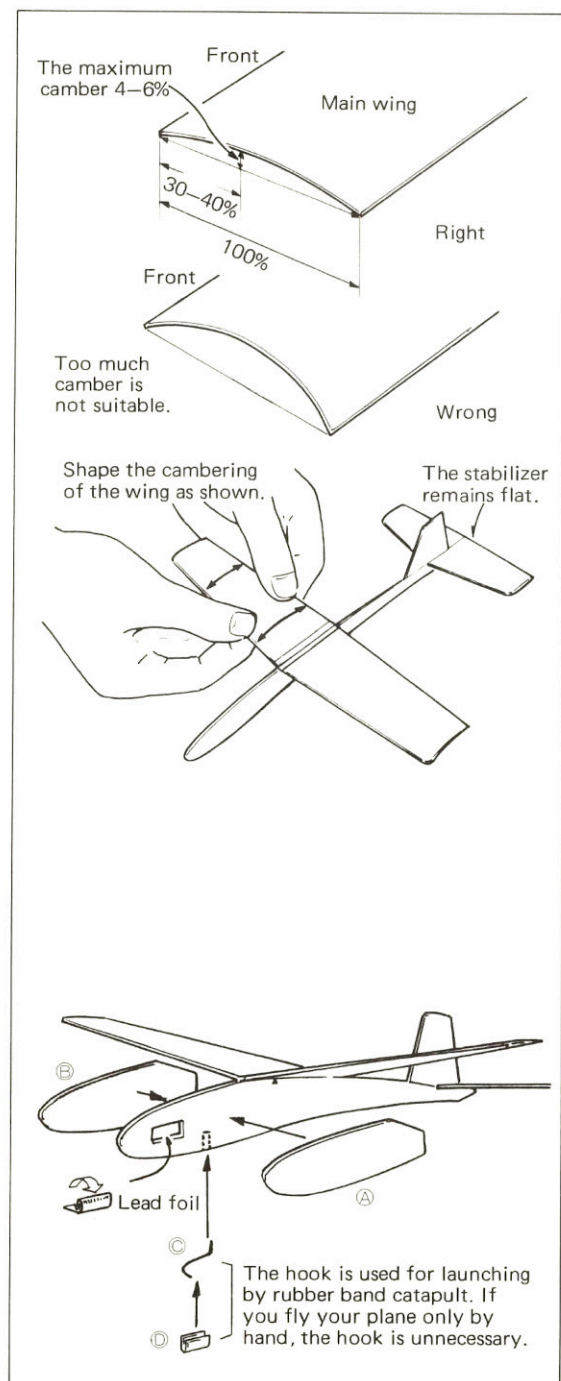
The importance of gluing the main wing firmly to the fuselage cannot be over-emphasized. In order not to leave any gap between the main wing and the body, press down firmly on the center of the main wing about 5–6 minutes after gluing. After gluing the main wing and stabilizer onto the fuselage, let it dry thoroughly for 3–4 hours.

FINISHING TOUCHES

After the wing has been attached to the body and the glue has set for at least 3–4 hours and has thoroughly dried, you are ready to put the finishing touches on your paper plane.

First, place a ruler along the center line of the main wing, and bend the wing slightly upward (called a dihedral angle) as shown in the figure. Since the dihedral angles vary from model to model, bend the wing upward until the angle is identical to the angle indicated in the assembly instructions for that particular model.

ASSEMBLY INSTRUCTIONS



To make a truly high performance plane, it is important that the cross section of the main wing be curved in such a fashion as to minimize drag and maximize lift.

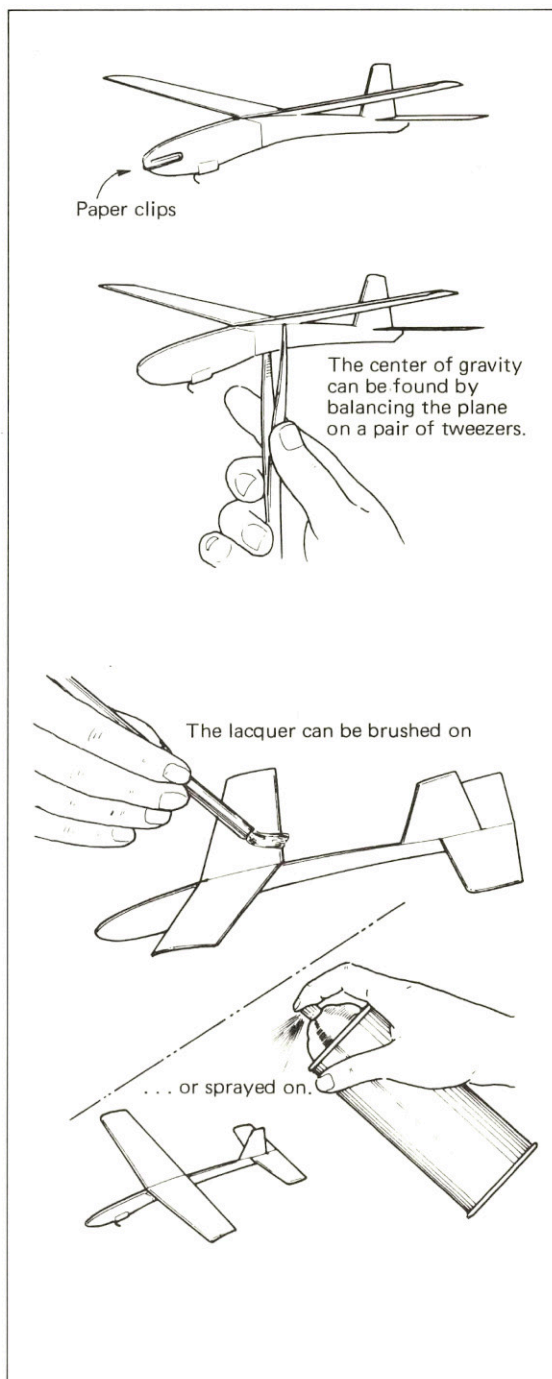
To make the proper curve, bend the main wing slightly in the manner shown in the figure (this is called cambering the wing). This shape is necessary for top performance.

Only the main wing is to be cambered. The stabilizer should be left flat.

The ▲ mark on the fuselage indicates the best location for the center of gravity. When you place weight in the nose of the plane, cut a hole in the assembled fuselage with a knife. Then, after the main wing and stabilizer have been glued on, insert the weight into the hole in the nose of the plane. By changing the amount of lead foil, the center of gravity can be properly aligned gradually, through trial and error. When testing the center of gravity, attach pieces (A) and (B) lightly to both sides of the fuselage by securing them with a small amount of glue for temporary purposes. Don't forget to insert the hook (C) into the nose while adjusting the weight, since the hook has an influence on the center of gravity. After the center of gravity has been properly aligned with the ▲ mark, (A) and (B) should be firmly glued onto the fuselage. Finally, cover the hook by gluing on (D) to hold it firmly in place.

Instead of putting lead foil into the plane nose you may put paper clips on the nose.

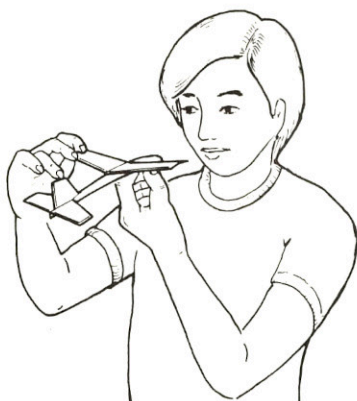
To test to see if the center of gravity is properly aligned or not, take an open pair of scissors or tweezers and balance the plane on the two tips at the ▲ mark as shown in the figure.



If your paper plane is coated with lacquer, it will become water resistant. Therefore when it lands on wet grass, if you quickly wipe the water off with a soft cloth, you're ready for another flight. For preserving the beauty of the white paper, clear lacquer is good, but if you want your plane to be a different color, you can use colored lacquer. It doesn't matter whether you spray it on or paint it on with a brush, but in order to keep the plane light and preserve its balance and center of gravity, be careful to coat the plane as thinly as possible.

ASSEMBLY INSTRUCTIONS

FLIGHT INSTRUCTIONS

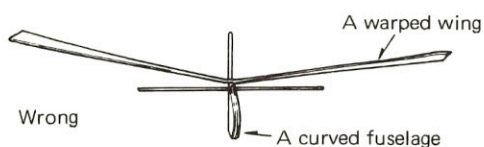


Straighten out all warps and twists in the plane.

Check the plane by viewing it from the back and the front.



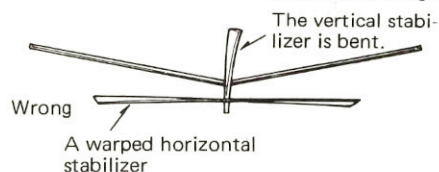
Right



Wrong

A warped wing

A curved fuselage



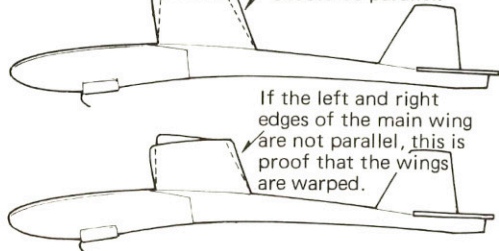
Wrong

The vertical stabilizer is bent.

A warped horizontal stabilizer

Side view of the plane

If the main wing is not warped, the edges of the left and right wings should be parallel.



If the left and right edges of the main wing are not parallel, this is proof that the wings are warped.

One of the secrets to flying a paper plane well is to view the plane closely from a head-on position and straighten out all warps, bends or twists with your fingers.

Inspect your plane thoroughly from the front:

- (1) Is the fuselage bent?
- (2) Are both the right and left main wings straight, perfectly matched, and are both inclined at the same angle?
- (3) Is the horizontal stabilizer warped or bent?
- (4) Is the vertical stabilizer warped or bent?

Check for these defects and straighten out the bent or warped areas gently and carefully.

Inspect your plane from the rear end and check for defects in the same manner as above.

Check the plane from both sides also.

- Do the inclinations of both the near and far wing tips match?

If they don't, this is proof that the main wing is warped, so straighten it out with your fingers until the wing tips line up perfectly.

TEST FLIGHT

The reason most model airplanes don't fly well is that they have not been properly adjusted. After finishing your plane, the importance of following the test flight and adjustment instructions carefully cannot be overemphasized!!

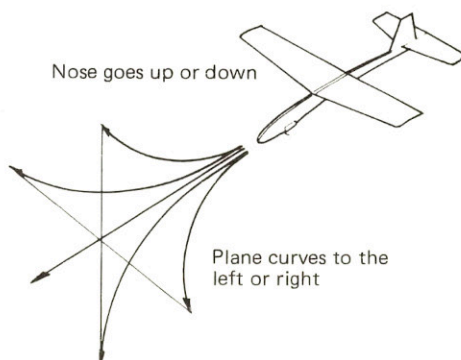
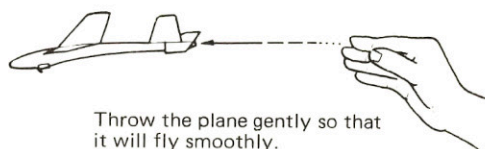
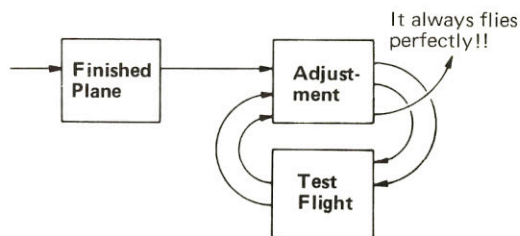
If you continuously repeat the test flight and adjustment procedures, adjusting your plane slowly but surely, you will finally arrive at a point where your plane will always fly smoothly and in a straight line. A perfect flight every time!

Try to test fly your plane when there is a gentle breeze. If there is a gentle breeze, always throw your plane straight into the wind. When test flying your plane indoors, always try to throw it toward a curtain. Also, don't throw it upward but, as when launching any glider, toss it gently forward, aiming it horizontally or slightly downward.

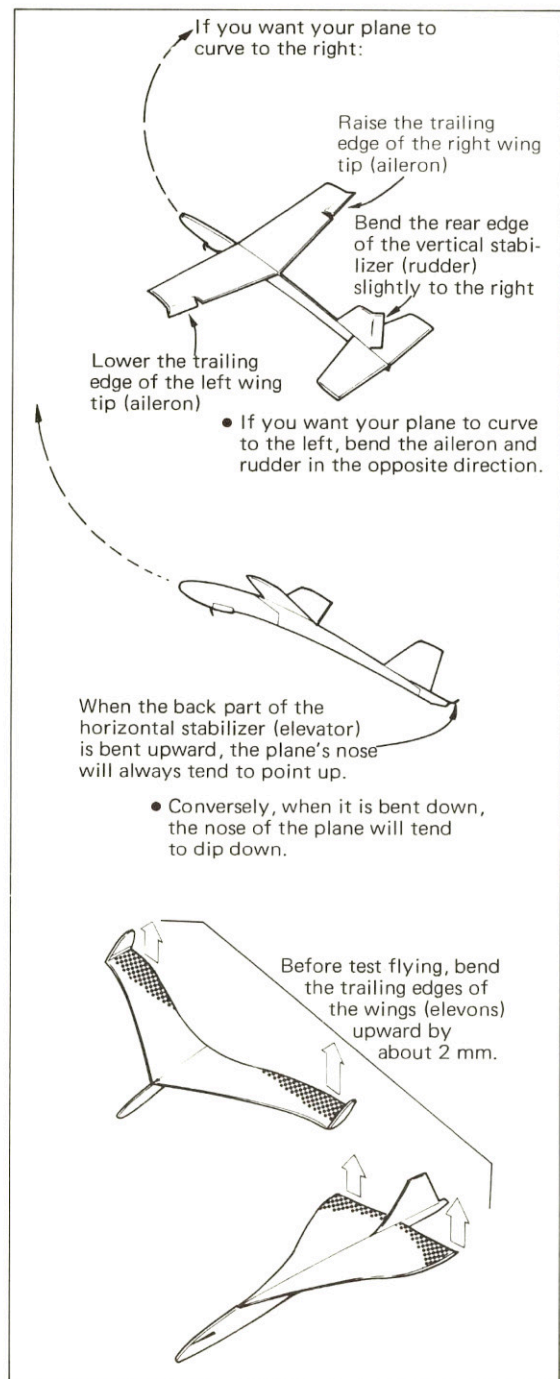
How to adjust your plane:

- When it curves to the left or right
- When the nose goes up or down

If you know how to adjust your plane to correct these two faults, your plane will be able to fly well. I will explain how to correct each of these faults with the proper adjustment.



FLIGHT INSTRUCTIONS



You can make your plane curve to either direction by bending the trailing edges of the wing tips (ailerons) and vertical stabilizer (rudder).

The first thing to look for when test flying your plane is whether it flies to the left or right. If so, perform the following adjustments and your plane will fly straight.

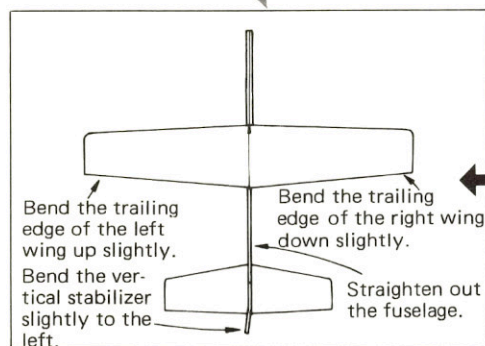
If a paper plane curves to the left or right, it is always because there is a bend or a warp somewhere on the plane. Therefore, the first step is to examine the plane again thoroughly, and straighten out the affected parts with utmost care. If the plane still curves to the left or right, bend the ailerons and rudder in the appropriate directions, according to the instructions in the accompanying figure, in order to correct this fault and ensure straight flight. (It's not necessary to make incisions in the wings; just bend the appropriate areas slightly with your fingers to adjust the ailerons and rudder.)

The second thing to test for is to see whether or not the nose gradually goes up and the plane loses speed; also watch if the plane's nose rises up, then suddenly dips down. This is known as stalling. If the glider does this, a smooth flight pattern can be assured by adjusting the back ends of the horizontal stabilizer (elevators).

On tailless and delta wing aircraft, the rear ends of the main wings serve as both elevators and ailerons. (These trailing edges are called the elevons.) When working with these models, the trailing edges of the main wings must be gently bent upward about 2 mm to prevent the nose of the plane from falling.

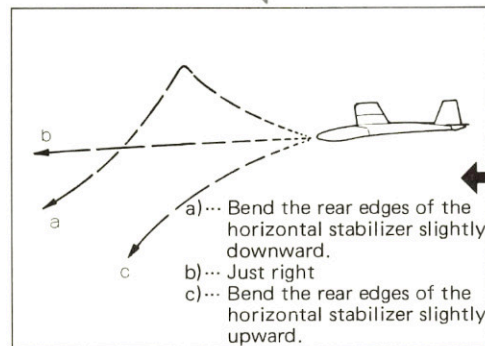
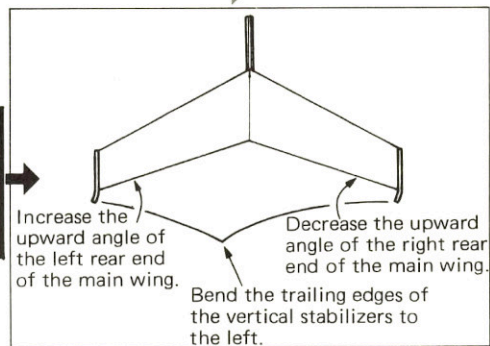
To ensure a straight flight, make the following adjustment.

Regular Models

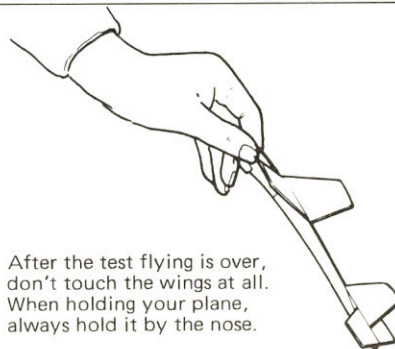
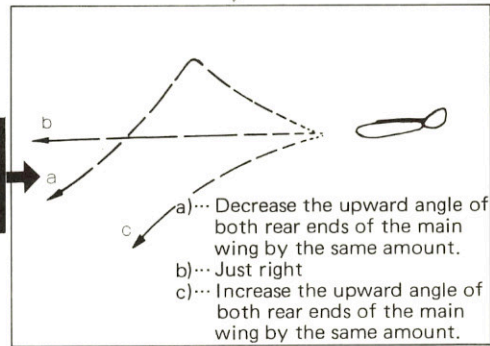


How to adjust when the plane curves right (If it curves left, apply the reverse adjustment.)

Tailless and Delta Wing Models

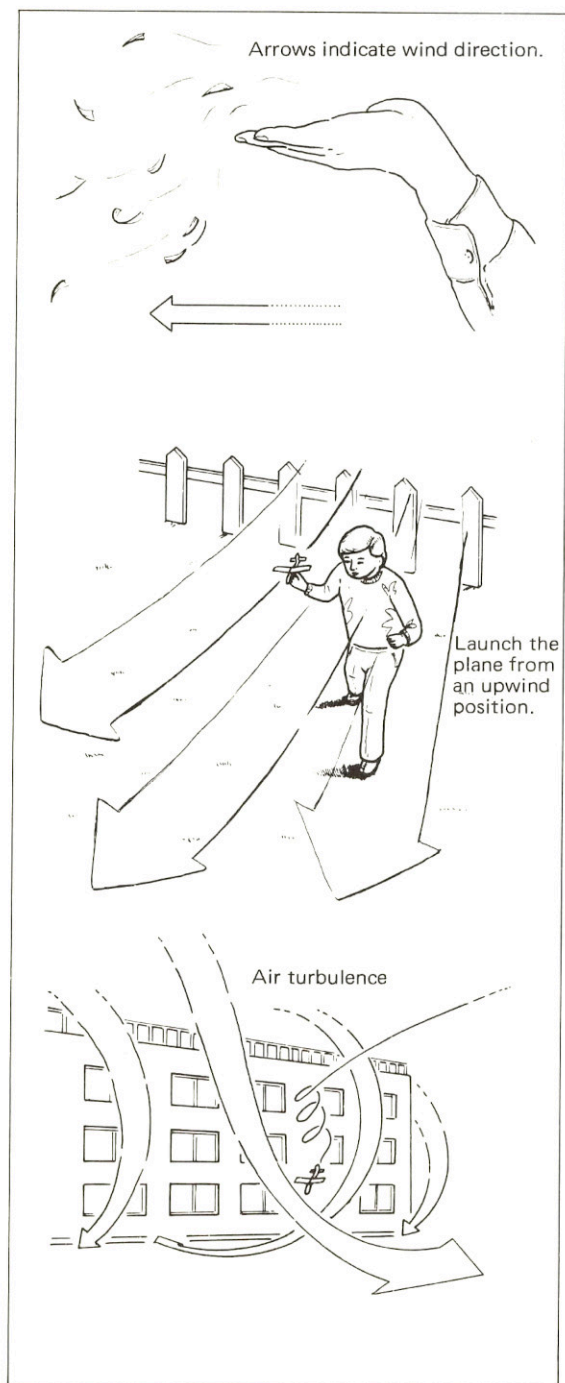


How to adjust when the nose goes up or down



After the test flying is over, don't touch the wings at all. When holding your plane, always hold it by the nose.

FLIGHT INSTRUCTIONS



ACHIEVING ALTITUDE

Now that the test flying is over, let's go outside to a wide open space to fly your plane! To protect your plane from wear and tear, it's best that you fly it in a field of soft grass. When you get out into the field, the first thing to do is to determine the wind direction. To do this, pull a few blades of grass and toss them into the air, or, if a chimney is nearby, note the direction in which the smoke rises.

If you are flying your plane outside with a wind blowing and want to keep your plane's flight pattern within a limited area, it is best to throw your plane with the wind from an upwind position. Always be sure to return to the original upwind position for launching in order to prevent the plane from gliding beyond the confines of the flying area.

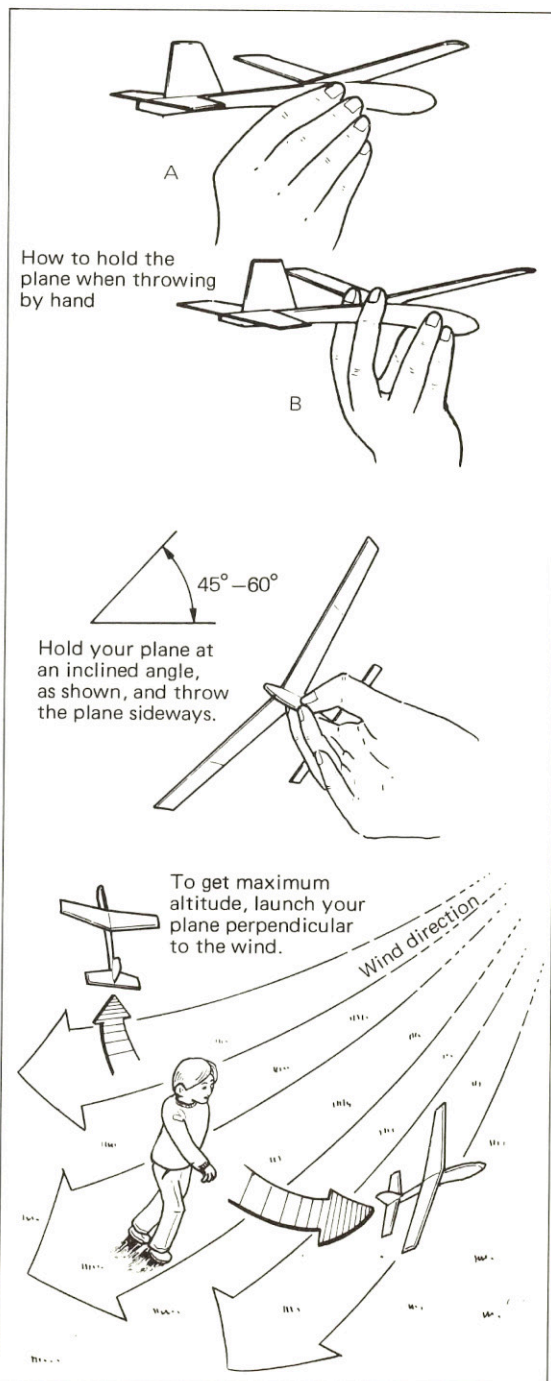
It's not good to fly your plane if the wind is too strong. When a strong wind is blowing, great turbulence is created in the vicinity of large buildings such as apartment houses or schools. In such places, you will never be able to fly your plane successfully when the wind is strong, so it's best to wait for a day when the wind is gentle.

To throw your plane high, there are two ways to hold it, as shown in the figure, either by grasping the body with your fingertips, or by placing your index and middle fingers behind the main wing, on both sides of the fuselage. Use whichever method you find easiest and most natural.

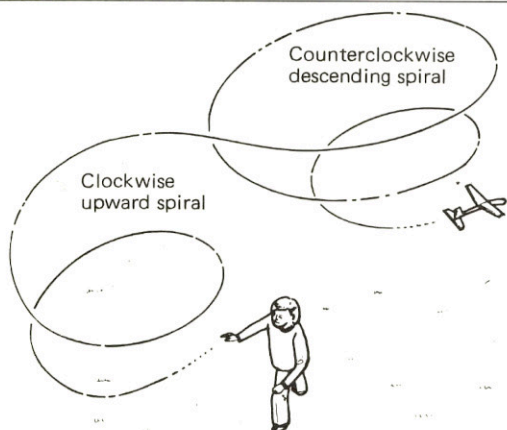
If you hold the plane horizontally, and throw it up and forward, it will "loop the loop" and dive down, so it is very difficult to get it to glide at a high altitude.

In order to overcome this difficulty, tilt the plane at a 45° – 60° angle when throwing. Your plane will curve outward as it gains altitude, then it will gradually level off and glide on a straight course. If your plane still tends to "loop the loop", bend both rear edges of the horizontal stabilizer slightly downward to minimize this tendency.

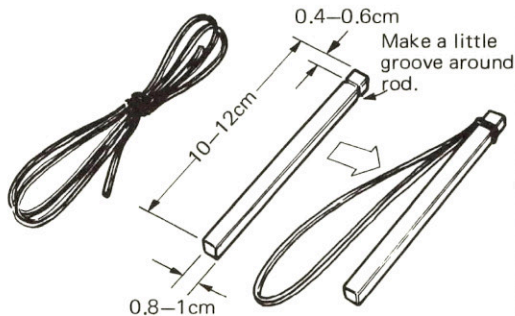
Contrary to test flying instructions, it's great to launch your plane perpendicular to the wind when "high-flying" it. The reason for this is that when throwing your plane upwind the plane has a tendency to loop; conversely, when throwing your plane downwind, the plane has a tendency to stall, due to the decreased relative airspeed over the wings. When throwing the plane perpendicular to the wind, none of these faults are apparent, so it is easier to obtain good flight results.



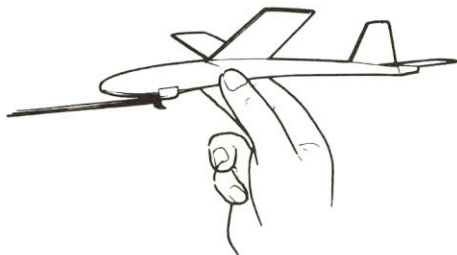
FLIGHT INSTRUCTIONS



Adjustments to be made to obtain better flight results



How to make a rubber band catapult



How to hold a plane when you launch it by the rubber band catapult

If an especially large wide open space is available, it's good to fly your plane in the following manner: before launching your plane, adjust the main wing and vertical stabilizer in the directions necessary for a left turn. Then, take the plane in your right hand, incline the plane to the right and throw it upward. If you do this, the plane will spiral upward in a clockwise fashion until it has obtained a considerable altitude, then it will slowly spiral to the left, in counterclockwise fashion, for its descent. If your plane has been well adjusted, it will remain aloft for at least 15–20 seconds.

If you use a rubber band catapult, you will be able to fly your plane at a high altitude for a long time. Another advantage to using the catapult is its ability to maintain the desired position of the plane, as at launching, and thereby ensure a proper flight course.

A catapult can be made easily from the included wooden rod and rubber band. Make a groove at the place shown in the figure and fasten the 40 cm long rubber band tightly onto the rod at the groove. When you fly the jet plane model, you may add one more rubber band.

When launching by catapult, suspend the rubber band on the hook, holding the fuselage securely with your fingers as shown in the figure. Then pull the plane back being careful not to bend the fuselage. You may pull back as far as you can but too much tension on the band will cause flutter. On a real plane, flutter will cause disintegration in mid-air. Flutter is occurring when your paper plane makes a vibrating sound. To avoid this problem, try not to put as much tension on the rubber band.

When using a catapult, as when hand-throwing your plane, incline your plane 60° – 90° from the horizontal to avoid loops. Bending the elevators downward slightly also serves to discourage loops.

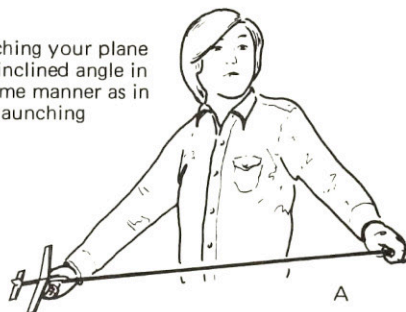
A rubber band is all that's needed for flying sports models and high performance competition craft. For heavy-bodied and jet craft, two rubber bands are more suitable.

-
- ☆ **Launch your plane in a wide open area.**
 - ☆ **Since the catapult-launched plane will fly at a high speed, take precautions to avoid hitting people in the area.**
-

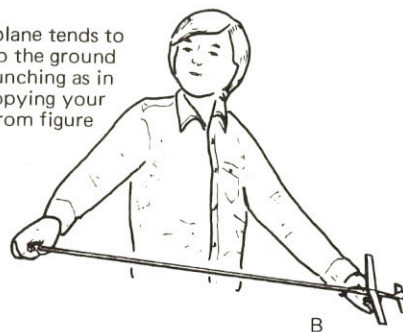
When considering the proper inclination that your plane should have when catapulting it, you must remember if you have a plane that tends to curve to the right, the more you incline it with the right wing downward (as in Figure A), the more the plane will tend to plunge down to the ground. If you try reversing this inclination and incline the left wing downward (as in Figure B), I guarantee that you will obtain better flight results.

Launching by the catapult

Launching your plane at an inclined angle in the same manner as in hand launching



If your plane tends to plunge to the ground when launching as in A, try copying your launch from figure B.



FLIGHT INSTRUCTIONS

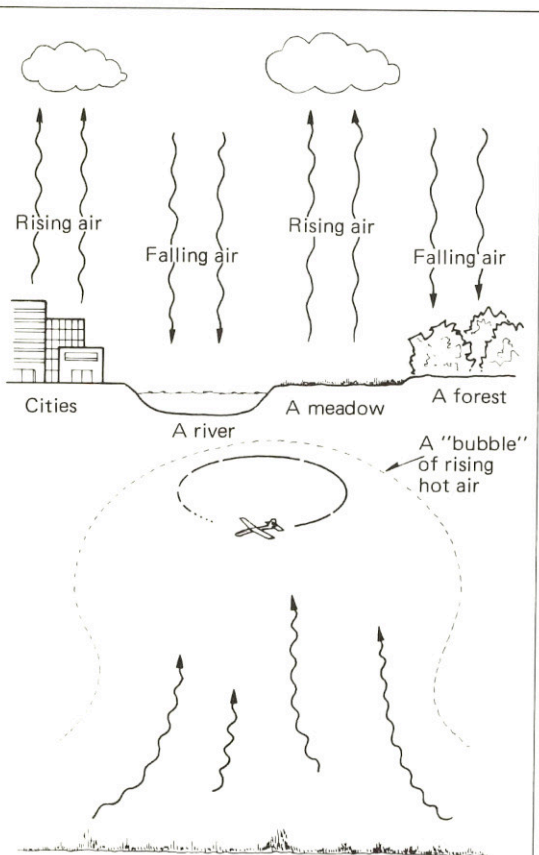
HOW TO CATCH RISING AIR CURRENTS

In order for a paper plane to stay aloft for over 30 seconds, it must make use of rising air currents. Rising air currents can be of two kinds: those resulting from the flow of wind over an inclined surface, and "thermals", which are rising columns of warm air. Paper planes fly well in thermals. "Thermals" originate when the earth's surface is heated by the sun. They usually originate over city streets, deserts, and plains with short grass. Lakes, rivers, and forests, however, are difficult to heat up, so these areas favor the formation of down-drafts, or descending air currents. You will be most able to make use of these "thermals" if you fly your plane over wide open grassy areas or concrete lots.

To enable your plane to make best use of these thermals, it's best to adjust it to fly in a circular pattern, then launch or throw it as high as you possibly can. Although invisible to the naked eye, there are what can be called "bubbles" of rising air, like that shown in the accompanying figure, over patches of heated ground. Therefore, if you throw your plane as stated above and get it to go around in circles and the plane enters one of these "bubbles", its chances for remaining inside this "bubble" for a considerable length of time are increased.

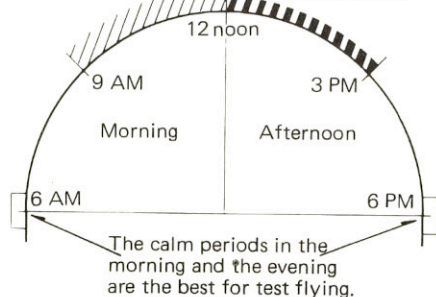
All the racer models included in the kit are designed to fly over one minute in rising air currents if adjusted carefully.

The best time to make use of thermals is between 9 AM and 12 noon on days when the skies are clear and the winds are gentle. Although the strength of thermals increases during midday (9 AM—4 PM) when the sun is shining most strongly and the highest temperatures are reached, in the afternoon, when thermals are strongest, gusty surface



9 AM—noon is the best time to make use of thermals.

Winds get strong in the afternoon.



winds also get stronger, often making it difficult to fly paper planes.

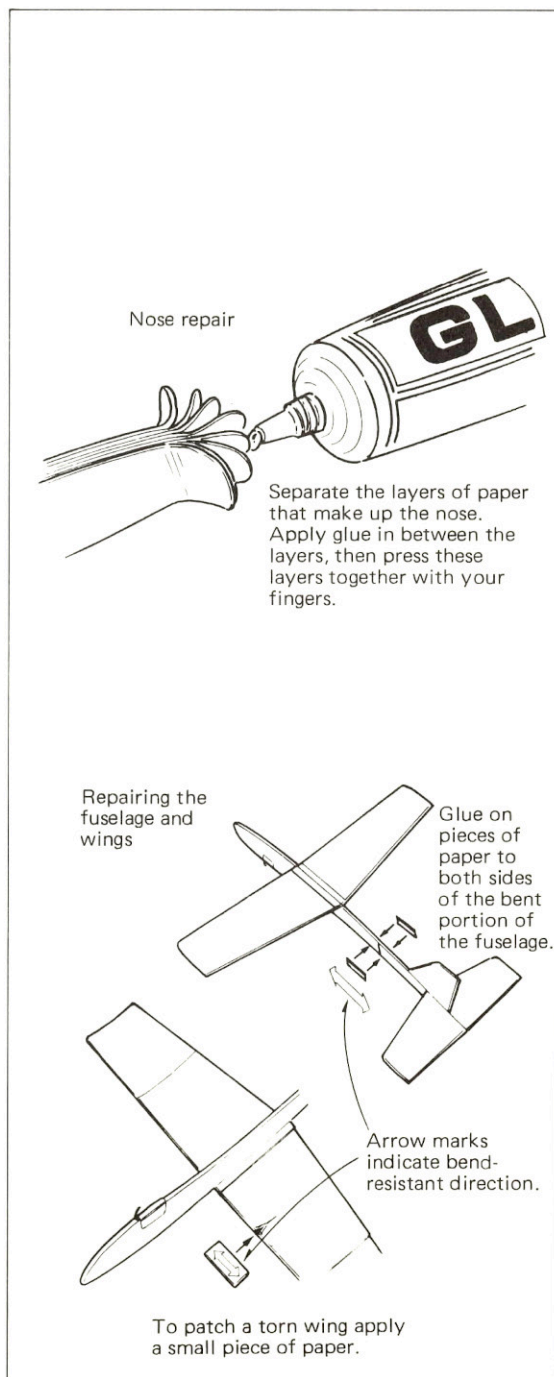
Actual atmospheric conditions will not always occur at the above-mentioned times however, so always keep an eye out for chances to fly your plane.

REPAIRS

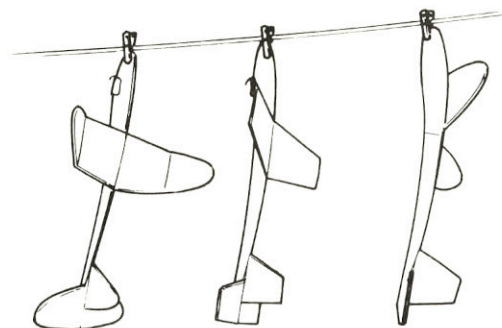
Even if your plane becomes damaged, if you repair it, you should be able to fly it again and again.

When paper planes dive to the ground or crash into a wall, the nose is especially vulnerable to damage. If any dirt or pebbles are imbedded in the nose, remove them with a pair of tweezers or a knife. Separate the various layers of paper as shown in the figure and coat all the inner surfaces with glue. Then press the layers together from the outside and, pressing hard, squeeze out all the excess glue, just as you did during assembly. Let the glue dry thoroughly.

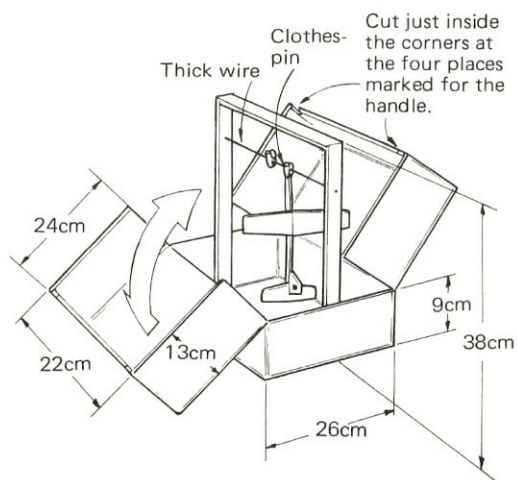
If the wings or fuselage are bent or torn, reinforce the damaged parts from the outside by gluing on small pieces of paper, as shown in the figure. These small pieces of paper should preferably be pieces of scrap paper left over from building your plane. These pieces of paper are bend-resistant in the direction of the wing tips so be sure to cut out and apply them in the proper direction. (Bend-resistant direction of the paper is indicated by an arrow in the lower right hand corner of each model sheet.)



FLIGHT INSTRUCTIONS



Stretch a wire across an open space and hang your planes up on it with clothespins.



STORAGE

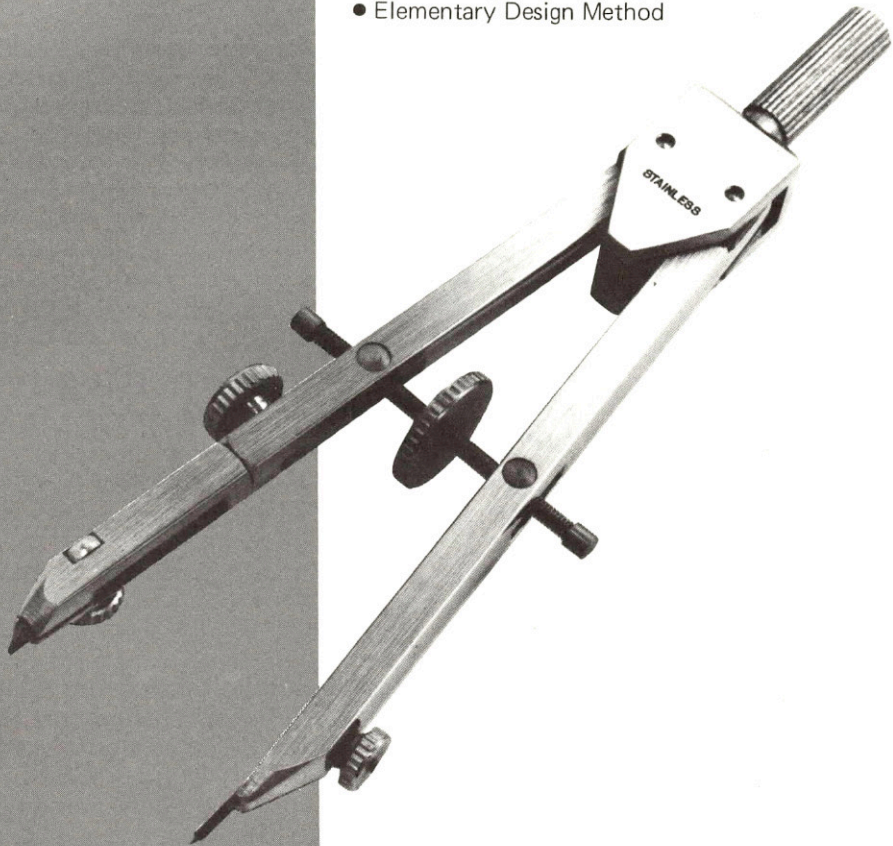
If your paper planes are well made, you should be able to preserve them with minimum care, thus enabling them to fly for many years. For storing a large number of planes when not in use, you should stretch a piece of wire between two hooks and fasten them with clothespins. Let them hang vertically as shown in the figure. This has the advantage of taking up only a small amount of space, and also of minimizing the accumulation of dust on the wings.

TRANSPORTING YOUR PLANE SAFELY

In order to transport your paper planes safely from your home to a open area, I recommend using a carrying case. You may make it by yourself from a carton box or a light wooden box. The carrying case should be large enough to accomodate each plane in its own space without overlapping with the others and so the planes are ready to fly with only a little adjustment. Here is one example of a carrying case I have made.

INTRODUCTION TO PAPER PLANE DESIGN

- How to Make Your Plane Fly Well
- How to Improve Flying Performance
- How to Improve Stability
- Elementary Design Method



INTRODUCTION TO PAPER PLANE DESIGN

HOW TO MAKE YOUR PAPER PLANE FLY WELL

To make a paper plane fly its best, two conditions are very important.

- 1) Since a paper plane is a glider it must have good gliding performance. This will be explained more later, but basically, this means that the glide ratio is high and the rate of descent is low.
- 2) The plane must have good stability. This means that it must be able to correct itself and maintain a nice flight after tilting or turning.

If your plane has these two qualities, when you throw it high into the air it will glide smoothly for a long distance even when there is slight air turbulence.

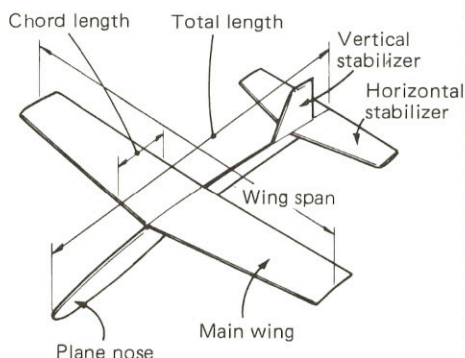


Fig. 1 Plane parts and special terms

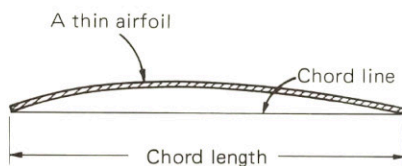


Fig. 2 Cross section of a thin airfoil

HOW TO IMPROVE FLYING PERFORMANCE

Figure 1 shows an airplane's parts and what they are called.

The most important part of a glider is the main wing. Its job is to support the plane in mid-air. The shape of a wing's cross section is called a wing section or airfoil. The chord line shown in the figure is the base line of the airfoil. Its length is called the chord length.

In Figure 3, we can see that the angle made by the chord line and wind direction is called the angle of attack. When the fuselage is designed, a base line is drawn across the body to assist in drawing and construction. The angle formed by this base line and the chord line is called the angle of setting. The angle of setting does not change on a plane's body, but the angle of attack changes as the plane's vertical direction changes (Fig. 4).

When the plane is gliding, wind pressure creates two forces on the wing as shown in Figure 3. One force is the upward draft of air (called lift) and the other force on the wing is called air resistance or drag. The ratio of these forces is called the lift/drag ratio. The higher the ratio of the wing (strong lift and little drag) the better the plane will fly.

As shown in Figure 5, the ratio between the distance a plane will glide and its altitude is called the glide ratio. A plane with a high glide ratio will fly farther than a plane with a lower glide ratio. The glide ratio has the same value as the lift/drag ratio of the entire plane so for long flights the lift/drag ratio must be as high as possible.

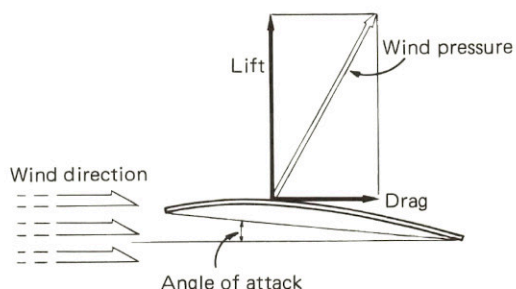


Fig. 3 Angle of attack and forces on wing

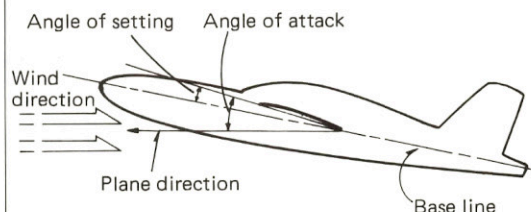


Fig. 4 Angle of attack and angle of setting

$$\text{Glide ratio} = \frac{\text{Distance}}{\text{Height}} = \frac{d}{h} = \frac{\text{Lift}}{\text{Drag}} = \text{Lift/drag ratio}$$

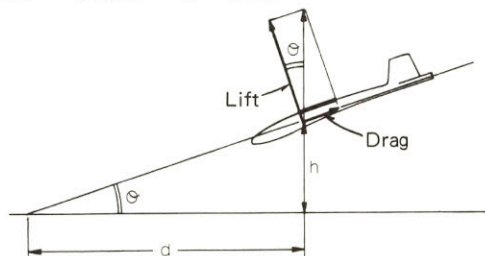


Fig. 5 Glide ratio and lift/drag ratio have the same value.

INTRODUCTION TO PAPER PLANE DESIGN

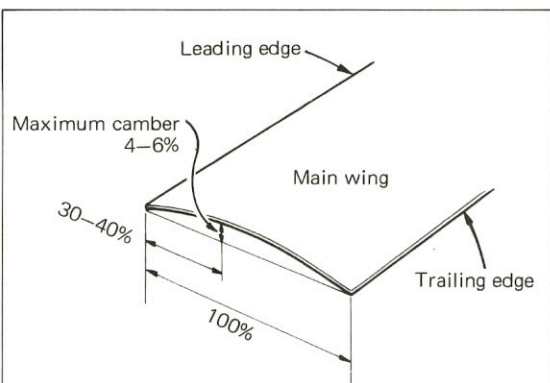


Fig. 6 A thin airfoil is easy to make and suitable for paper planes.

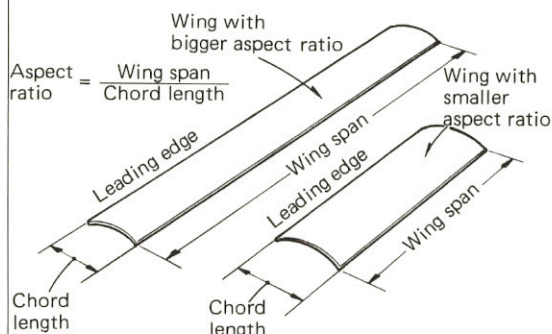


Fig. 7 Aspect ratio

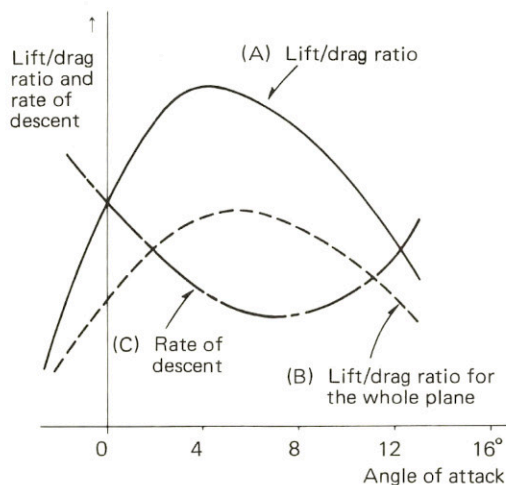


Fig. 8 Lift/drag ratio and rate of descent depending on angle of attack

In order to have a high lift/drag ratio you must choose a good wing shape. A wing that is easy to make with a high lift/drag ratio is shown in Figure 6. As described in the chapter "Assembly Instructions", this thin type of wing is easily made by cambering the wing carefully with your fingers.

It is very important to decrease the air-drag by slimming the fuselage or by omitting parts which jut out such as the landing gear, struts, etc. as much as possible. A special ratio used to decrease drag on the wing is called the aspect ratio.

The aspect ratio is found by dividing the wing span by the chord length. The greater the aspect ratio the more slender the wing will be. As the aspect ratio of the main wing becomes larger, the less the drag on it. Real gliders and planes designed for long distance flights have long slender wings for less drag and greater lift. On a paper plane, however, which has a small body and flies at low speeds, there is no need to make the wing too slender. Rather it is best to build a light and sturdy main wing with an aspect ratio of about 5 or 6.

The lift/drag ratio changes with the glider's angle of attack. Figure 8 shows the changes. Line (A) shows the lift/drag ratio for the main wing. A 3° or 4° angle of attack is most desirable. Line (B) shows the lift/drag ratio of the whole glider. Since there is more drag on the entire glider, a 5° or 6° angle of attack is best.

When a plane is gliding and slowly losing altitude, this is called the rate of descent. It is measured in meters per second. For a long duration flight you must decrease the rate of descent. In Figure 8, line (C) shows the rate of descent. When the angle of attack is a little larger, (i.e. 1°-2° greater than that for the best lift/drag ratio), the rate of descent is the smallest.

The weight of the whole plane, divided by the surface area of the main wing, is called the wing loading. A heavy plane with small wings will have a large wing load. The Lockheed F-104 is an example of this principle. Planes with high wing loads glide faster and so their rate of descent is high.

On an actual light plane or glider the surface area of the main wing is relatively large, and because the plane is light, the wing loading is small. Due to these factors, the rate of descent is low. Accordingly they can glide, cruising for long periods of time.

When designing paper planes for long duration flights, it is best to have a low wing load by making a large wing area with a body as light as possible so your plane will fly for a long time.

HOW TO IMPROVE STABILITY

For a plane to fly well, it must be stable. Figure 9 shows the movements of a plane in flight. The parts which control stability are:

- HORIZONTAL STABILIZER
– controls pitching
- VERTICAL STABILIZER
– controls yawing
- DIHEDRAL ANGLE ON MAIN WING
– controls rolling

For a stable plane all of these must be designed and attached properly as described in the next chapter.

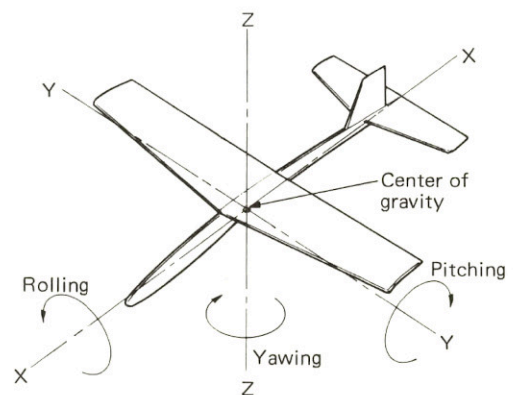


Fig.9 In-flight motion

INTRODUCTION TO PAPER PLANE DESIGN

ELEMENTARY DESIGN METHOD

1. Designing The Main Wing

The plane's gliding speed and rate of descent depends a lot upon the wing loading. You must decide on the wing area that is best for the plane you are building.

- When you design a plane for a long, slow, buoyant flight, give it a large wing area.
- When you design a high-speed, sleek jet plane, make the wing area small.

However, be careful not to make the wing loading too small. Although it will decrease the rate of descent, the plane won't go up very high when thrown into the air, resulting in a short flight. A wing span of less than 30 cm is recommended considering the strength of the paper.

2. Main Wing Surface Shape

You can choose the wing shape you like best from the shapes in Figure 10. If the wing is either too narrow (high aspect ratio) or too wide (low aspect ratio) the plane will not be stable nor fly well. For a good flying airplane, try to avoid odd shaped wings.

The sweptback wing tends to cause "tip stall" which sends the plane into a spin, so it is best to avoid a wing with a large sweptback angle.

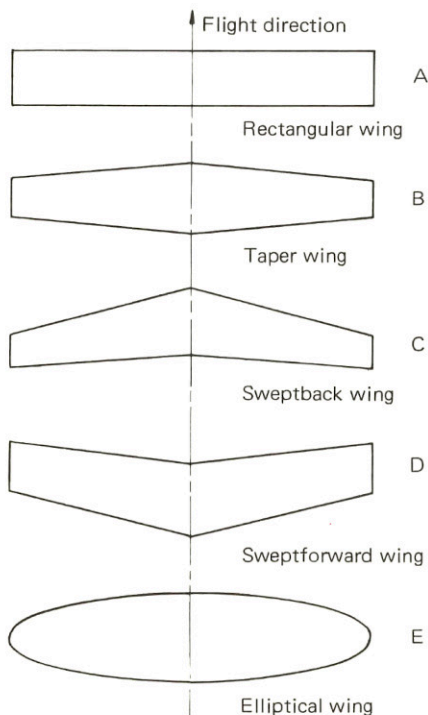


Fig. 10 Wing shapes

Figure 11 shows the relationship between the angle of attack and stalling on the rectangular wing and the sweptback wing. On the rectangular wing, air turbulence affects the central part of the wing, while on the sweptback wing, turbulence affects the wing tip which sends the plane into "tip stall." When tip stalling, the plane suddenly loses its lift.

Differences in the effect of air turbulence and bends or warps in the wings cause differences in wing lift. This will result in stalling (Fig. 12). The sweptback wing plane will go into a "spin" when it stalls. And so although the sweptback wing looks quite good its design does present some problems.

3. Center of Gravity and Wing Angle of Setting

The angle of attack must be determined according to the type of glider you choose, whether it is for a long duration flight or a long distance flight. The placement of the center of gravity and the angle of setting for the main wing and horizontal stabilizer for these two types of gliders are shown in Figures 13 and 14. When the wings are positioned in this way, the angle of attack of the plane will be near to that previously explained (See Fig. 8).

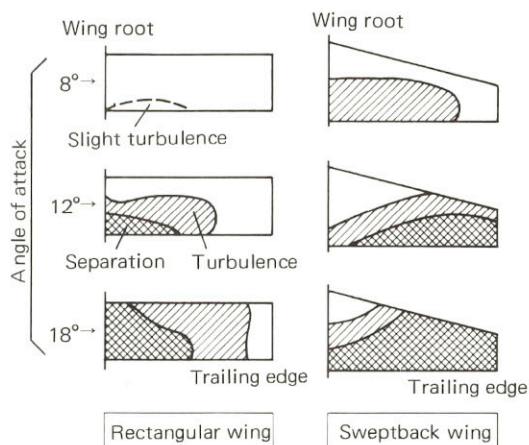


Fig. 11 Occurrence of stalling differs for planes with rectangular wings and those with sweptback wings.

(From "Report and Memorandum No. 1976 of the Royal Aircraft Establishment")

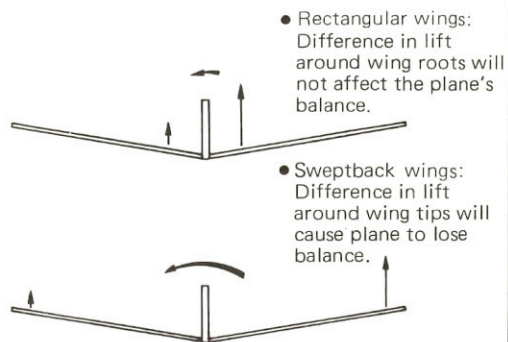


Fig. 12 Difference in wing tip stall on rectangular wings and sweptback wings

INTRODUCTION TO PAPER PLANE DESIGN

When the wings and the center of gravity are placed according to the guidelines, then the fuselage can be designed according to what glider type you choose. The horizontal stabilizer setting might have to be adjusted to get good balance but this can be done after the test flight.

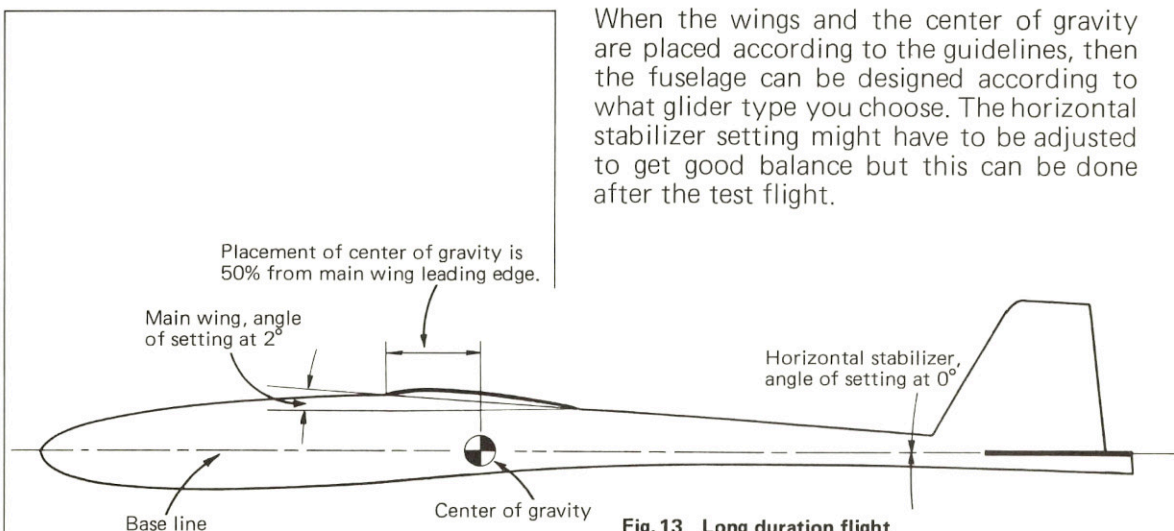


Fig. 13 Long duration flight

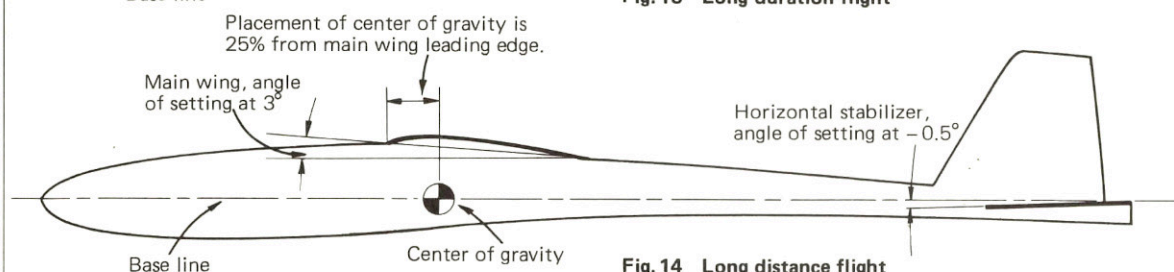


Fig. 14 Long distance flight

4. Center of Gravity on Non-Rectangular Wing Planes

In Figures 13 and 14, the center of gravity of the airplane is placed at a point 25% or 50% of the chord length from the main wing's leading edge. For the rectangular wing (Fig. 10-A) the chord length is the same for every part of the wing so it is easy to find the center of gravity. In the other wing shapes, the chord length changes at different places on the wing. The center of gravity on these wings depends upon the average chord length which represents the aerodynamic characteristics of the wing. This chord length is called the Mean Aerodynamic Chord (MAC) and it is easy to find. The shaded parts in Figure 15 are half the main wing (from center to wing tip).

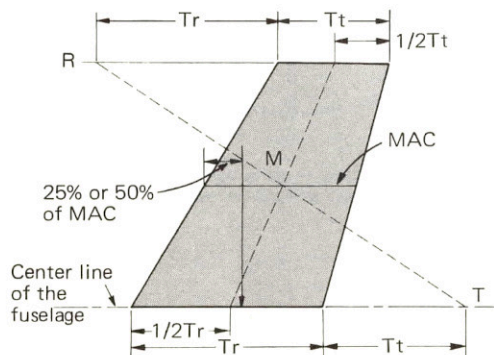


Fig. 15 How to find Mean Aerodynamic Chord (MAC)

Make a sketch of the wing in which T_t is the chord length at the wing tip and T_r is the chord length at the wing root. Extend line T_t the distance of line T_r and extend line T_r the distance of line T_t . Connect the two points (T & R) at the end with a dotted line. Find $\frac{1}{2}T_r$ and $\frac{1}{2}T_t$ and divide the wing with another dotted line. These two lines form point M. Draw a line parallel to the plane's body through M. This line will be the Mean Aerodynamic Chord length of the wing. The center of gravity should be placed at a point 25% or 50% of the MAC as seen in Figure 16.

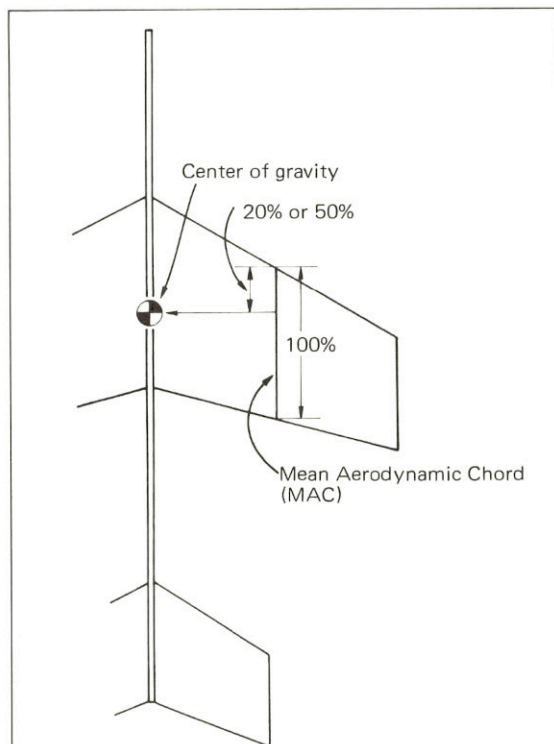


Fig. 16 Center of gravity on a plane with main wings (not rectangular wings) will be decided by means of MAC.

5. The Dihedral Angle

The reason a plane can right itself when it rolls to either side is because of the dihedral angle put on the main wing. As shown in Figure 17 the dihedral angle should be 5° – 15° on a high wing glider and 15° – 25° on a low wing glider.

The sweptback wing of the jet plane serves the same function as a dihedral angle. On jet planes with sweptback wings a small dihedral angle should be used.

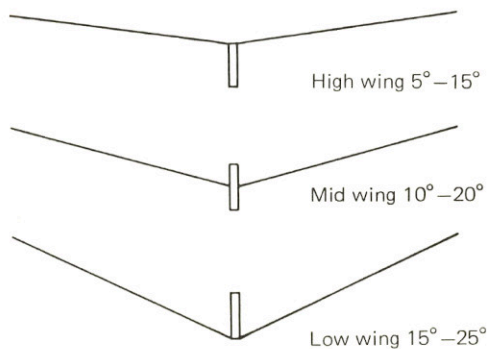


Fig. 17 Wing position and suitable dihedral angle

INTRODUCTION TO PAPER PLANE DESIGN

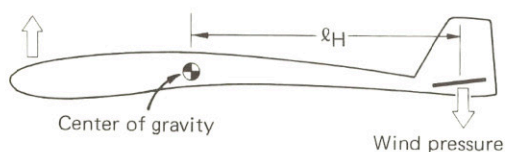


Fig. 18 Stabilizer works as a lever with center of gravity as a fulcrum.

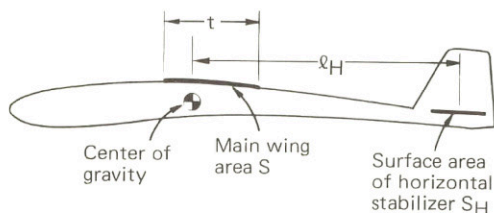


Fig. 19 How to find surface area of the horizontal stabilizer

6. The Horizontal Stabilizer

The horizontal and vertical stabilizers act independently as levers supporting the center of gravity. The distance (ℓ) between the center of gravity and the horizontal and vertical stabilizers is very important. By multiplying the size of the stabilizers by this distance (ℓ) we can find how well the stabilizers work. This product is called the tail volume.

To find the best surface area for the horizontal stabilizer (S_H) the following formula is used.

■ Long duration flight

$$S_H = 1.2 \frac{S \times t}{\ell_H}$$

■ Long distance flight

$$S_H = 0.6 \frac{S \times t}{\ell_H}$$

S = Main wing surface area (cm^2)

t = Chord length (cm)

ℓ_H = Distance from center of gravity to horizontal stabilizer (cm)

The surface area of S_H as determined by the above formula is bigger in Figure 13 than in Figure 14. This is because the further back the center of gravity, the more unstable the plane will be. Therefore, a large surface area on the horizontal stabilizer is necessary.

7. The Vertical Stabilizer

$$S_v = 0.05 \frac{S \times b}{\ell_v}$$

S = Main wing surface area (cm^2)

b = Main wing span (cm)

ℓ_v = Distance from center of gravity to vertical stabilizer (cm)

The surface area of the vertical stabilizer is found using the above formula. This figure is only an estimate of the stabilizer's size. For a more precise figure the surface area of the plane body and main wing dihedral angle must also be taken into consideration.

If the vertical stabilizer is too big, or too small, the glider will not fly well. If the stabilizer is too large, the glider will tend to go into a spiral descent. If it is too small the plane will tend to spin. To find the best size for the vertical stabilizer, make it slightly larger than the size you figured in the above formula. During test flights trim it until the back end begins to sway slightly from side to side. It's fun to practice this method, so give it a try!

As long as the size of the horizontal and vertical stabilizers is right, then you may choose whatever shape you like.

8. Test Design

Let's design a paper plane now using the aforementioned explanations. We will design a rectangular winged plane for long duration flying. If we make the main wing span 22 cm, and the chord length 4 cm, then the main wing surface area calculation is:

$$S = 22 \times 4 = 88\text{cm}^2$$

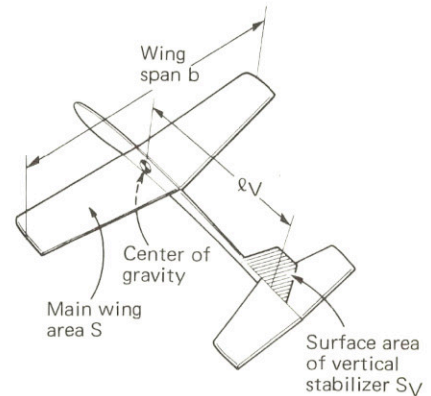


Fig. 20 How to find surface area of the vertical stabilizer

INTRODUCTION TO PAPER PLANE DESIGN

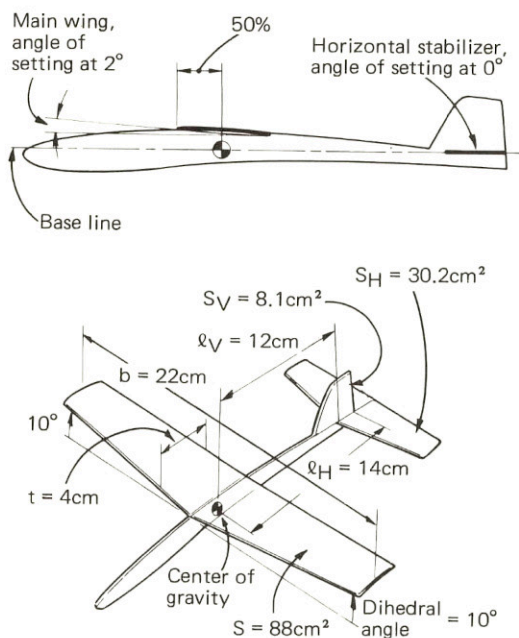


Fig. 21 Test design for long duration flight

Layering the nose increases strength.

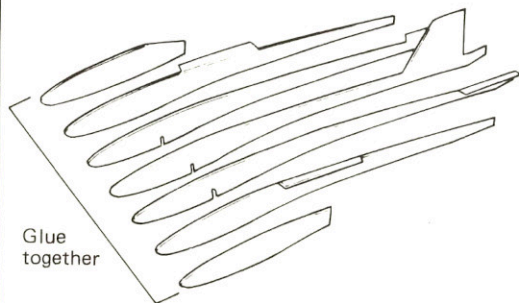


Fig. 22 Composition of the fuselage

If we put the center of gravity 50% back from the main wing's leading edge (See Fig. 13) and make the distance from the center of gravity to the horizontal and vertical stabilizers respectively $l_H = 14$ cm and $l_V = 12$ cm, we can calculate S_H and S_V using the following equations (See Fig. 19 and Fig. 20).

$$S_H = 1.2 \frac{88 \times 4}{14} = 30.2 \text{ cm}^2$$

$$S_V = 0.05 \frac{88 \times 22}{12} = 8.1 \text{ cm}^2$$

When deciding the distance from the center of gravity to nose tip, choose a length similar to that of one of the White Wings models. If the distance is either too long or too short, the plane will fly poorly. You can, however, design the shape as you like.

From the above values your design will be similar to the glider in Figure 21. I have made a test model of this plane and I have found that it flies very well. Enjoy designing one for yourself!

9. Plane Body Construction

When throwing the glider by hand or by catapult, the wings must be able to withstand extreme wind pressure. Also, the plane must be sturdy so it will not bend or rip when it hits the ground or walls.

For a top quality glider, some parts are designed for strength while others need to be as light as possible. The shape of the glider should be designed with the following conditions in mind. It must be easy to launch by hand, simple to repair when damaged, and it must have little wind resistance.

To meet these requirements, the actual construction of the plane body, as shown in Figure 22, is made up of layers of heavy paper. There are more layers in the nose for added strength. In Figure 23, the dashed lines show where the glider tends to bend easily. To prevent this, parts (A) and (B) extend past the arrow marks for reinforcement. This flat type of body is superior to the monocoque (tube body) as it is easy to construct, repair, launch and it also has less wind resistance.

As shown in Figure 24, a backing is glued to the underside of the wing's center in order to keep the main wing sturdy. Further, to obtain better performance, the wing should be slightly cambered as in Figure 6. This type of main wing is also easy to repair.

This concludes my explanation of simple design methods. You can now use this knowledge to help you design your own gliders.

Good Luck and Good Flying!

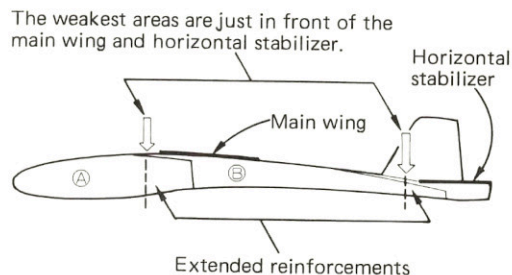


Fig. 23 Reinforcement of easily bendable parts

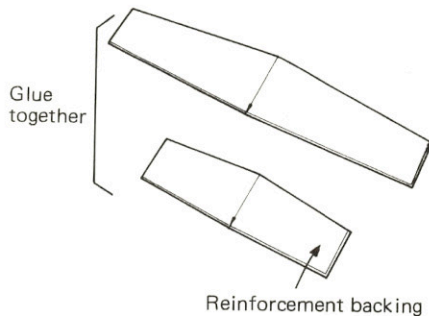
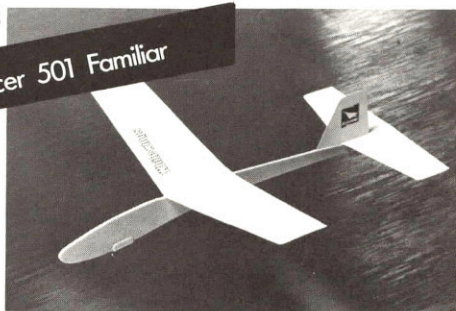


Fig. 24 Composition of the main wing

HOW TO BUILD "WHITE WINGS"

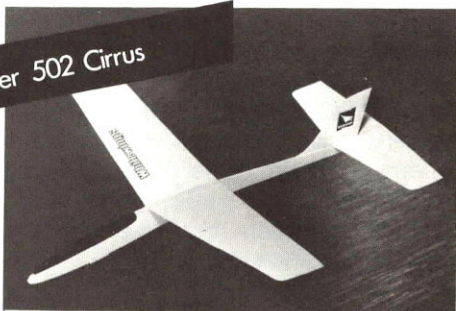
P. 38

Racer 501 Familiar



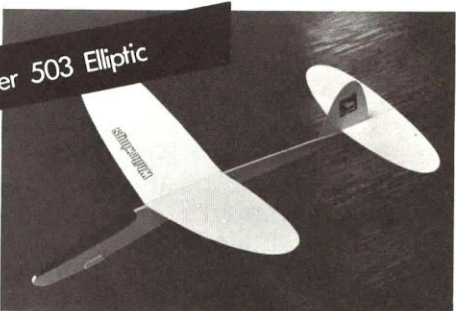
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Racer 502 Cirrus



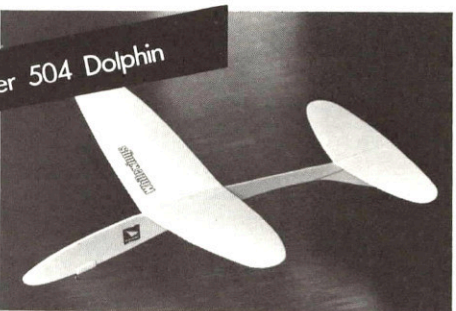
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Racer 503 Elliptic



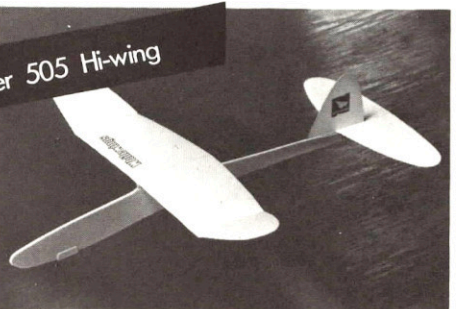
P. 41

Racer 504 Dolphin



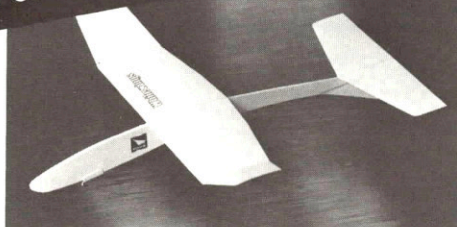
P. 42

Racer 505 Hi-wing



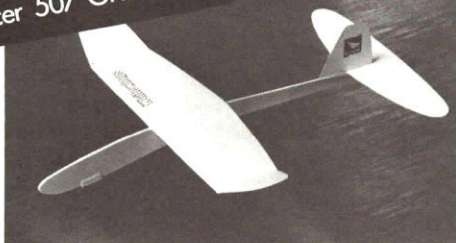
P. 44

Racer 506 White Panther



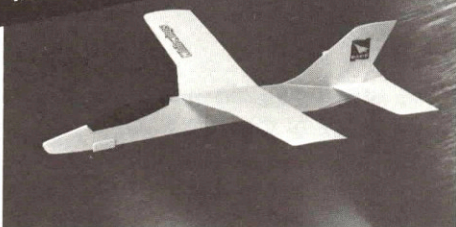
P. 46

Racer 507 Grace



P. 48

Jet Trainer



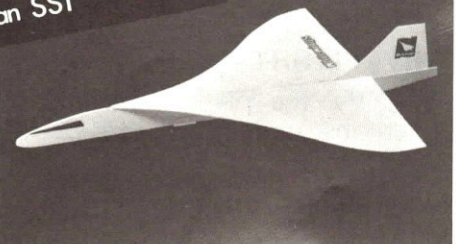
P. 49

Tailless Plane



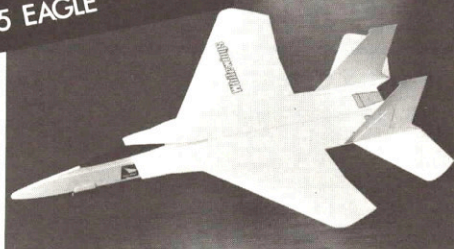
P. 50

Clean SST



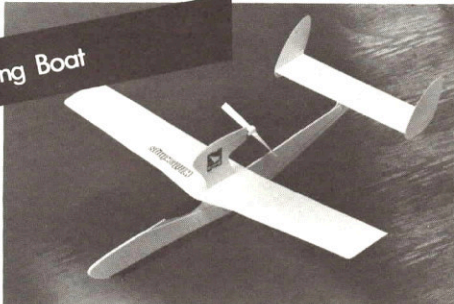
P. 51

F-15 EAGLE



P. 52

Flying Boat



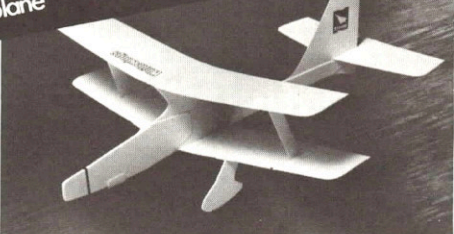
P. 54

Spirit of St. Louis



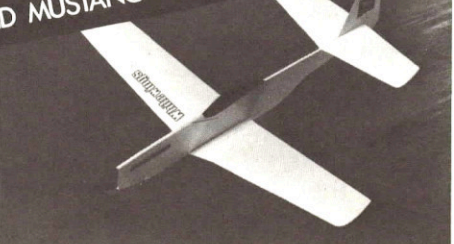
P. 56

Bi-plane



P. 58

P-51D MUSTANG



WhitewingsTM

Racer 501 Familiar

• How to Glue the Parts

Glue the parts together in the order indicated.

- 3.** Glue ⑨ to the underside of ⑧. After the glue is dry, cut off the protruding portions.

Arrows point forward.

- 5.** Glue the main wing ⑧ + ⑨ firmly to the fuselage.

- 4.** Glue horizontal stabilizer to the fuselage.

- 2.** Glue ① through ⑦ in the order shown in the drawing.

- 1.** Fold all tabs outward.

- 7.** Make a 15° dihedral angle.

Camber the wings slightly.

- 8.** Glue ⑩ to the center of the main wing.

- 6.** Insert the hook into the fuselage and glue on ⑬.

• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and

straighten any warps or bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Racer 502 Cirrus

• How to Glue the Parts

Glue the parts together in the order indicated.

- 3.** Glue ⑨ to the underside of the main wing ⑧. After the glue is dry, cut off the protruding portions.

- 2.** Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together.) If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

5. Glue ⑧ + ⑨ to the fuselage.

- 6.** Insert the lead foil into the plane nose. Adjust the weight of lead foil, aligning the center of gravity at the ▲ mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly onto the nose of the fuselage. Also insert the hook in the nose.

- 7.** After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

- 8.** Insert the hook into the fuselage and glue on ⑬.

Arrows point forward.

- 4.** Glue the horizontal stabilizer ⑪ to the fuselage.

- 1.** Fold all tabs outward.

Camber the wings slightly.

- 9.** Make a 15° dihedral angle.

- 10.** Glue ⑩ to the center of the main wing.

• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the

nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Racer 503 Elliptic

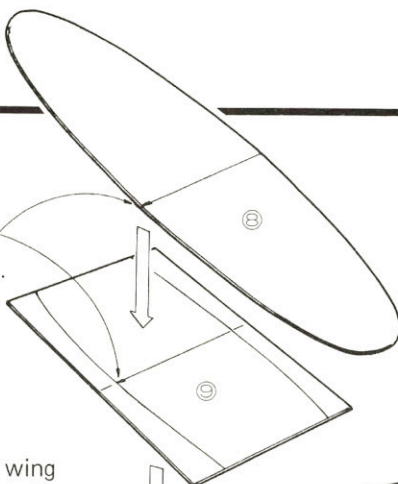
• How to Glue the Parts

Glue the parts together in the order indicated.

3.

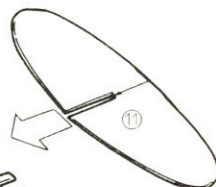
Glue ⑨ to the underside of the main wing ③. When dry, cut off the protruding portions.

Arrows point forward.



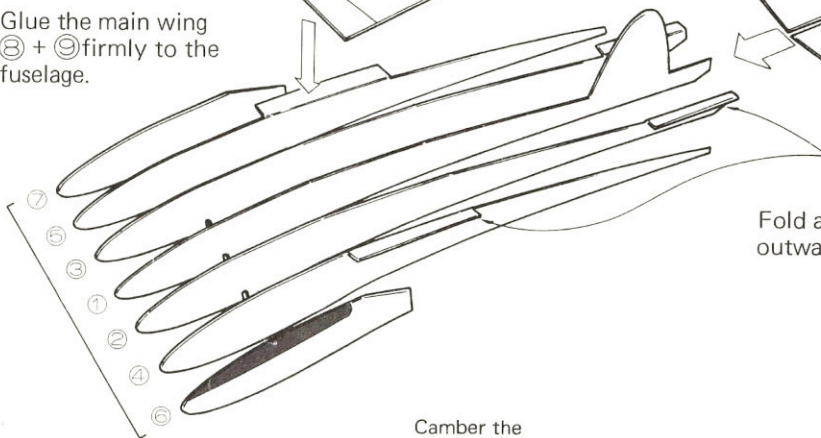
4.

Glue horizontal stabilizer ⑪ to the fuselage.



5.

Glue the main wing ③ + ⑨ firmly to the fuselage.



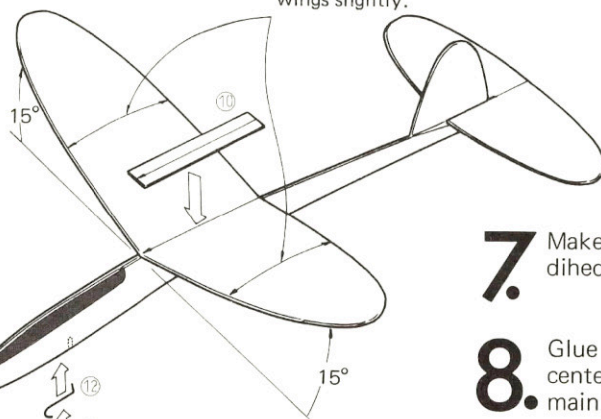
2.

Glue ① through ⑦ together in the order indicated.

1.

Fold all tabs outward.

Camber the wings slightly.



6.

Insert the hook into the fuselage and glue on ⑬.



7.

Make a 15° dihedral angle.

8.

Glue ⑩ to the center of the main wing.

fuselage and wings.

• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

Racer 504 Dolphin

• How to Glue the Parts

Glue the parts together in the order indicated.

Arrows point forward.

3. Glue ⑨ to the underside of ⑧. When dry, cut off the protruding portions.

5. Glue the main wing ⑧ + ⑨ firmly to the fuselage.

2. Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose.
(You may cut out the squares before gluing together.)

If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

6. Insert the lead foil into the plane nose. Adjust the weight of lead foil, aligning the center of gravity at the ▲ mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly onto the nose of the fuselage. Also insert the hook in the nose.

7. After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

8. Insert the hook into the fuselage and glue on ⑬.

4. Glue horizontal stabilizer ⑪ to the fuselage.

1. Fold all tabs outward.

Camber the wings slightly.

9. Make a 15° dihedral angle.

10. Glue ⑩ to the center of the main wing.

⑥ nose, aligning the center of gravity at the ▲ mark.

• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Racer 505 Hi-wing

• How to Glue the Parts

Glue the parts together in the order indicated.

2.

Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together.) If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

1.

Fold all tabs outward.

Arrows point forward.

3.

Glue ⑨ to the underside of ③. When dry, cut off the protruding portions.

4.

Fold up tabs on the main wings with a ruler and cut in toward the center to the dashed line.

5.

Camber the main wing carefully.

7.

Glue ⑧ + ⑨ firmly to the fuselage.

6.

Glue ⑫ to the fuselage.

9. Apply glue to the top surface of the folded tabs and attach wing tips ⑩ and ⑪ respectively. (Dot mark points forward.)

If you follow instructions 5 through 9 precisely, the angle of the wing tips in relation to the central wings will naturally form a 35° dihedral angle.

10.

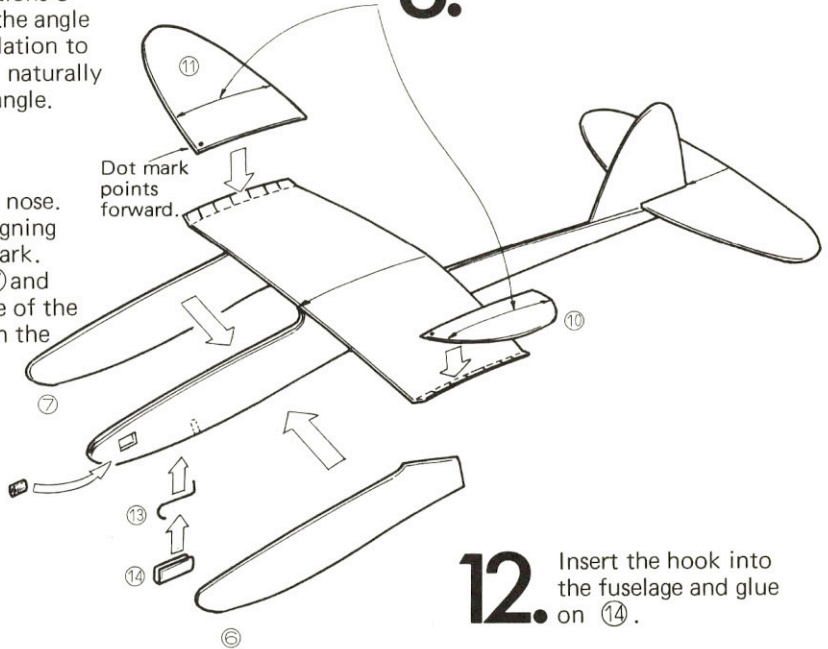
Insert the ballast into the plane nose. Adjust the weight of ballast, aligning the center of gravity at the ▲ mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly onto the nose of the fuselage. Also insert the hook in the slot.

11.

After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

8.

Apply a camber to both wing tips ⑩ and ⑪.



12.

Insert the hook into the fuselage and glue on ⑭.



• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

Racer 506 White Panther

• How to Glue the Parts

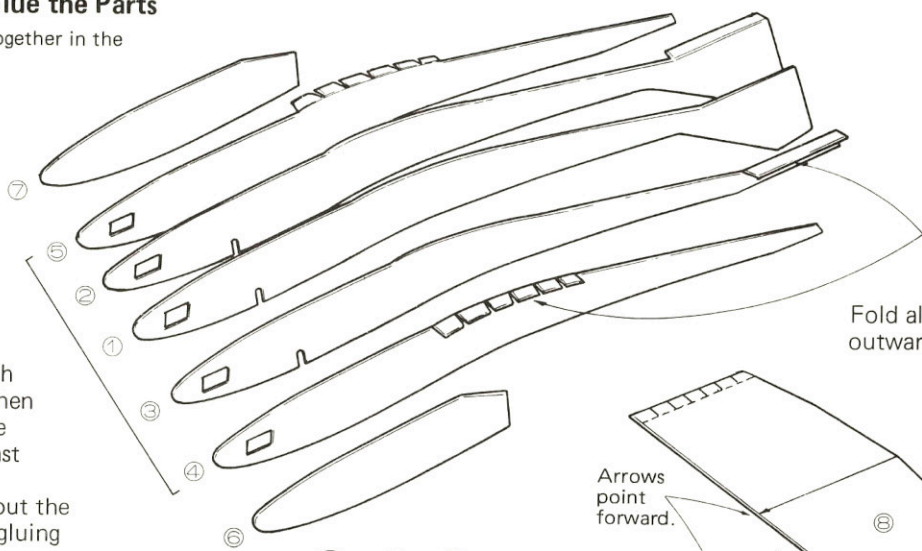
Glue the parts together in the order indicated.

2.

Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose.

(You may cut out the squares before gluing together.)

If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.



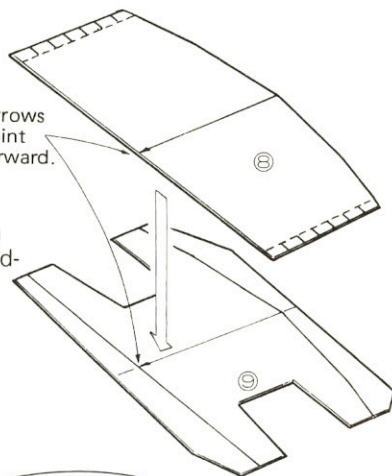
1.

Fold all tabs outward.

3.

Glue ⑨ to the underside of ⑧. When dry, cut off the protruding portions.

Arrows point forward.

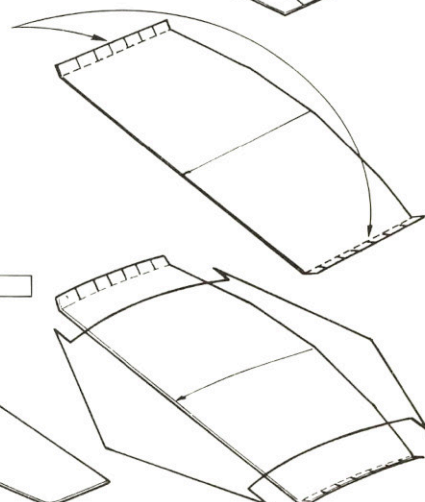


4.

Fold up tabs on the main wing with a ruler and cut in toward the center to the dashed line.

5.

Camber the main wing carefully.

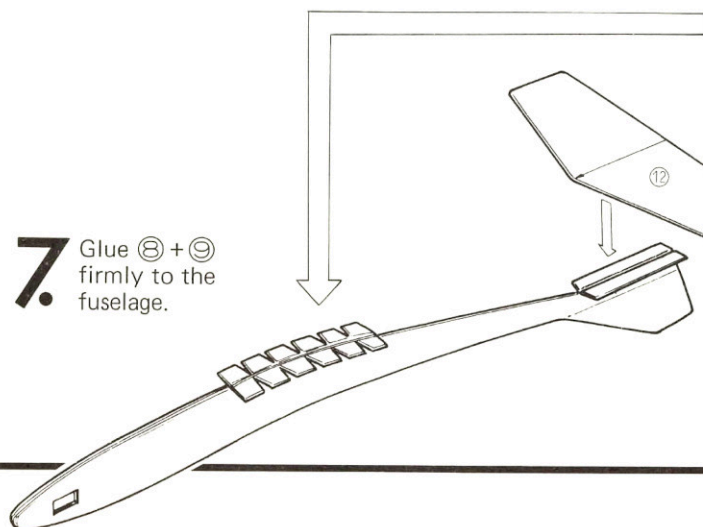


7.

Glue ⑧ + ⑨ firmly to the fuselage.

6.

Glue ⑫ to the fuselage.



9.

Apply glue to the top surface of the folded tabs and attach wing tips ⑩ and ⑪ respectively. (Dot mark points forward.)

If you follow instructions 5 through 9 precisely, the angle of the wing tips in relation to the central wings will naturally form a 35° dihedral angle.

10.

Insert the ballast into the plane nose. Adjust the weight of ballast, aligning the center of gravity at the ▲ mark.

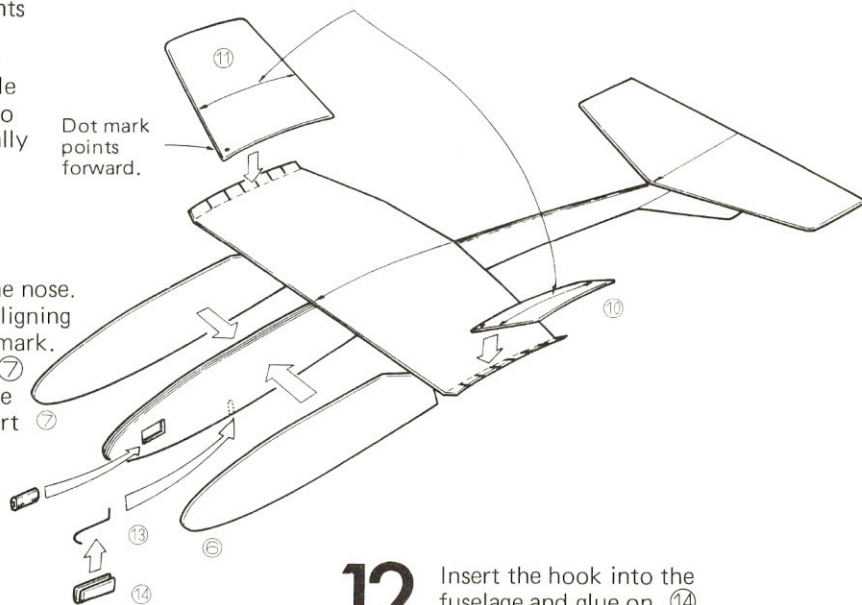
Apply a bit of glue to ⑥ and ⑦ and stick them lightly onto the nose of the fuselage. Also insert the hook in the slot.

11.

After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

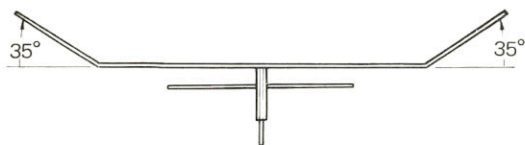
8.

Apply a camber to both wing tips ⑩ and ⑪.



12.

Insert the hook into the fuselage and glue on ⑭.



• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

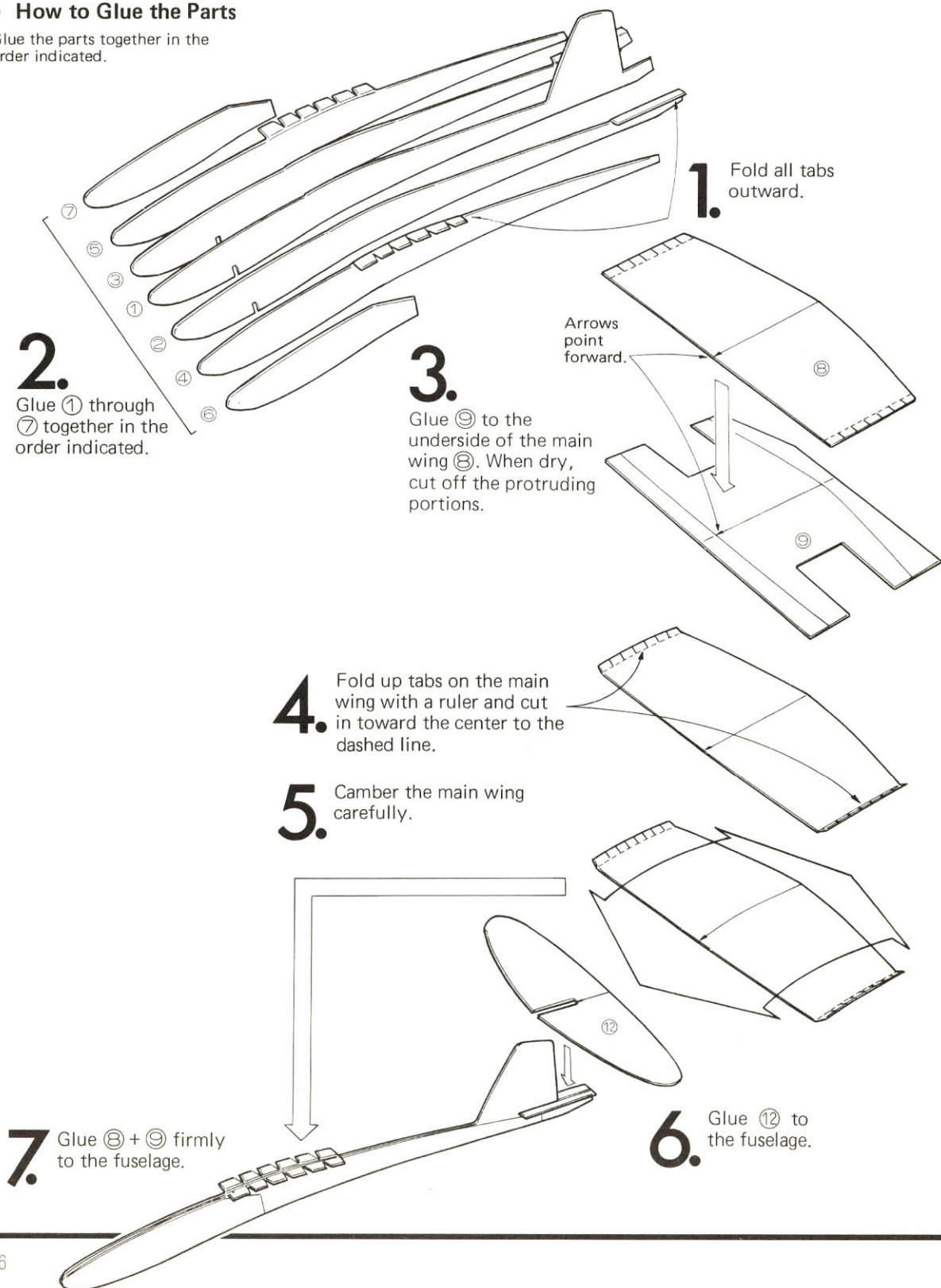
- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

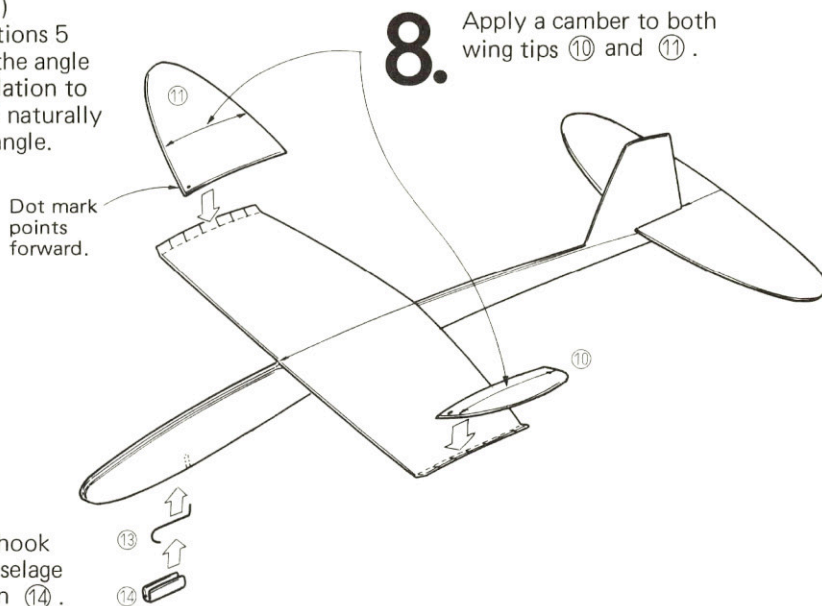
Racer 507 Grace

• How to Glue the Parts

Glue the parts together in the order indicated.

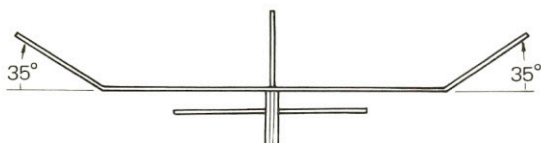


- 9.** Apply glue to the upper side of the folded parts of the main wing and attach wing tips ⑩ and ⑪ respectively. (Dot mark points forward.)
If you follow instructions 5 through 9 precisely, the angle of the wing tips in relation to the central wings will naturally form a 35° dihedral angle.



- 8.** Apply a camber to both wing tips ⑩ and ⑪.

- 10.** Insert the hook into the fuselage and glue on ⑭.



• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

Jet Trainer

• How to Glue the Parts

Glue the parts together in the order indicated.

- 3.** Glue ⑨ to the underside of the main wing ⑧. When dry, cut off the protruding portions.

- 5.** Glue ⑧ + ⑨ firmly to the fuselage.

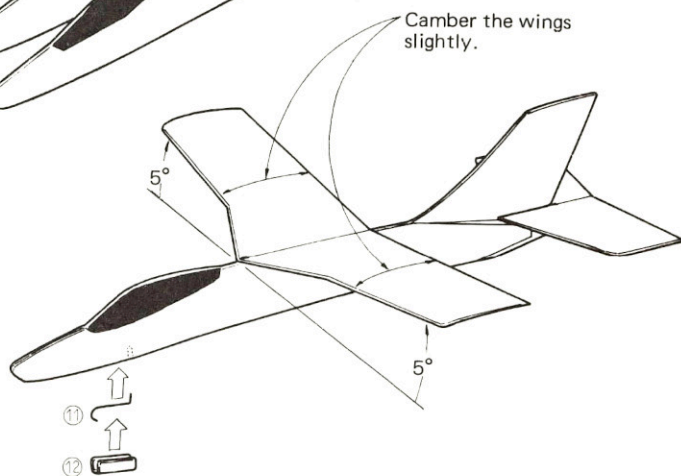
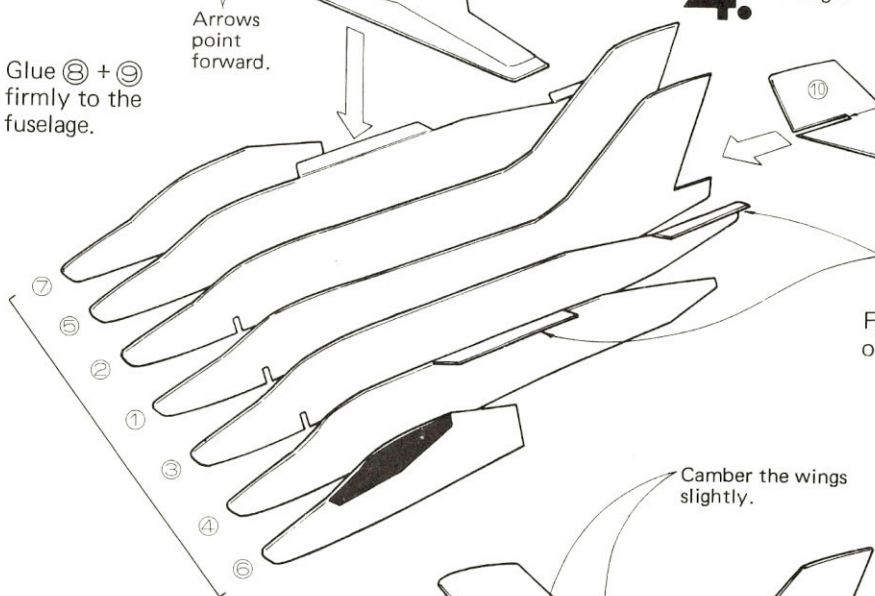
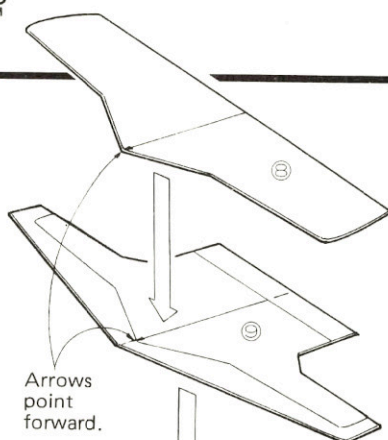
- 2.** Glue ① through ⑦ together in the order indicated.

- 4.** Glue ⑩ to the fuselage.

- 1.** Fold tabs outward.

- 6.** Insert the hook into the fuselage and glue on ⑫.

- 7.** Make a 5° dihedral angle.



• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and

straighten any warps or bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

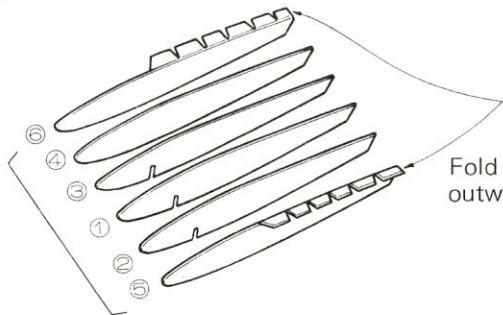
Tailless Plane

• How to Glue the Parts

Glue the parts together in the order indicated.

2.

Glue ① through ⑥ together in the order indicated.

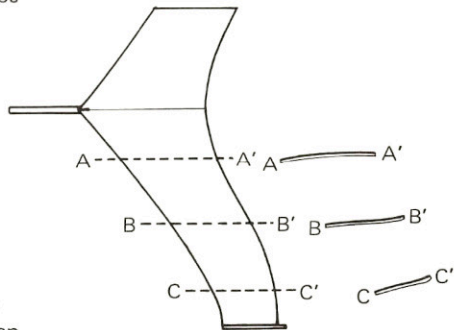


1.

Fold all tabs outward.

Please note:

- Unlike other planes, the trailing edge of the main wing must be cambered upward as explained below.

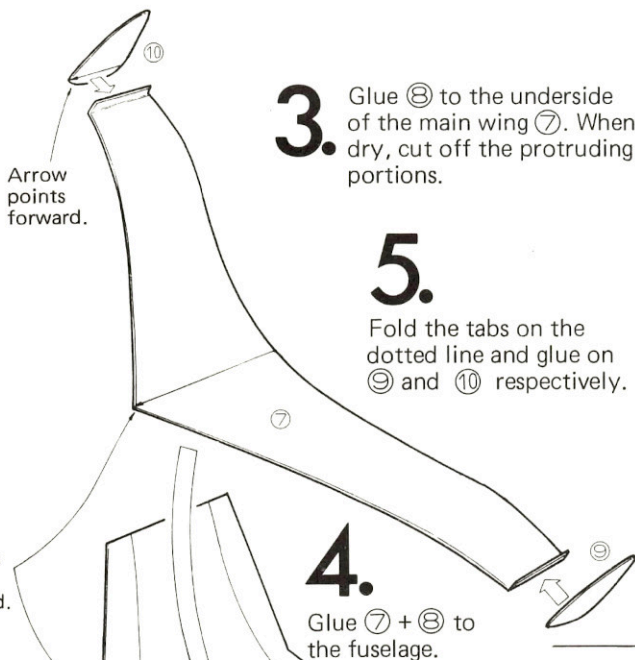


3.

Glue ⑧ to the underside of the main wing ⑦. When dry, cut off the protruding portions.

5.

Fold the tabs on the dotted line and glue on ⑨ and ⑩ respectively.



4.

Glue ⑦ + ⑧ to the fuselage.

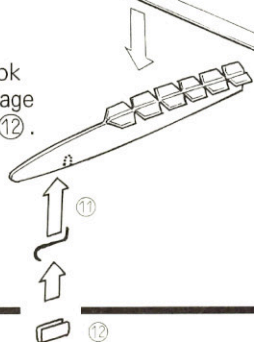
Front view of the plane



- Trailing edges on both sides of the main wings are turned up slightly so that when viewed head-on, the upper surface of the back wing edges should be visible.

6.

Insert the hook into the fuselage and glue on ⑫.



• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Camber the main wings carefully according to the above instructions.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Clean SST

• How to Glue the Parts

Glue the parts together in the order indicated.

3. Glue ⑨ to the underside of ③. When dry, cut off the protruding portions.

4. Glue ⑧ + ⑩ firmly to the fuselage.

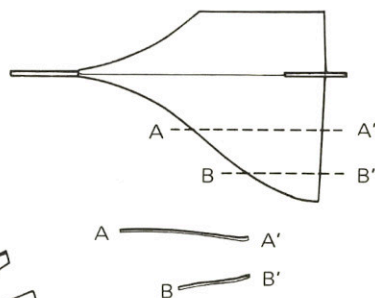
2. Glue ① through ⑦ in the order shown.

Arrows point forward.

1. Fold all tabs outward.

Please note:

- Unlike other planes, the trailing edge of the main wing must be cambered upward as explained below.



Front view of the plane



- Shape the back edges of the main wing slightly upward. When viewed head-on, the upper surface of the back wing edges should be visible.

• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Camber the main wings carefully according to the above instructions.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

5. Insert the hook into the fuselage and glue on ⑪.

Whitewings™

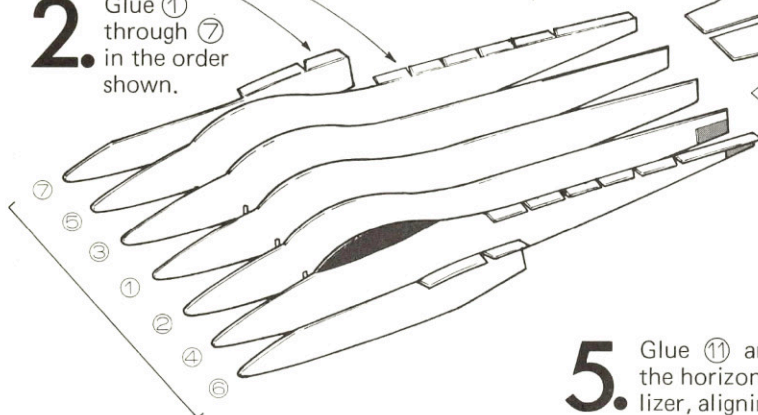
F-15 EAGLE

• How to Glue the Parts

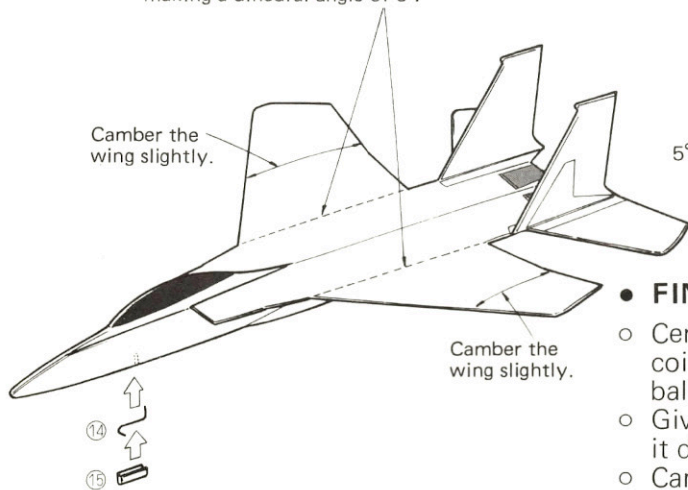
Glue the parts together in the order indicated.

1. Fold tabs outward.

2. Glue ① through ⑦ in the order shown.



Put your ruler along the dashed line and bend the main wing slightly upward, making a dihedral angle of 5°.



Camber the wing slightly.

Camber the wing slightly.

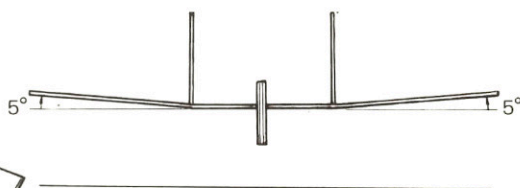
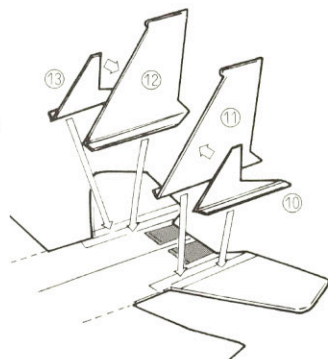
7. Insert the hook into the fuselage and glue on ⑮.

3. Glue ⑨ to the underside of ⑧. When dry, cut off the protruding portion.

4. Glue ⑧ + ⑨ firmly to the fuselage.

5. Glue ⑪ and ⑫ to the horizontal stabilizer, aligning the rear edges.

6. Next, glue ⑩ to the side of ⑪ and ⑬ to the side of ⑫.



• FINISHING TOUCHES

- Center of gravity of the plane will coincide naturally with the ▲ mark when ballast is not used.
- Give finishing touches to the plane after it dries well.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps and bends in the fuselage and wings.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Flying Boat

• How to Glue the Parts

Glue the parts in the order indicated.

3.

Glue ⑨ to the underside of ⑧. When dry, cut off the protruding portions.

6.

Glue ⑧ + ⑨ firmly to the fuselage.

2.

Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together.)

If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

7.

Make a 5° dihedral angle.

4.

Glue ⑪ and ⑫ to the horizontal stabilizer matching the lines.

5.

Glue ⑩ + ⑪ + ⑫ to the fuselage.

Be sure to fold these tabs correctly, as shown.

1.

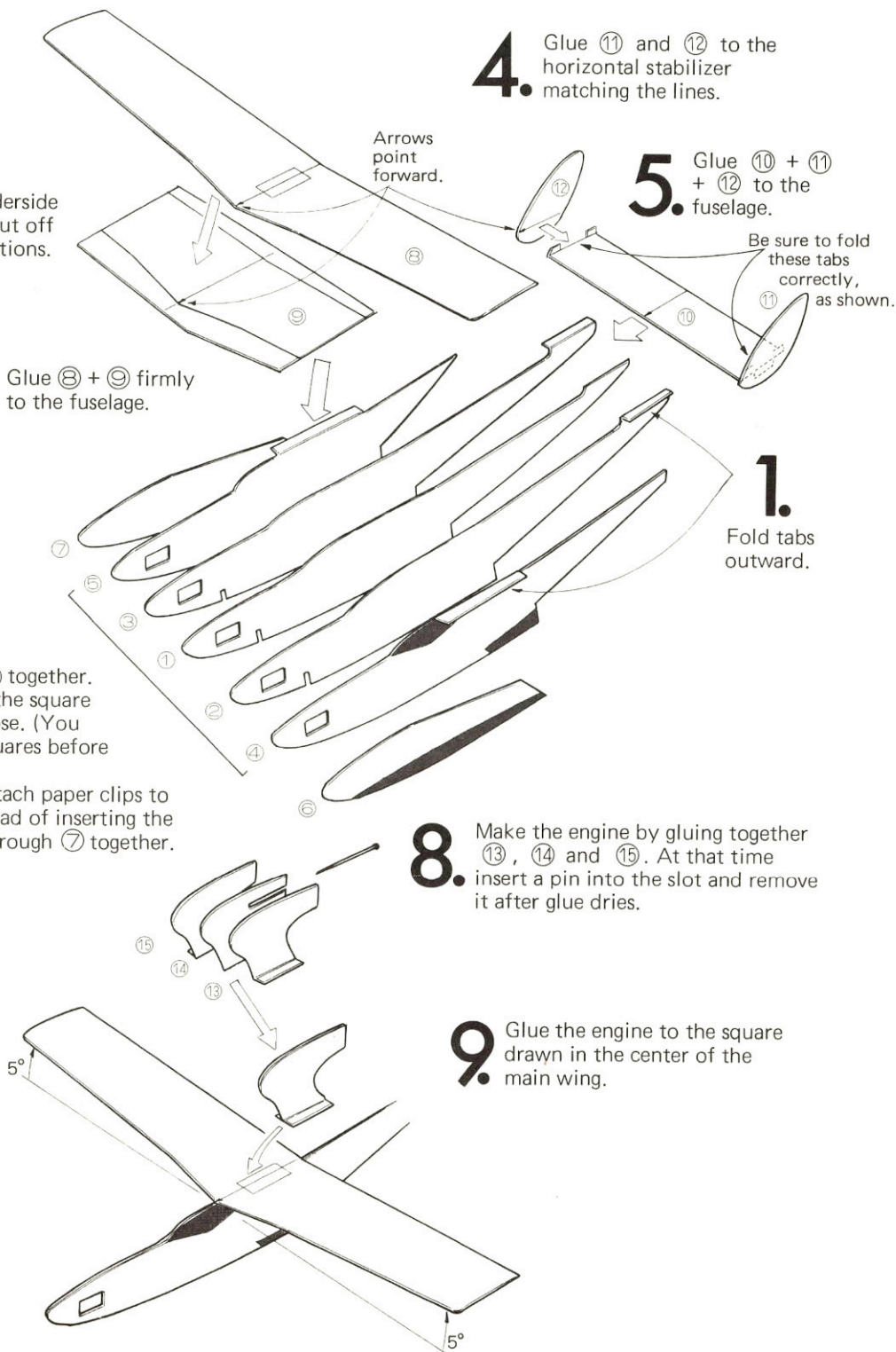
Fold tabs outward.

8.

Make the engine by gluing together ⑬, ⑭ and ⑮. At that time insert a pin into the slot and remove it after glue dries.

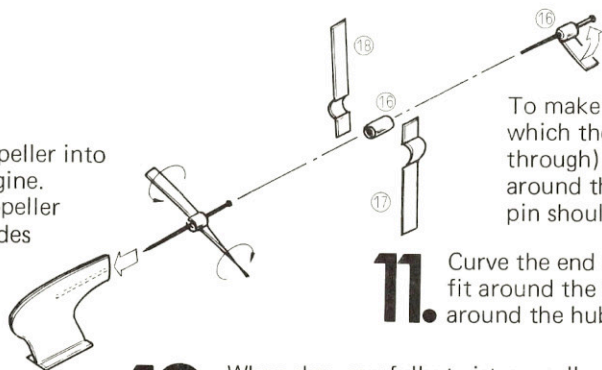
9.

Glue the engine to the square drawn in the center of the main wing.



13.

Insert the pin with propeller into the back end of the engine. After inserting, cut propeller blades so that both blades are balanced.



10.

To make the propeller hub (the part which the propeller shaft passes through), wrap the ribbon (16) around the pin. The hub around the pin should revolve smoothly.

11.

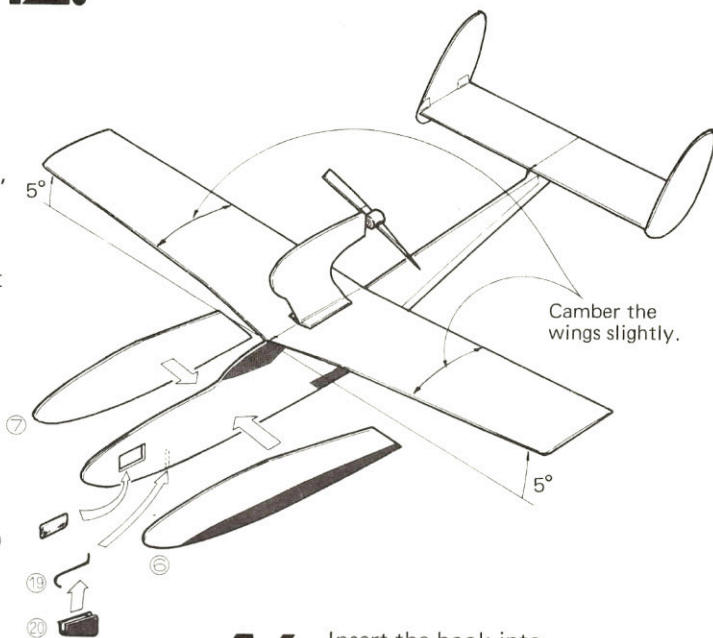
Curve the end of both propeller blades to fit around the hub as shown. Wrap blades around the hub and glue on.

12.

When dry, carefully twist propeller blades in opposite directions.

14.

Insert the lead foil into the plane nose. Adjust the weight of lead foil, aligning the center of gravity at the ▲ mark. Apply a bit of glue to (6) and (7) and stick them lightly onto the nose of the fuselage. Also insert the hook in the nose.



Camber the wings slightly.

15.

After making sure that the center of gravity is at the ▲ mark, re-apply (6) and (7) securely to the fuselage.

16.

Insert the hook into the fuselage and glue on (20).

• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

WhitewingsTM

Spirit of St. Louis

• How to Glue the Parts

Glue the parts in the order indicated.

- 3.** Glue ⑨ to the underside of the main wing ③. When dry, cut off the protruding portions.

- 5.** Glue ⑧ + ⑨ to the fuselage.

- 2.** Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together.) If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

- 7.** Glue ⑯, ⑰, and ⑱ together.

- 10.** Glue ⑪ and ⑫ together and attach to the fuselage.

- 4.** Glue ⑩ to the fuselage.

- 1.** Fold all tabs outward.

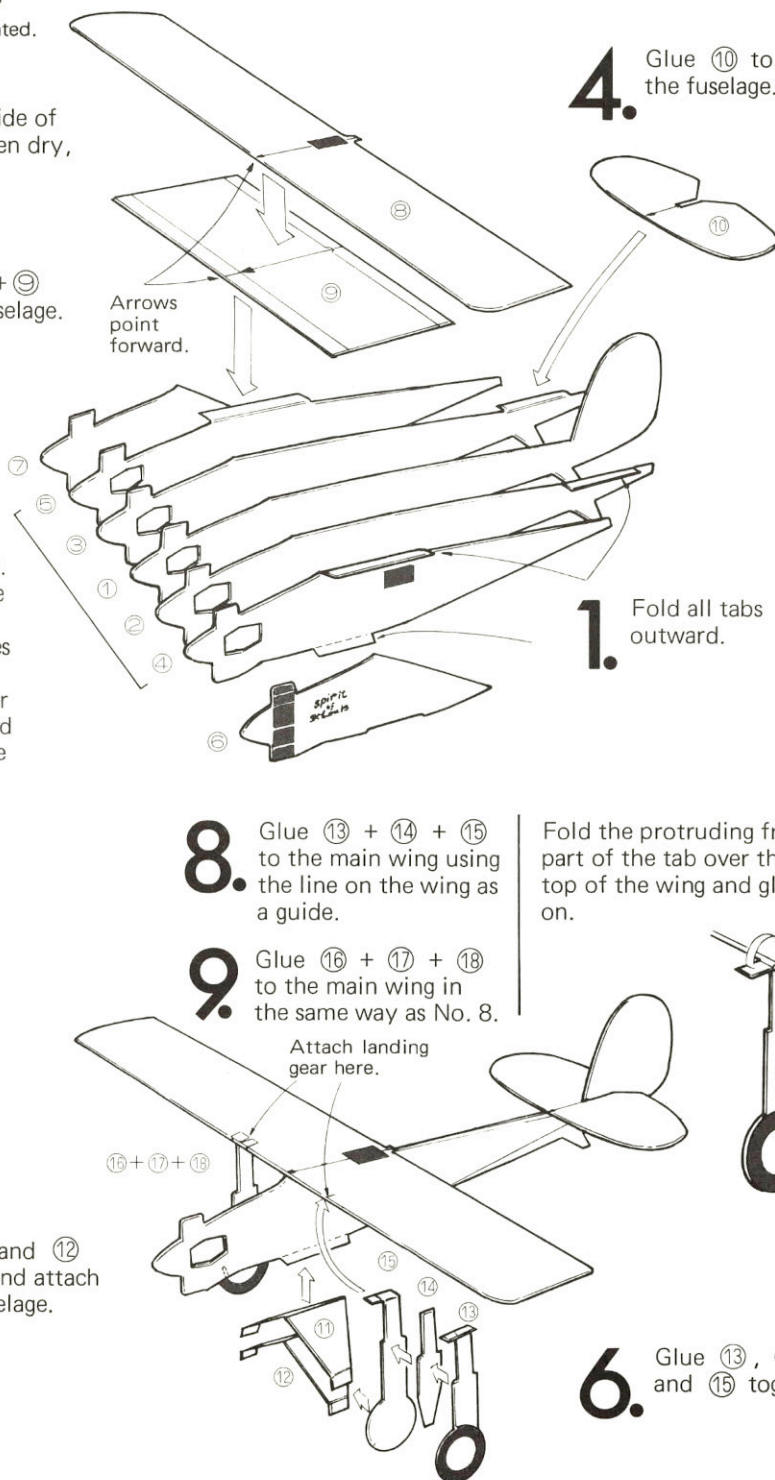
- 8.** Glue ⑬ + ⑭ + ⑮ to the main wing using the line on the wing as a guide.

- 9.** Glue ⑯ + ⑰ + ⑱ to the main wing in the same way as No. 8.

Attach landing gear here.

Fold the protruding front part of the tab over the top of the wing and glue on.

- 6.** Glue ⑬, ⑭, and ⑮ together.



13.

Insert the lead foil into the plane nose. Adjust the weight of lead foil, aligning the center of gravity at the ▲ mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly onto the nose of the fuselage. Also insert the hook in the nose.

14.

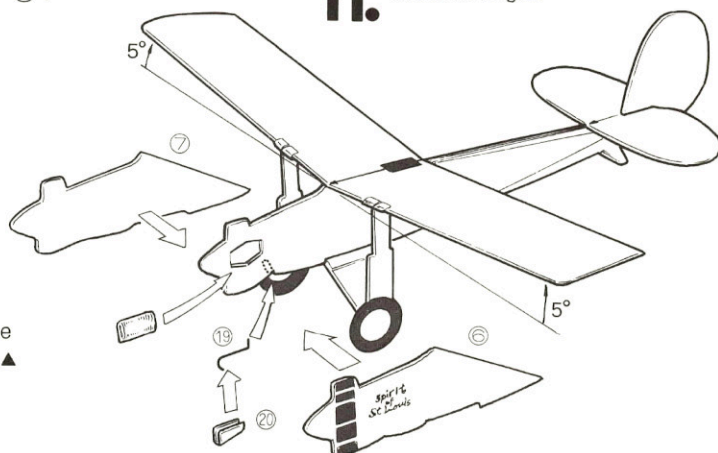
After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

12.

Glue both wheels to ⑪ + ⑫.

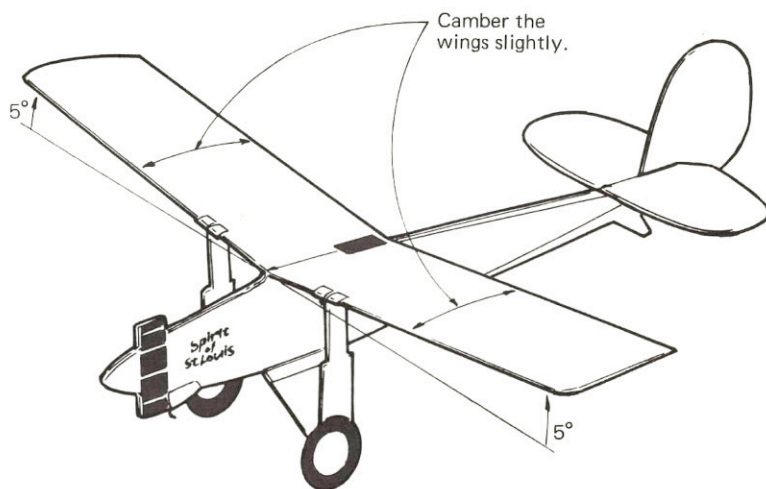
11.

Make a 5° dihedral angle.



15.

Insert the hook into the fuselage and glue on ⑫



Camber the wings slightly.

• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the

nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

Bi-plane

• How to Glue the Parts

Glue the parts in the order indicated.

2.

Glue ① through ⑤ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together) If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

3.

Glue ⑩ to the underside of ⑨. When dry, cut off the protruding portions.

7.

Glue ⑮, ⑯, and ⑰ together and attach them to the lower main wing in the same way as No. 6.

6.

Glue ⑫, ⑬, and ⑭ together and attach them to the underside of the lower main wing, using the line on the wing as a guide.

4.

Glue ⑪ to the fuselage.

1.

Fold all tabs outward.

5.

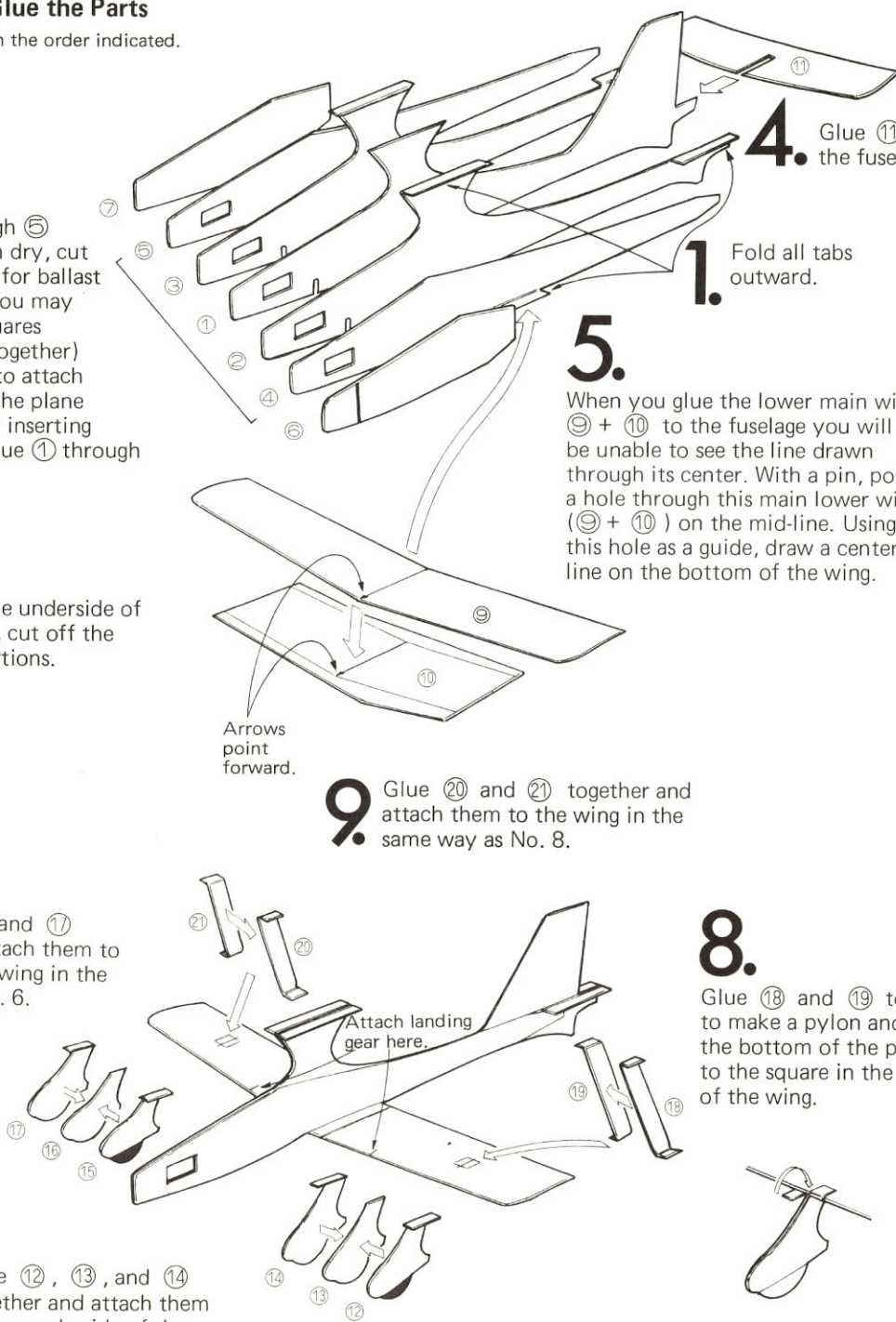
When you glue the lower main wing ⑨ + ⑩ to the fuselage you will be unable to see the line drawn through its center. With a pin, poke a hole through this main lower wing (⑨ + ⑩) on the mid-line. Using this hole as a guide, draw a center line on the bottom of the wing.

9.

Glue ⑳ and ㉑ together and attach them to the wing in the same way as No. 8.

8.

Glue ⑱ and ⑲ together to make a pylon and glue the bottom of the pylon to the square in the middle of the wing.



Fold the protruding front part of the tab over the top of the wing and glue on.

- 11.** Glue the upper wing to the fuselage. When dry, make a 5° dihedral angle. (Do not glue the upper part of the pylons to the wing yet.) View the wings from the top, bottom, back and front and make sure they are parallel.

- 12.** When dry, glue the top part of the pylons to the underside of the fuselage.

13.

Insert the lead foil into the plane nose. Adjust the weight of lead foil, aligning the center of gravity at the \blacktriangle mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly to the nose of the fuselage. Also insert the hook in the nose.

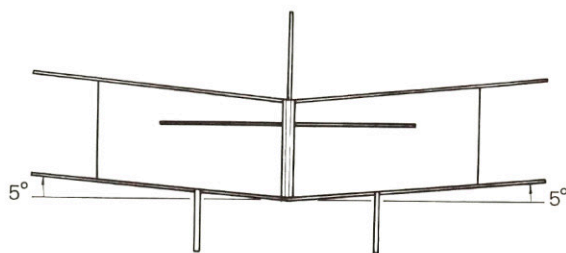
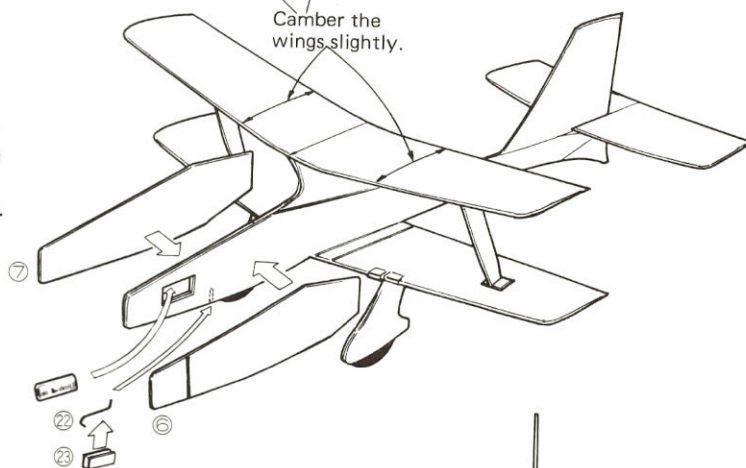
- 14.** After making sure that the center of gravity is at the \blacktriangle mark, re-apply ⑥ and ⑦ securely to the fuselage.

- 15.** Insert the hook into the fuselage and glue on ②③.



10.

Raise the lower wing slightly to make a 5° dihedral angle.



• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the

nose, aligning the center of gravity at the \blacktriangle mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

Whitewings™

P-51D MUSTANG

• How to Glue the Parts

Glue the parts in the order indicated.

2.

Glue ① through ⑦ together. When dry, cut out the square for ballast in the nose. (You may cut out the squares before gluing together.) If you choose to attach paper clips to the plane nose instead of inserting the lead foil, glue ① through ⑦ together.

6.

Insert the lead foil into the nose. Adjust the weight of the lead foil, aligning the center of gravity at the 10–15° ▲ mark. Apply a bit of glue to ⑥ and ⑦ and stick them lightly to the nose. Also insert the hook in the nose.

8.

Insert the hook into the fuselage and glue on ⑫.

3.

Glue ⑧ to the underside of ③. When dry, cut off the protruding portions.

Camber the wings slightly.

7.

After making sure that the center of gravity is at the ▲ mark, re-apply ⑥ and ⑦ securely to the fuselage.

9.

Make a 5° dihedral angle.

4.

Glue ⑩ to the fuselage.

1.

Fold all tabs outward.

5.

Glue ③ + ⑨ firmly to the fuselage.

Arrows point forward.

• FINISHING TOUCHES

- Give finishing touches to the plane after it dries thoroughly.
- Camber the main wings carefully with your fingers.
- View the plane from the front and straighten any warps or bends in the fuselage and wings.
- If you choose not to insert the lead foil in the nose, put a few paper clips on the

nose, aligning the center of gravity at the ▲ mark.

• TEST FLIGHT

- Test fly the plane according to Test Flight instructions on pages 13–15.

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**Please observe carefully
the following precautions
when flying your planes.**
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- When you are throwing your planes be careful to check the area around you so as not to hit people.
- Don't fly your planes where there are cars passing.



**Follow these rules
for an enjoyable sport**

.....
■ DESIGNER'S PROFILE
.....

Dr. Yasuaki Ninomiya, born in 1926, has been fascinated by airplanes since early childhood, an interest which later developed into his present hobby of designing and building paper airplanes.

He received his doctorate in 1962 in the field of microwave measurement theory. He is recognized as a pioneer in micro-communications engineering, and as such, in 1975, was invited by the Iranian government to act as principal advisor of the joint Japan-Iran Electronic Communications Research Center for a period of two years.

Drawing upon this distinguished background and expertise, Dr. Ninomiya designs aviationally sound and sleek, high performance paper planes based upon principles of industrial design and mechanical functionality. Convincing evidence of his talent is his garnering of the grand prizes in the Duration Flight and Distance Flight categories of the 1st International Paper Plane Contest (Pacific Basin Division) in San Francisco in 1967. Again in 1970, at another paper plane contest held in Columbus, Ohio, his entry received the Originality Prize for its outstanding design.

Dr. Ninomiya is recognized widely as a respected authority on paper planes. His

5 volume publication, "Collection of High Performance Paper Planes", has become a million seller.

Today, he is a leading researcher at the Electrical Communications Laboratory of the Japan Telegraph and Telephone Public Corporation, and holds a private plane operator's license.





AG CO., LTD.

11-16, 1-CHOME, NISHINAKAJIMA
YODOGAWA-KU, OSAKA, JAPAN
TELEPHONE: 06-303-8001 / 8436

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