

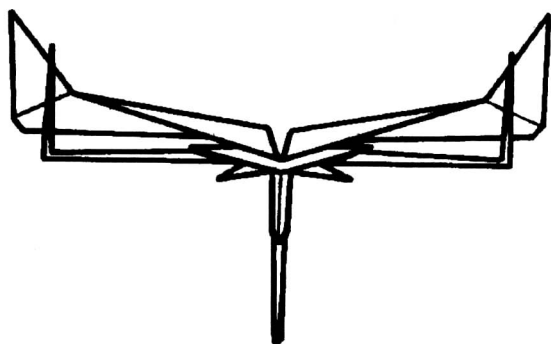
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RETURN to the FOLD

COLLINS • GARWOOD • YANG





RETURN to the FOLD

John M. Collins ■ Don Garwood ■ Thay Yang

McGraw-Hill, Inc.

*New York St. Louis San Francisco Auckland Bogotá
Caracas Lisbon London Madrid Mexico Milan Montreal
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RETURN TO THE FOLD

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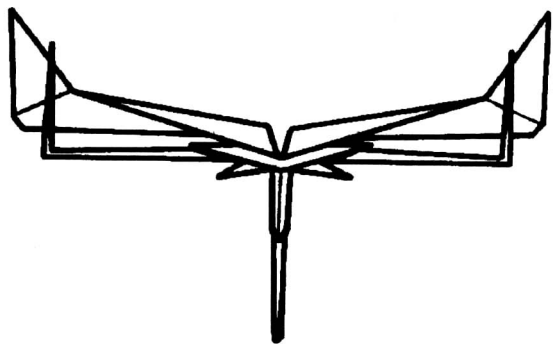
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Editor: Todd Bull

Folding Illustrations: Thay Yang

Cover Design and Graphic Design: David M. Daly

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Introduction

Wonderous and thrilling. From the lowly aphid to the top secret project Aurora, the spectacle of flight is amazing. Isn't it miraculous that simple folding can emulate a feat that took millions of years to evolve? How do paper airplanes fly? It is exhilarating watching a paper glider on its maiden flight. You've managed to turn one of the most basic and widely available building blocks of civilization into a gliding machine. This handmade machine easily accomplishes an act fascinating to humans for milenia: flight. Your spirit soars with the plane as it performs its dance on the air. You may almost sense yourself onboard gracefully floating or perhaps careening at break-neck speed through the air.

The variety of possible shapes is also astounding. The ordinary 8 1/2 x 11 inch sheet of paper (lettersize) has yet to be exhausted; even though it's been available in this country for about 250 years!

This book is a collaboration between three people who really enjoy (read that obsess about) creating and flying paper airplanes. New paper glider designs, new folding techniques, as well as some novel launching and flying techniques are all explained in easy details. All you need to start is a piece of paper.

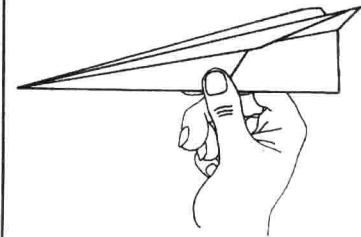
There are several ways to use this book. But foremost is to let yourself fantasize. You are the creator of an elegant paper form: its story and meaning, too. We have given some of the gliders names, but feel free to rename as suits you. Secondly, enjoy the folding. Be aware of the new shapes as they emerge. Enjoy some of the folding tricks (moves) that magically produce a whole new or unexpected shape. And finally, experience your growing power and control over flight. We explain enough of flight mechanics so you can develop mastery based on understanding. It's a good feeling, knowing how to achieve your desired flight.

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RETURN to the FOLD



Why Paper Gliders?

DON GARWOOD

For a few wonderful years I lived in a small cabin on the Pacific coast near Mendocino. One winter the rains just would not stop. Everyday I woke up to the sound of rainfall on the roof. Rain and more rain. And the wind! The rain came at you horizontally! So we stayed indoors most days, and I was going bananas with cabin fever.

One day in desperation I braved the stormy wet in order to visit the kite shop in Mendocino. Don't ask me why. The conditions were far from favorable to kite flying. I guess I was just over the edge and needed something different to do. The shop had a paper glider book for sale, Hans Bergan's The Lingore Paper Airplane Folding Manual. Scanning the book I realized I didn't know paper airplanes could be so intriguing. I purchased a copy, and protecting it from the rain inside my rain coat, took it home.

That book saved my sanity from the endless rain. I folded glider after glider. I accumulated several large cardboard boxes full of the things. They whizzed around the cabin. They were all over the place. I hung some by strings from the ceiling. I went out again and got books on origami and some especially large sheets of paper from a printer to make some really big ones. I invented new folds and gliders.

I was running out of space in which to store them all when the weather finally broke. At last the sun appeared! I had forgotten what it looked like.

The cabin was on the rising side of a hill facing the ocean. I began flying gliders off of the deck - one after the other out

of those cardboard boxes full. They sailed beautifully out onto the breezes coming off the ocean. One particularly enormous one with a huge wingspan made a complete circle around the cabin! It really happened! Diana was a witness. Of course, it was a small cabin.

Another glider, made of bright yellow paper, sailed way out and down the hill and landed on the hairy back of my dear friend Zeb, our big Toggenburg billy goat. I always thought Zeb was some sort of philosopher, maybe a reincarnated college professor. He was a little startled when that glider touched down on his back, and he jumped. Sorry, Zeb!

But then the paper glider wasn't so much different than the starlings that Zeb was accustomed to giving rides. They would come in for a landing onto his back, too. Often four or five of them perched in a row along his backbone. They weren't just visiting; They were on business! They waited and watched for Zeb's browsing to stir up insects hidden in the grass. Then they would jump down and gobble up a few. It was a funny sight to see them going for a ride on his back and him not caring a whit. I think he liked their company; they kept him from feeling lonely.

While Zeb wasn't all that enamored of the idea, I myself was hooked on paper gliders. He got used to them, too. But might they be good to eat? He'd sniff them over when they landed near him to see. Then he would turn his head disdainfully away as if to say, 'Blah! Worse than that damned spinach!' He hated spinach. It really disgusted him if I gave him any.

"The cabin was on the rising side of a hill facing the ocean. I began flying gliders off of the deck—one after the other out of those cardboard boxes full. They sailed beautifully out onto the breezes coming off the ocean. One particularly enormous one with a huge wingspan made a complete circle around the cabin! It really happened! Diana was a witness. Of course, it was a small cabin."

—DON GARWOOD

"My friends were naturally curious about these folded fighter planes. They were always asking to be taught, and I usually obliged. After teaching dozens of kids—friends, friends of friends, friends of their friends—I realized that there might be a demand for my brand of folding. It was time to do a book."

—THAY YANG

THAY YANG

I have always loved paper airplanes. My family came to the United States in 1980 from Thailand. Riding the Boeing 747 "Flying Tiger" to America was my first real flight experience. The cabin of the airplane was enormous. The seats seemed countless—at least to a six year old. I fell asleep after take-off, but I remember landing in San Francisco. A few days later, we got on another plane that landed in Minnesota.

As for paper airplanes, it was an elementary school teacher that introduced me to some simple designs during a summer program. I enjoyed folding the planes, but they lacked sophistication somehow. I wanted planes that looked like the real thing.

Before that summer ended, my two brothers and I had experimented with a wide variety of planes; changing their shapes and styles. We built more and more sophisticated models. I still believed that a true replica was waiting to be discovered.

Finally, I tried a move that was to become my standard fuselage technique. I made a giant, inside reverse fold on a model, following with the wing and tail fin creases. I had done it! The breakthrough was simple yet profound. One elementary origami move cleared the way into a world of flying, replica, paper planes.

My friends were naturally curious about these folded fighter planes. They were always asking to be taught, and I

usually obliged. After teaching dozens of kids—friends, friends of friends, friends of their friends—I realized that there might be a demand for my brand of folding. It was time to do a book.

It's my hope you will enjoy the beauty of the folding and form of the planes.

JOHN COLLINS

My family lived almost 300 miles north of San Francisco in the 60's and 70's. McKinleyville seemed out of reach of the turbulence of the times, a cultural vacuum—caught in the rug fringe of day to day living. Two dogs, three meals a day, and a war, from very far away, on the t.v.. And something called the cold war... too complex for a kid to comprehend.

On windy days behind the "redwood curtain" my brothers and I would launch a version of the "Flatbed" from the "wind shadow" of our house. If you got the right throw, the plane would go straight up, get caught in the wind whipping over the house and fly over power lines, over the neighbor's field, and over the towering spruce trees a quarter mile away. We wrote our phone number and address on some planes hoping to learn just how far they traveled. No one ever called. To a kid of ten or eleven, that can only mean one thing: the plane is still flying.

The simple act of creating a toy—a flying toy at that—from a cast away piece of material has always appealed to me.

Perhaps having parents who survived the depression somehow imbued me with that ethic. It is certain that my mother, Marie, was the first to teach us how to fold paper airplanes. She introduced us to the waterbomb base, although I'm sure she didn't know it was called that. And both parents encouraged us to explore and experiment with any hobby we might dream up. I liked to fold. I even dreamed up new ways of folding that I was sure were unique in the universe.

In the fourth grade, my school had an arts and crafts day. One of the student teachers thought it would be a great idea to teach origami. She must have spent half the night cutting colored paper into squares. (You can find origami paper in Humboldt County now, but not then.) One of the great things about paper folding is the built-in accuracy. You can tell immediately if a square isn't square by folding it diagonally. Perhaps it was the timing of me pointing out her errors in cutting. Perhaps it was the frustration of teaching the folding of models she was unfamiliar with. She promptly took a break after I pointed out the umpteenth unsquare, leaving the origami book (by Harbin) sitting there on the table.

I picked it up and thumbed through. There were all the folds I had invented! And so many more. I had intuitively figured some things out, but the array of complex moves—petal folds and sinks—I was hooked. A virtual toy chest could be created with scratch paper and folding.

The paper world is confined only by imagination. A piece of paper is the original multi-media: at once interactive or passive/linear. A pile of blank pages can be foreboding to a

writer. A pile of typed pages can make you laugh or cry. A square can be turned into any animal you can think of. And of course, there are paper airplanes.

I'm 33 now— a television director, screenwriter, media consultant, and kid at heart. And I've got a kid of my own. We fly planes in our Marin County back yard. It's a game of imagination. The picnic table is an aircraft carrier, extra points for looping, extra points for a safe landing, and rule changes with the wind— literally. We have stunt contests and time aloft competitions. Every once and a while, we lose a plane over the roof. We can't seem to find it after diligent searching. It seems to have simply flown away.

The question remains: Is the plane still flying? I still have to believe, YES!

*"If you got the right throw,
the plane would go straight
up, get caught in the wind
whipping over the house
and fly over power lines,
over the neighbor's field,
and over the towering
spruce trees a quarter mile
away. We wrote our phone
number and address on
some planes hoping to learn
just how far they traveled.
No one ever called. To a
kid of ten or eleven, that
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the plane is still flying."*

—JOHN COLLINS

Paper

"All of the gliders in this book can be made from common, every day lettersize or notebook size paper. In Europe lettersize has somewhat different dimensions. You'll find that some planes will be impossible to recreate with A-4 and others will have only small differences. It's all in the geometry."

The best paper to use is 20 pound copier paper. The brand found in most office copy machines works great; particularly if it's been copied onto once. Follow Foils need phone book paper, but that's noted in the instructions. If you need more information than this, or if you need to turn A4 into 8 1/2 x 11 ratio, please read on.

All of the gliders in this book can be made from common, every day lettersize or notebook size paper (8.5 x 11 inches or in metric units 216 x 279 millimeters). In Europe lettersize has somewhat different dimensions (200 x 300 millimeters). You'll find that some planes will be impossible to recreate with A-4 and others will have only small differences. It's all in the geometry. By removing 7/8 of an inch (22mm) from the bottom of an A-4 sheet, you can obtain the correct ratio of height to width.

Very thin, flimsy paper, may not provide enough structural integrity. Paper too thick may rip apart when the layers start stacking up on complex planes. There is certainly a lot of room to experiment. We discourage buying paper just for airplanes. Some people might consider paper airplanes a waste of the resource. Old memos, employee manuals, school assignments or the like work better than unxeroxed paper anyway. The heat process stiffens the paper as does the microscopic plastic coating of printing.

Another property of paper is how well it holds a fold. Some paper just won't take a crease and springs back so the fold opens up. Other papers fold too easily in the sense that paper fibers at the fold weaken and tear due to being folded rather

than being simply bent. Then the fold is flimsy even though sharp. Such a fold may not be able to hold the wings out stiffly from the fuselage or keel of the paper glider. As a result the wings will droop or may flap when the glider is flown. So find a paper that holds a fold and isn't weakened by being folded.

The way paper is manufactured usually gives it a grain much as wood has a grain. This is the direction the fibers have been given a favored orientation by the paper making process. The paper is stiffer in this direction than in the perpendicular direction. For photocopy and typing paper the grain is usually in the lengthwise direction.

The vast majority of previously published paper gliders have been folded with lengthwise symmetry, i.e. the keel direction or the glider's center line is in the long dimension. This has been the conventional way to approach paper gliders. In this book, in addition to the conventional lengthwise center line folding, we use a new approach, crosswise folding. In this approach the center line of the glider runs crosswise rather than lengthwise.

The values of crosswise folding are (1) the paper grain runs roughly from wingtip to wingtip, giving stiffness to the wing and strength in its joint to any fuselage and (2) the paper is orientated to most easily make lightly loaded wings having high aspect ratios (wings that are long relative to their mean width or chord). Why a high aspect ratio is desirable for certain classes of gliders is discussed later.

If the gliders are all made from the same size and weight

paper stock then they will all weigh the same. They will probably have different wing areas, so their wing loadings will differ. In fact, since they all weigh the same, their wing loadings will differ precisely inversely as their wing area. A large glider (one with a big wing area) will have a relatively low wing loading. Conversely, a small glider will have a high wing loading. The significance of wing loading and how it is related to flight performance will also be discussed further in later chapters.

“No matter how complex a folding move may seem, don’t be daunted by it. Every step in folding is nothing but some combination of simple valley-folds and mountain-folds. Most steps are quite elementary in that only a single kind of fold is made. Sometimes more than one fold happens at once. So any folding step is really easy to analyze, understand and execute.”

Folding Instructions

A matter of valleys and mountains

First, there is no substitute for crisp, accurate folding. A well made crease is easier to manipulate than a soft bend in the paper and provides better structural integrity. If you make an error in your folding, and you probably will, make a bold one. Sometimes you can salvage a plane by making a matching “mistake” on the other side of the plane, and then continuing with the instructions.

A valley-fold is made by folding towards yourself. If the newly formed valley-fold is spread open again, the crease as seen from above is a small indentation in the paper. A valley perhaps to something, say, the size of an ant.

A mountain-fold is just the opposite: fold away from yourself.

If this fold were to be opened back up, the crease would appear as a small hump when viewed from above. Or a mountain if you were small enough. One way to execute a mountain-fold is to flip the paper over and make a valley-fold. Then flip the paper back. The mountain-fold is also known as a ridge-fold or a peak-fold.

The folding instructions are broken down into individual folding steps or moves. No matter how complex a folding move may seem, don’t be daunted by it. Every step in folding is nothing but some combination of simple valley-folds and mountain-folds. Most steps are quite elementary in that only a single kind of fold is made. Sometimes more than one fold happens at once. But in any case, the step involves only valley and mountain-folds. So any folding step is really easy to analyze, understand and execute.

When a fold position is not critical or accurately located we call it a RAT fold (“right about there” or “relieved accurate tolerance”). But in such cases we give measurements, also, which we have found give good results. This is to satisfy the engineer in some glider folders who might feel that, while it is laudable in pure origami to find folding positions and dimensions without measuring, practical aeronautical engineering can’t afford such a luxury.

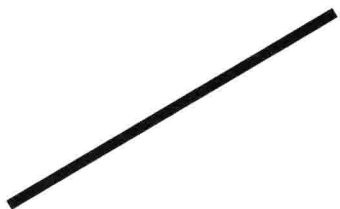
This book employs well known standard origami techniques: the Randlet/Yoshizawa system. Once you learn this system, you can fold models from books in Japanese, Italian, Spanish and others without reading a word of foreign language. You’ll just follow the symbols. They are consistent internationally, and they are simple.

For easy reference, we’ve printed them on the inside cover of the book.

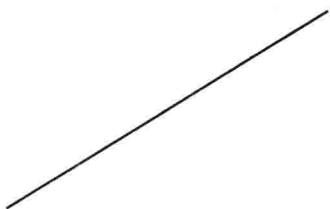
NOTE: on bases 1 and 2 (on the following pages), the flaps are shown not touching the center line. They should line up exactly on the center line. Throughout the book, layers are shown in this way. You should assume that all layers line up exactly, unless mentioned specifically. This is a basic diagramming convention used in origami to help the reader understand all the layers present on a model.

Here they are:

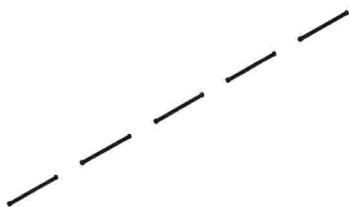
A heavy or bold line indicates either a raw edge of the paper or a folded edge.



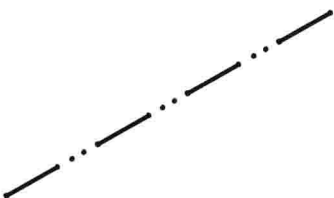
A light or thin line shows a crease that was formed in some previous folding step.



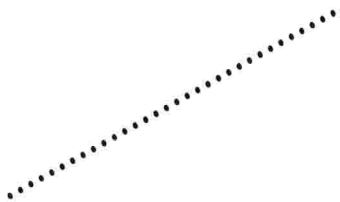
A dashed line signifies the position of a valley-fold to be formed in the current step,



A dashed-and-dotted line signifies the position where a mountain-fold is to be made in the current step.



A dotted line shows where some hidden feature lies underneath a layer or several layers of overlying paper.



There are also other symbols used in the diagrams mostly consisting of arrows of various kinds. Their meanings are as follows:

Move in direction of arrow.



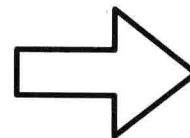
Unfold a previously made fold.



Valley-fold then unfold to a valley-crease.



Reverse a fold; squash fold; sink fold.



Turn the paper model over.



A significant point such as when two separated positions are to be brought together by a fold.



Bases

BASE ONE

Step 1

Fold in half.

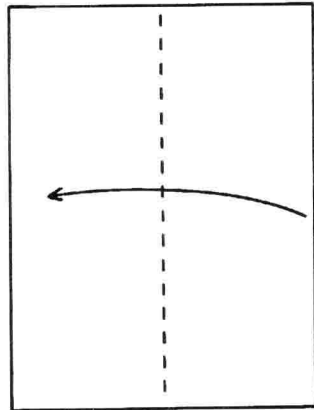
Step 2

Unfold.

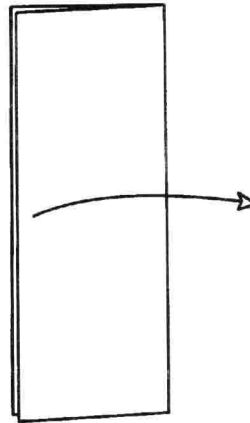
Step 3

Bring the corners to the center.
The raw edges line up on the center crease Base 1 complete.

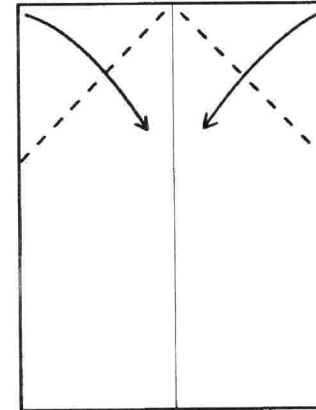
BASE ONE



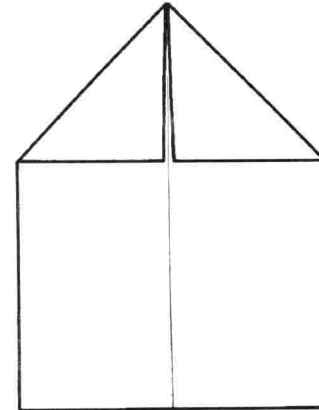
1



2



3



BASE TWO

Step 1

Start with the long side up. Fold in half.

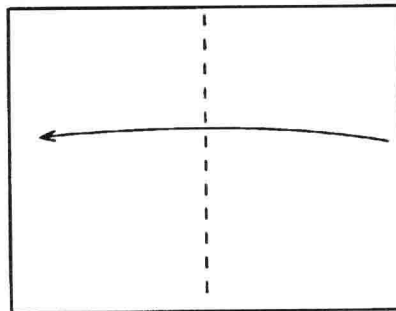
Step 2

Unfold.

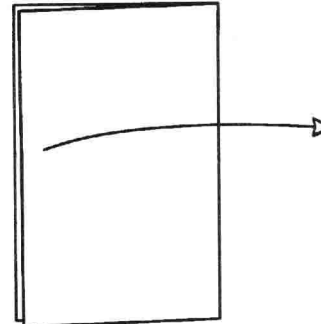
Step 3

Bring the corners to the center.
The raw edges line up on the center crease. Base 2 complete

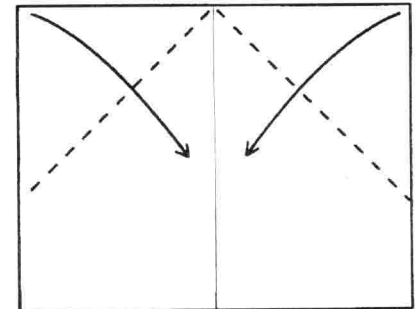
BASE TWO



1



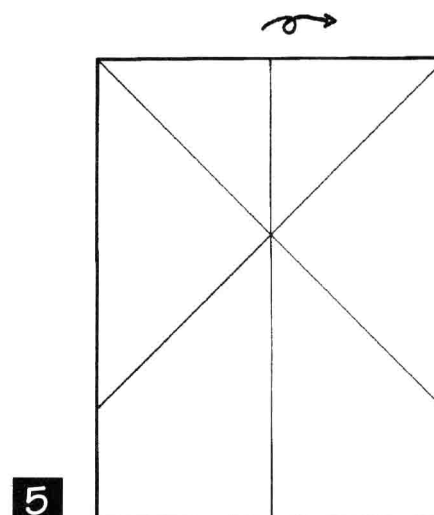
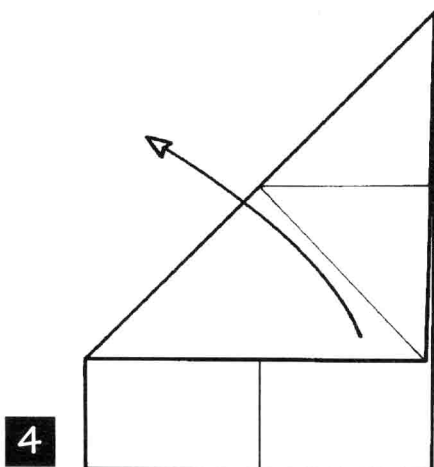
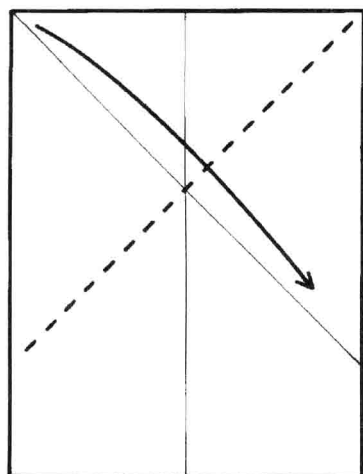
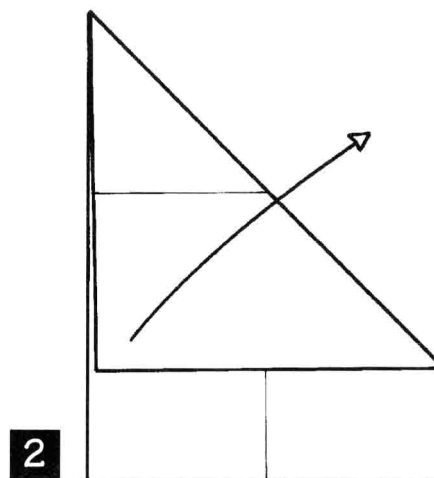
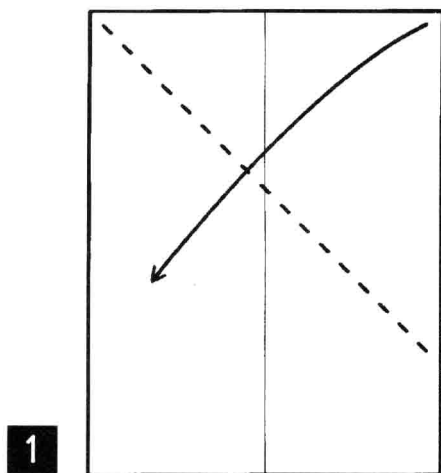
2



3

WATERBOMB BASE

Bases 1 and 2 are simple using only three creases. The Waterbomb base involves only three creases as well. In this case we'll need more precise folding and we'll manipulate the creases after they're made.



Step 1

Make a diagonal fold.*

Step 2

Unfold.

Step 3

Make the other diagonal crease.

Step 4

Unfold.

Step 5

Flip over.

* A lot of people have trouble with nailing down diagonal folds. The top of the page is going to end up laying against the side of the page. Start by moving it close to the correct position. Next, really define the corner. Start a crease right on the point. Just start it. Pinch the corner between your index finger and the table or flat surface you're working on. Now pivot the free corner, lining up the raw edges. Flatten the crease starting at the pinched corner. keep the raw edges lined up as you sweep down diagonally, making a crisp fold.

NOTE: There is a center line crease. This is not strictly need to assemble a Waterbomb base, but most airplanes end up having this crease for the fuselage fold.

Step 6

Make a crease that goes straight across where the diagonals intersect.

Step 7

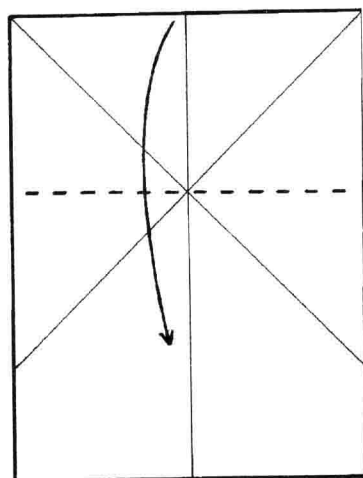
Unfold.

Step 8

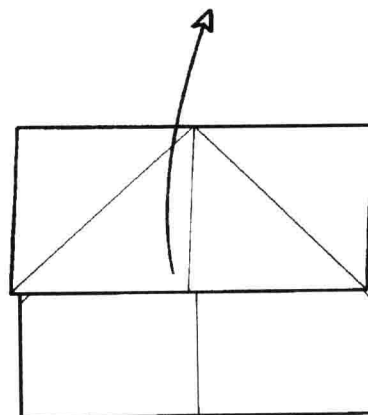
Flip over.

Step 9

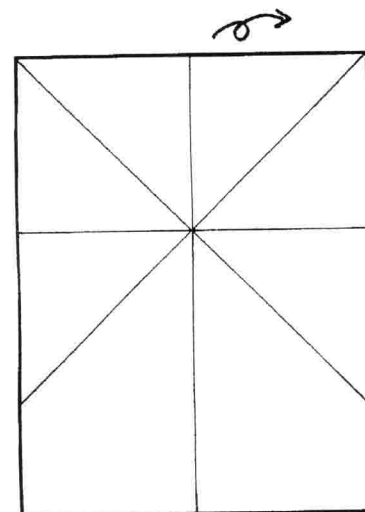
Follow the existing creases. No new creases are made in this step. Everything pivots around the intersection of the creases. Start by gently pressing the intersection with a finger. The mountain creases breaks in the middle and both ends come together in the center. The top edge follows the ends down. The whole thing gets pressed flat.



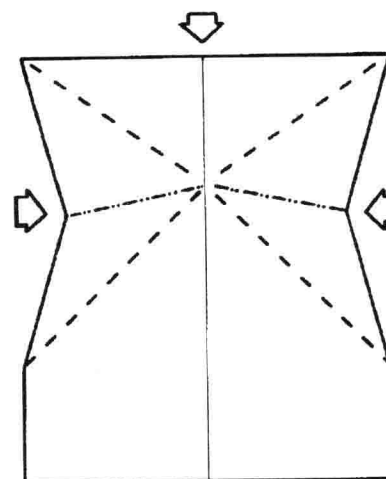
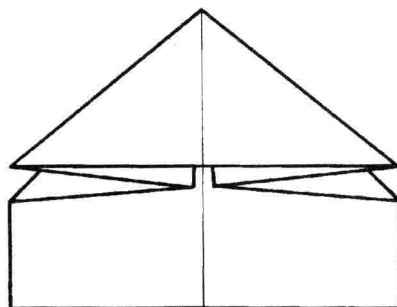
6



7



8



9