Digital Edition

New Ultimate Boomerang Book

All about throwing, making and catching a boomerang and a lot more

Original by Michael Siems

Boomerangliv.dk

"Ultimate Boomerang Book"

Based on Michael Siems' "The Ultimate Boomerang Book" from 1996

Redesign and revised with permission from the author 2012

Digital Publisher:
David B Bjørklund
David@boomerangliv.dk
Boomerangliv.dk

Cover: David B. Bjørklund, Michael Siems
Graphics: Gerrit Lemkau, Doug DuFresne, Michael Siems
Translation: Maryka Kimmins
Wording: Doug DuFresne
Revision: David B. Bjørklund, Sara B Bjørklund, Peter Jacobsen

Acknowledgements

I would like to thank all those who have helped me with this book.

My special thanks to:

Günther Veit	It all started with his book
Max Hoeben	He made the Boomerang popular in Europe
Rob Overdijk	Best European thrower 1983
Barnaby Ruhe	He motivating during tournament in Amsterdam
Doug DuFresne	Helped me develop the construction disk
Axel Heckner	Provided constructive advice and wrote the preface
Gerrit Lemkau	Drew the illustrations
Ulf Steinmaier	And Technischen Universität Darmstad for Information on currents and lift conditions at airfoils
Dietmar Reinig	Produced various boomerang plans
Jojo Jahr	Provided information on synthetic materials
Ted Bailey	For current addresses
Achim Lojet	For the support on DTP
Jens Krabbe	and the The FUN Boom group for FUN rules

Plans by

Günter “Tapir” Möller, Adam “Schlitzer” Müller, Fridolin Frost, Axel Heckner, Eric Darnell, Doug DuFresne, Michael Siems, Michael “Gel” Girvin, Earl Tutty, Volker Behrens and Michel Dufayard

Preface

If you can only own one book about boomerangs - this is the book! After nearly two decades, this book is still going strong. Now in a new revised edition, with a digital taste. We have added a digital index, digitized all the drawings, redesigned the whole book and a lot more.

Boomerangliv.dk gained special rights to publish this online edition of the book, and you may use it fair. This means you may NOT publish this book on your own site. Your may not copy the book in any way or reproduce it. New updated editions of the book will be posted on Boomerangliv.dk.

Every contribution, will is appreciated. If you have any ideas or corrections for the book, or you want to be a part of the development please send a mail to david@boomerangliv.dk

Best Regards
David Bjerre Børklund
Boomerangliv.dk

Part of the old preface

When most people hear the word boomerang, the first things that spring to mind are a bent piece of wood and Australia. Today's boomerangs are, however, quite different from the original shape. More new designs and techniques are currently being developed in Europe and the USA than by the Australian Aboriginees. New shapes, including multibladers are being developed to fly steady, accurate flight patterns. They are made from special plywoods and other hi-tech materials and adjusted by weighting and bending to achieve flights which would not have been considered possible until just a few years ago. There have been significant developments in the '90s that have not been published in boomerang literature.

"The Ultimate Boomerang Book" is an indispensable adviser for all boomerang freaks and for those who want to be. The book is also being translated into french, japanese and danish. The "Ultimate Boomerang Book" adds significantly to the international collection of literature on boomerang making and throwing.

My Story

My interest began at the boardingschool “Kildevæld” in 2006–2007. My friend Peter Jacobsen had brought a boomerang he had once made in Woodwork in primary school.Unfortunately the was boomerang broken. We were allowed to borrow a workshop at the boarding school and immediately began to make copies of the broken left-hander boomerang out of old trailer floor. Quick was the message spread on boarding school and we were several who threw boomerangs. We also made a few right-hander boomerangs to meet the others interested. During the school-year, we always had our boomerangs hanging on our shoulder and we were often out to throw.

But a boarding school year does not last forever and I came home on summer holiday. When I got home I made many three-winged boomerangs, but most of them broke because of the bad quality plywood. After a quick search på the internet I found out that the Danish Boomerang Club stayed in Fælledparken. Several times during the summer I was out throwing, and bought my first boomerang by “TAF”, a Rudolf. One day I met Jens Krabbe and this became the beginning of my passion for boomerangs. He gave me my first plastic boomerang and my first decent plywood. Before the summer was over I had made two of my trusty plywood boomerangs I still use.

When summer was over I had to start on the boarding schools, a bible school focused on travel, dance and drama. In my time here I talked with a teacher at the boarding school who had shown great interest in boomerangs.We decided to use part of his teaching electives on the boarding school to teach the students to throw and produce their own boomerangs. Danish boomerang club recommended me “The Ultimate Boomerang Book” as we quickly got acquired together with 6 sheets of plywood from Rediboom. Once a week I was teaching at the boarding school with “The Ultimate Boomerang Book” as a reference book, and here I discovered the potential of this book. My greatest challenge then was that the book was written in English, so even then I attempted to scan the book with OCR text recognition, and then to translate it. I have now thrown since early 2007 and made me many lessons since. Among others, I was a part of the crew who started Boomerangliv.dk and for that purpose, created illustrations for boomerang guides.

In 2009 my during my first high school year I paid exam in communication and got top marks with my flyer about boomerang throwing. In 2010 I got the second highest grade in English for my presentation about boomerang history and the early diffusion of boomerang sport. In 2010 I wrote a study project about boomerangs physics and mathematics. To understand the physics I translated the first chapters of Felix Hess' "Boomerang's Aerodynamics and motion". On 13 March 2010 I started Boomerangliv.dk as my own project and 20 April 2011 Boomerangliv.dk was signed as an official association by at a general assembly.

On the 6th of December 2011 I received the original files from 2004-2006 with "The Ultimate Boomerang Book". On December the 7th I was nearly finished with redesigning the front and 8 December, I had converted all the old files to modern formats was to work with.On December the 22nd, after more than 70 hours of work, the first revision, bitmap tracing and enrollment in LaTeX, was finished. The book was then published as a free download on Boomerangliv.dk and my boomerang passions were thus united.

After many years of passionate work I hope you will enjoy reading this great book that combines Michael Siems good original and my many boomerang projects.I would like to thank everyone who has supported me on the road: Peter Jacobsen, my wife Sara Bjørklund, Jens Krabbe, Harald Toft, Dietmar Reinig, Michael Siems, Tim Fischer ("TAF"), Henrik Breum, David Kristensen Erling Thyde, Henrik Aagaard and many others.

David Bjerre Bjørklund

Story of Michael Siems

My first contact with a boomerang was during my childhood. The first time I threw one I had to search for it! The boomerang tended to land as far away as possible, instead of, as I had hoped, landing near me. From that moment, this mysterious object, the boomerang, simply would not leave my mind. Most people have the same experience during their first encounter with a boomerang and for me, the subject was forgotten for a while. However, the boomerang was never far from my mind.

One day I had a strong urge to make one myself and I asked myself, how are boomerangs made? There was no information available so once again the subject was forgotten. But then in April 1983, I passed a huge athletic field south of Amsterdam. My immediate thought was: I just have to throw something over it. Back home again, I explained my ambitions to a friend. As luck would have it, a few days later I was given "Throwing and catching boomerangs" by Günther Veit. He placed the book on the table and three hours later I'd finished making my first boomerang. That was the beginning of a new hobby, which gradually began to take shape after a slow start. In May 1983 I visited the Whitsun Tournament in Amsterdam with my first 5 boomerangs. It was there that I met Barnaby Ruhe, who was one of the talented throwers competing. It was at this championship that I was amazed to see this American Champion running and climbing trees to retrieve his boomerang! The fact that even champions had to perform these tasks improved my self-confidence so much that shortly afterward I entered the German Championship and was placed third. Since then I have participated in almost all the German and European Championships and many Tournaments abroad. I have served as Captain of the German Team four times during 9 World Championships.

Competition performances have improved significantly during the last few years. In 1983 the record for Maximum Time Aloft (MTA) was 27 seconds (David Schummy, Great Britain). Now it is more than 2 minutes 59 seconds (Dennis Joyce, USA). Similar advances have also been recorded in other events.

Boomerang throwing is a sport which costs next to nothing. A piece of wood, an hour to make a boomerang, a field to throw and away you go! Once you have caught on to it, you can design your own models, create new shapes and forms and decorate your boomerangs. You will meet interesting people, who out of curiousity come up and ask “Is that a boomerang?” In many cases they catch the “boomerang fever”.

Boomerang throwing is by no means a single faceted sport. You have to be able to run, throw and catch and to deal with the wind. Above all: maintain concentration — or you’ll end up with scratches and bruises! You have to be able to climb trees, crawl, dive, swim and finally: be able to search with a lot of patience, perserverance and intelligent guesswork.

Contents

Chapter 1

The Basics

1.1 What a boomerang looks like

Boomerang models can be classic (see figure 1.1 and section 3.1), or unusual shapes (e.g. coathanger or scissor shape) to amaze people being introduced to boomerangs, or simply for the amusement of the thrower. Any boomerang may be appropriate for some type of competition. Boomerangs has many different shapes, still they have a few things in common.

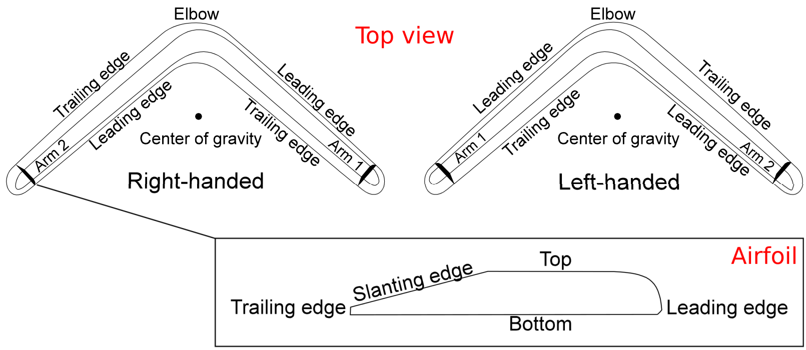


Figure 1.1: Technical terms

Each boomerang has a certain shape and set of airfoils that makes it fly the way it does (see figure 1.1). Left- and right-handers uses different boomerangs. As you may have noticed, Left-handed boomerangs are identical to the mirrored image of a right-handed.

1.2 Why does a boomerang come back

I will only discuss the subject of physics briefly. If you would prefer a more detailed explanation, I recommend the work of Dr. Felix Hess, "Boomerangs: Aerodynamics and Motion" (see Literature list). The following two questions are essentially for the return of a boomerang:

1. Why is the flight path circular?
2. Why does a boomerang thrown vertically lay-over to a horizontal position during flight?

I will try to explain these phenomenons as simply as possible.

Why is the flight path circular? First, we need to realize that the wings of a boomerang have airfoils that create "lift" (see figure 1.2)

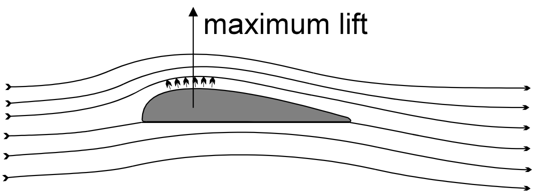


Figure 1.2: Max lift on wing profile

Now keep in mind the following two rules:

A) The faster the air passes over the airfoils, the greater the lift.

B) The better the angle of the air passing the wing (see figure 1.3), the greater the lift.

To help us understand where a boomerang develops its lift let's look at a construction disk (see figure 4.1). The circular lines represent air speed relative to the point around the boomerang is rotating at a moment in time. If you put the centre of rotation on the instant centre

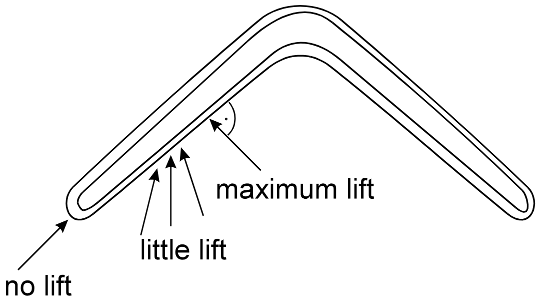


Figure 1.3: Max lift on boomerang

(i.e. forward speed equals zero) you can see how the air flows over the wings during the hover at the end of the flight. The faster the forward speed is in relation to the rotation speed (i.e. during the first part of the flight) the further the boomerang's centre of rotation is from the instant centre. The centre of rotation is always on line V (see 4.3).

The boomerang has a forward speed and rotation speed when thrown. Let's look at an example to see how the forward and rotation speeds combine. We will assume that forward speed (V_t) equals the rotation speed (V_r). The boomerang is placed on the construction disk as shown in figure 1.4. Let's look at the total speed of any point on the boome-

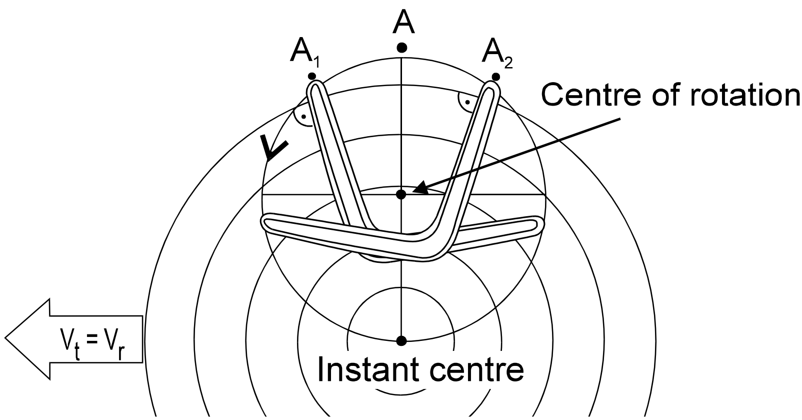
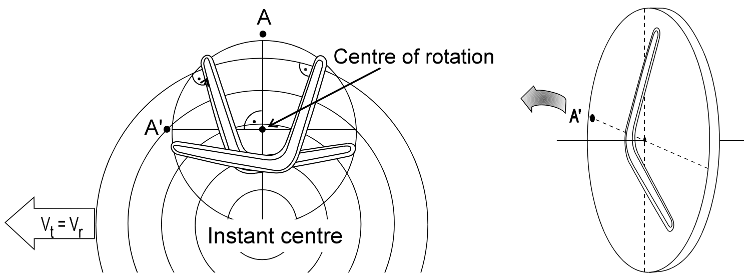


Figure 1.4: Speed and rotation combined

rang above the centre of rotation at a moment in time. The forward speed is toward the left. Its rotation speed is also towards the left, so the total speed of the point is found by adding the two speeds [1]. When a wing is below the centre of rotation, its forward speed is still toward the left, but rotation speed is to the right, so the total speed is the forward speed minus the rotation speed. Because of the higher total speed of the wing above the centre of rotation, it generates more lift than the wing below the centre of rotation (see rule a).

Since lift increases with speed, we would expect the maximum lift force in each wing to occur near the top of the diagram where the speed and spin are combined - near point A. Lift is greatest when the air travels at a right angle to the wing (see rule b). Points A_1 and A_2 represent points of maximum lift for the respective wings. If the boomerang did not behave as a gyroscope we would expect it to tilt toward the centre of the flight path. However, because of its rotation, it does behave as a gyroscope. Because of gyroscopic precession the lift force at A has its effect 90° later at point A' (see figure 1.5a). This makes the boomerang turn left on its vertical axis, counter clockwise when viewed from above (see figure 1.5b).



(a) Effect of liftforce

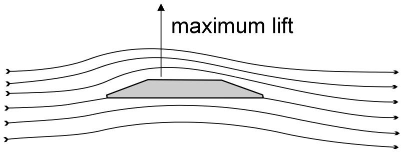
(b) Turning caused by gyroscopic precession

Figure 1.5: Gyroscopic effect on Boomerang

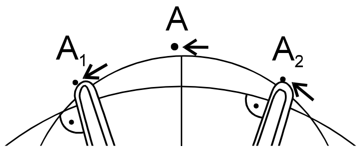
[1] Actually these speeds need to be added as vectors with speed and direction (horizontal and vertical) considered. When this is done, for several points, the relative speeds shown by the concentric speed circles can be seen.

Why does a boomerang lay-over?

1. The lift of a wing occurs near the front - not in the centre of the airfoil (see figure 1.2). Surprisingly, this is even true of symetrical airfoils (see figure 1.6a). The point of average maximum lift A_{max} is therefore moved slightly to the left (see figure 1.6b).



(a) Lift on symetrical airfoil



(b) A_{max} is moved

Figure 1.6: Average lift

The actual turning force is therefore below the horizontal centre-line at point A'. The boomerang tends to roll clockwise when viewed from behind. This is called lay-over (see figure 1.7).

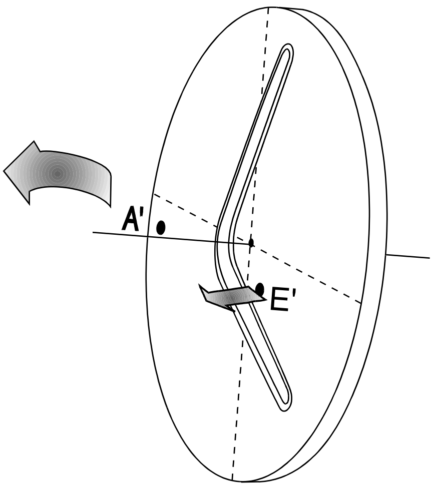


Figure 1.7: Layover

2. If the airfoil is symetrical the elbow normally causes more lift in front of the centre of rotation at Point E than it does during the other half of the rotation when it is behind the vertical centreline of the rotation disk (see figure 1.8).

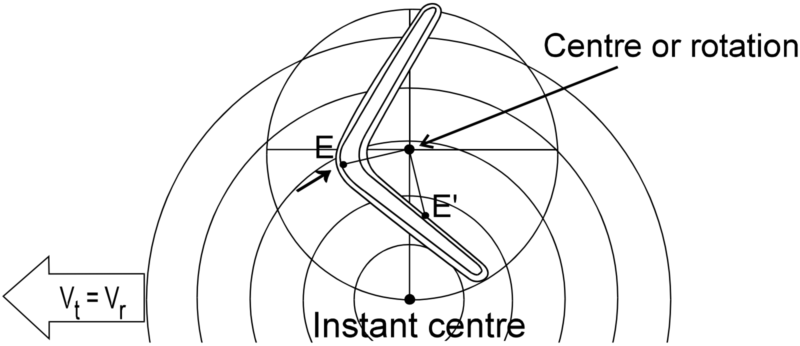


Figure 1.8: Lift acting on elbow

That is because of some shading effects to the inner elbow. The actual turning force, at Point E', is 90° later, in the lower half of the rotation disk. When making two-bladers the airfoil of the elbow can be changed to alter the flight characteristics (for further information, see section 3.9). With symetrical multibladers the larger the area around the centre of rotation, the larger the lay-over.

Because the resulting turning force is generally in the lower half of the rotation disk for most boomerangs, they lay-over in flight.

1.3 Making a boomerang

First of all you need the appropriate material. One of the best materials is aircraft grade Finnish birch plywood. Typically, its plies are 0.5 mm thick. The boomerang designs in the attached foldout sheets refer to this material. Next you will need some tools: a jigsaw- or coping saw, a file, 80 and 180 grit sandpaper, 2 clamps, the edge of a table, a pencil, a paintbrush and paint. When using power tools such as a jigsaw or sander you should wear safety glasses. In addition you should wear a dust mask. When working with Fibre glass or Phenolic it is extremely important to use a filter mask!! Choose one of the provided plans. You can copy the shape and airfoil to make a boomerang. If you need to make a left-hander using a right-hander model, draw a mirror image of the outline and airfoil onto the plywood.

Follow the steps below to make your boomerang.

1. Choose the concave side of the plywood for the top side of the boomerang. This will ensure that the boomerang will not have negative dihedral (mentioned later in text). Draw the shape of the boomerang onto the plywood so that the grain of the wood runs from one wing to the other (see figure 1.9). This adds strength to the elbow of the boomerang.

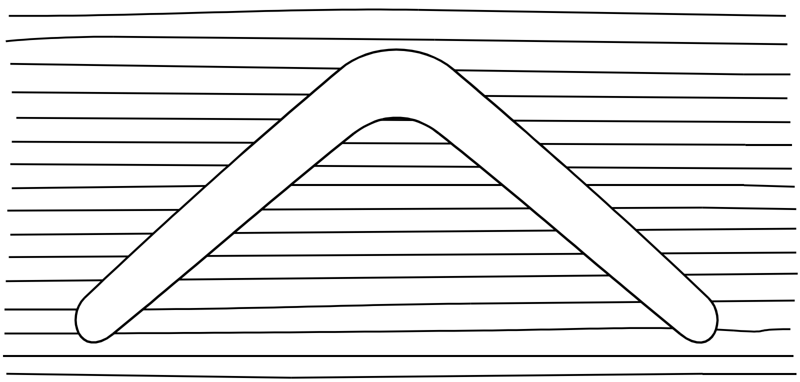


Figure 1.9: Wood Grains across boomerang

2. Saw out the shape of the boomerang with a jigsaw - or coping saw.

3. Draw the airfoil onto the piece of wood (see figure 1.10).

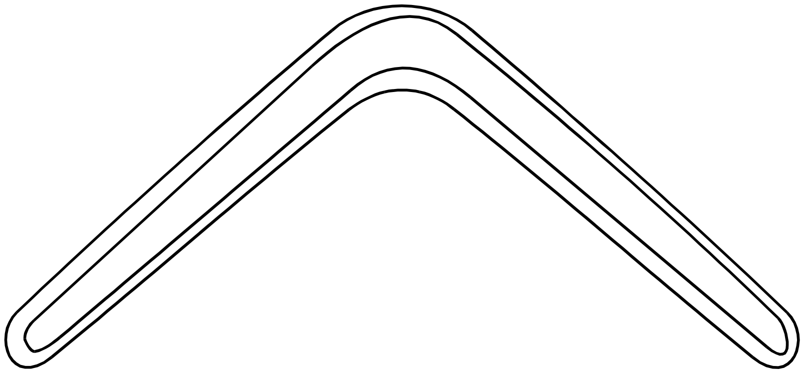


Figure 1.10: Airfoil drawn onto the wood

4. Clamp the piece of wood onto the edge of a table.
5. Form your desired airfoil by filing. Ensure that the trailing edge is tapered and the leading edge is rounded (see figure 1.1).
6. Remove the file marks by sanding with 80 grit, then resand with 180 grit sandpaper.
7. Apply sanding sealer compatible with the finish of your choice and let it dry.
8. Test throw your boomerang and make any changes you find necessary (see the chapter 2).
9. Resand with 180 grit sandpaper, then apply the decoration and finish coats.

1.4 Throwing

The most important consideration is safety. Please read the following instructions carefuly.

SAFETY

1. Length and width of your throwing area needs to be 2 to 3 times the range of the boomerang.
2. You should never throw anywhere near people.
3. If you are throwing in a group, only one boomerang at a time should be in the air.
4. Make sure you warn people in time, if the boomerang flies towards them.
5. Never take your eyes off a boomerang while it is flying.

Most throwers throw from the middle of the field. Use a flag or throw a bit of grass into the air to check the wind direction and speed before each throw. If the wind is too strong (i.e. more than 4 Beaufort, table p. 43) go fly a kite instead.

Now to the throw: You decide which wing to throw from. Try different wings and do what works best for you. The boomerang should be held between the index finger and thumb with the top of the boomerang toward you. There are two different grips, one is the pinch grip (see figure 1.11a) and the other is the fore-finger grip (see figure 1.11b). Try using both grips to see which works best for you. When throwing, the following 3 angles are important.

1. The angle to the wind (see figure 1.12)
2. The tilt angle (see figure 1.13)
3. The height of throw (see figure 1.14)

It is important to give the boomerang enough spin when you throw. If you don't it cannot return. Because all boomerangs fly differently, you may need to adjust one or more of your throwing angles to make a certain boomerang return (see chapter 2.)

(a) Pinch grip (b) Fore finger grip

Figure 1.11: Common grips

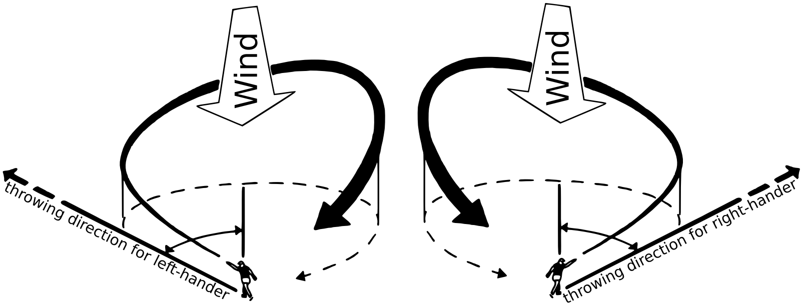


Figure 1.12: Angle to the wind (Compass angle)

1.5 Catching

If your first attempts at throwing were successful, you can try to catch your boomerang. It should be lying flat toward the end of its flight and should approach you at a slow speed. If it was a particularly good throw, it almost appears as though the boomerang expects to be caught. The safest catch is a two-hand catch. Both palms should be held parallel to the boomerang as it hovers toward you. If they aren't the boomerang may hit your fingers and spin back at you. Try to catch the boomerang by clapping the palms of your hands together, one hand below and the other above the boomerang (see figure 1.15).

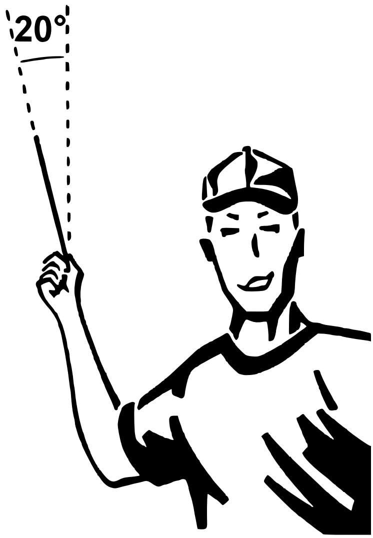


Figure 1.13: Tilt angle

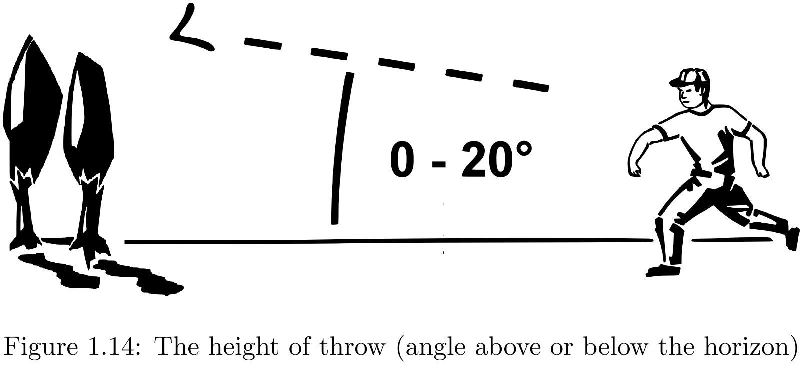


Figure 1.14: The height of throw (angle above or below the horizon)

Figure 1.15: Two methods of catching. Two- and one-handed.

A one-hand catch is much more difficult. It is easiest when the boomerang hovers down to you. Two-arm boomerangs look as though there is a hole in the centre. You can either reach through the hole with your fingers or with your thumb to make the catch. Generally, multibladers are easier to catch one-handed. It is helpful to turn your hand in the direction of rotation as you make the catch (see figure 1.15). I recommend that you wear gloves if you are new to catching boomerangs.

1.6 Wind

Generally it is important to be careful when throwing in strong wind. A rule of thumb is 0-4 Beaufort is appropriate for most throwers. It is better to have a lot of stable wind rather than unpredictable and unsteady winds.

Beaufort	Effect	m/s
0	Calm	0 - 0,2
1	Slight draft, smoke does not rise completely upwards	0,3 - 1,5
2	Slight breeze, noticeable	1,6 - 3,3
3	Weak breeze, leaves flutter	3,4 - 5,4
4	Steady breeze, twigs move	5,5 - 7,9
5	Fresh breeze, movement in bigger twigs	8,0 - 10,7
6	Strong wind, movement in bigger branches	10,8 - 13,8
7	Stormy, movement in smaller trees trunks	13,9 - 17,1
8	Gale, movement in bigger trees trunks	17,2 - 20,7
8	Strong gale, roof tiles are lifted	20,8 - 24,4
10	Very strong gale, uproots trees	24,5 - 28,4

1.7 Accessories

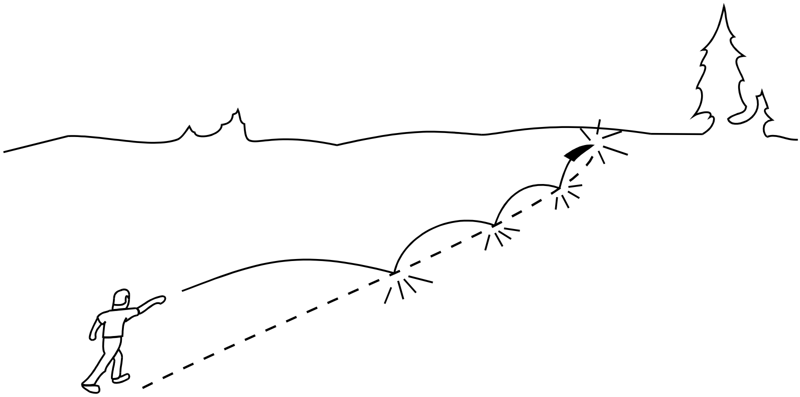
Apart from boomerangs, there are many useful accessories which should always be in your bag

1. Cycling gloves, goalkeeper gloves, wool gloves
   - To protect your fingers while catching, and to keep your hands warm in cold weather
2. Towels, cotton cloths, socks
   - For drying or cleaning the boomerangs
3. Windflag, a stick with a piece of yarn attached
   - For reading the direction and speed of the wind
4. Safety glasses / sunglasses
   - To protect your eyes from injury / excessive sunlight; also helps to see the boomerang in a bright sky
5. Bandages
   - For small cuts; or to prevent wounds from throwing or catching
6. Permanent marker (fine tip)
   - For making notes on the boomerang
7. Stopwatch
   - For timing
8. Sandpaper, sanding block, file
   - For modifying your boomerangs
9. Coins, pieces of lead and electrical tape
   - For adding weight to boomerangs

Chapter 2

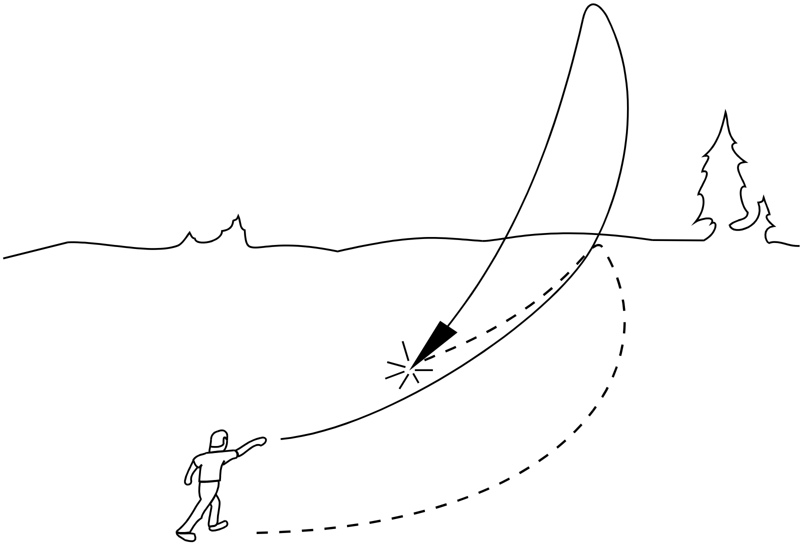
Typical Throwing and Construction Problems

2.1 Flies straight ahead



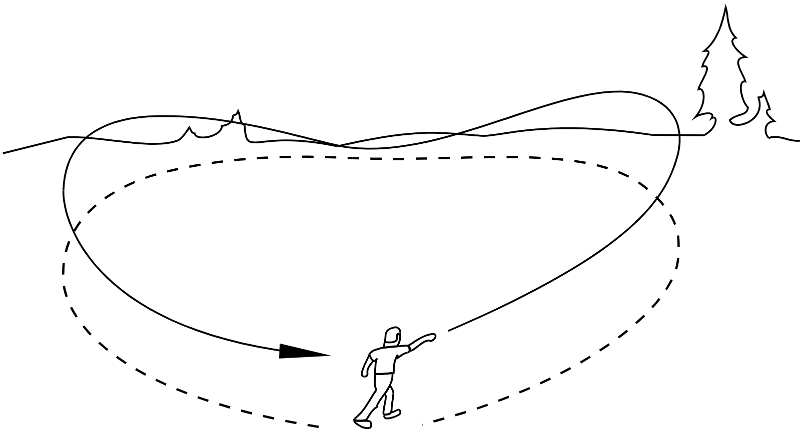
- Either a right-hander has thrown a left-handed boomerang or the other way around.
- The profiled side (top) of the boomerang was not facing towards the thrower when launched
- The boomerang is a non-returner, also called a hunting stick.
- The boomerang has too much negative dihedral (see section 3.5)
- The boomerang has too little airfoil - not enough lift. This is often true of commercial boomerangs.
- The boomerang is too heavy.
- There was too little spin when launched.
- The boomerang has too many holes or flaps.
- You twisted your wrist instead of throwing it straight.

2.2 Flies toward the ground, flies sharply upward and then dives down out of control



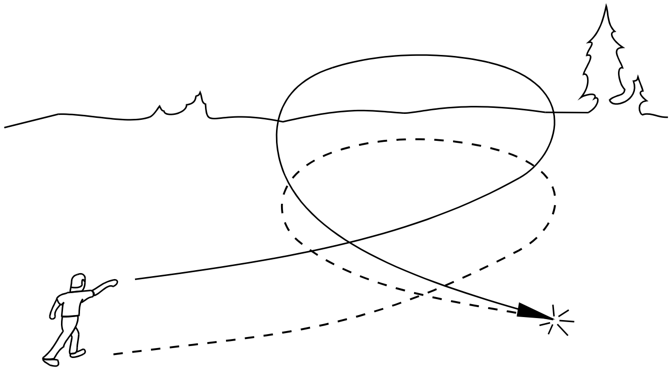
- The tilt was almost 90° (sidearm throw), when it should have been approximately 20° from vertical (see section 1.4).
- The boomerang could be warped. Normally the wing tips and the rest of the boomerang should lie flat on a counter.
- Arm 1 has too much lift.
- The average maximum lift of the boomerang is too far ahead of the centre of rotation (see chapter 4).

2.3 Flight path is circular but the boomerang touches the ground during flight



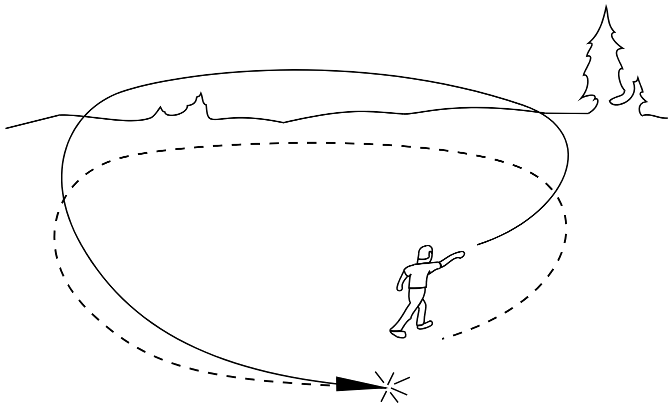
- The throw was too weak.
- The boomerang was thrown too high.
- The tilt is too small or even negative.
- At least one wing has a negative dihedral (see chapter 4).
- The shape of the boomerang has an average maximum lift behind the centre of rotation (see chapter 4).
- Arm 2 has too much lift compared to Arm 1.
- If this happens to a multiblader, the hole in the middle is too big.

2.4 Crosses in front of the thrower and lands to the right (RH) / left (LH)



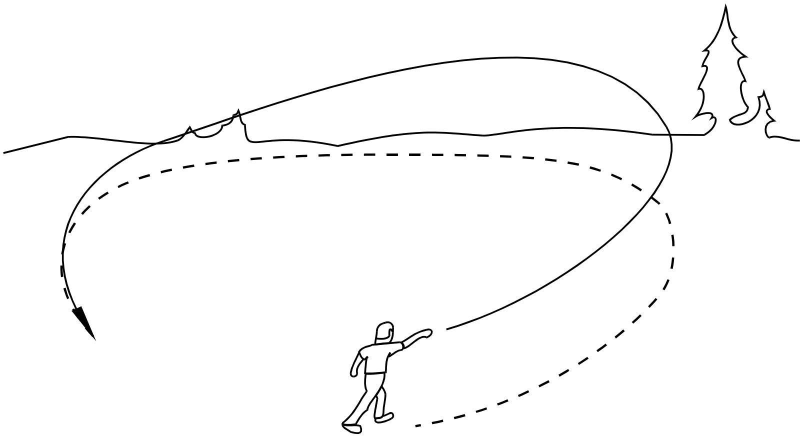
- The angle to the wind is too big (too far “out of the wind” see section 1.4).

2.5 Passes by behind the thrower and lands to the left (RH) / right (LH)



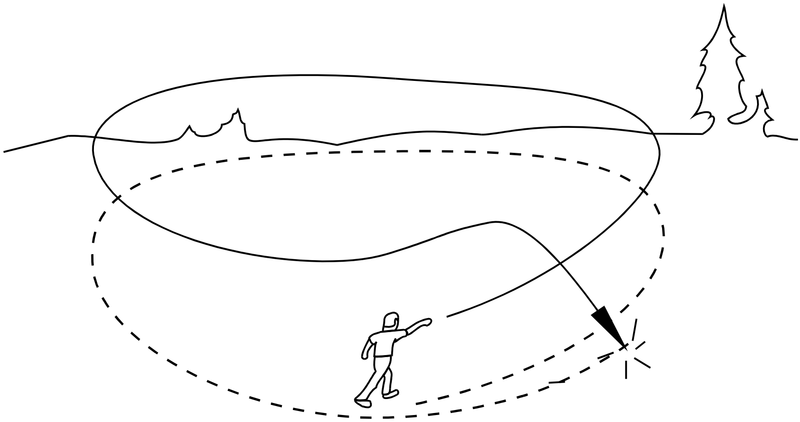
- The angle to the wind is too small (too close "into the wind" see section 1.4).

2.6 Returns toward the thrower, but falls short



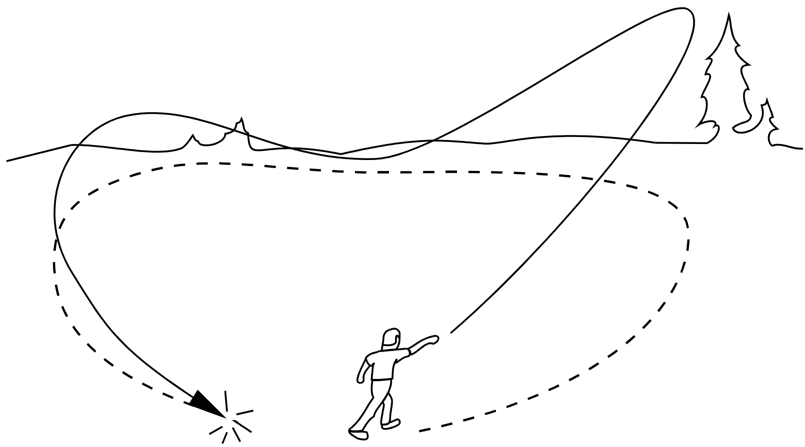
- Throw lacked sufficient power. (Advanced: or had too much spin.)
- There was too little spin when launched.
- The tilt is too small or even negative.
- The boomerang has too many holes or flaps or is too rough.
- Arm 2 has too little lift compared to arm 1.
- The multiblader has too little lift (see chapter 5).
- Check the wind direction. There is no wind. The boomerang needs more wind.

2.7 Returns over and beyond the thrower



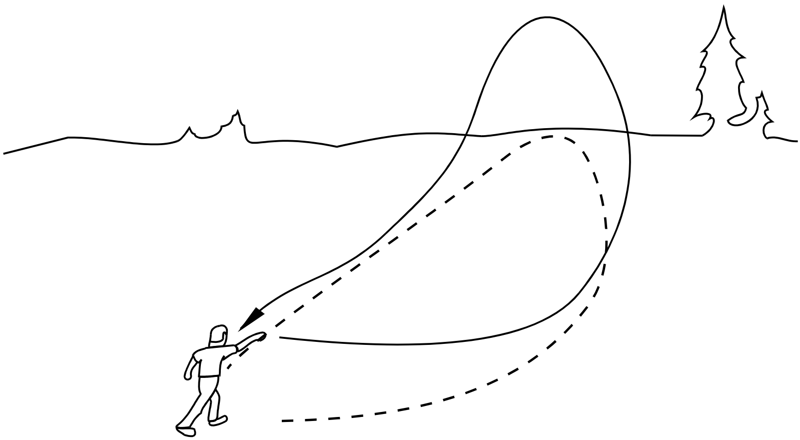
- Thrown with not enough tilt (see section 1.4).
- The throw was too low (see section 1.4).
- Arm 1 has too little lift compared to arm 2.
- The multiblader has too much lift (see chapter 5).
- Check the wind. The wind is too strong.

2.8 Flies upward during the first half of the flight but then crashes during the second half



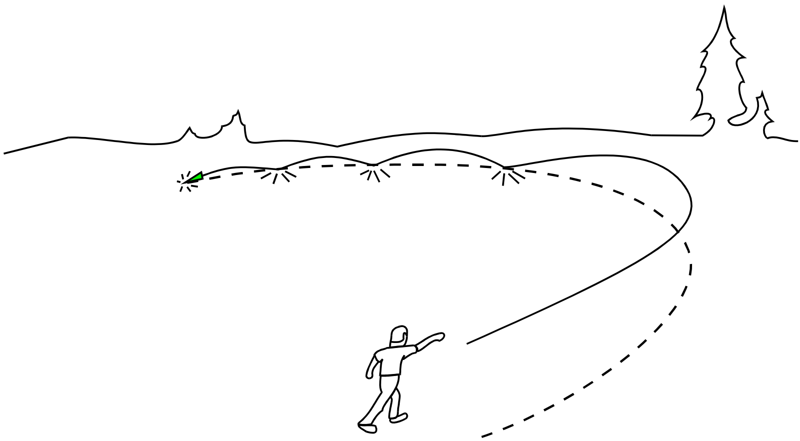
- The height of throw is too great (thrown too high see section 1.4).

2.9 Flies close to the ground during the first half of the flight path but then rises during the second half.



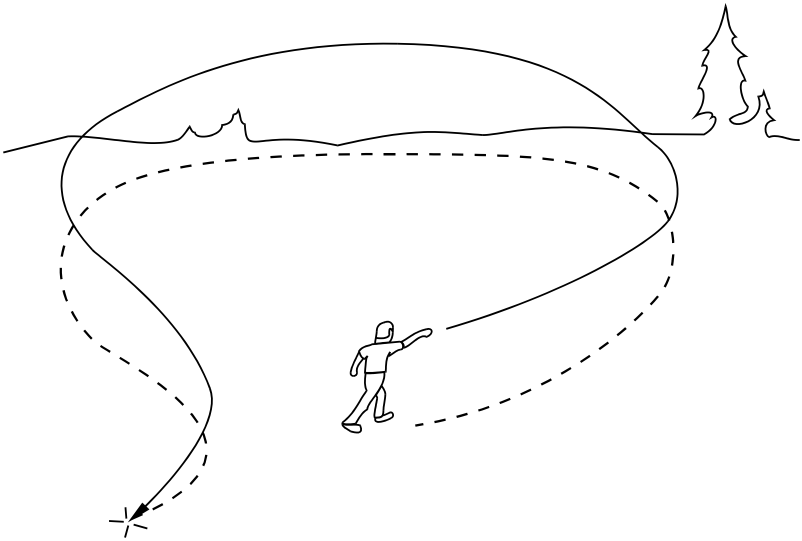
- The height of throw is too small (thrown too low see section 1.4).
- Arm 1 has too much lift compared to arm 2

2.10 Does not lay-over - maybe even rolls inward



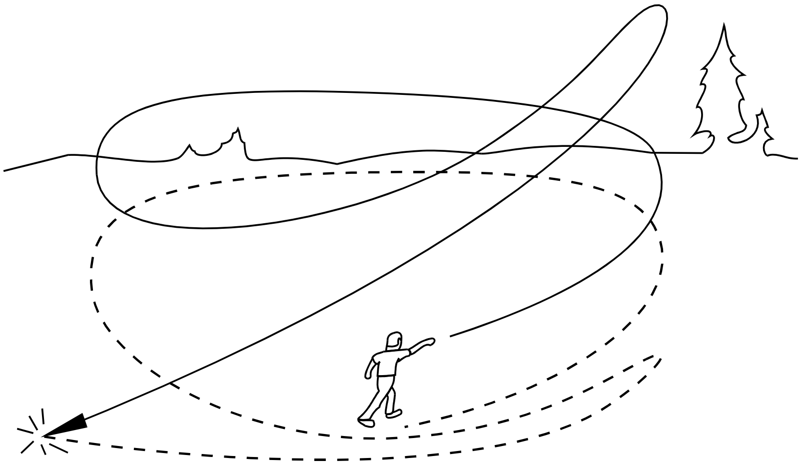
- Arm 2 has too much lift in relation to arm 1. (This sometimes depends on the shape of the booomerang, i.e. if arm 2 is bigger, wider and thicker than arm 1).
- The shape of the boomerang has average maximum lift behind the centre of rotation (see chapter 4)
- The boomerang is warped. One or more arms have too much negative dihedral, or Arm 1 has negative angle of attack (see p. 14).

2.11 Flight path of the boomerang looks like an „S“ in the final stage



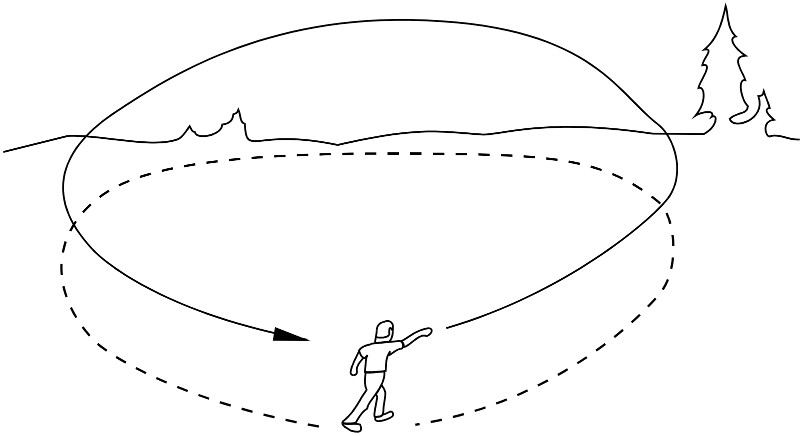
- Arm 1 has too much lift compared to Arm 2.
- Because of its shape the boomerang has average maximum lift too far ahead of the centre of rotation (see chapter 4)
- The boomerang is warped.
- The height of throw is too small (thrown too low see section 1.4).

2.12 Flies a few extra loops in the final stage



- Thrown too hard!
- The boomerang has too little drag (see chapter 5).

2.13 Flies perfectly



- Great job! You got it.

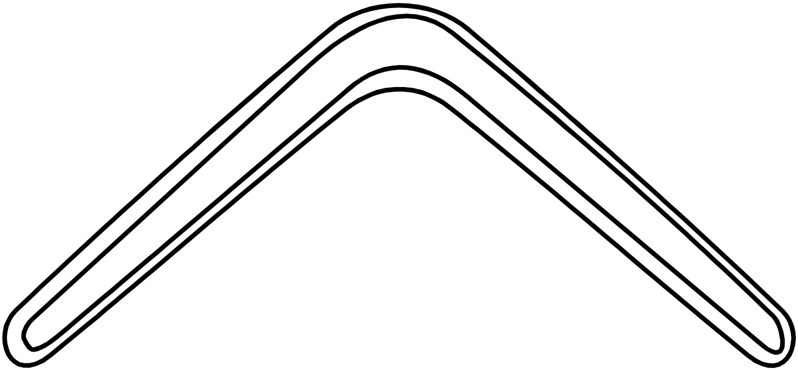
Experienced throwers often purposely use the above-mentioned "errors", to make use of their effects during certain situations (e.g.competitions or dealing with unusually windy or calm conditions). Correctness of a throw is subjective. A seemingly erroneous flight may be perfect for the conditions. A throw is "good" if it achieves the return the thrower wants or needs.

Chapter 3

Basics for Conception and Improvement

3.1 Basic shapes

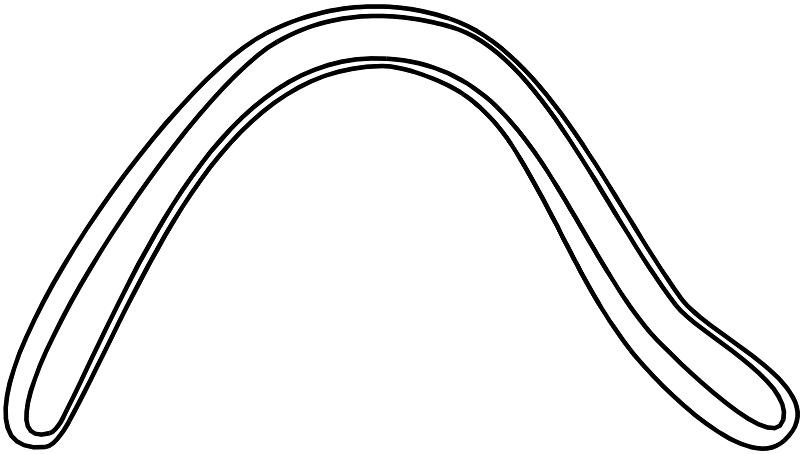
The "traditional" shape



The "traditional" shape is the simplest. With this you can achieve anything from long distance flights to short range low, rapid flights, to long flight durations. Since both wing tips are relatively far away from the centre of rotation, however, these designs tend to maintain their "spinning momentum", making it easier to injure your fingers when catching.

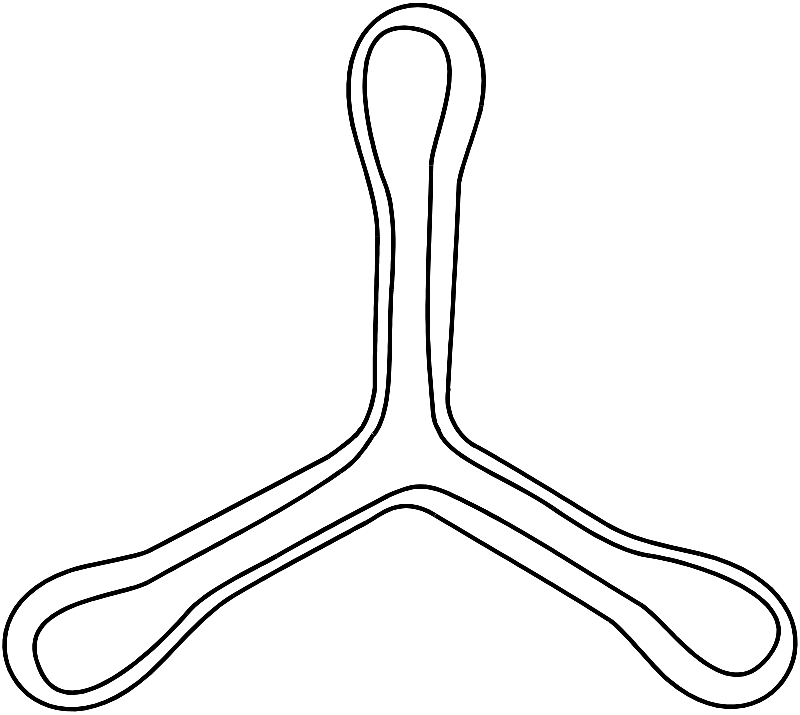
The hook shape

These are more or less the basic forms from which all other boomerang shapes are derived.



The hook form is especially designed for long distance. It is more difficult to catch, because of the wide inner-circle yet less painful than the standard form.

The multiblade shape

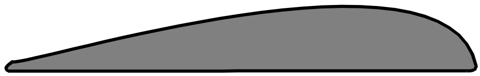


The multiblader shapes tend to have shorter range, but retain their rotation and stability to the end of the flight. Catches are easier since there is material at the centre of rotation.

3.2 Airfoils

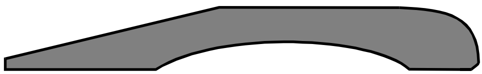
Choice of airfoil depend on the flight characteristics desired. The following airfoils are considered as basic airfoils:

Standard airfoil



Completely profiled airfoil

Standard airfoil with undercut

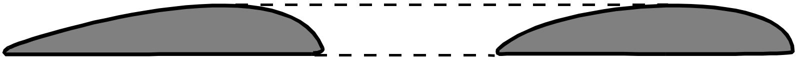


Hollowed out standard airfoil

"Neutral" airfoils e.g. on the elbow

Airfoil for right- and left-handers

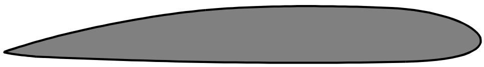
Reverse airfoil (the boomerang can be thrown upside-down)



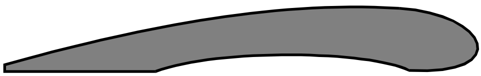
Slit airfoil

The following airfoils are merely recommendations for various types of boomerang.

MTA - airfoils



Long Distance airfoil



Fast Catch airfoil

Strong wind airfoil

3.3 Material

The best material, as already mentioned, is finnish birch plywood as it is easy to work with, tough and flexible. Boomerangs can also be made out of other plywoods, solid and balsa wood, as well as paper, cardboard and various synthetics such as plexiglass, polypropylene, ABS, phenolic and fibreglass or carbon fibre reinforced plastic (see appendix, for addresses). The toughness and density of the material is also of interest (see appendix - Material facts). Choose the appropriate material for the boomerang design you are making. Costs of materials vary considerably. All the materials have one thing in common: they are all strong yet flexible and fairly tough. Finnish birch plywood is still the best compromise for beginners and for "normal" boomerangs, even though polypropylene and ABS is becoming more and more popular.

For example, for MTA boomerangs, the material should be between 1.5 mm and 3 mm thick. If you use wood it should be 3 mm thick. Polypropylene, 3 mm thick is not stiff enough. carbon fibre, fibreglass or plexiglass are too heavy. 1.5 - 2.0 mm Phenolic is almost ideal. It is strong enough, without being too heavy. It is fairly tough but a touch too heavy. For Long Distance boomerangs, carbon fibre, fibre glass, phenolic and wood work well. Fibreglass and carbon fibre tend to be more expensive.

Finnish birch plywood: 2 layers of wood per mm, should be at least 3 mm thick, easily bendable, compact/density: approx. 0,7 Kg/dm3

Phenolic: paper dipped in phenol resin, should be at least 2 mm thick, soft, easily bendable, density approx. 1,5 Kg/dm3

PP: polypropylene, at least 3 mm thick, very soft, easily bendable, unbreakable, density: approx. 0,92 Kg/dm3

ABS: durable polystyrol mixed with butadien and acylic nitril, at least 3 mm thick, hard, easily bendable, relatively fragile, density approx. 1,05 Kg/dm3

Plexiglass: acrylic glass or polymethylmetha-crylat, usable at a thickness of 3 mm, soft, difficult to bend, unbreakable, density: 1,18 Kg/dm3

Fibre glass: Glass fibre synthetic, usable at a thickness of 1,5 mm, hard, bendable, fairly tough, density: 1,8 Kg/dm3

Carbon fibre: carbon fibre synthetic, usable at a thickness of 1,5 mm, hard, bendable, fairly tough, density; approx. 1,8 Kg/dm3

3.4 Surface

The texture of the surface can influence the boomerang's flight pattern. A rough surface tends to reduce hover at the end of the flight. A boomerang with a smooth surface flies faster, retains its spin, and tends to hover more. More lift can be produced by a smooth topside and a rough underside. For reverse circumstances (rough topside and smooth underside) the lift is decreased. The increase in lift is, however, not as significant as an increase in positive angle of attack, for example.

3.5 Tuning (Bending and twisting)

There are two methods of bending a boomerang. The first is bending a wingtip up to increase “dihedral” (see figure 3.1). The second method is twisting the leading edge of the wing upward to increase angle of attack (see figure 3.4).

Dihedral

Generally speaking, a slight positive dihedral in both arms, stabilizes the flight of a boomerang. If there is too much dihedral the boomerang rises too high and tends to have an S-shape flight path. A boomerang with a negative dihedral flies further and lower. If it has been tuned too negative, the boomerang is most likely to fly straight ahead and then crash to the ground.

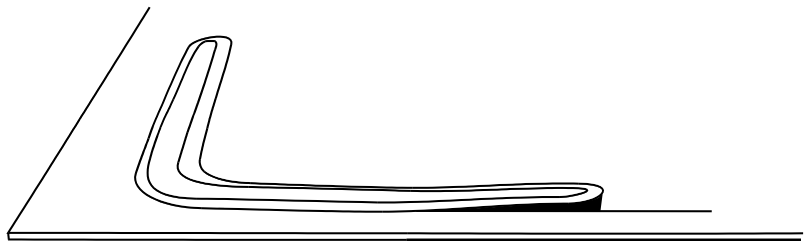


Figure 3.1: Positive Dihedral

With the help of the construction disk (see p. 20), you can see what happens (wing tips gather more forward speed (V_t) than rotation speed (V_r)). The positive dihedral creates maximum lift at Points B_1 and B_2. The resulting turning force occurs 90° later at B_1' and B_2'.

When arm 1 has positive dihedral, the boomerang has more lay-over and will fly a bit further. Positive dihedral on arm 2 just tends to cause more lay-over. Positive dihedral on arm 2 has a larger effect than arm 1 because it flies through the air at a higher speed (see figure 3.2). The higher the forward speed (V_t), in relation to the rotation speed (V_r), the greater the effect of the positive dihedral. The positive dihedral loses its effect during the autorotation phase (i.e. no forward speed $V_t = 0$) (see figure 3.3).

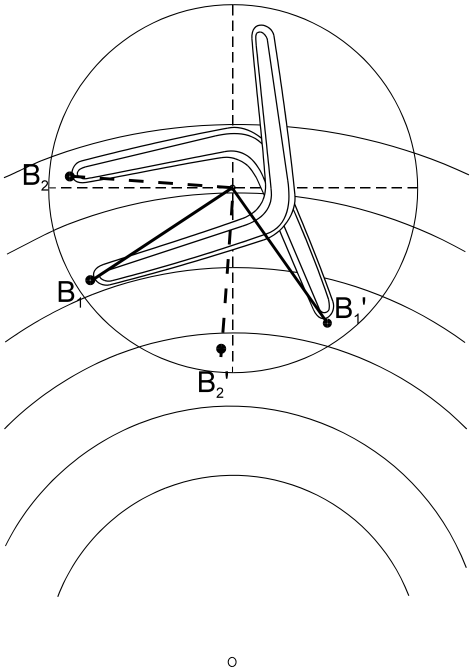


Figure 3.2: Dihedral $V_t > V_r$

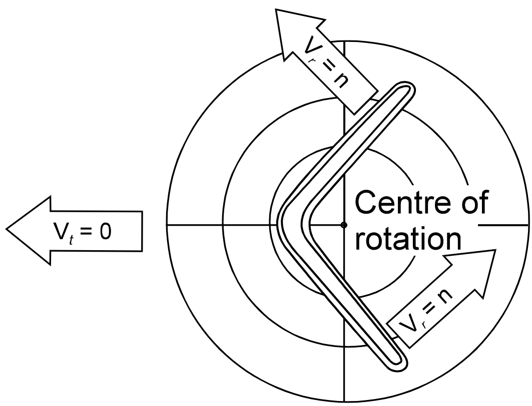


Figure 3.3: Dihedral $V_t = 0$

The angle of attack:

Positive angle of attack acts similar to an undercut. A positive angle means more lift and a negative angle less lift (see section 3.4). Increasing angle of attack increases the drag of the airfoil. A positive angle of attack reduces range and rotation in the final stage of flight. If the angle is too sharp, the boomerang may not quite make it back because it loses rotation during the second half of the flight. If Arm 1 has a negative angle of attack the boomerang will normally fly further. With a steep negative angle it will simply fly straight ahead. With a symmetrical multiblader it doesn't matter which arm is bent. The effects just add up.

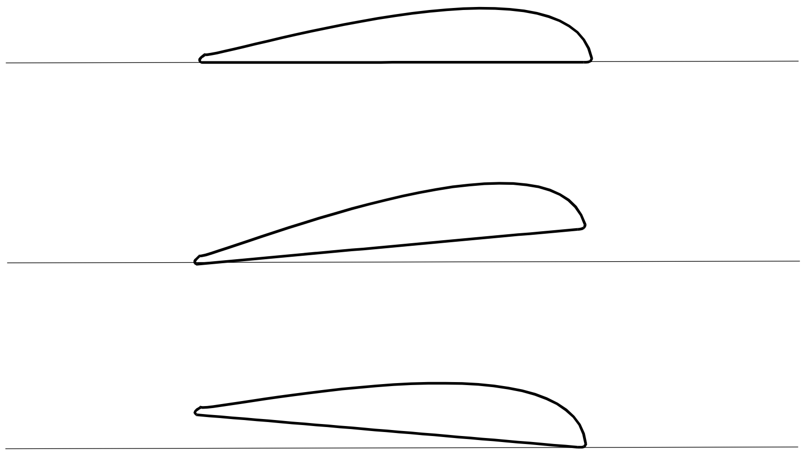
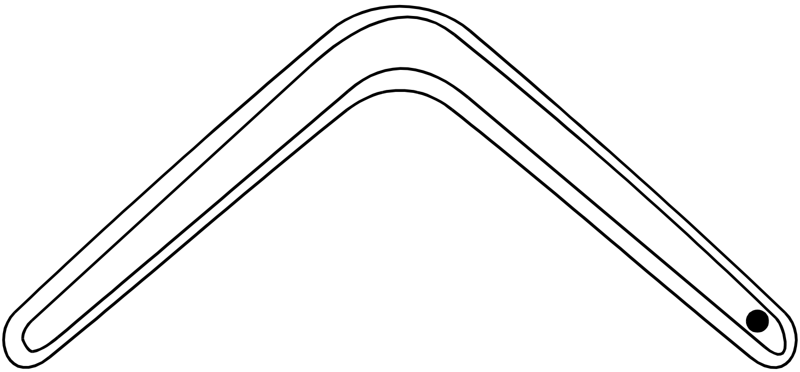


Figure 3.4: Different angles of attack

3.6 Boomerang weights

There are various techniques of weighting a boomerang. Weights or coins can be attached with tape, or embedded permanently in the boomerang. Usually, permanent weights are installed in drilled holes and filed flush with the wing. Taped on weights, in contrast to carved in weights, change the centre of rotation not only in a horizontal but also a vertical direction. The boomerang is, therefore, slightly tilted and effects similar to a warp or an under-cut area can be obtained. Special attention should be paid to how the weights are taped onto the boomerang, as there will be a change in the airfoil where the weight is attached. Because of differences in boomerangs and weighting techinques, the following effects may or may not be noticeable. Weights can be attached to the following points:

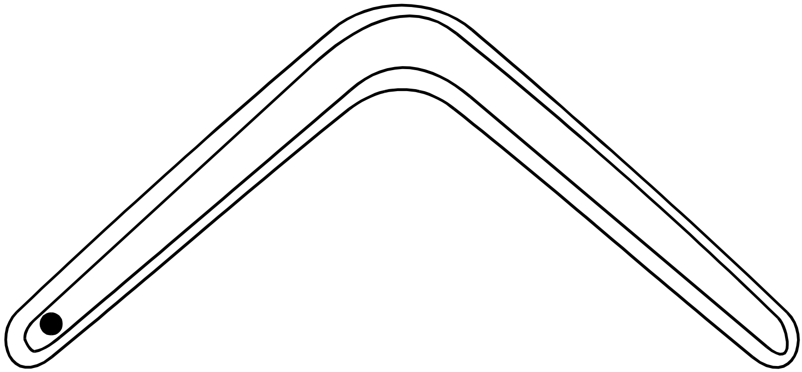


Basic feature:

- further distance
- less lay-over
- U-shaped flight path

Variations:

- on top: boomerang flies higher
- underneath: boomerang flies lower

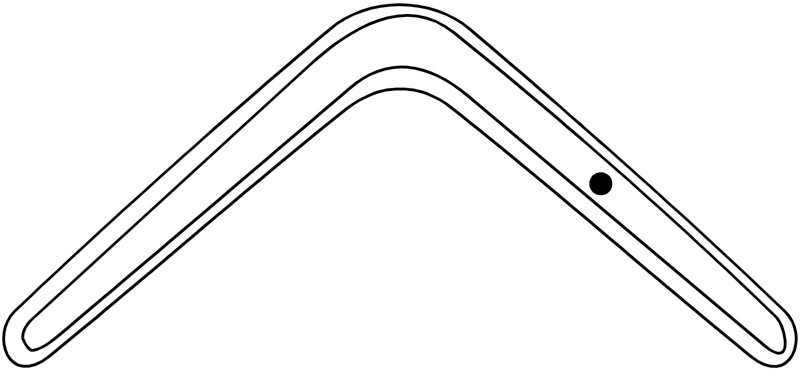


Basic feature:

- further distance
- more lay-over
- S-shaped flight path

Variations:

- on top: boomerang flies lower
- underneath: boomerang flies higher

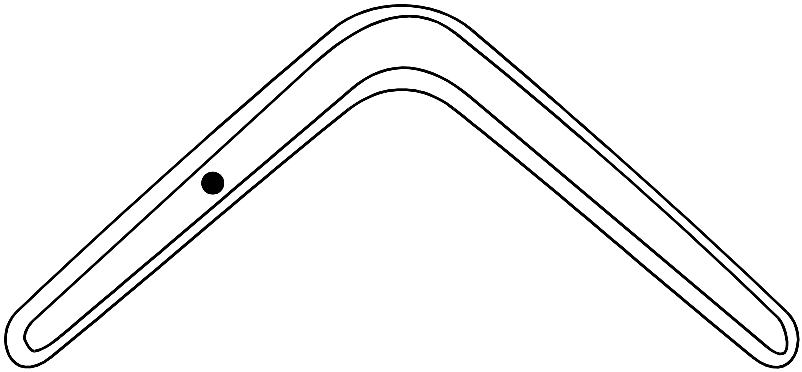


Basic feature:

- Boomerang flies lower
- Boomerang keps its rotation
- less lay-over

Variations:

- on top: Boomerang flies higher
- underneath: Boomerang flies lower, Boomerang flies further

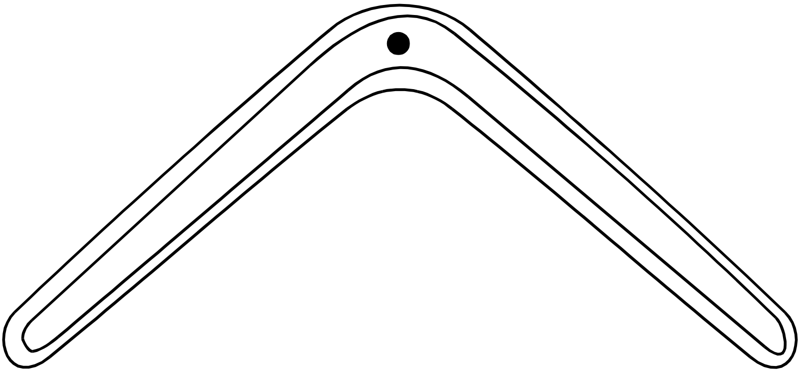


Basic feature:

- Boomerang flies higher
- Boomerang keeps it's rotation
- more lay-over

Variations:

- on top: Boomerang flies lower, Boomerang flies further
- underneath: Boomerang flies higher

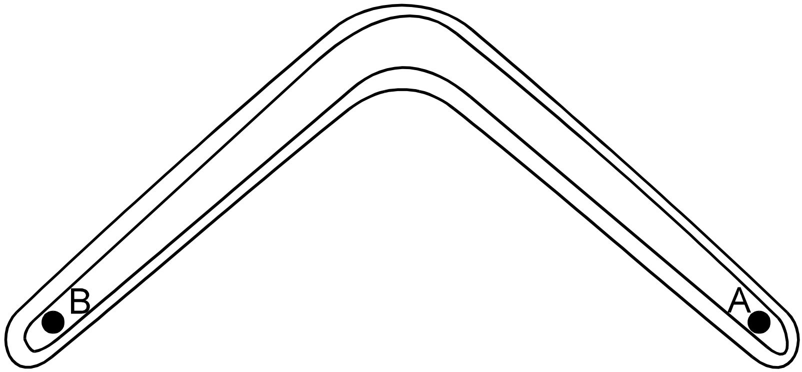


Basic feature:

- shorter distance

Variations:

- on top: Boomerang flies lower
- underneath: Boomerang flies higher

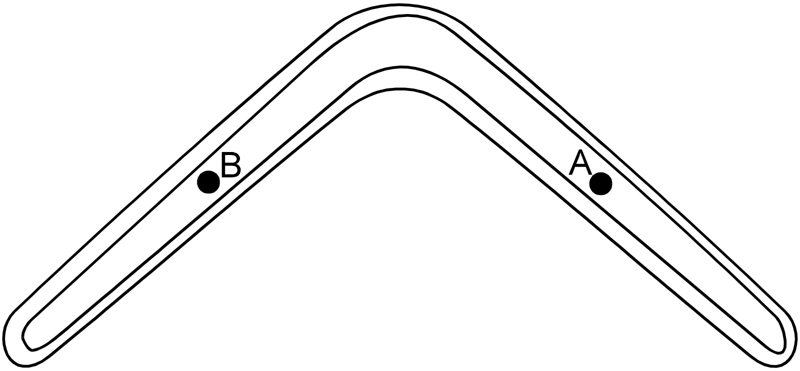


Basic feature:

- further distance

Variations:

- A,B, on top: Boomerang flies higher
- A,B, underneath: Boomerang flies lower
- A on top, B underneath: Boomerang flies shorter distance and higher
- A underneath, B on top: Boomerang flies lower

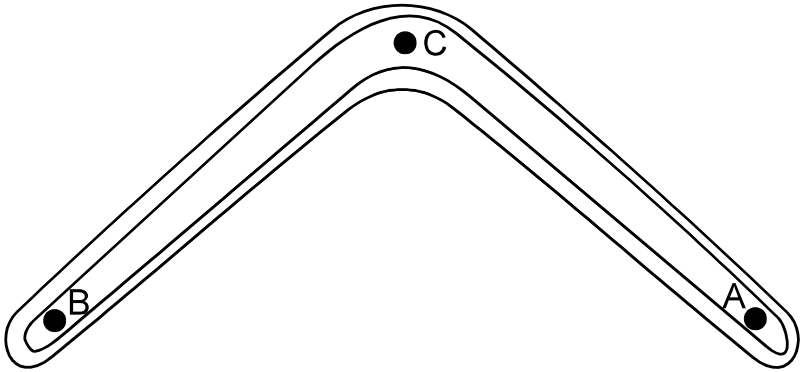


Basic feature:

- wind stabilized - unchanged distance

Variations:

- A, B on top: unchanged distance
- A, B underneath: unchanged distance
- A on top, B underneath: Boomerang flies a shorter distance and higher
- A underneath, B on top: Boomerang flies further and lower



Basic feature:

- Further distance
- Boomerang keeps its rotation
- Boomerang flies as though unweighted

Variations:

- A, B, C on top: no further change
- A, B, C underneath: no further change
- A, B on top, C underneath: Boomerang flies higher
- A,B, underneath, C on top: Boomerang flies further and lower
- A, C on top, B underneath: Boomerang flies a shorter distance and higher
- A on top, B, C underneath: Boomerang flies a shorter distance and higher
- A underneath, B, C on top: Boomerang flies further and lower
- A, C underneath, B on top: Boomerang flies further and lower

3.7 Carving out

To “carve out” means to remove substance from the topside or underside of the boomerang. Usually, either a whole arm is carved out, or just the tip is carved out. (see 3.5).

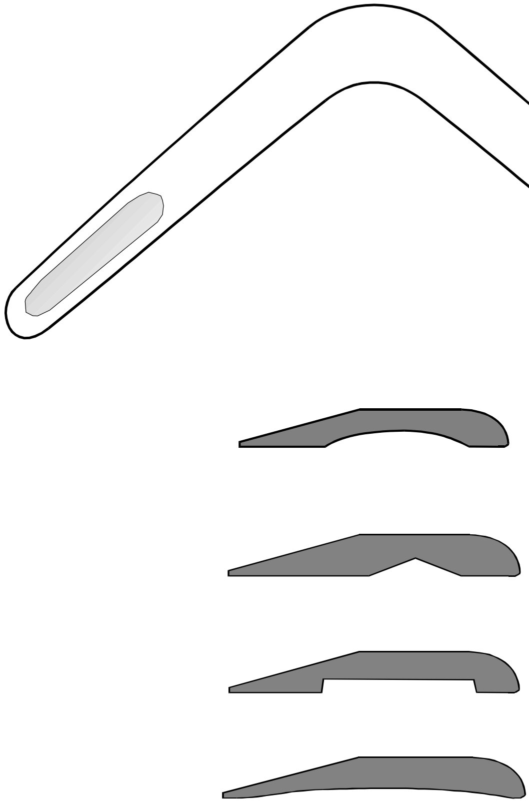
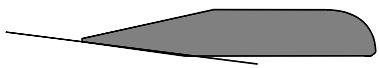


Figure 3.5: Carved out boomerang profiles

Carving reduces the weight of the boomerang and tends to weaken it while causing it to fly a shorter distance and higher. You can expect an extensively carved out boomerang to be more fragile and to have shorter range. If one arm is carved out significantly more than the other, the centre of rotation may shift significantly. This can affect overall lift and wind resistance.

3.8 Undercut or bevel

An undercut is an area where material has been removed from the underside of the wing from either the leading or the trailing edge. A leading edge undercut causes more lift but also increases drag whereas a trailing edge undercut reduces lift and tends to increase spin (see figure 3.6). Undercutting usually starts at the wing tip. It varies in



(a) Trailing edge

(b) Leading edge

Figure 3.6: Undercuts

length (see 3.7). Undercuts can be used at any point on the boomerang even at the elbow. In later discussion in this book, an "undercut" will

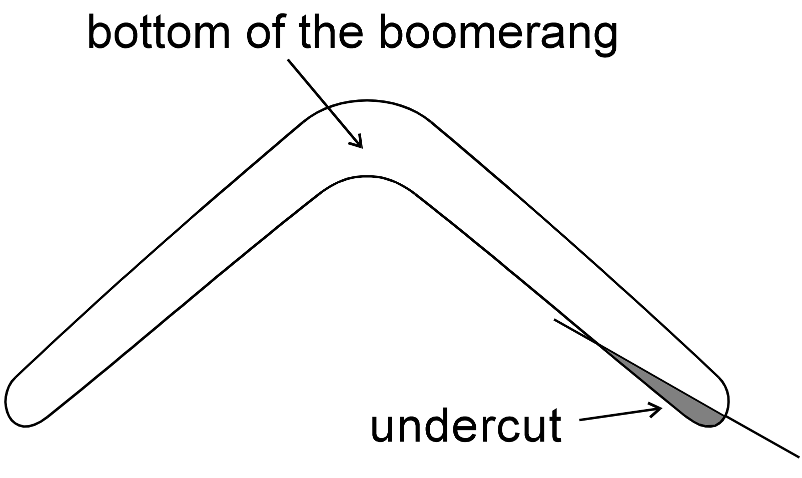


Figure 3.7: Undercut viewed from bottom

be referring to a 2-inch long undercut on the leading edge starting from the tip of the arm.

3.9 The elbow

The profile of the elbow can have a large effect on the lay-over of a two-arm boomerang.

- An undercut on the outside edge of the elbow or a bevel on the top of the inner edge of the elbow increases the lay-over. The elbow causes lift ahead of the centre of rotation - E_1 positivel- and negative lift behind the centre of rotation - E_2 negative -.

- An undercut on the inner edge of the elbow or a bevel on the top of the outer edge of the elbow decrease the lay-over. The elbow causes negative lift ahead of the centre of rotation - E_1 negative - and a positive lift behind the centre of rotation - E_2 positive - (see figure 3.8).

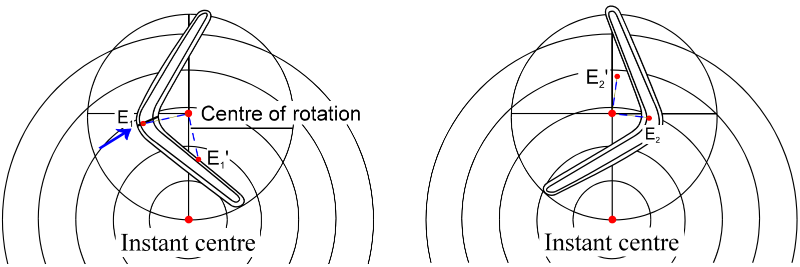


Figure 3.8: Effect of elbows wingprofile

3.10 Holes

Various sizes and shapes of holes can be used anywhere on a boomerang. Generally holes increase the drag and can have other large effects on a boomerang's flight. They can also be used for decoration or as a launching aid.

It can generally be said that:

- the closer the hole is to the wing tip, the slower the rotation at the end of the flight.

- the closer the hole is to the centre of rotation, the less influence it will have on the rotation, but it does tend to reduce the speed of the boomerang.

- The larger the hole at the centre of rotation of a multi-blader, the smaller the lay-over the boomerang will have.

Variations: (see figure 3.9)

- The position of the holes on the boomerang relative to the elbow and wingtip
- The position of the holes on the airfoil relative to the leading and trailing edge
- The size of the holes
- Sharp or rounded-off edges
- The slant of the holes
- Holes taped off on the top or underside
- Holes taped off on the top and underside
- Holes partly taped off.

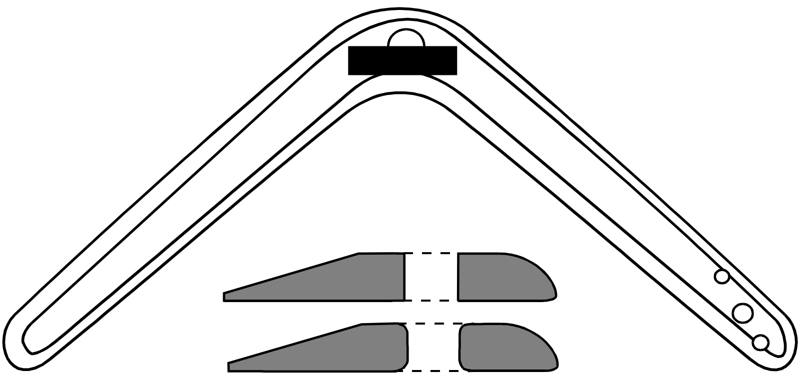


Figure 3.9: Holes half covered

3.11 Flaps

A flap is a piece of tape that is stuck onto the boomerang - usually in such a way that it stands erect on the top or bottom of the boomerang. It has similar effects to a hole (see 3.10). The flap is much easier to attach and remove. It is easy to learn to use flaps, since they can be made and installed within a few seconds and can be easily removed and adjusted. The boomerang can then be re-tested before conditions change.

Variations: (see figure 3.10)

- The position on the boomerang
- The position on the profile
- Shape
- Length
- Direction
- Material

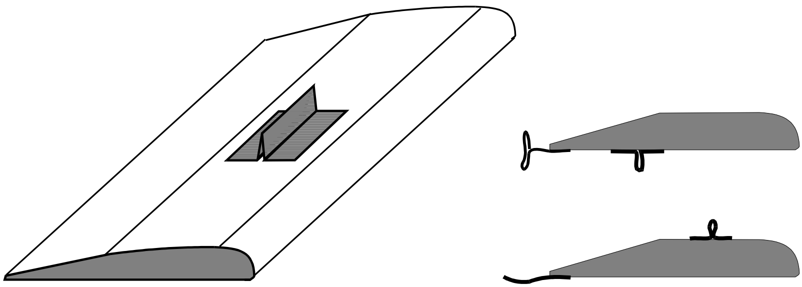


Figure 3.10: Flaps mounted on wing

3.12 Windbreakers in general

Windbreakers can be anything that change the behaviour of the boomerang during flight. There is no limit on ingenuity. Experiment on the following windbreakers:

- Rubberbands
- Bandages
- A complete roll of cellotape
- String
- Wire
- $\cdots$

3.13 Rubberbands

Rubber bands are easy to carry, easy to add and can largely replace major surgery on boomerang, as well as stabilize the boomerang, when thrown into the very wind. The general purpose of the rubber band is to slow the boomerang. The placement of rubber bands thus determines what is dulled. The following are just rules of thumb when using rubber bands.

3.13.1 General

The closer to the center of mass rubber bands are placed, the more it reduces the boomerang speed, and the closer rubber bands placed at the wing tips, the more brakes the rotation and reduces buoyancy.

> "Rubber Bands reduces lift on the wings, helping to boomerang flies anymore, because it no longer turns so sharp." [1]

3.13.2 Twobladers

Specifically for twobladers, rubber bands put on wing 1 delay the return lay-over so that the boomerang will lie down later in it's orbit. Rubber bands mounted on wing 2 do the opposite, namely that the Boomerang will layover earlier in it's course.

3.13.3 Multibladers

The multiblader's center is in the middle and a rubber band in the center can stabilize the boomerang when throwing in the wind. It may be useful to put rubber bands on the tips of the wings of a multiblader if it has a tendency to fly past you too fast so that you can catch the boomerang.

[1] Jens Krabbe (Former President of Danish Boomerang Club.)

3.13.4 Installing rubber bands

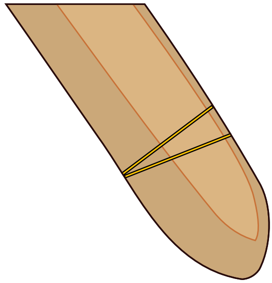
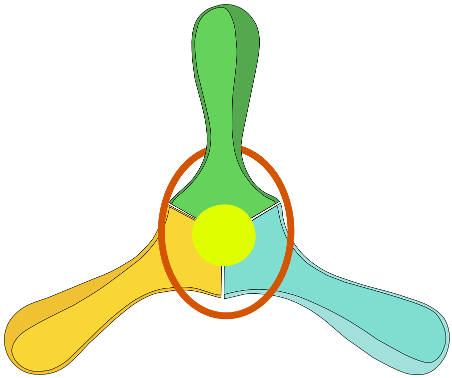
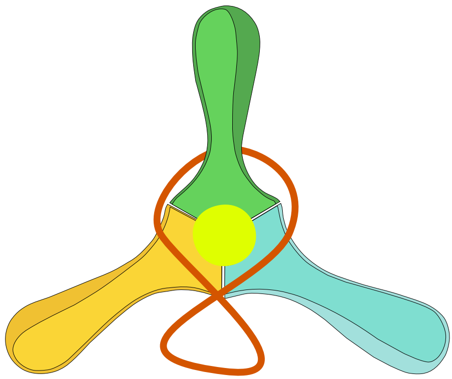


Figure 3.11: Rubberband on wing

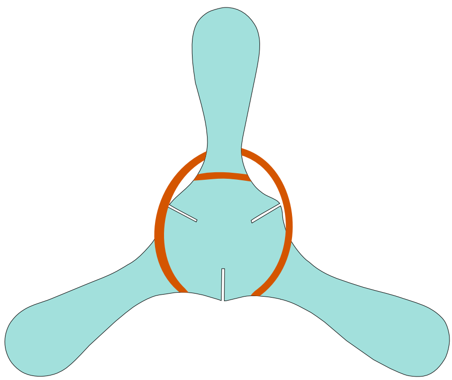
When mounting th rubber bands, you can do it in different ways: You can either put them on so that they sit together, or you can wrap them around twice and spread them apart (see figure 3.11). Spreading the rubber band creates more wind resistance resulting in a stronger effect. You can also mount the rubber bands on tribladers on the wings and in the middle. When you want to put a rubber band onto the middle of a triblader, place one of the wings through the rubber band, twist it half a turn and pass the rubber band over the middle, between the two opposing wings, and then back over the first blade again (see figure 3.12)



(a) First step



(b) Second step



(c) Third step

Figure 3.12: Installing rubberbands on tri-blader.

3.14 Slits

Slits are, in principle, nothing more than elongated holes. They can be narrow or wide, long or short, profiled or unprofiled in various positions on the boomerang. Adam "Schlitzer" Müller developed the slotting and comb (see next section) technology used in competition boomerangs today.

The wing is, in effect, divided into two small wings with a wide profiled slit between them. The boomerang tends to be more stable in wind and retains most of its spin but loses much of its forward speed. Be careful! Avoid weakening the wings excessively. Polypropylene, fibreglass and carbon fibre are generally the best materials for making slotted boomerangs.

3.15 Combs

Combs are thin slits on the front or back of the airfoil (see figure 3.13). They cause slight turbulence, similar to flaps or holes but the effect is more even.

The boomerang flies further with a comb on the trailing edge without losing much rotation. It is not necessarily more stable in wind. If the comb is on the leading edge, stability in wind is improved. The closer the comb is to the tip, the more the rotation is reduced. The thicker the airfoil, the greater the effect.

The length and width of the comb area that is practical, depends on the strength of the material. But be warned! Because of the combs, the wing loses strength and is much more easily broken. Polypropylene, Fibre glass and Carbon fibre are the best materials.

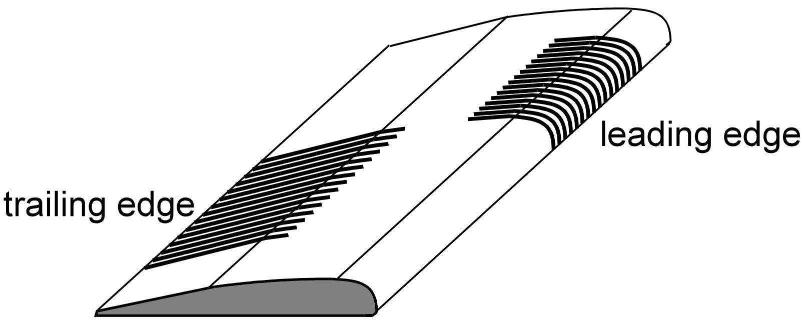


Figure 3.13: Combs cut into the airfoil

Chapter 4

Making and Using a „Construction Disk“

4.1 The construction

Using a construction disk helps you to discover what changes you can make to improve your boomerang. With it you can better understand why your boomerang flies like it does. You will need a wooden board or thick cardboard approx. 50 X 100 cm. Draw circles and lines onto the board, according to figure 4.1.

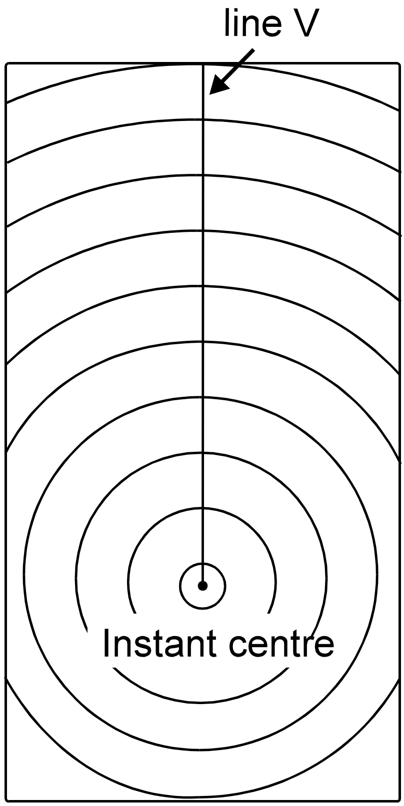


Figure 4.1: Construction disk

4.2 Finding centre of rotation

First you will have to find the boomerang's centre of rotation. The simplest way to do this is to place the boomerang on the edge of a sharp-edged table with one tip near the edge of the table. Balance the boomerang so that it just starts to tip, then mark the boomerang directly above the edge of the table. Repeat again with the other tip of the boomerang near the edge of the table (see figure 4.2). Connect the points with tape (see figure 4.2). Draw lines on the tape from one arm to the other along the line on which the boomerang first balanced and then along the second balance line. The cross point represents the boomerang's centre of rotation.

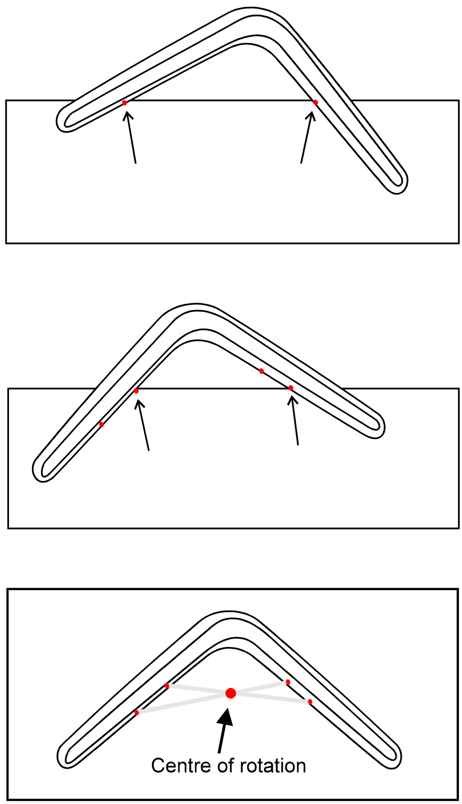


Figure 4.2: Finding the center of rotation

4.3 Placing boomerang on construction disk

Now try to estimate the ratio of V_t (forward speed) and V_r (rotation speed). In the following example, I am assuming that $V_t = V_r$ which means that the forward speed equals the rotation speed.

Place the boomerang with the centre of rotation on the vertical line V so that one wing tip is just above the instant centre on the construction disk (see figure 4.3). The lines represent the direction and relative speed of the air flow on the wing. The lines which are further away from the instant centre represent a higher speed of air flow. If you turn the boomerang around its centre of rotation in small steps, you can see that the air flows across the wings at different angles as it rotates.

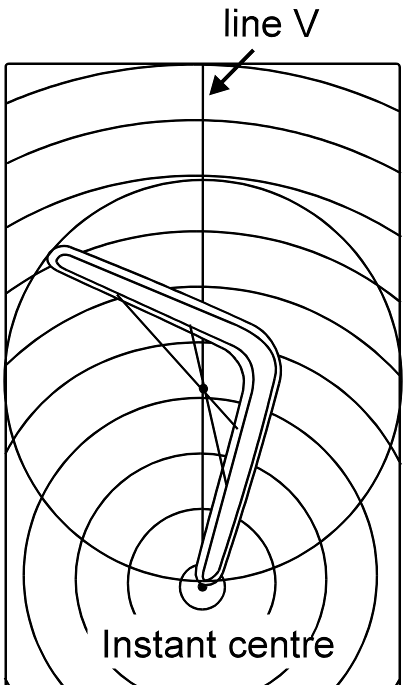


Figure 4.3: Placing boomerang on Construction disk

4.4 Find the following points

- maximum lift of each wing, when each is at a right angle to the air flow. Turn the boomerang to the left (to the right for left-handers) until the tip (the last 2 inches) of one wing lies at a right angle to the circle lines and mark the appropriate point (see figure 4.4). Do the same to all other wings.

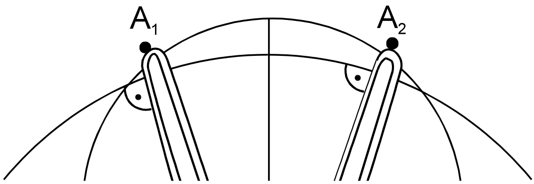


Figure 4.4: Maximum lift of wing

- maximum lift of each wing, caused by dihedral (if present). Turn the boomerang to the left (to the right for left-handers) until the tip of one wing (the last 2 inches) lies parallel to the circle lines and mark the appropriate point (see figure 4.5). Do the same to each other wing. Note whether the dihedral is positive or negative.

- maximum lift of the elbow (if present) Turn the boomerang so the centre of the elbow lies at a right angle to the circle lines (see figure 4.6). This is not as easy. Mark whether the lift is positive or negative created by the elbow.

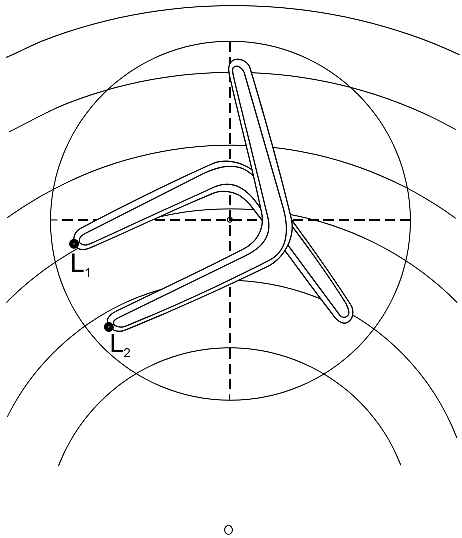


Figure 4.5: Max lift caused be dihedral

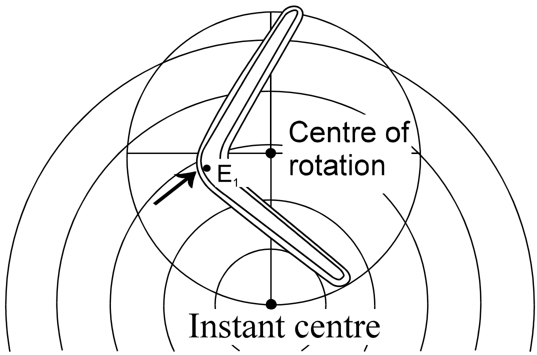


Figure 4.6: Max lift on elbow

To determine the average point of lift, start by assuming that the wings have the same profile, width etc. Make adjustments if you think it is necessary. If arm 2 is hit by a faster air flow than arm 1, for example, arm 2 will have more lift. This will move the average maximum point of lift slightly towards arm 2. Increases or decreases of lift caused by undercutting or carving out must also be considered.

Determining the average maximum point of lift from all points on the boomerang is a difficult mathematical task. To simplify, just try to find the average point of lift resulting from the lift at points A_1 and A_2.

Once the average maximum point of lift has been determined, mark 90° ahead in the direction of rotation as the actual point of attack. If it lies exactly on the horizontal line, the boomerang will have little or no lay-over. This would be ideal for “Fast Catch”. If it lies below the horizontal line, the boomerang has lay-over. The lower the point the more lay-over it has and the higher the boomerang will tend to fly. If it lies above the line, it will be very difficult to get the boomerang to return, because it will roll inward and dive.

At points L_1, L_2 and E_1 it is very difficult to estimate the lift. Generally, positive dihedral increases lay-over and negative lift of the elbow decreases the lay-over. The value of these numbers is not important. However, you can see what changes might be expected if you change the dihedral or alter the airfoil at a certain place on one of the arms or at a place on the elbow.

Try to analyze, for example what would happen if the lift on the middle of arm 2 was increased significantly. Analyze that point during all of its 360° degrees of rotation. Then analyze another point on the boomerang throughout its rotation. Then try placing the boomerang at a point further from the instant centre. Typically, boomerangs have significantly more forward speed than rotation speed when thrown. The instant centre is therefore at least one boomerang span from the centre of rotation. At the end of their flight, V_t approaches 0. This is why lay-over is different early in the flight than it is late in the flight.

By experimenting, with the construction disk as your guide, you should be able to find points on the boomerang that you can carve that will have significant effect during the first part of the flight, without affecting the latter part of the flight and vice versa.

Chapter 5

Correction of Throwing and Construction Errors

5.1 Basic procedures

There are many factors influencing the flight of a boomerang. It is impossible to predict the desired effect exactly, but with experience, you will have a fair idea how a boomerang will fly before it is thrown.

The only real promise of success in addition to various rules is usually: try, try and try again. Rusty Harding claims:

> “Give me a rule of how to construct a boomerang and I will show you the boomerang to which it does not apply”.

When correcting throwing and construction errors, you should proceed step by step:

1. First you should try different throws.
   Read about throwing and use section 2 to troubleshoot your throw.
2. “Small” non destructive adjustment
   Bending of the wing tips, brake flaps, weighting with coins, smoothing down or roughing up the finish etc. See Chapter 3.
3. “Big” modifications
   Undercuts, carving out, installation of weights, holes and slits. See Chapter 3.
4. Make another similar boomerang
   Start the profiling differently. i.e. start with less trailing edge cutting, and a blunter leading edge.
5. Test changes in a different sequence.
6. Try a different shape or material.

See Chapter 3 and 4. See how a slight change in boomerang shape changes the average point of lift. It is these changes that make the construction disk useful.

5.2 How to achieve certain features

5.2.1 How to increase the effective lift

1. Apply or increase the positive dihedral or angle of attack
2. Carve out the underside (hollow)
3. Undercut the leading edge
4. Blunt leading edge
5. Make a longer trailing edge
6. Smooth the topside, make the underside rougher
7. Make another boomerang with:
    - Thicker material
    - Lighter material (to increase effective lift)
    - More distance between the wing tips and the centre of rotation

5.2.2 How to decrease the effective lift

1. Apply or increase the negative dihedral or angle of attack
2. Make the leading edge sharper
3. An undercut trailing edge
4. Make holes in the wing
5. Add flaps
6. Roughen the topside, smooth the underside
7. Make another boomerang with:
    - Thinner material
    - Shorter trailing edge
    - Heavier material
    - Less distance between the wing tips and centre of rotation
    - Narrower wing (reduced chord)

5.2.3 How to increase rotation

1. Throw with more spin
2. Install weights near the wing tips
3. Reduce positive angle of attack or make it negative
4. Smooth the surfaces
5. Streamline the airfoils
6. Make another boomerang with:
   - Thinner material
   - Wider wings at the tips (increase chord)

5.2.4 How to decrease rotation

1. Throw with less spin
2. Apply or increase the positive angle of attack
3. Make the wing tips more blunt
4. Make the leading edge more blunt
5. Holes or slots in the wing especially near the tips
6. Add flaps near the wing tips
7. Make another boomerang with thicker material

5.2.5 How to increase the range

1. Throw with less tilt and harder
2. Add more weight near the wing tips
3. Decrease the effective lift (see section 5.2.2)
4. Move the centre of rotation towards the wing tips (e.g. with weights on the tips)

5.2.6 How to reduce the range

1. Throw with more tilt and less power

2. Remove weights

3. Increase the effective lift (see section 5.2.1)

4. Move the centre of rotation towards the elbow (e.g. with weights on the elbow)

5.2.7 How to increase the flight height

1. Throw with more tilt

2. Throw higher and harder

3. Add more lift on arm 1 (with two-bladers)

4. Apply or increase the positive dihedral

5. Add weights

6. Add flaps on the underside

5.2.8 How to reduce the flight height

1. Throw with less tilt

2. More lift on arm 2 (for two-bladers)

3. Negative dihedral on both arms, to reduce "diving" add a slight positive angle of attack on both arms

4. Add flaps on the topside especially towards the trailing edge

5. Add weights

6. Drill a hole in the area of centre of rotation of a multiblader

5.2.9 How to increase the lay-over

1. Increase dihedral or make it more positive
2. For two-bladers, increase the lift on arm 1 and decrease it on arm 2
3. Increase the lift at the elbow; direction of air flow from the elbow towards the centre of rotation.

5.2.10 How to decrease the lay-over

1. Reduce dihedral or make it more negative
2. For two-bladers, decrease the lift on Arm 1 and increase it on Arm 2.
3. Decrease the lift at the elbow; with the outside of the elbow as the leading edge

Chapter 6

Games

6.1 Suicide

All throwers line up in a row. They all throw their boomerangs simultaneously on command. Those who catch their boomerangs are allowed to participate in the next round. Those who do not catch their own boomerangs are eliminated. The number of players is gradually reduced until one is left - the winner. Towards the end of the game, if the weather conditions are good, the game can be made more difficult for catching (e.g. by one-handed catching, catching behind the back, catching with the feet etc.) In order to ensure that there is little danger of injury, only small and light boomerangs should be used.

6.2 Boomerang Rugby

The rules for this game are very simple, making it even more fun. A player throws his boomerang and then he and as many other players as desired try to catch it. The one who catches, is thrower in the next round etc.

6.3 Supercatch

An MTA is thrown and while it is in the air, the thrower throws and catches a “Fast-Catch” boomerang as many times as possible. No catches are counted if the MTA boomerang is not caught. It is useful to have someone watch the MTA while the “Fast-Catch” boomerang is being thrown to advise the thrower when to start running for the MTA and where to catch it.

6.4 Fächerwurf

The object of "Fächerwurf" is to throw three boomerangs in a row and then to catch them. The most difficult part is selecting the appropriate boomerangs and throwing them in the right order. There are many different strategies for success, two of which are: Throw a boomerang with a short flight, then one with a medium flight and finally a boomerang with a longer flight. If three similar boomerangs are thrown, they should hover slowly above the launching position and then gradually descend. They should be thrown at intervals of approximately 2 - 3 seconds. The "Fächerwurf" can, of course, be played with more than 3 boomerangs.

6.5 As many boomerangs as possible in the air

In this game, try to keep as many boomerangs as possible simultaneously in the air. The boomerangs thrown before the first one touches the ground count towards the score.

6.6 Schnelle Feile - Boomerang making race

The goal is to make a boomerang as fast as possible out of Finnish birch using only a saw, a rasp and a file and then throw and catch it 5 times. The first one to finish wins.

6.7 Throw off Fast Catch

Two throwers launch simultaneously. The first one to catch his boomerang five times advances to the next round.

6.8 Team Relay

The playing field consists of two concentric circles. The inner throwing circle is 4 metres and outer circle is 30 metres in diameter. Two teams consisting of 3 - 6 throwers stand outside the 30 metre line. The 30 metre line is the start and finish line. On command, the first thrower of each team starts. The boomerang must be thrown from the 4 metre circle. After catching, the thrower touches the 4 metre circle before running back to the team. If he doesn't make the catch he returns to the 4 metre circle and throws again. Upon catching it, or recovering it if he does not catch it, he touches the 4 metre circle and runs back to tag a teammate at the 30 metre line to start his turn and so on. All throwers throw twice in rotation. The winning team is the one whose final thrower touches or crosses the 30 metre line first. To make the game a bit more interesting, try using only one boomerang for the team. This can, however, be a bit tricky for left-handers, as they will of course have difficulties throwing a right-handed boomerang.

6.9 Chaos

Two people (or more - in this example we will use two, but the rules are the same for more people) have one boomerang each, preferably the same style to insure fairness. Start the game by throwing your boomerang around the central marker.

General Rules

One point is scored each time a player catches his/her own boomerang–a defensive point. Three Points are scored each time a player catches his/her opponent's boomerang–an offensive point.

A throw may be made from any spot on the field, so long as it goes around the central marker. If it does not go around the marker, no defensive point may be scored, but offensive points may still be scored by an opponent catching it. There is no time limit, and players may throw their boomerangs again as soon as they catch or retrieve them. A winner is determined when one player reaches 11 points.

Free Throws

A Free Throw is when play has ceased and one player is allowed one throw without any interference from other players. If it is caught, the player gets a point, and normal play resumes. There are two circumstances for a Free Throw: (Starring Dick and Jane)

First, if there is a foul. Chaos is a “non-contact” sport like basketball, so if Dick slaps Jane’s hand while trying to catch her boomerang, Jane may call ”Foul!” She then gets a Free Throw.

Second, if a player looses his/her boomerang (in a tree, over a fence, in tall grass, or just didn’t watch where it landed), he can call “Out of Play”. Play then stops and Jane gets ONE Free Throw while Dick looks for his lost boomerang. Calling “Out of Play” is in Dick’s Best interest, even though Jane will probably get an easy point, because she will not be able to rack up point after point while Dick is combing through the neighbor’s garden and climbing trees looking for his boomerang. Still, it is Dick’s decision, whether it is worth it to call “Out of Play” or not.

This game was originally invented by J and N Boomerangs, and rules was provided by Master-Designs.com

Chapter 7

FUN Boom Tournament

These rules are drawn up in order to put the FUN back into boomerang tournaments.

7.1 General FUN Boom Tournament Rules

1. No competition can start or be said to be valid without a round of Team Ben Ruhe Has a Posse (TBRHAP). At start of each tournament day, one round of TBRHAP must be completed.

2. No general warm up is allowed.

3. Any warm up for ordinary (boring) events must be in the form of a FUN game.

4. FUN games are scored separately and count for nothing at all, but to have FUN. If no FUN has been had during the FUN game, another FUN game must be completed before the ordinary event can start.

7.2 Event FUN Boom Rules

1. The FUN game before Accuracy can be Team Hackuracy or Team Accuracy.

2. The FUN game before Fast Catch can be Team Fast Catch.

3. The FUN game before Endurance can be Team Fast Catch.

4. The FUN game before Aussie Round can be Super Mario Brothers.

5. The FUN game before MTA can be Suicide MTA.

6. The FUN game before Trick Catch can be GLORP.

7. Long Distance isn't FUN.

7.3 FUN Games Rules

7.3.1 Team Ben Ruhe Has a Posse

All participants, their friends and families join in for a suicide throw. Everybody throws at the same time, and all who catches are documented and posted on host's website. Only one attempt must be made each day of the tournament.

7.3.2 Team Hackuracy

Each member of the team in turn throws a boomerang and the whole team helps hacky (kick) the boomerang toward the bull's eye. The number of hackies is added to the score.

7.3.3 Team Accuracy

Each member of the team in quick successive turns throws a boomerang such that the next thrower throws before the previous has landed. This means, that the whole team must be ready to go in line. As ordinary Accuracy rules apply, no boomerang must be touched by anyone on the team until it has been scored, so watch out for all those incoming boomerangs while you're busy throwing your own before the previous one has landed! When all boomerangs have landed, the four best scores are counted and added to the total score.

7.3.4 Team Fast Catch

Two teams are made from all available persons on the field. The first thrower of each of the two teams starts throwing at the same time. When the thrower has retrieved his boomerang and touched the bull's eye he runs out to tag the next thrower ready at the 10-meter line. Each team must make twenty catches and the one catching number 20 runs to a chair which is set up at equal distance from the two circles. The first team to get a person in the chair wins.

7.3.5 Super Mario Brothers

Everybody throws at the same time. The object is to catch your boomerang in the bull's eye or as close as possible. The ones catching in the bull's eye, or if none, the closest to the bull's eye, get one point. Those who didn't catch their boomerang get minus three points. The rest get no points. The first person to get 10 points wins. No one can have less than minus three points. If two or more throwers are equally close to the bull's eye, both are awarded points. To shorten the game, the minus three points for dropping can be dismissed, and the goal can be set to 3 or 5 points for the winner.

7.3.6 Suicide MTA

Everybody throws at the same time. The last person to catch wins the round. Five or ten rounds should be enough for warm up.

7.3.7 GLORP

G-L-O-R-P is a freestyle trick catch game. To start with the throwers are ranked according to the number of years they have thrown boomerangs. The first person (the dominator) attempts a trick catch of his own choosing. If he succeeds, all the others must duplicate it, or else get a letter. If the dominator fails to catch the boomerang, the domination is passed to the next one in the ranking line. If the previous dominator caught the boomerang, but missed the trick catch he attempted, the next dominator must catch his boomerang in his attempt, or else he gets a letter. When a thrower has got the five letters G-L-O-R-P he is out of the game. The last person in the game is the winner.

Chapter 8

Competition Events

8.1 General rules

A competition field consists of several concentric circles. The inner circle with a 2 metre radius is the bull's-eye from which throws are made. The boomerang has to fly over the 20 metre circle with every throw. The number of circles used depends on the competition and there are, of course, specific rules which can differ from nation to nation. International rules are being developed.

8.2 Accuracy

In this event, the boomerang is thrown five times in a row from the centre of concentric circles with a radius of 2, 4, 6, 8, 10 and 20 metres. The boomerang must neither be caught nor touched. Points are awarded based on how close the boomerang lands to the centre. Scoring is the same as the accuracy portion of "Australian Round" (see 8.1).

If the boomerang lands outside the 10 metre circle or the thrower touches the boomerang, the thrower receives no points. If the boomerang touches a circle line, the mid-score of the two circles is given. For this competition, I would recommend a boomerang which flies neither too high nor too far. It should not have too much spin when it returns or it will tend to bounce usually away from the bullseye. You should use only as much strength as necessary when throwing.

8.3 Australian Round

In Australian Round, points are awarded for accuracy, catching and distance. Catching within the 20 metre circle earns 4 points and outside earns 2 points. Points for accuracy are counted even if the boomerang isn't caught. In addition to the circles for Accuracy there are 30, 40 and 50 metre lines. Distance points are awarded based on the largest circle the boomerang crosses before returning. Distance points are awarded only if you received points either in accuracy or in catching (see 8.1). All players make 5 throws, and the results are added together. Up to 100 points can be scored.

When the wind is not turbulent, throw the largest range boomerang you can get bulleyes with. In windy or turbulent conditions, when accurate returns are elusive, use a 50 metre boomerang. If you catch it within the 20 meter circle you can earn a total of 50 points for range and catching, and if you catch within the 10 metre circle, you will receive additional accuracy points.

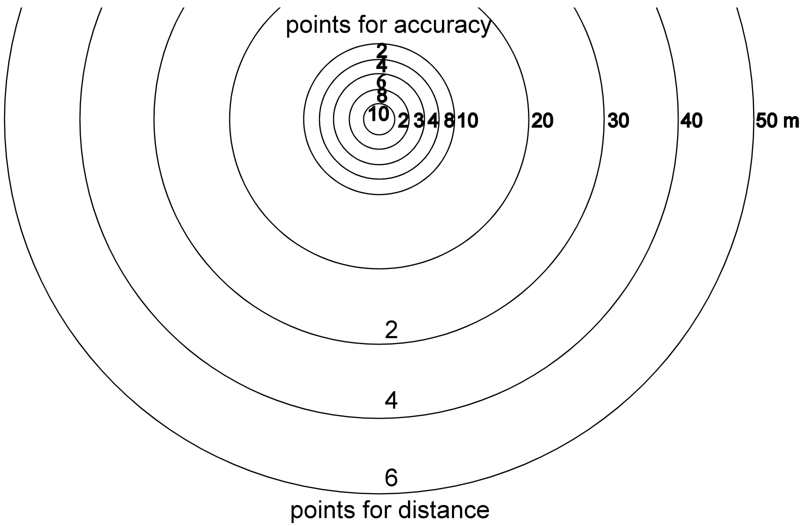


Figure 8.1: Accuracy and distance points

8.4 Trick Catch

This game consists of 2 parts.

8.4.1 Part 1

10 different catches are required. You receive points for each successful catch. The catches are as follows:

1. Left-hand clean catch (2 points)
2. Right-hand clean catch (2 points)
3. Two-hand catch behind the back (3 points)
4. Two-hand catch under the leg (3 points)
5. Eagle catch (4 points)
6. Hackey catch (6 points)
7. Tunnel catch (6 points)
8. One-hand catch behind the back (7 points)
9. One-hand catch under the leg (7 points)
10. Foot catch (10 points)

It is best to use a boomerang which flies relatively high and which hovers down slowly to the thrower. Use a boomerang that has reduced spin at the end of its flight to make catching easier. If it has too little spin, however, it will be unstable and unpredictable, and more difficult to catch.

8.4.2 Part 2

The aim is to throw two boomerangs simultaneously (figure 8.2) and catch both with the following trick catches:

1. Catch behind the back; Catch under the leg
2. Left hand catch; Hackey catch
3. Right hand catch; Tunnel catch
4. One-hand behind the back; One-hand under the leg
5. Eagle catch; Foot Catch

Figure 8.2: Double Grip

Use two boomerangs with the same point of return, but a different flight path and duration. One boomerang should return quickly, the other should hover longer. This will give you enough time to catch the second after catching the first. If the boomerangs touch each other shortly after the launch, they will be difficult to catch (at best) ; one or both may stop spinning and fall. In order to avoid this, you can grip the "Outsider" by arm 1 and the "Insider" by arm 2 or vice versa. Or try making the Outsider heavier or swap the Outsider with the Insider (see also section 5.2). The most unusual pair of Doublers I have seen in practice, was a Fast Catch and an MTA.

8.5 Fast Catch

The object is to throw one boomerang and catch it 5 times as quickly as possible. Time starts at the first throw and ends after the 5th catch when the thrower touches the 2 metre circle. All throws are made from within the 2 metre circle. The boomerang must pass the 20 metre line on each throw for the catch to count. The best boomerang for this competition is one which returns fast that you can catch reliably. Suitable boomerangs have many different shapes and sizes. But they all have one thing in common: they don't have much lay-over. This can be achieved through a specific shape, (see Chapter **??**), a certain airfoil or tuning - usually, a combination. Fast Catch boomerangs tend to fit into two categories. One has quite a high drag and needs a strong throw - when these return, they have nearly no spin so they are easy to catch. The other has a low drag and doesn't require a strong throw but still flies fast. Fast Catch boomerangs are often thrown with a tilt of 0° or less and on the whole, can't take much wind.

I prefer the type of Fast Catch boomerang with a high drag. This means that the boomerang has to be thrown very hard but is harmless in the final stage of flight and easy to catch. This is an advantage for saving time. The Fast Catch should be tuned to 22 – 23 metres. Even if the flight time is longer, you can ensure that the boomerang flies 20 metres if there is a gust of wind or if the throw is poor.

8.6 Long Distance

Long Distance boomerangs are thrown from the centre point of a 40 metre base line. The returning boomerang must fly over this line (see figure 8.3), otherwise the throw doesn't count. It is not necessary to catch the boomerang. Generally speaking, the heavier the model, the better it is. Long-distance boomerangs are usually weighted with lead or made out of a heavy material. The hook shape is most preferable.

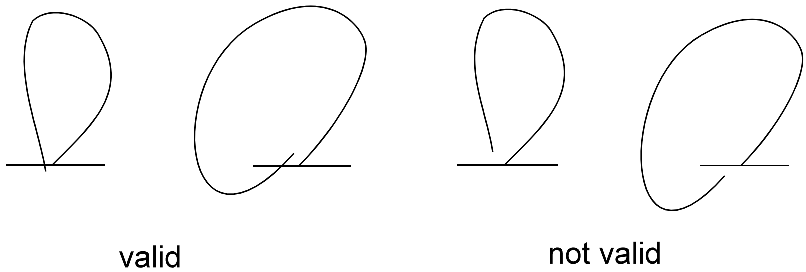


Figure 8.3: Valid and unvalid flight

The difficulty in construction is that you need to produce just enough lift to support the heavy boomerang long enough for it to return. Too much lift causes a premature turn - and shorter range. You normally throw at a tilt of 45° or more and with a lot of force. Most Long Distance boomerangs need a medium to strong wind. They should only be thrown on VERY large fields. Make sure there are no people around as Long Distance boomerangs can easily get out of control! They can fly a long distance in any direction.

8.7 MTA 100 - Maximum Time Aloft in 50 metre circle

The object of this event is to keep the boomerang in the air as long as possible, before catching it. The longest time in five tries is your score. Throw from within the 50 metre circle (100 metres in diameter, which is why the event is called MTA 100) and then catch - also within the 50 metre circle. The throw doesn't count if thrown or caught outside this circle. Arm 1 of the conventional MTA shape is much longer than Arm 2. The inventor of this MTA shape is Wilhelm Bretfeld from Norderstedt, Germany. Ted Bailey (USA) has refined Bretfeld's designs. Most of the MTA's currently used in competition are based on these refinements. Ideal weather conditions for MTA are low temperatures with strong sunshine and a light wind (thermal). On such a clear day, the boomerang might even stay in the air for minutes.

If the wind isn't too strong, you can use a wooden MTA, however, with more than 2 or 3 beauforts it is better to use a phenolic MTA. You should make the most of the 50 metre circle. The ideal position for launching is to stand on the circle line with the wind blowing from you toward the centre point. Try to get a good average time first and then risk aiming for a better time.

8.8 Juggling

Juggling is done with two boomerangs. One boomerang should always be in the air, while the other is caught and thrown. The event continues until one is dropped. Score is the number of catches made consecutively. It is preferable to use two similar boomerangs. They should fly high and descent slowly providing plenty of time to decide where to catch and where to throw the next boomerang.

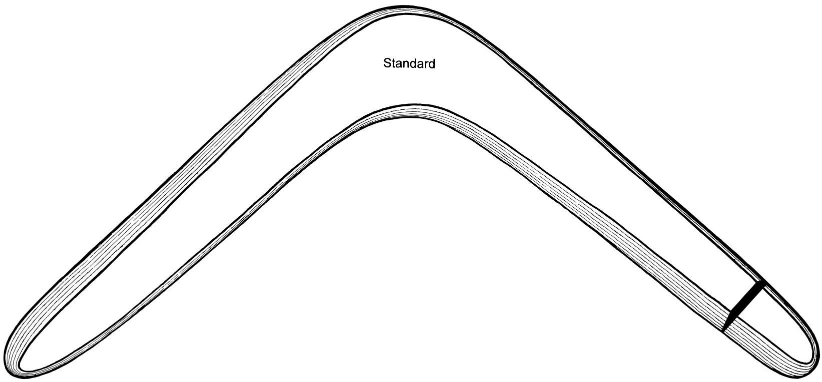
Chapter 9

Boomerang Plans

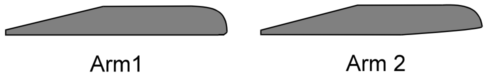
The following descriptions indicate characteristics and options for the boomerangs which can be adopted when constructing these boomerangs. For further details see previous chapters.

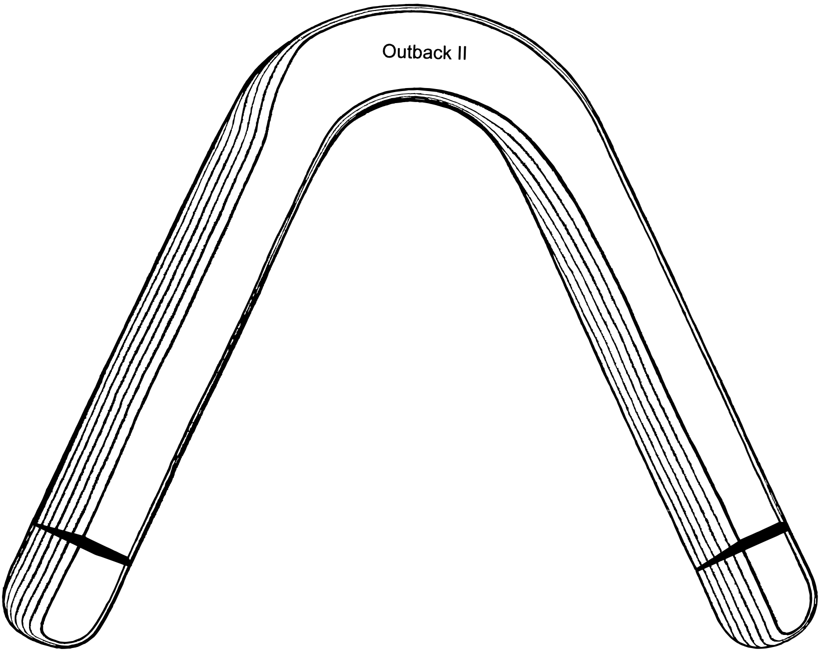
9.1 Standard

Shape:	Michael Siems (Germany)
Use:	Boomerang for beginners
Flight distance:	approx. 20 metres
Thickness/material:	4-5 mm finnish birch plywood
Weight:	80 g / 2.85 oz.
Airfoil:	
Underside:	Try a slight undercut on both arms.
Tuning:	Slight positive dihedral on both arms.
Wind:	0 - 2 Beaufort (see Appendix, Wind force)



9.2 Outback II

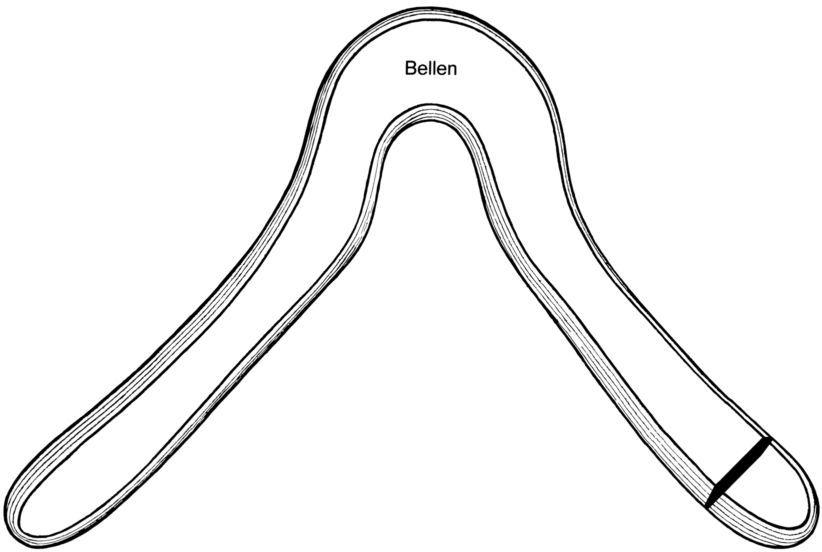
Shape:	Doug DuFresne (USA)
Use:	Boomerang for beginners, Trick Catching
Flight distance:	approx. 20 - 30 metres
Thickness/material:	4 - 5 mm finnish birch plywood
Weight:	75 g / 2.7 oz.
Airfoil:	
Underside:	Pronounced undercut on arm 2 from elbow to wing tip.
Wind:	0 - 2 Beaufort (see appendix, Wind force)



9.3 Bellen

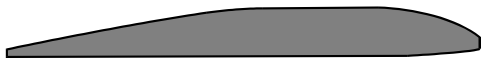
Shape: Michael “Gel” Girvin (USA)
Use: Boomerang for beginners, Trick Catching, Accuracy, Juggling
Flight distance: Approx. 20 metres
Weight: 72 g / 2.6 oz.
Thickness/material: 4 - 5 mm finnish birch plywood
Airfoil:

Underside: Try a slight undercut on both arms
Wind: 0 - 3 Beaufort (see appendix, Wind force)
Special features: John Flynn and Michael „Gel“ Girvin both held the world record in Juggling with „Bellens“

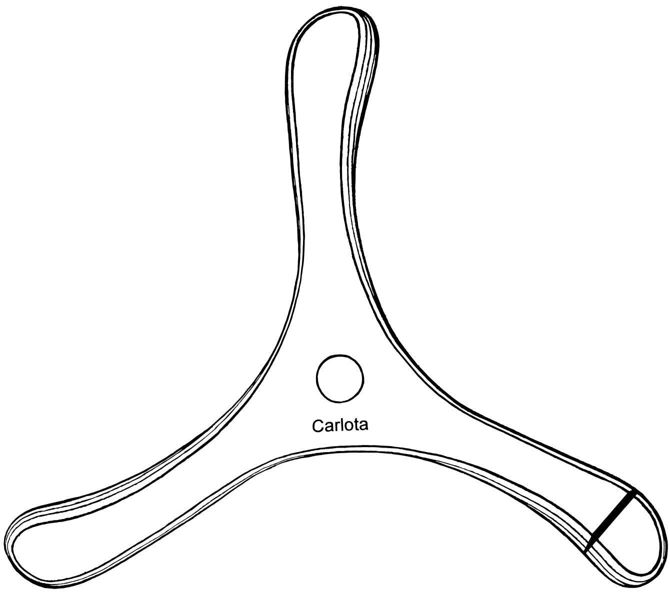


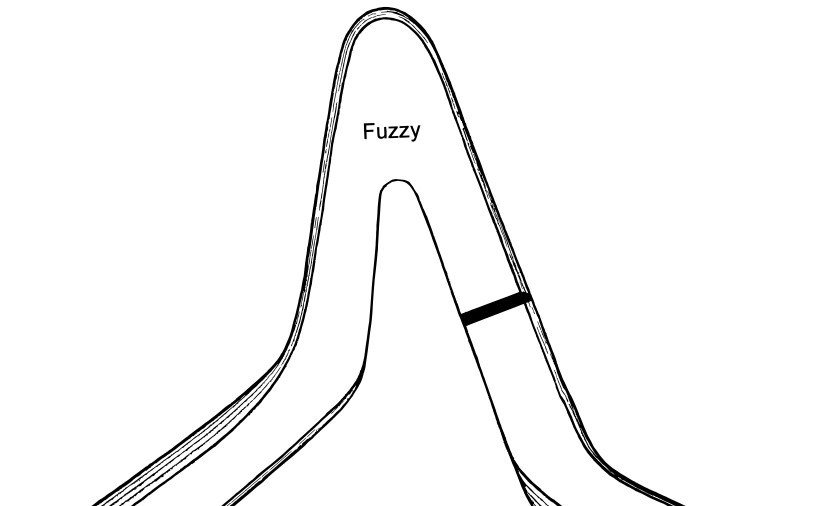
9.4 Carlota

Shape: Michael "Gel" Girvin (USA)
Use: Trick Catching, Juggling, Doubling
Flight distance: Approx. 20 metres
Thickness/material: 3 - 4 mm finnish birch plywood
Weight: 40 g / 1.4 oz.

Airfoil: 

Holes: There should be holes on the ends of a pair of doublers
Wind: 0 - 2 Beaufort (see appendix, Wind force)
Special features: Two Carlotas, as similar as possible, should be used for Juggling. Doubling should be performed with a boomerang with holes in the wing tips or flaps at the centre of the wings.




Fuzzy

9.5 Fuzzy

Shape: Axel Heckner (Germany)

Use: Trick catching, Accuracy, Fast Catch, Australian Round

Flight distance: Approx. 20 - 50 m, depending on the features

Thickness/material: 4 mm finnish birch plywood

Weight: Between 35 g / 1.25 oz and 70 g / 2.5 oz.

Airfoil:

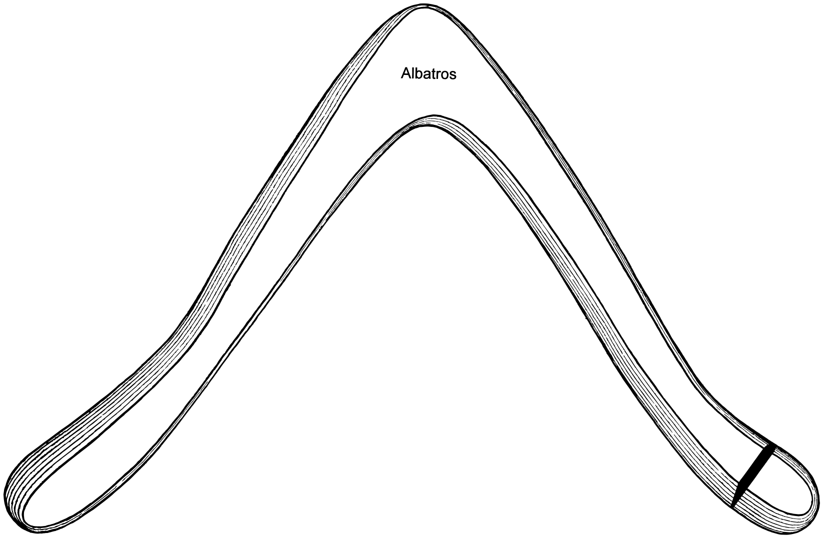
Underside: Try slight undercut on both arms

Wind: 0 - 4 Beaufort (see Appendix on Wind force)

Flight path: Circular, flies at one level, lies flat at end of flight

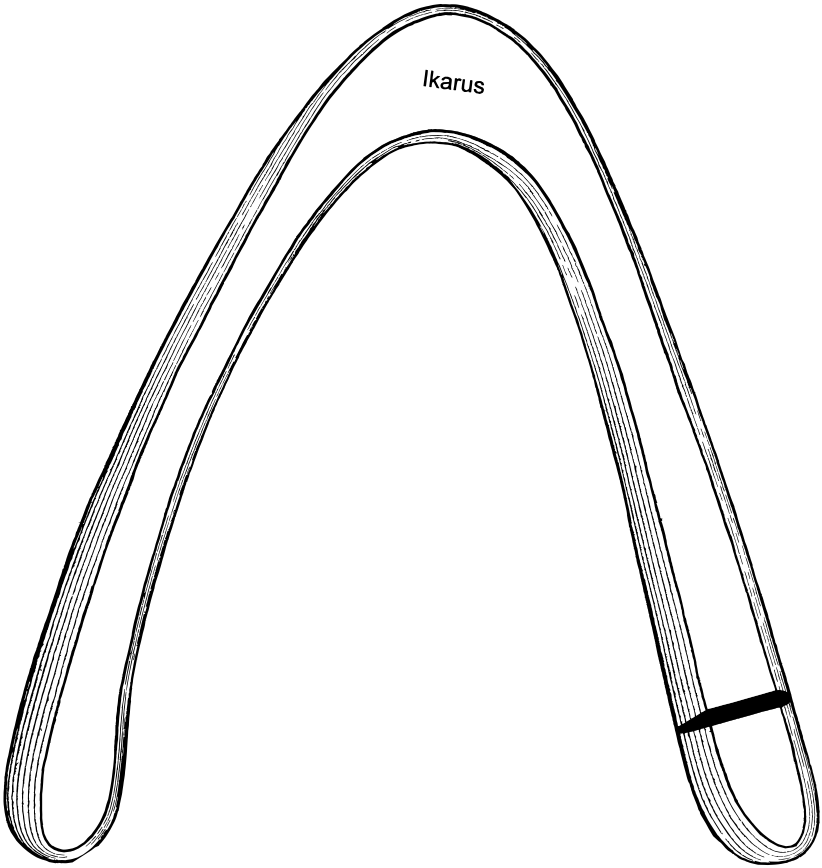
Tips: Weights close to the centre of rotation make it unusually stable in wind

Special features: A very accurate return. By adjusting weights at the wing tips, it is easy to adjust the distance. Wheighted, Fuzzy can have a range of up to 50 metres


Albatros

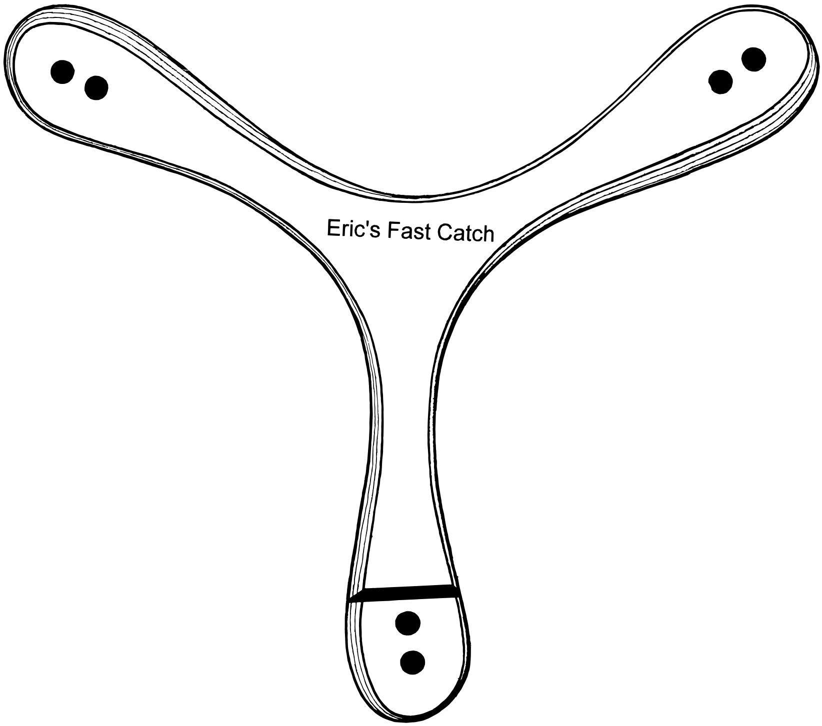
9.6 Albatros

Shape:	Michael Siems
Use:	Australian round
Flight distance:	50 - 60 metres
Thickness/material:	5 - 6 mm finnish birch plywood
Weight:	100 g / 3.6 oz.
Airfoil:	
Underside:	Slight undercut on both arms
Weights:	10 mm diametre lead weights in both arms, in addition tape two small coins on top of arm 1 and one small coin on top of arm 2 on the middle of the airfoil
Tuning:	very slight positive dihedral on both arms
Wind:	1 - 4 Beaufort (see appendix on Wind force)
Throw:	80° angle to the wind, 30° - 45° tilt, 0° height of throw. If there is little wind, use more tilt and angle to the wind and throw lower
Flight path:	Big circle, flies fairly low
Tips:	The 6 mm thick Albatros returns even if there isn't much wind

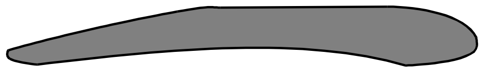

Ikarus

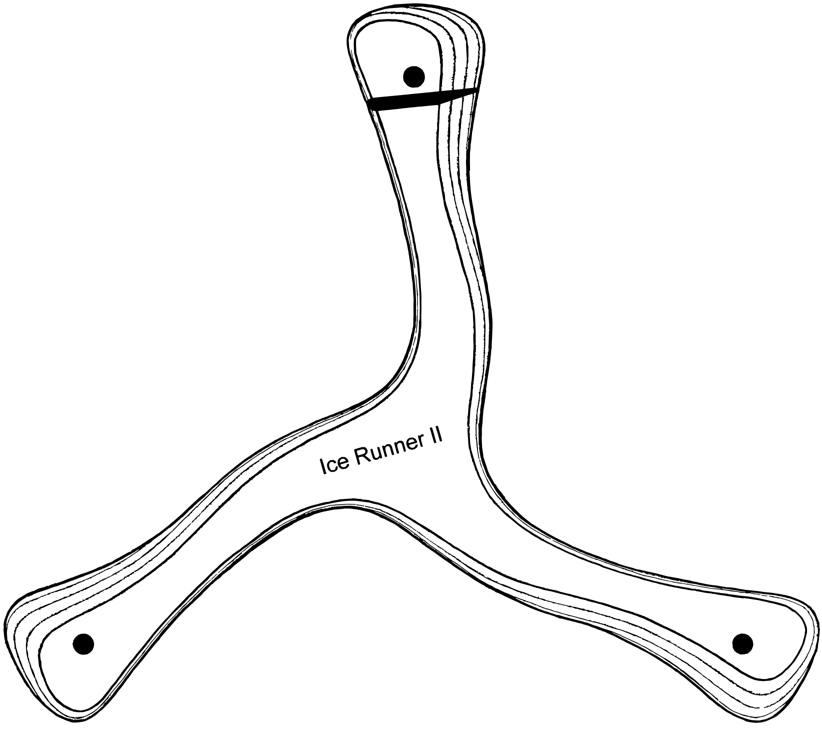
9.7 Ikarus

Shape:	Axel Heckner
Use:	Australian Round
Flight distance:	Approx. 50 metres
Thickness/material:	5 - 6 mm finnish birch plywood
Weight:	70 g / 2.5 oz.
Airfoil:	
Underside:	An undercut on the leading- and trailing edge
Weights:	With a weight on arm 1, distances of up to 80 metres can be reached. If the boomerang flies too low, put a small weight on the elbow or arm 2
Wind:	0 - 1 Beaufort, up to 4 Beaufort with a weight on arm 1 (see Appendix on Wind force)
Throw:	80° angle to the wind, 20° - 30° tilt, 0° - 5° above horizontal angle
Flight path:	Circular, low and steady
Tips:	If it is a clumsy flight, more undercut will help on the leading edge especially on arm 2
Special features:	Flies surprisingly far for a wooden boomerang and needs little wind. With a thickness of 5 mm, it can fly approx. 40 metres and needs a bit more wind


Eric's Fast Catch

9.8 Eric's Fast Catch

Shape:	Eric Darnell (USA)
Use:	Fast Catch
Flight distance:	Approx. 20 metres
Thickness/material:	4 mm finnish birch plywood or a TriFly (see Appendix on boomerang manufacturers)
Weight:	30 g / 1.1 oz.
Airfoil:	
Weights:	Possibly wrap tape around the wing tips (2 to 5 times) to reach the required distance. Holes: one to two holes (7 - 10 mm / 1/4" - 3/8") on the wing tips on all arms
Tuning:	Negative dihedral and positive angle of attack on all arms.
Wind:	0 - 2 Beaufort (see appendix on Wind forces)
Throw:	Approx 80° angle to the wind, 0° height of throw and -5° to 5° tilt
Flight path:	Circular and low
Tips:	The tuning is very important with this boomerang. By tuning you can adjust the distance and height
Special features:	Because of the holes, the boomerang must be thrown very hard (and is therefore very fast), it will return with little rotation and translation speed, but is easy to catch


Ice Runner II

9.9 Ice Runner II

Shape: Fridolin Frost

Use: Fast Catch

Flight distance: Approx. 20 metres

Thickness/material: 4 mm in finnish birch plywood or polypropylene

Weight: 35 g / 1.25 oz in wood; 40 g / 1.4 oz in polypropylene

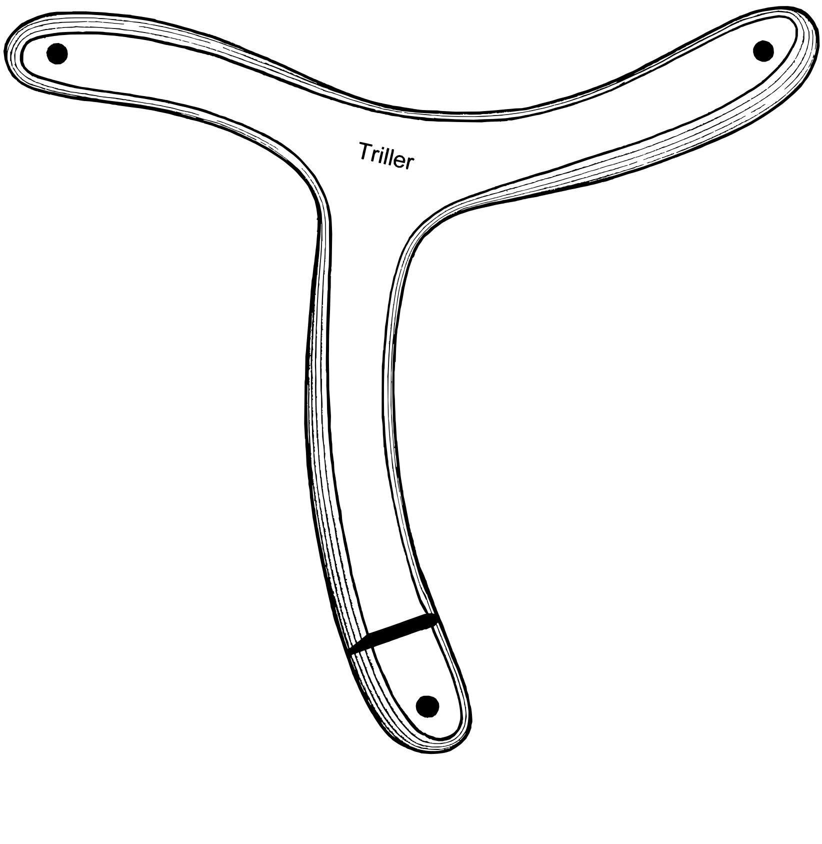
Airfoil: 

Underside: Try slight undercut on all three arms

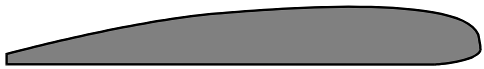
Weights: Wrap tape around the wing tips. (1 - 3 times) in order to reach the required 20 m if necessary. Throw: approx. 80° angle to the wind, approx. 0° height of throw, -5 to 5 tilt

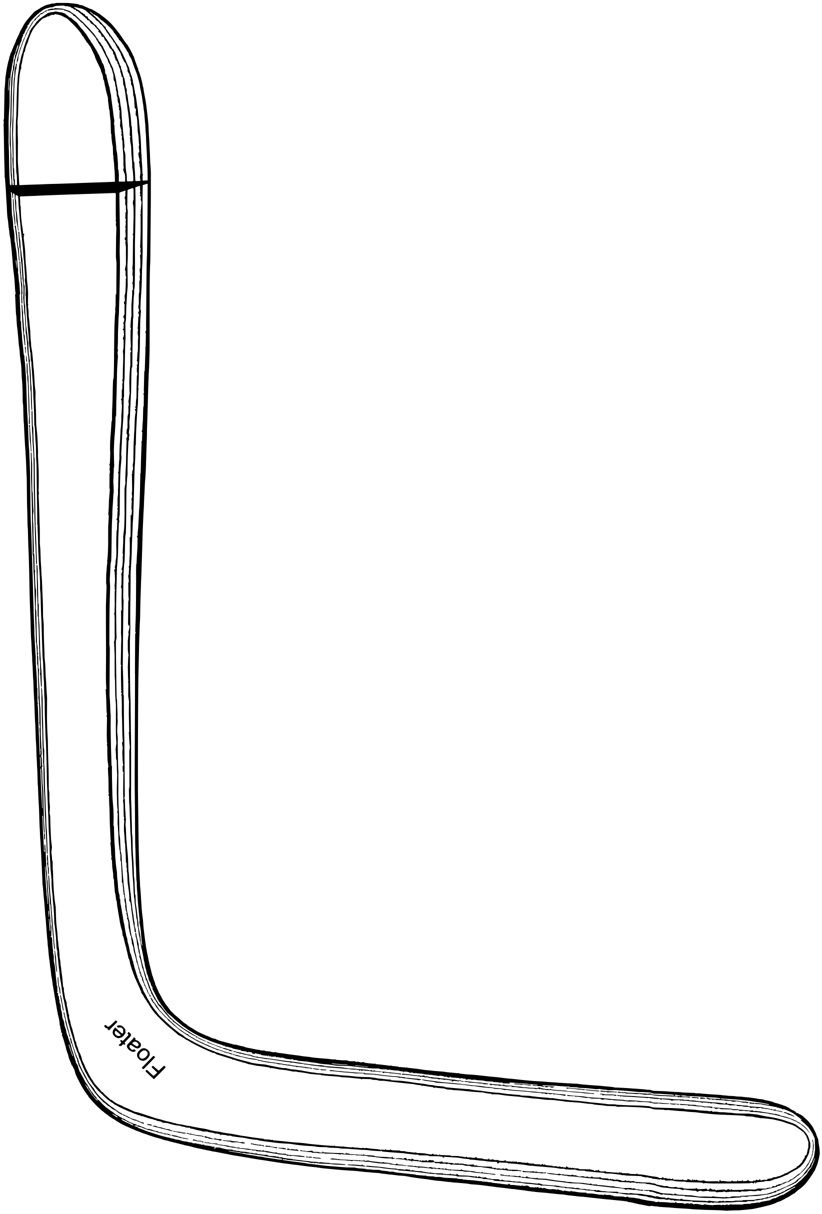
Flight path: Circular, low, fast return

Tips: Depending on the force of the throw, you might need dihedral: if it suddenly crashes to the ground, you will need positive dihedral, if it flies too high towards the end of the flight, negative dihedral is needed


Triller

9.10 Triller

Shape:	Axel Heckner
Use:	Fast Catch
Flight distance:	Approx. 20 metres
Thickness/material:	4 mm finnish birch plywood
Weight:	37 g / 1.3 oz.
Airfoil:	
Underside:	Slight undercut along the whole of the airfoil, on all three arms
Weights:	Wrap tape around the wing tips (1 - 3 times) to reach the required 20 metres distance if needed
Wind:	0 - 1 Beaufort (see appendix on Wind forces)
Throw:	Approx. 80° angle to the wind, approx. 0° tilt, -5° - 5° height of throw
Flight path:	Circular, low, fast return
Tips:	If the triller is too fast, it can be slowed down and wind stabilized by putting holes or flaps on the wing tips
Special features:	It flies extremely fast, even with a gentle throw. If it is windy, the boomerang can be wind stabilized roughening the wing tips. and attaching small weights

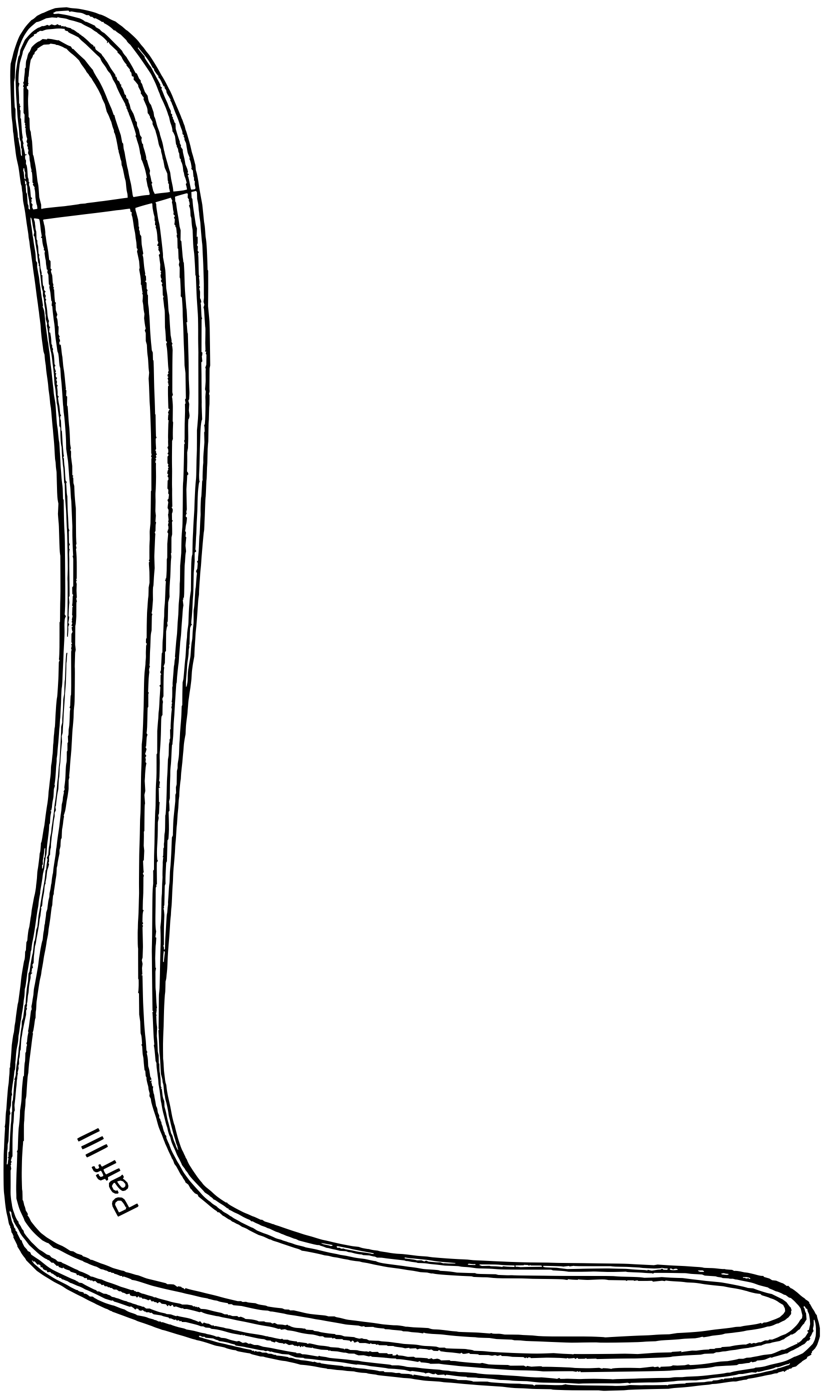

Floater

9.11 Floater

Shape: Ted Bailey (USA)
Use: Maximum Time Aloft (MTA)
Flight distance: 20 metres in wood
Thickness/material: 2 - 3 mm wood
Weight: 25 g / 0.9 oz.

Airfoil:

Upper surface: As smooth as possible
Tuning: Arm 1: positive dihedral 6 - 10 mm; positive angle of attack 1 - 2 mm. Arm 2: positive dihedral 2 - 5 mm; negative angle of attack 0 - 1 mm
Wind: 0 - 2 Beaufort (see Appendix on Wind forces)
Throw: 5° - 10° angle to the wind, 30° - 50° height of throw, -10° - 20° tilt
Flight path: Rises immediately and lies flat. At a height of about 10 - 30 metres it reaches the hovering phase and slowly descends with the wind
Remarks: It is very difficult to tune and throw an MTA boomerang. Beginners should be advised by experienced throwers


Paff III

9.12 Paff III

Shape: Günter "Tapir" Möller (Germany)

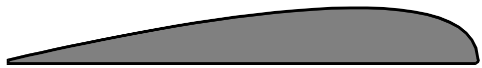
Use: MTA

Flight distance: 40 - 50 metres in Phenolic, 20 - 30 metres in wood

Thickness/material: 2 mm Phenolic, 2 - 3 mm wood

Weight: 30 g / 1.1 oz in Phenolic, 25 g / 0.9 oz in wood

Airfoil:



Surface: As smooth as possible

Tuning: Arm 1: positive dihedral 6 - 10 mm; positive angle of attack 1 - 2 mm . Arm 2: positive dihedral 2 - 5 mm; negative angle of attack 0 - 1 mm

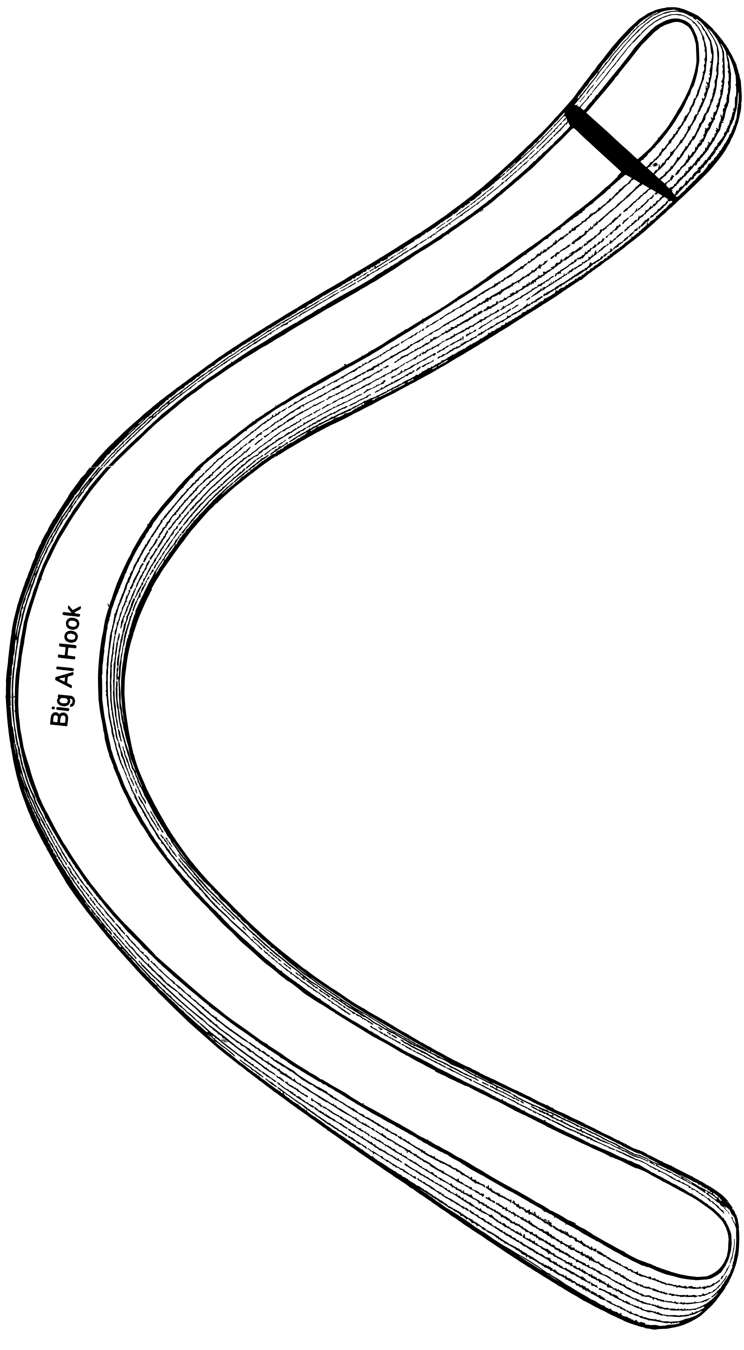
Wind: 1 - 4 Beaufort (see appendix on Wind force)

Throw: 5° - 10° angle to the wind, 30° - 50° height of throw, -10° - 20° tilt, throw very hard with lots of spin

Flight path: A boomerang made of phenolic will fly straight ahead for about 40 m, rises continuously and then lies itself flat. At a height of approx. 25 - 40 metres it reaches the hovering phase and descends slowly

Observations: It is very difficult to bend and throw a MTA. Beginners should be advised by experienced throwers

ATTENTION: MTA boomerangs take up a lot of space and often crash, especially when learning, therefore, make sure that there is nobody on the playing field


Big Al Hook

9.13 Big Al Hook

Shape:	Al Gerhard (USA)
Use:	Long distance
Flight distance:	70 - 120 metres
Thickness/material:	6 mm finnish birch plywood
Weight:	90 g / 3.2 oz - 136 g / 4.9 oz fully weighted
Airfoil:	
Surface:	Smooth
Weights:	Add weights on both wing tips
Tuning:	Slight positive dihedral on arm 1
Wind:	1 - 5 Beaufort (see appendix on Wind force)
Throw:	60° angle to the wind, 0° height of throw, 40° - 50° tilt, throw hard
Flight path:	Very long ellipses, almost circular

Chapter 10

Dictionary

Eagle catch A catch imitating a hunting eagle performed with a multi-winged boomerang. You catch the boomerang with one hand from above by closing your fingers around the center of the boomerang.

Foot catch Just what it sounds like. A catch performed by catching the boomerang with your feet. Your feet are not allowed to touch the ground while catching and the boomerang has to be hold a few seconds.

Lay-Over Layover generally refers to the boomerangs angle to vertical. The greater the angle, the more layover. It can also refer to the act; the boomerang lays-over from a vertical position to a horizontal position.

Tunnel catch A catch performed by standing with both feet on ground, while catching the boomerang between the legs. This means you have to have one hand behind your legs and one hand in front and then “sandwich” the boomerang while passing it between your legs with one hand.