An Introduction to Boomerangs

Third Edition

by John B. Mauro

1989

"GOOD, MISS HUTCHINS, BUT I THINK OUR REGULAR INTER-OFFICE MEMO SYSTEM MIGHT WELL SERVE US BETTER!"

An Introduction to Boomerangs

Third Edition

by John B. Mauro

1989

Published by Smith & Flannery, Inc.
Richmond, VA

Illustrations by Donna Pinnix and Brenda Martin
Richmond, VA

Cartoons by Chuck Stiles
Riverside, CA

Printed by Spectrum Press
Richmond, VA

Table of Contents

(continued next page)

Preface

Many people have heard of boomerangs. The word itself is used often to describe something that returns or something that flies in the face of itself. Many people have never seen a boomerang fly, however. They joke about boomerangs and generally do not take boomerangs seriously. Many think a boomerang is a toy only for children.

To the few who take boomerangs seriously, it is a sport which connects physical agility to intellectual stamina. Once you catch on to boomeranging, you never want to let go. You go deeper and deeper into its soul and you find yourself holding on tighter and tighter.

Like snowflakes, no two boomerangs are alike, although each may be manufactured or handcrafted in an identical manner.

Much has been written about what makes a boomerang go out and return. Current knowledge probably explains about 80% of the phenomenon. The other 20% is anyone's speculation. A well-designed boomerang will return reasonably well when not thrown exactly as it should be thrown. Conversely, a badly-constructed boomerang may return satisfactorily when it is thrown well. For example, a boomerang with proportionately less lift in design than intended will perform well if thrown with more force and if thrown with a bit more sidearm (layover). In essence, the thrower starts the return process by the manner of the throw. Therefore, one cannot separate the throw from the design of the boomerang.

A baseball pitcher can throw the same curve regardless how many different baseballs he uses. Not so with a boomerang. No two boomerangs behave identically and no two boomerangs can be thrown identically.

How quickly a boomerang returns, how long it stays in the air, how well it hovers, how far it goes out, how wide its orbit, and how well it handles the wind all have to do with the design and construction as well as the manner of throw. All these factors enter into the sport of boomeranging. Perhaps that is why the boomerang often has been called the thinking man's frisbee.

EARLIEST THEORY OF BOOMERANG

SIR ISAAC NEWTON!

THE THINKING MAN'S FRISBEE

History of the Boomerang

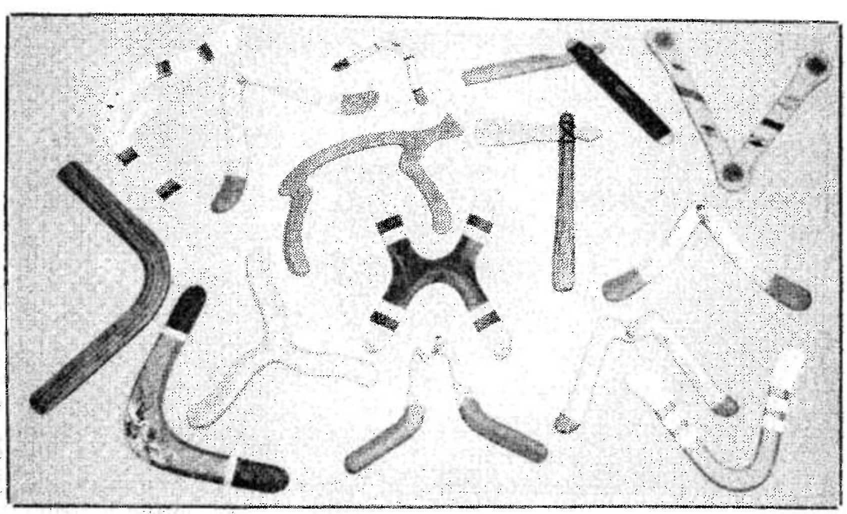
Little is known about the origin of the boomerang. The oldest known boomerangs are between 11,000 and 15,000 years old.

A probable theory is that primitive hunting societies in Australia and elsewhere used sticks, rocks and spears for hunting purposes. Anything that improved distance and accuracy would be important to such societies. It is likely that the non-returning boomerang was discovered by trial and error. But having been discovered and its benefits appreciated, it was probably copied and subsequently improved upon. The value of the boomerang was in its precision and its ability to be thrown farther. In those days a spinning boomerang cut a swath 30 inches or so wide giving its thrower more margin for error.

The returning boomerang probably was developed from the earlier non-returning type and is used only for sport. It would be hardly effective against most animals or birds.

The boomerang's greatest value to man is in its intellectual stimulation of its design variations and the physical agility required to throw and catch it successfully.

As is the practice, one needn't be an expert to find the boomerang an adventuresome and enthralling sport.

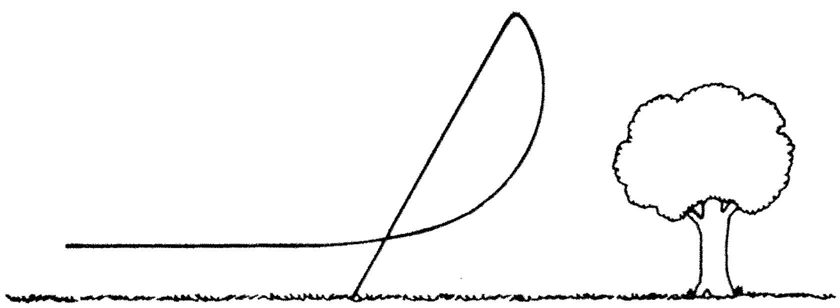


Why A Boomerang Returns

There are two scientific principles that govern the flight behavior of a boomerang: One is the principle of aerodynamic lift and the other is the principle of gyroscopic precession. Both principles work in concert to provide a circular path.

The arms of a boomerang are constructed similarly to the wings of an airplane having a contoured top and a flat bottom. Sometimes the leading edge of the underpart of the arms at the tips is cut to increase the lift of that arm. Suffice it to say at this point, the arms of a boomerang resemble airplane wings, but when thrown, spin like a propeller.

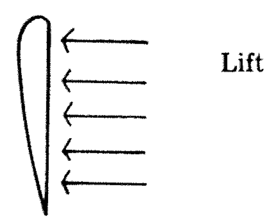
If the boomerang is spinning horizontally when launched, it will just climb high and then dive straight down - no circle.



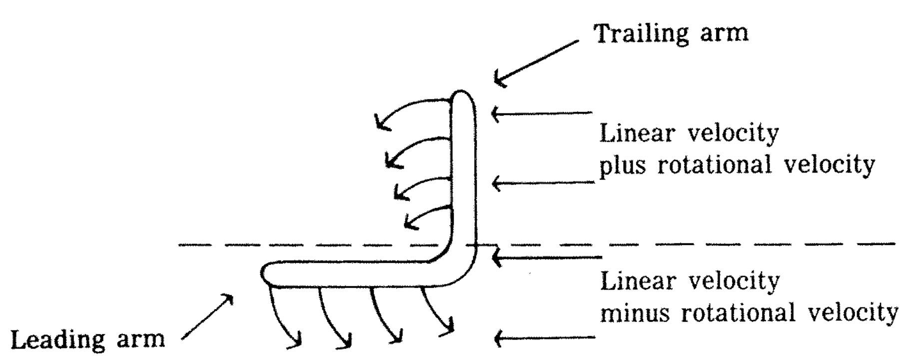
For a boomerang to circle, it must be thrown rotating in basically a vertical plane. When this is done, the lift generated by the forward moving and spinning arms is horizontal or sideways (not upward), and the direction of the lift will be away from the contoured side of the arms.

These conditions suggest that it is possible to have boomerangs that will turn clockwise or counterclockwise. But since the spin and throw are always in the forward direction, boomerangs must be designed so that the flat surface is always on the outside of the thrower. Ergo, there are left-hand boomerangs and right-hand boomerangs. Since most persons are right-handed, we shall use right-hand boomerang concepts to make all subsequent analogies.

When a boomerang is thrown vertically or near vertically, the lift is horizontal from the flat side of the arms.



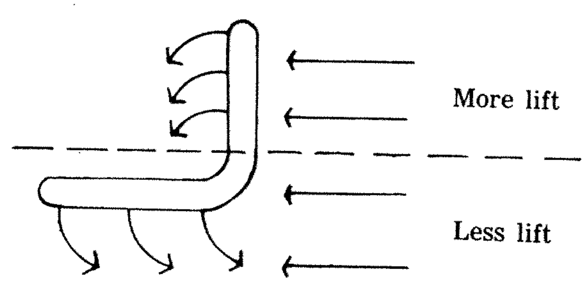
But since the boomerang is spinning at the same time, when one arm is at the top, the forward movement and the spin movement are in the same direction. Therefore the velocities are added.



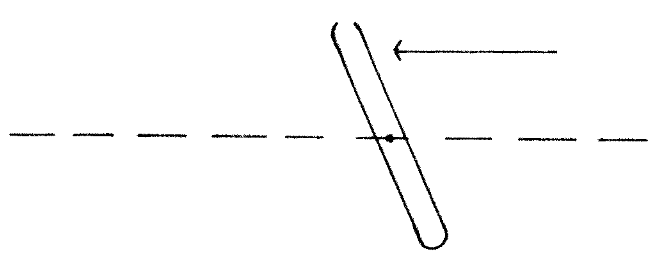
When the arm is at the bottom, its spin movement is in the opposite direction of the throw movement. Accordingly, one is subtracted from the other. We have here a condition in which each arm, when it is at the top, moves through the air substantially faster than it does when it is at the bottom.

The principle of aerodynamic lift stipulates that the amount of lift created by an airfoil is in direct proportion to the speed by which the air travels past it. In other words, a wing having the same airfoil contour traveling faster through the air will generate more lift than the same wing traveling through the same air at a lesser speed.

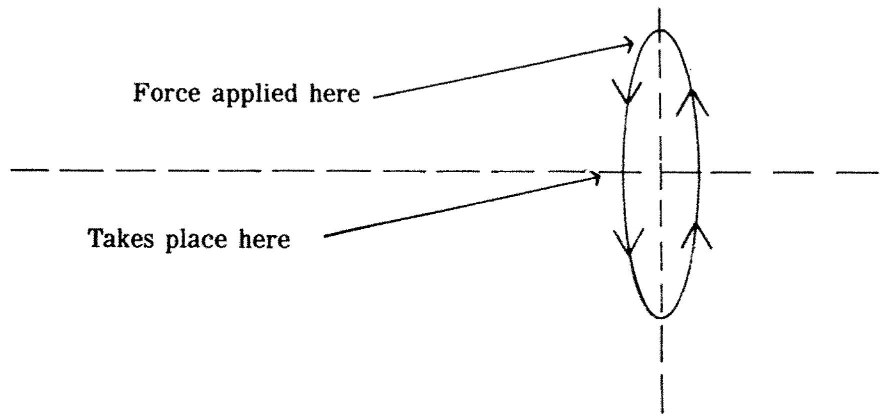
In that case, the boomerang arm at the top of the spin is moving through the air substantially faster than the arm at the bottom of the spin. This generates more lift at the top than at the bottom.



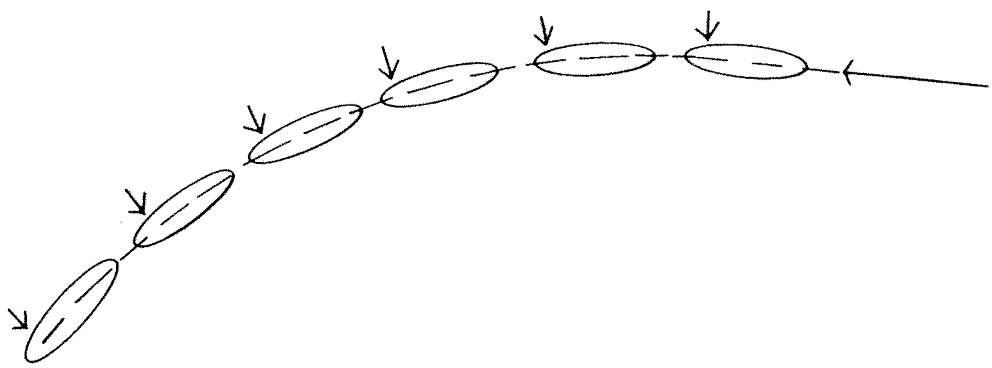
If would seem that a boomerang thrown vertically, having more lift at the top than at the bottom, would tilt from the top as illustrated.



But this does not happen because of the principle of gyroscopic precession which simultaneously has its effect. This principle stipulates that if a force is applied to a spinning body in one direction, the movement actually takes place 90° forward, in the direction of the spin.



Accordingly, the force does not tilt the boomerang from top down but from right to left (of a right-hand boomerang).



Ergo! The turning of a boomerang.

Why a Boomerang Lays Down

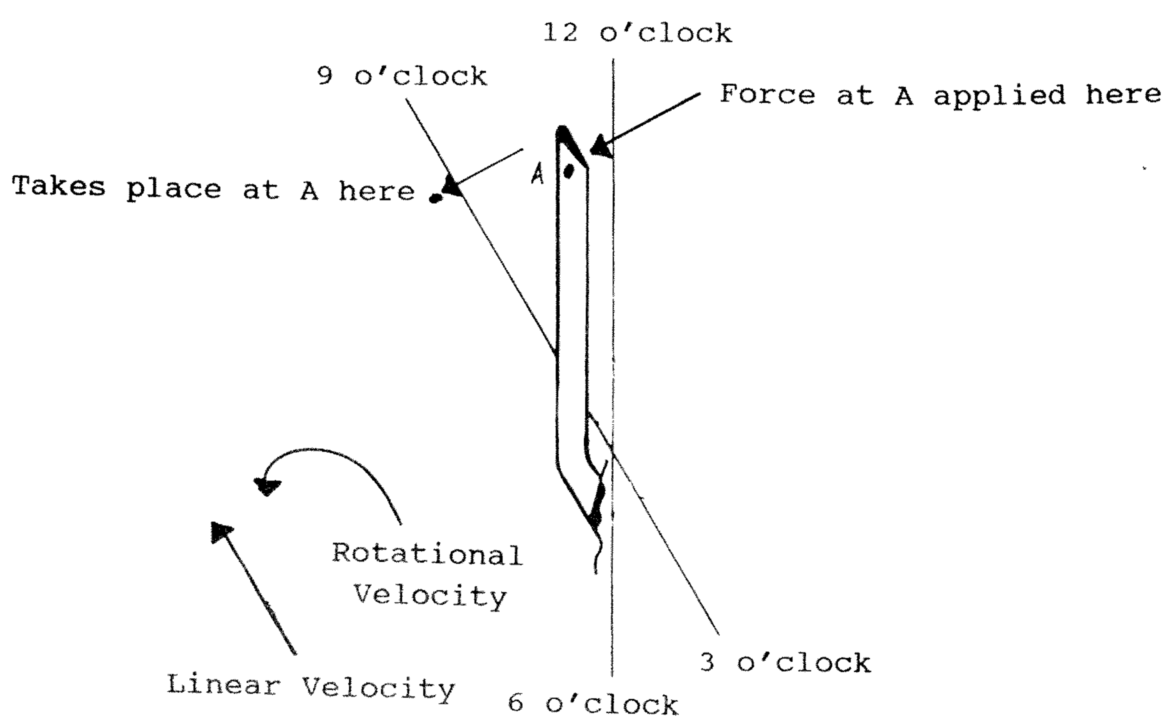
But, the boomerang has another quality that makes its flight all the more beautiful to behold. The boomerang lays down on its return so that it gently lands top side up.

There have been several theories on why a boomerang, launched vertically, returns in a horizontal position. The most logical of these explanations comes from Raymond Rieser, former treasurer of the United States Association, in an unpublished manuscript, 1986.

This theory suggests that the laying down quality is the result of the boomerang's asymmetric shape which develops difference in lift by each arm as the boomerang moves forward and spins through the air. The leading arm is always in front of the axis of rotation while the trailing arm is always behind the axis of rotation. A symmetrical cross-type boomerang having its center of lift at the same point at the axis of rotation experiences no lay down. This idea was supported by experiments by Dr. P. Musgrove, 1973.

To illustrate Rieser uses two positions of the boomerang in flight: when the leading arm, and trailing arm, is at maximum lift - when each is at 12 o'clock. He views the function from the perspective of the axis of rotation. When the leading arm is at 12 o'clock, the lift force is applied at point A, above and forward of the axis of rotation.

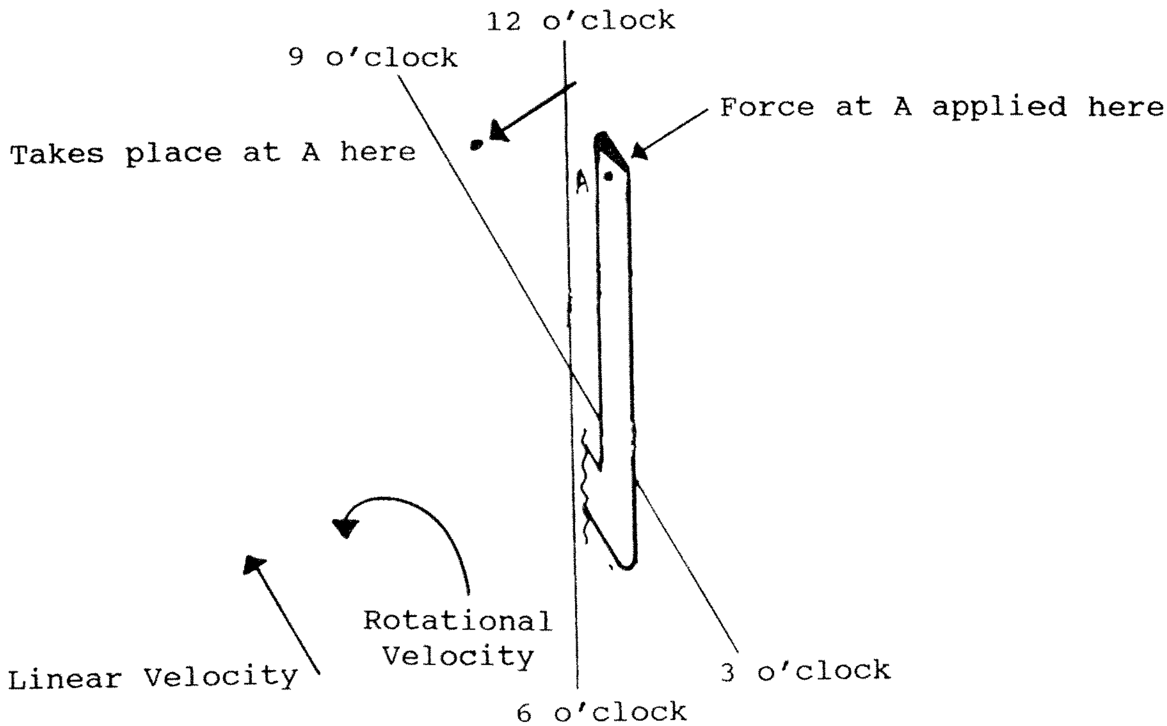
<u>Leading Arm at Position of Maximum Lift</u>



Since the boomerang is rotating the lift force precesses 90 degrees ahead, and takes place slightly below the 9 o'clock position. This force is forward of the axis of rotation causing the boomerang to turn, and since it is below the axis it causes the boomerang to lay down.

When the trailing arm is in the 12 o'clock position, the lift force acts at point A, which is above and behind the axis of rotation. Again, because of precession this force acts 90 degrees ahead and slightly above the 9 o'clock position. Since this force is forward of the axis of rotation it also causes the boomerang to turn, but since it is above the axis, it opposes laydown.

Trailing Arm at Position of Maximum Lift



Role of the leading arm

More lift: Produces faster turn and quicker laydown

Less lift: Produces slower turn and slower lay down

Role of trailing arm

More lift: Produces faster turn and slower lay down

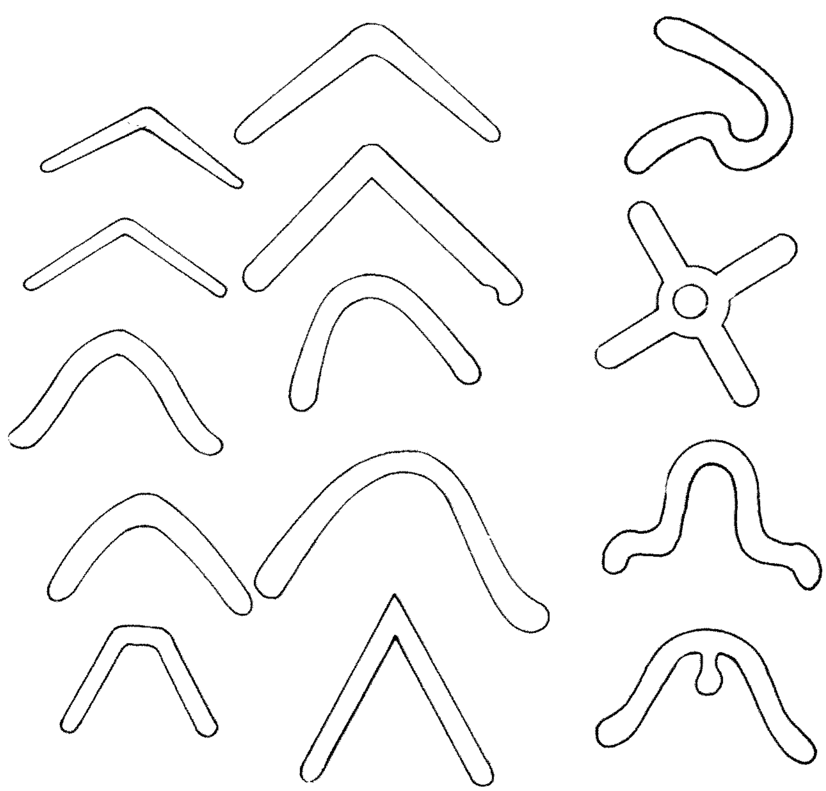
Less lift: Produces slower turn and quicker laydown

Design and Construction

Obviously, the amount of lift built into the boomerang during construction, the difference in lift between arms, its overall weight and area, and the manner of throw all have a bearing on how a boomerang performs in the air. And, since we cannot quantify the amount of lift on either arm or both without a great deal of difficulty, the only reliable method of fine-tuning a boomerang is by trial and error.

Various Shapes

Boomerangs can be designed in various shapes and sizes as illustrated below, and made of various materials.



Design Factors

1) Lift: Airfoil, dihedral, angle of attack

2) Angle between arms

3) Length, width and thickness of arms

4) Density of material, weight distribution, overall weight

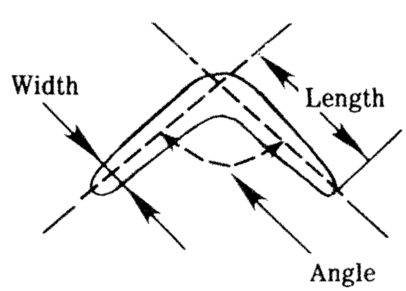
General Dimensions

If you can't seem to get started in constructing the first boomerang, this simple rule will give you at least a beginning until you develop your own skills. One way to make a boomerang is to construct both arms the same size. This will provide you with a well-balanced boomerang. Using a fairly good one-quarter-inch thick 5-ply plywood will give you a reasonably strong boomerang.

The following rule usually applies to a 5-ply birch or some very similar density plywood one-quarter inch thick. It probably will not apply to other materials that are more or less dense.

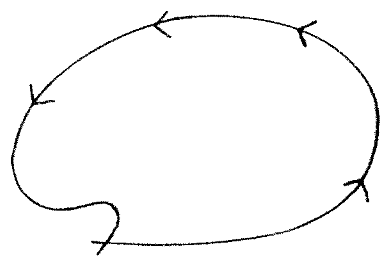
The rule is simple: Let the width of the arms be equal to the thickness of the material divided by .16 and the length of the arms be equal to the width divided by .16, or the thickness divided by $.16^2$.

A 1/4" thick plywood would provide a boomerang arm widths of 1/4/.16 or 1 9/16". Length of each arm, $1/4/.16^2$ or 9 3/4". A blank designed L-shaped with these dimensions should provide the foundation of a well-performing boomerang.



Lift Considerations

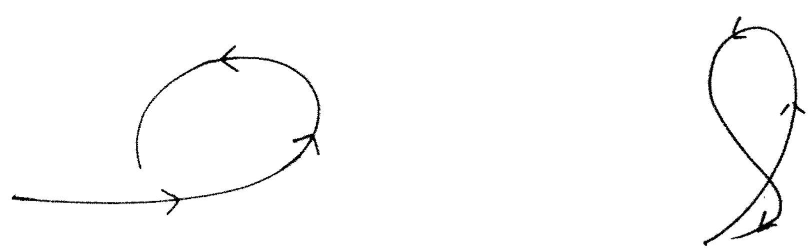
Generally when both arms of a boomerang have equal lift, the boomerang, if launched properly, will return well. On its return it will hover topside up and gently drop down at the feet of the thrower.



More lift applied to a boomerang overall will tighten the circle it will circumscribe.

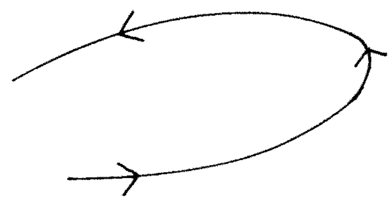
It follows that less lift in relation to the same mass and area will produce a wider circle and would require more launching force. If there is insufficient lift overall, the boomerang will drop to the ground before completing its orbit.

Disproportionately more lift on the leading arm usually will result in the boomerang lying down prematurely and returning substantially in front of the thrower. If launched with great force, the flight is likely to result in a figure 8 or S-shaped path.



Disproportionately less lift on the leading arm will produce a slower turn and a slower lay down.

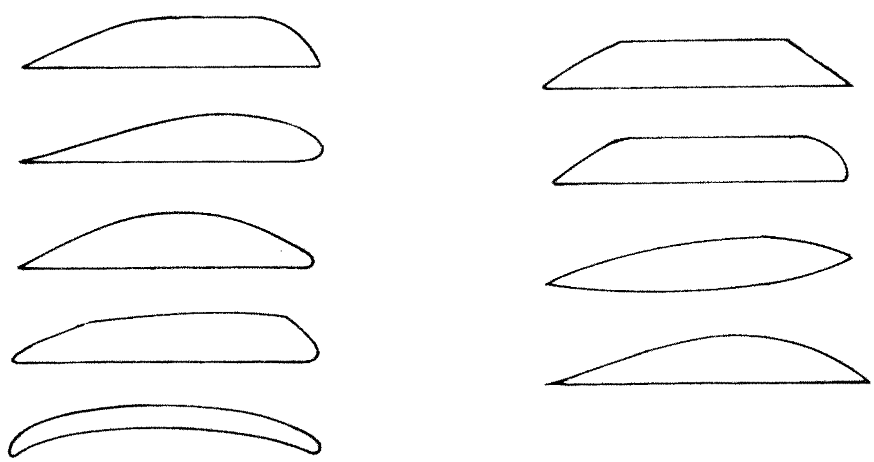
Disproportionately more lift on the trailing arm produces a faster turn and a slower lay down usually resulting in an incomplete or a U-shaped return.

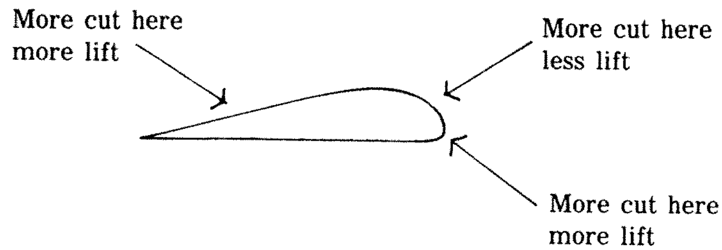


Disproportionately less lift on the trailing arm produces a slower turn and a quicker laydown.

Airfoils

Airfoils can be shaped in many ways for desired effects.





To Produce More Lift

>More undercut at the leading edge of the arms, particularly at the tips.

>More cut at the top of the trailing edge of the arms.

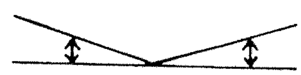
>Hollow out the underside of the arms, although the popular concept is to keep the underside of the arms flat.

>Thicker arms will generally produce more lift but will also produce more drag causing the boomerang either to lose spin prematurely, produce only a partial return, reduce hovering quality, or all three.

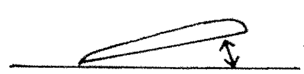
>Rough the upper portion of the arms while keeping the bottom smooth.

>Positive dihedral - maximum approximately 15 degrees.

Dihedral



>Positive angle of attack - maximum 18 degrees; more than that will increase drag.



Angle of Attack

>Reduce weight evenly throughout the boomerang.

To Produce Less Lift

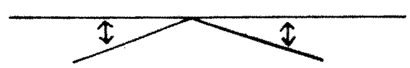
>More cut at the top of the leading edge of the arms.

>Thinner arms.

>Less cut at the top of the trailing edge of the arms.

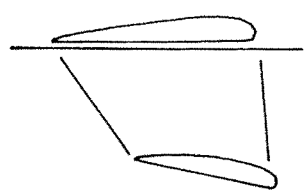
>Smooth upper portion of arms.

>Negative dihedral.



>Negative angle of attack.

>Washout - negative angle of attack at the tips of the arms.



>Add weight evenly throughout the boomerang.

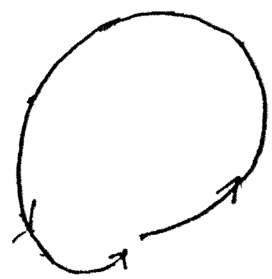
Angle Between Arms

Generally, angles between arms range from 70° to 140°. Boomerangs having angles less that 70° and more than 140° are basically unstable.

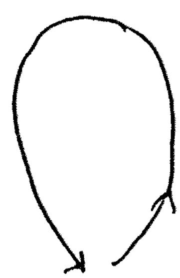
Reducing the angle between the arms will result in a small increase in the distance the boomerang will travel.

Findings of an empirical study of three boomerangs having different angles (Mauro, 1988) show that, although all the boomerangs tested were identical in dimensions and had the same range in flight, the boomerang with the smallest angle between the arms circumscribed the most circular path.

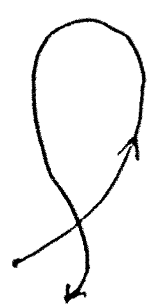
It was observed that a boomerang having 70° between its arms consistently circumscribed an almost perfect circle going slightly past the thrower then turning to the thrower as illustrated below.



A 90° boomerang consistently flew in an elliptical-shaped path.



A 100° boomerang consistently circumscribed a path similar to an S, returning in front of the thrower and attempting to go around the thrower from the other side as illustrated.



The traditional 90-degree angle boomerang seems to circumscribe a flight path desirable for most of the current competitive events.

Dimensions of Arms

Generally, wider arms (larger chords), with all other dimensions kept constant, produce less lift, greater spin retention, and require a stronger throw. Thinner arms produce the same effect.

Arms that are narrower (smaller chords) often produce more lift and consequently more drag. It follows that thicker arms often produce the same results.

Longer arms usually generate less spin retention.

Weight and Weight Distribution

Weight can be distributed evenly throughout the boomerang by adding heavy paint or some similar covering.

Weight for a given area is an important factor in determining distance - i.e., more weight in the same design will make a boomerang travel farther.

Heavier or denser material will generate greater distance for the same design area.

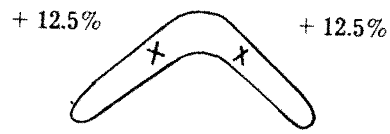
Shaping usually will reduce the weight of a boomerang blank by about 20%.

Adding weights without increasing launching force will result in less laydown or drop prematurely.

Adding Weights for Desired Effects

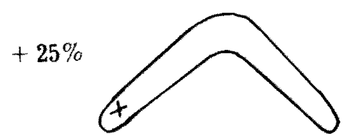
Adding 25% more weight in various locations on a V-shaped test boomerang produced consistently different flight patterns as a result of the location of the additional weight.

*To make a boomerang wind resistant without increasing distance, place equal weights on each arm close to the elbow as illustrated below.



Similarly, adding weight in the above position will reduce its laying down quality.

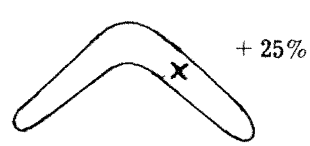
*Adding weight to the tip of the trailing arm will increase distance substantially.



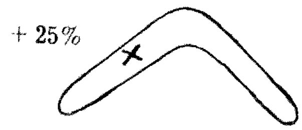
It will also reduce or eliminate laydown, change its flight so it goes straight out, zoom upward and quickly come down in front of the thrower forming a figure 8 or S.

*Adding weight to the tip of the leading arm will increase its distance significantly while creating a delayed, U-shaped return with little or no laydown.

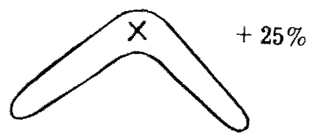
*Adding all of the additional weight to the leading arm closer to the elbow produces less laydown; is likely to retain spin better; reduces distance by about 20%; and climbs less.



*Similarly applying all the additional weight to a section near the elbow on the trailing arm reduces distance by about 20% also; produces less laydown; climbs substantially higher; and makes a tighter circle.

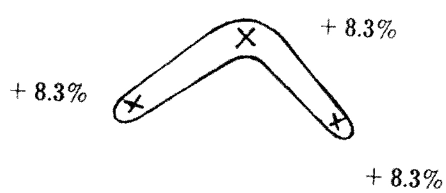


*Applying all the additional weight to the elbow will reduce distance by about 20%. It will also reduce laydown but will return well.



*Distributing the added weight one-half at the tip of each arm will increase distance substantially, produce a fair flight while reducing its laydown.

*Adding one-third of the additional weight at each of the wing tips and at the elbow will increase distance substantially, produce a similar flight path as the un-weighted boomerang, and improve spin retention.



Factors That Should Increase Distance

1. More weight overall within the same design
2. Greater proportion of weight at the wing tips
3. Less airfoil lift
4. Shorter arm length
5. Narrower arm width (chord)

Factors That Should Increase Spin Retention

1. Shorter arms
2. Wider arms - greater chord
3. Thinner arms
4. More weight at the elbow and wing tips
5. More taper at wing tips

<u>Note.</u> It is difficult to isolate one dimension for change without affecting another. For example, it would be impossible to make arms narrower without affecting overall weight or without changing the contour of the airfoil. Similarly, it would be difficult to increase the arm span without increasing its weight. Weight could likely remain the same if less dense material were substituted, but that becomes another boomerang. You can see, therefore, that a change in one dimension causes change in other dimensions. sometimes changes in other dimensions cancel the original effect desired.

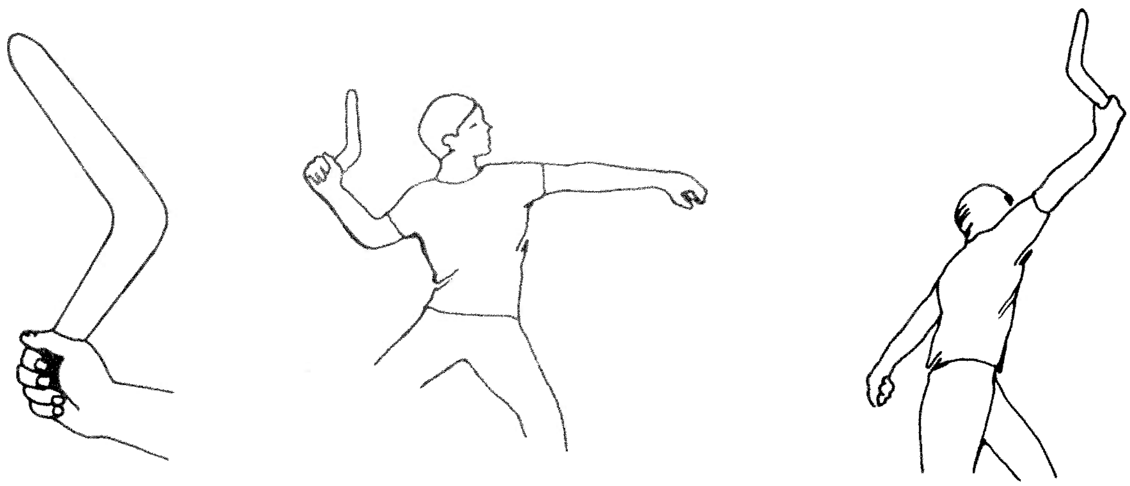
<u>Elements of Throwing and Catching</u>

General Considerations

Conditions for throwing are a large, grassy field away from people and objects, and a calm day. Usually, boomerangs function best when there is no wind or when there is only a slight breeze. Windy conditions will cause boomerangs to go astray, land unpredictably and possibly cause damage, although some experts and long distance throwers prefer a steady, light breeze and use it effectively.

Manner of Holding and Throwing

The boomerang is held in the manner illustrated here. It may be gripped by as many fingers as desired and held by the tip of either arm. It is hardly ever held at the elbow. The boomerang is always held with its flat side facing away from the thrower. It is thrown overhand at an angle close to 90 degrees from the horizon.



Throwing Factors

1. Angle of throw (overhand vs. sidearm)
2. Direction of throw in relation to wind
3. Height of aim (straight ahead, upward, or downward)
4. Force of throw
5. Amount of spin

Angle of Throw

(/) - Often called Layover Angle

(View facing thrower)

*Each boomerang has its own built-in throwing angle based on its design and the desirable angle will be discovered by trials.

*A totally vertical throw overhand (|), usually will produce a return in front of the thrower.

*A totally horizontal (—) throw, sidearm, will produce an immediate laydown. The boomerang will soar straight up and accordingly drop straight down.

*A desirable angle of throw is somewhere between (/) vertical and horizontal. Gènerally, the boomerang flight will be level until it completes the first half of the flight. On its return, it usually will rise and then as it gets closer to the thrower will lay down.

*A boomerang thrown with somewhat more sidearm (⁄) will climb excessively on return, drop excessively and generally perfrom a rocking effect.

*Under certain conditions - usually when there is a strong wind - it may be desirable to reverse the tilt (\ ) slightly. Some expert throwers do this.

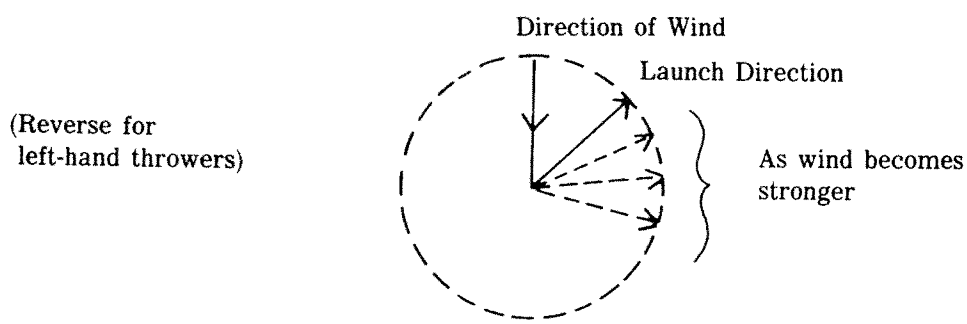
The Throw Relative to the Direction and Speed of Wind

*Usually, a boomerang is launched in the direction about 2 o'clock or 45° to the right of an oncoming light wind if right-handed, and at 10 0'clock or 45° to the left of an oncoming wind if left-handed.

*It usually is necessary to adjust the direction of launch more toward 3 0'clock, 4 o'clock, or 5 o'clock as the wind velocity increases.

*When there is no wind, the boomerang may be launched in any direction.

*If a boomerang that ordinarily returns well but at this particular time returns to the left of the thrower, the aim should be directed more to the right of the wind direction, and vice versa.

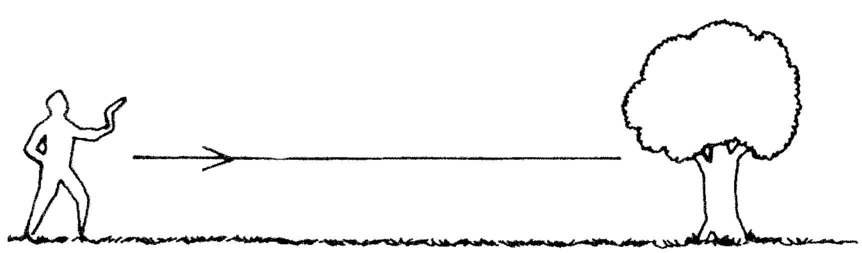


Height of Aim

*Generally, a boomerang is thrown straight out - neither up or down.

*If more time aloft is desired, the boomerang should be thrown in a more upward direction and with substantially greater force and less layover.

*A downward throw is hardly ever desired, except when used by experts for certain desired effects.



Force of Throw

*Each boomerang should be thrown with precisely the correct amount of force based upon its design dimensions.

*If a boomerang is thrown with substantially more force than required, it may go past the thrower or may not hover.

*If a boomerang is thrown with insufficient force, it will fall before completing a full return.

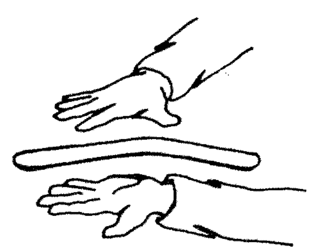
*Often trials are needed to adjust to the required launching force.

Spin

*Sufficient spin must be given to complete the flight process. If a boomerang is thrown with little or no spin, it will not perform. Although the exact amount of spin is not important, getting a sufficient amount of spin is important. As mentioned earlier, the linear velocity working in tandem with the rotational velocity causes the boomerang to return. Therefore, it is better to have more spin than not enough.

Catching Technique

*The safest way to catch a boomerang is by clasping it between the palms of the hands, sandwich style.



*One-hand catch may be made by catching the boomerang between the thumb and the other fingers reaching for the hole which the boomrang appears to make when spinning.

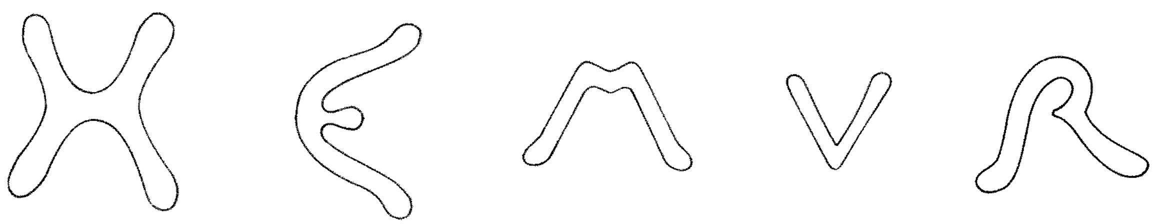
Different Shapes for Different Purposes

For the Fun of It

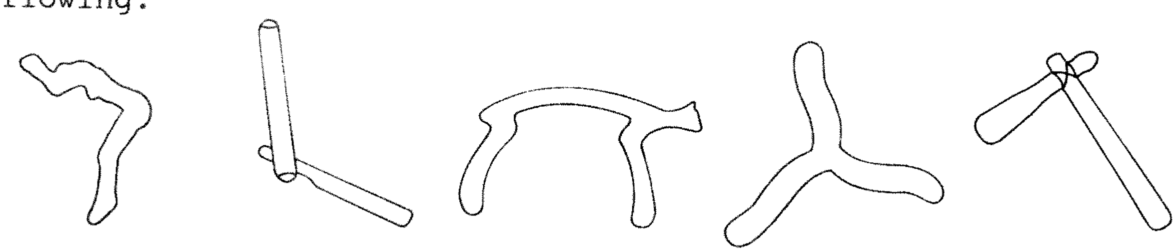
Traditionally, the returning boomerang is shaped like an L or a banana as some people describe it. Although the traditional shape remains the most popular, modern man's curiosity and inventiveness and his desire to beat his competitors spawned a generation of different boomerang shapes.

The whole idea of a boomerang today is for it to return accurately to the thrower, since hunting with a non-returning boomerang is not a practice of the "civilized" man.

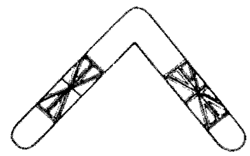
Today the curious have successfully designed boomerangs in just about every letter of the English alphabet.



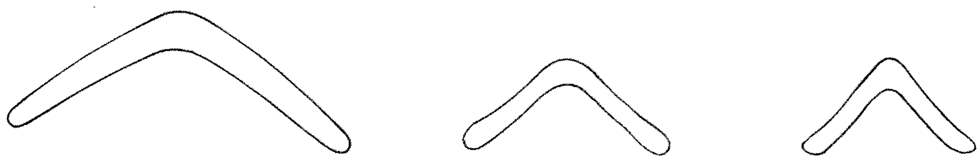
Other experimenters designed successfully-returning boomerangs in shapes of objects such as a tomahawk, straight razor, etc. and whatever else starts the imaginative current flowing.



For novelty and esthetics some boomerangs are constructed with inlaid wood or other materials of different colors displaying flag designs or patterns appealing to the maker. One man inlays silver used by dentists for filling teeth. Usually these boomerangs return fairly well, for that is the object of a boomerang. But persons acquiring such delicately constructed boomerangs usually use them for dispaly purposes, after they make an initial toss to see if, in fact, the boomerang returns well. No self-respecting boomeranger ever hangs up a boomerang before determining if it will return appropriately. A boomerang that doesn't return is called a stick regardless of its cosmetic appearance. Usually, these beautifully-constructed boomerangs are made in the traditional shape. Unfortunately only one of these is available for illustration.



Some boomerang affecionados let nature select the shape. They scour the forests for boomerang-shaped tree limbs or roots.



For A Competitive Advantage

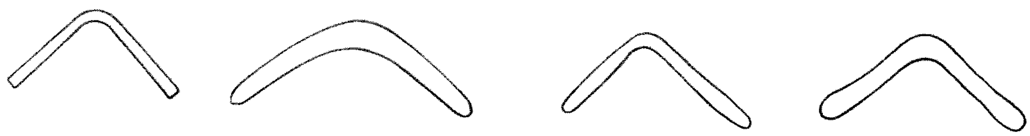
Unlike other sports such as football or baseball which have the dimensions of the instrument of play exactly specified, boomerang competitors have the freedom, and thus the responsibility, to select the instrument they will use in competition. A good competitor physically may do badly in a particular competitive event if the boomerang used is not suited for that event, and a less physically agile competitor may do better because his boomerang is more suited to the event.

Recently there was a general agreement on competitive events within boomerang associations of the world. Knowing how the sport is to be played, created new interest in boomerang shapes, not for curiosity's sake, but to gain a competitive advantage in these newly defined competitions. In addition, materials other than wood, intelligence on application of ballast and other scientific aerodynamic principles were sought to gain better prediction of flight behavior. The most confounding of these paths has been the effects of different boomerang shapes.

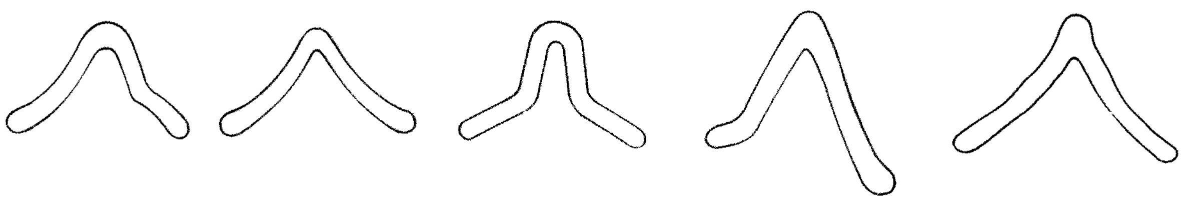
Most of the new shapes have been developed by repeated trials. Little has been written about flight behavior caused by varied shapes, and no hypotheses have been tested. The best a designer can do is to try a certain shape, tune it as best as possible, and if the boomerang's flight behavior is not as expected, then the process is begun all over again.

Current boomerang shapes come in four general categories:

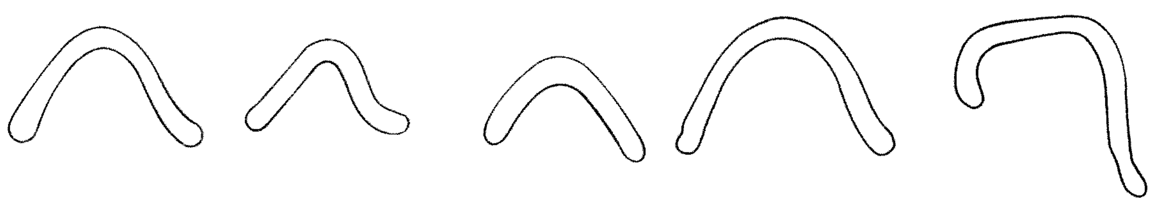
<u>Traditional</u>. Usually the traditional-shaped boomerang has an angle between the arms from 90 degrees to 120 degrees. Both arms are approximately equal in length, although either the leading or the trailing arm may be shorter (or longer, depending on how you view it) to create certain flights effects. The arms are approximately straight.



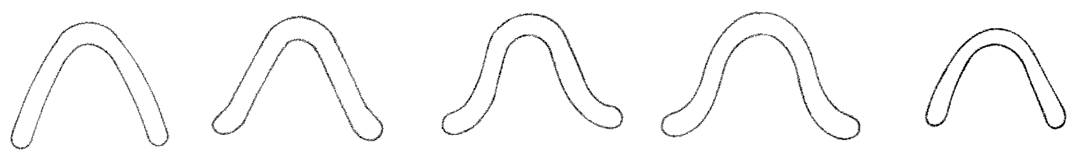
<u>V Shape</u>. This design is similar to the traditional, except that the angle is less than 90 degrees. Usually the arms are symmetrical, often straight but sometimes flared.



<u>Hook</u>. As its name implies, this shape resembles a hook, having a well-rounded elbow. It is hardly symmetrical. The tip of the leading arm is often carved for convenient gripping. Other designs have a much shorter trailing arm more closely resembling a hook. The angle between the arms is always less than 90 degrees.



<u>Omega</u>. This term hardly describes this category of boomerang shapes, but somehow it became universally used, so it remains. Omega-shaped boomerangs generally resemble a parabola having well-rounded elbows and symmetrical arms. Angles between the arms are less than 90 degrees.



Construction materials vary. The most popular material is birch plywood usually in five ply but also in seven or ten ply. Polypropylene has become a popular material with small manufacturers. Aluminum, paxolin, figerglas, or other high density materials are used by long distance throwers to achieve more distance.

There are probaly as many competitive events as there are varieties of trees. Those accepted by serious boomerangers require both physical and intellectual skill. Virtually all require accuracy of return and a catch. To make competition more difficult obstacles such as speed, distance, or difficulty of catch are put into the events so that it is not just a simple throw, return, and catch.

The most universal competitive event is appropriately called the <u>Australian Round</u>. This event requires each competitor to launch his boomerang from a small center circle of a target drawn on the field similar to the target on a dart board but of a much larger dimensions. The closer the boomerang lands to the center of the target, the more points the competitor receives. Additional points are earned for extra distance the boomerang travels, and even more points are earned if the boomerang is caught before landing on the ground. Competitors are graded on total number of points.

Boomerangs shaped in any of the four categories are suitable for this event, although the Omega and the V shape have recently gained in popularity. The idea here is to design a boomerang that travels just, but not substantially more than, the prescribed distance for the maximum number of distance points while returning accurately with a little hover to permit the thrower to get under it for an easy catch, but not so much hover as to be affected by the wind.

The <u>Accuracy</u> event is designed for all kinds of throwers, the young, the old, the experienced, and the inexperienced. One launches a boomerang from the center of a target drawn on the ground. Points are earned according to the place the boomerang lands on the target. Competitors are graded on number of points.

Since no catch is required, the Accuracy event may take any shape of boomerang. Usually it is a boomerang designed with substantial lift to keep it short range, just beyond the required distance. Weights are added to the center of each arm to reduce hover thus minimizing the effect of wind. The traditional shape has been the most popular for this event.

The most sought after record is that of Distance. The idea here is to launch a boomerang from a prescribed base line so that it travels a long distance, usually more than 100 meters and returns past and within the limits of the base line. No catch is required because of the extreme weight of the boomerang and its speed as it returns. As a consequence this event has been eliminated from many tournaments. Grading is based on the distance a boomerang travels as it begins its return.

Omega and Hook shapes recently have been preferred by distance throwers using boomerangs made of wood. Weights are added to the tips of the arms to gain distance and to effect an ellipical-shaped flight pattern with no hover. The same affects are achieved by traditional-shaped boomerangs constructed using more dense materials such as paxolin.

Fast Catch is an event that requires speed and accuracy. The event calls for five consecutive throws and catches made from a small circle drawn on the ground. The returning boomerang may be caught outside of the circle but must be launched each time from within the circle. Competitors are graded on the least amount of time to complete five consecutive catches.

The boomerang for this event is usually V-shaped (for ease of catching) having extraordinary lift to maintain a short range. Weights are usually added to the center of both arms in sufficient amount to eliminate any hover.

The reverse of this is an event called Endurance, which has the same rules except that each competitor is given the same amount of time and is graded on how many throws and catches he can successfully make during that time.

An event for the agile person is Consecutive Catch. This event requires a more difficult catch after the previous successful catch. Usually competitors launch boomerangs simultaneously, so that there may be scores of boomerangs in the air at one time. The catching progresses from simple catches with both hands, then one hand, behind the back, to the final round, catching with feet. Winners are those remaining, having successfully eliminated all other competitors.

Any shape boomerang is used with this event. Distinguishable colors are desired so that competitors may easily spot their own boomerang. The boomerang is designed for ease of catch. Traditional and V-shaped boomerangs are usually less difficult to catch since when spinning they do not have a large hole in the center. The boomerang is designed to travel a short distance. Since the catch is the unit of grading, plenty of hover is desired particularly for the very difficult catches, so that the thrower has ample time to get under the boomerang for the catch.

<u>Juggling</u> is an event that requires two boomerangs of identical flight behavior, each having a somewhat short range and good hover. The requirements of this event are for the competitor to make as many consecutive catches with two boomerangs as he can, launching first one then the other repeatedly so that there is one boomerang always in the air. Scoring is based on total number of consecutive catches.

V-shaped boomerangs with flared tips are popular for this event. Plenty of hover is desired.

<u>Doubling</u>, on the other hand, requires the competitor to launch two boomerangs simultaneously, catch each, and repeat the procedure until a boomerang is not caught. Grading is based on total number of consecutive catches.

For this event, the competitor desires one boomerang that circumscribes a small circle, having not too much hover, while the other boomerang circumscribes a wider circle and has substantial hover to give the thrower an opportunity to get under it.

A popular "inside doubler" boomerang has two blades but resembles a three bladed boomerang in its stable flight behavior. The boomerang is so designed so that the elbow looks like a narrow U, then the arms are extended and flared out. The flared part of the arms is as long as the other part of the arm. It easily resembles the pitch and steeple of a church roof. An illustration of this kind of boomerang may be seen in the previous section depicting V-shaped boomerangs. The "outside doubler" is usually a Hook or an Omega.

<u>Maximum Time Aloft</u> is an event in which a competitor launches a boomerang from anywhere in a 100-meter diameter circle and is expected to catch it within the same circle. Grading is based on how long the boomerang remains in the air.

The design for this event requires that the boomerang makes a hasty turn-about, coming to a hover almost immediately, while retaining spin like a maple seed. Its design is slick, thin, having a shape almost identical to an upper case L, sans serif, and a trailing arm about half the length of the leading arm.

It is not likely that boomerang shapes have reached the apex of design. As more inquisitive people discover boomerangs, many will experiment and probably discover much of what we have accomplished already, but among them will emerge other designs and other avenues of exploration, and who knows, you, dear reader, may be the next one to unlock another door in this magical world of boomerangs. (For more on boomerang shapes, refer to Hawes, "All About Boomerangs" - 1987.)

Where to Buy Boomerangs

Usually the company distributing this booklet will have quality boomerangs for sale. We urge the company to affix its address and telephone number below.

Credits

We are grateful to the following authors and their works for making this publication possible.

Carmichael, B. H. "Low Reynolds Number Airfoil Survey." Vol. I, NASA. 1981.

Hakansson, Carolyn Ann. "A Thesis Presented to the Division of Mathematics and Natural Sciences." Reed College. 1984.

Hawes, Lorin L. and Mauro, John B. "All About Boomerangs." Hawes Boomerangs. Runaway Bay, Queensland. 1987.

Hess, Felix. "The Aerodynamics of Boomerangs." Scientific American. November, 1968. pp. 124-136.

Hess, Felix. "Boomerangs: Aerodynamics and Motion." PhD. Thesis. University of Gronigen, Holland. 1975.

King, Allen L. "Project Boomerang." American Journal of Physics. Vol 43, No. 9. September, 1975.

Mason, Bernard. "Boomerangs: How to Make and Throw Them." Dover. New York. 1974.

Mayhew, H. L. "The Big Book About Boomerangs." Comeback Press. Columbus, Ohio. 1982.

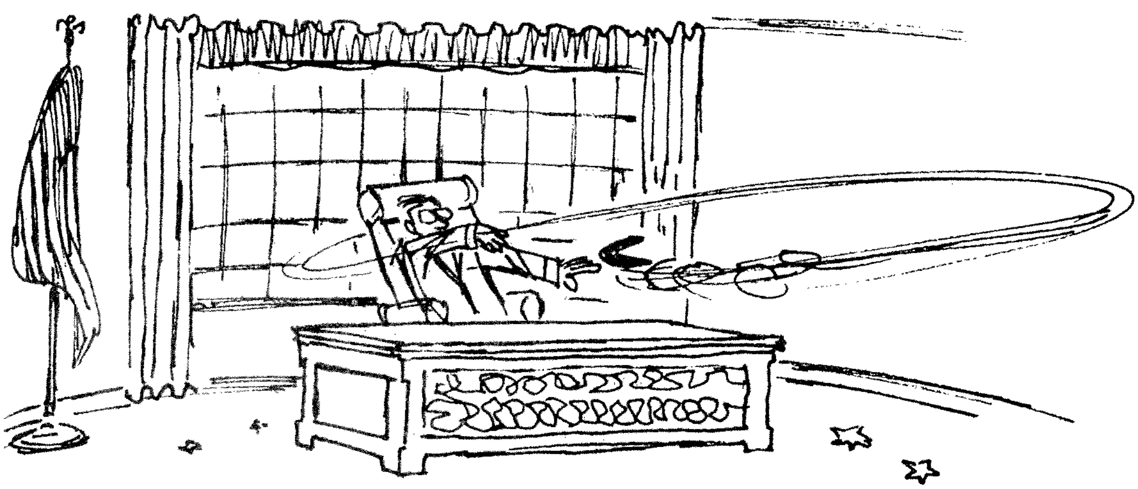
Musgrove, P. "The Aerodynamics of Boomerangs." 1973.

Rieser, Raymond. "A Question of Dihedral." Unpublished Manuscript. Lower Burrell, PA. 1986.

Smith, Herb. "Boomerangs: Making and Throwing Them." Gemstar. Littlehampton, England. 1975.

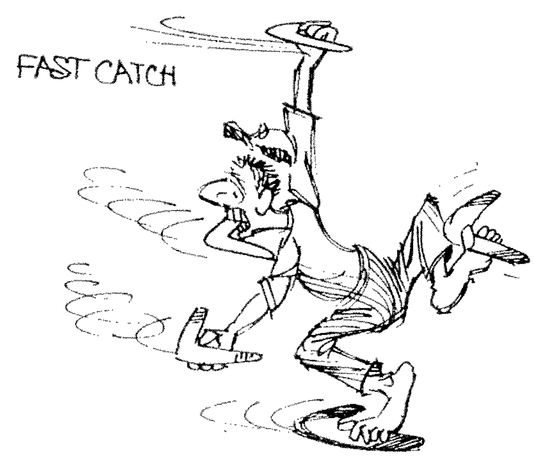
Walker, Jearl. "Boomerangs! How to Make Them and Also How They Fly." Scientific American. March, 1979. pp. 162-172.

Walker, Jearl. "More on Boomerangs, Including Their Connection With the Dimpled Golf Ball." Scientific American. April, 1979. pp. 180-189.




653 CATCHES


GREATEST
DISTANCE —


FAST CATCH