An Introduction to Boomerangs

Second Edition

by John B. Mauro

12 July 1985

To a great boomeranger and dear friend - Ted Bailey.

Best wishes,

John Mauro

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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 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 even 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 less lift in design than intended will nevertheless perform well if thrown harder and if thrown with a bit more sidearm. In essence, the thrower starts the return process by the manner of throw. Therefore, one cannot separate the throw from the design of the boomerang.

A baseball pitcher can throw the same curve regardless of 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 is 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.

HISTORY OF THE BOOMERANG

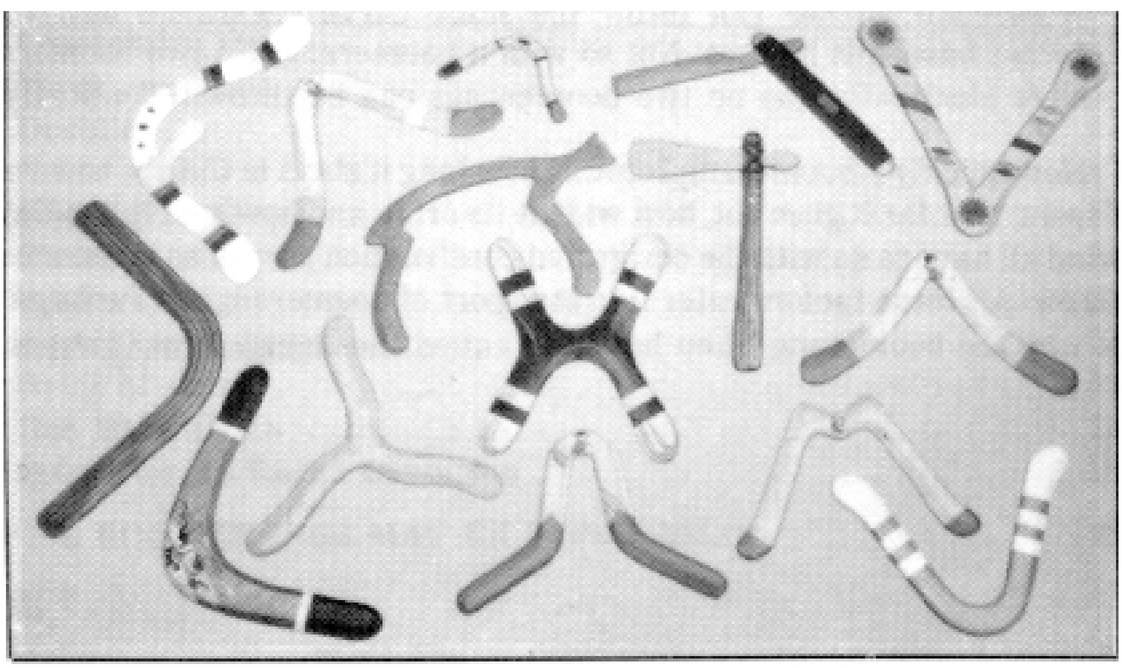
Little is known about the origin of the boomerang. The oldest known boomerangs are between 11,000 and 15,000 years old.

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 further. A spinning boomerang cuts a swath 30 inches or so wide, substantially larger than a spear, thereby giving its thrower more margin for error.

The returning boomerang probably was developed from the earlier nonreturning type and is used only for sport. Although if hit by one considerable damage can be caused, it would hardly be 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.

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

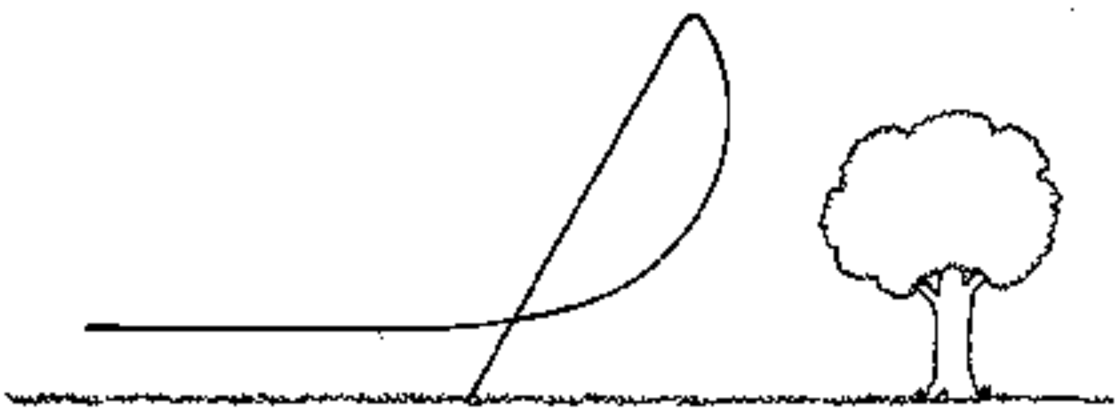


WHY A BOOMERANG RETURNS

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 flat bottom. Sometimes the underpart of the arms at the tips is cut to increase the lift of that arm. Suffice it to say at this point that 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.

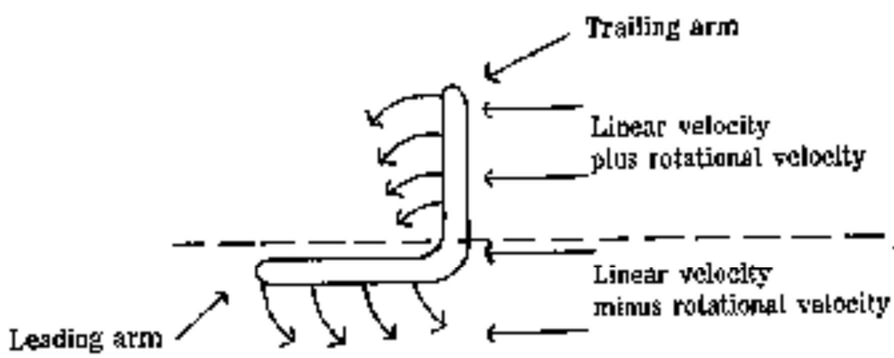


For a boomerang to circle, it must be thrown rotating in basically a vertical plane. When this is done, the lift generated by the forward moving and spinning arms is horizontal or sideways (not upward), and the direction of the lift will be away from the contoured side of the arms.

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 will 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.

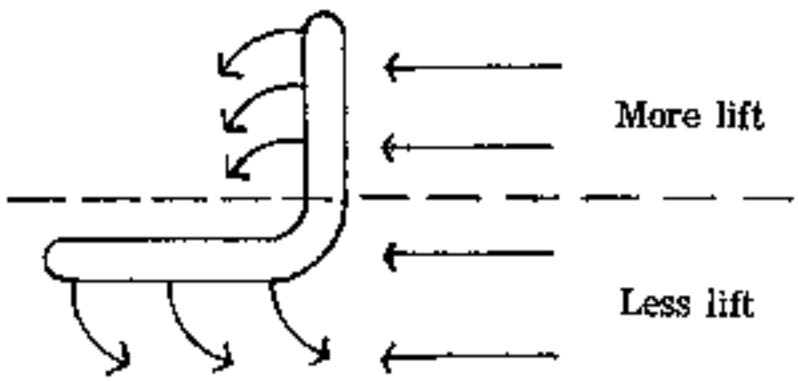
But since the boomerang is spinning at the same time, when one arm is at the top, the forward movement and the spin movement are in the same direction.



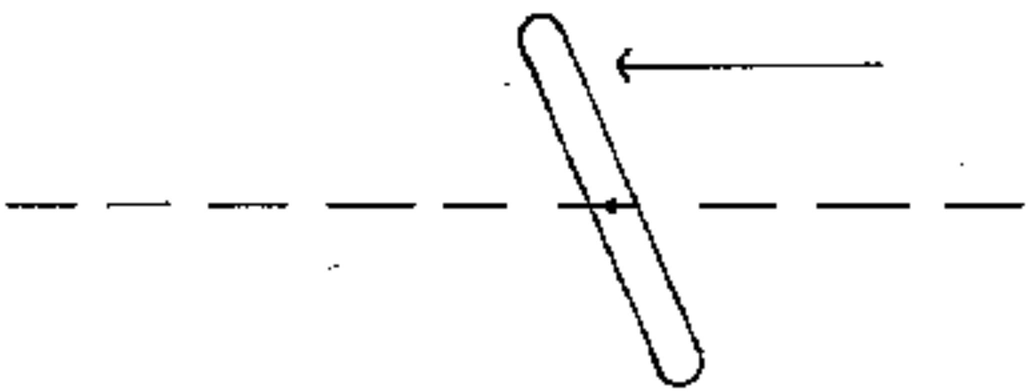
When the arm is at the bottom, its spin movement is in the opposite direction to the throw movement. Accordingly, one is subtracted from the other. We have here a condition in which each arm, when it is at the top, moves through the air substantially faster than it does when it is at the bottom.

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. 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.

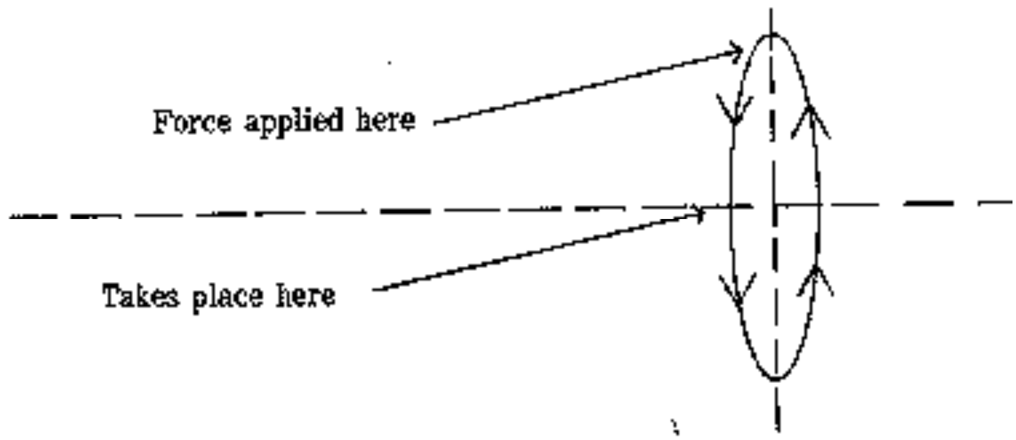
In that case, the boomerang arm at the top of the spin is moving through the air substantially faster than the arm at the bottom of the spin. This, therefore, generates more lift at the top than at the bottom.



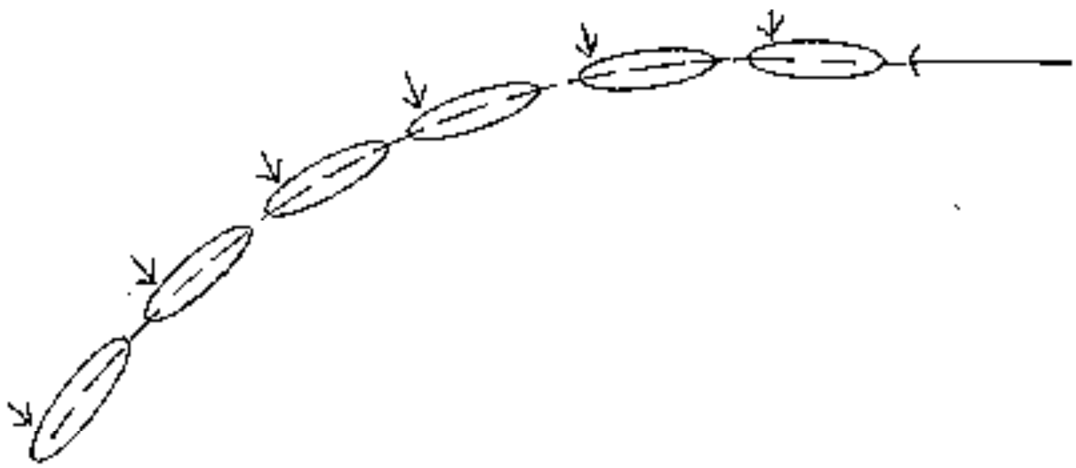
It would seem that a boomerang thrown vertically, having more lift at the top than at the bottom would tilt from the top.



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.

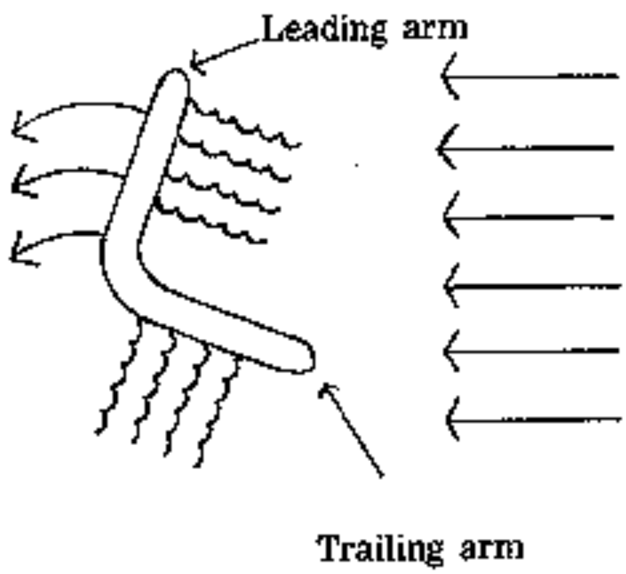


Ergo, the turning of a boomerang.

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 are two theories on why this happens.

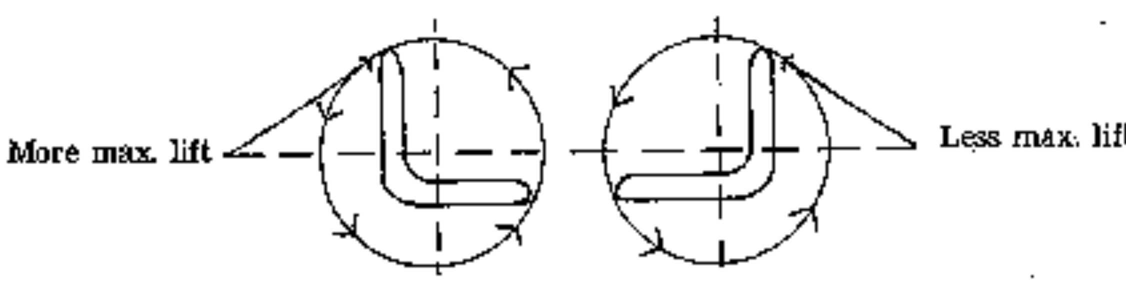
One theory, (Robson, 1977) suggests that the laying down quality is the result of the boomerang's asymmetric shape and, therefore, its asymmetric lift development because of the difference in the lift generated between its arms as it moves forward and spins through the air.

This theory suggests that as the boomerang moves and spins through the air, the first arm moves through the air that has not been disturbed.

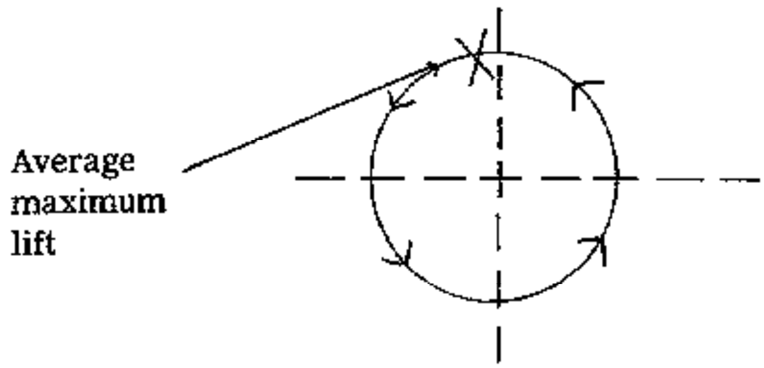


The trailing arm moves through air that has already been disturbed by the movement of the leading arm. For this reason, the trailing arm never generates as much lift as the leading arm.

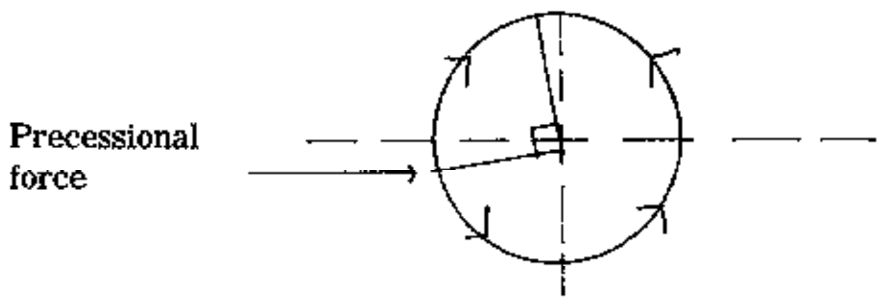
When each arm is at the absolute top, each has its maximum lift, as we learned earlier, but the leading arm has more lift than the trailing arm even at this point.



Therefore, the combined (average) maximum lift is somewhat forward of the absolute top since, as mentioned previously, the leading arm generates more lift than the trailing arm.

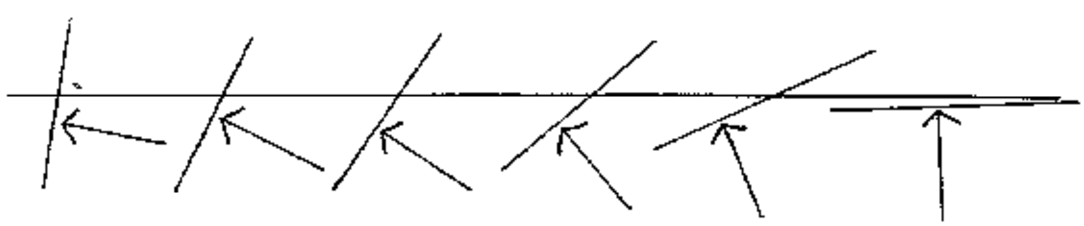


The effect of precession then is not in an absolute side direction as previously indicated but sideways and somewhat upward.



The other theory (Harding, 1982) suggests that asymmetric lift is developed by giving more lift to the leading arm than to the trailing arm. This will move the center of the average lift forward of the vertical point of rotation. Once this happens the effects are the same as previously described.

Each theory supports the same results. The boomerang turns and eventually lays down into a graceful and gentle landing.



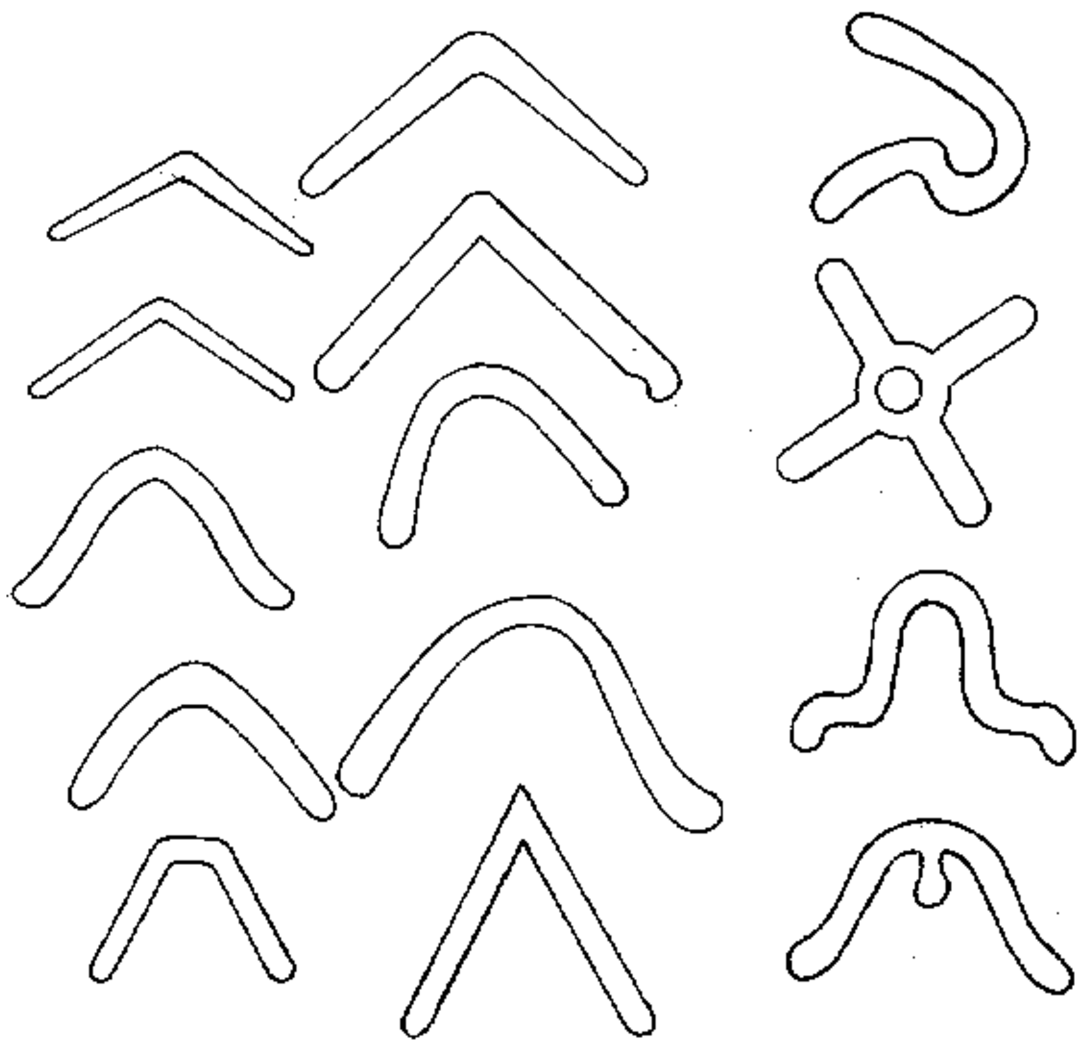
Perhaps both theories apply.

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, the only reliable method of fine-tuning a boomerang is by trial and error.

DESIGN AND CONSTRUCTION

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 and width of arms

4) Weight

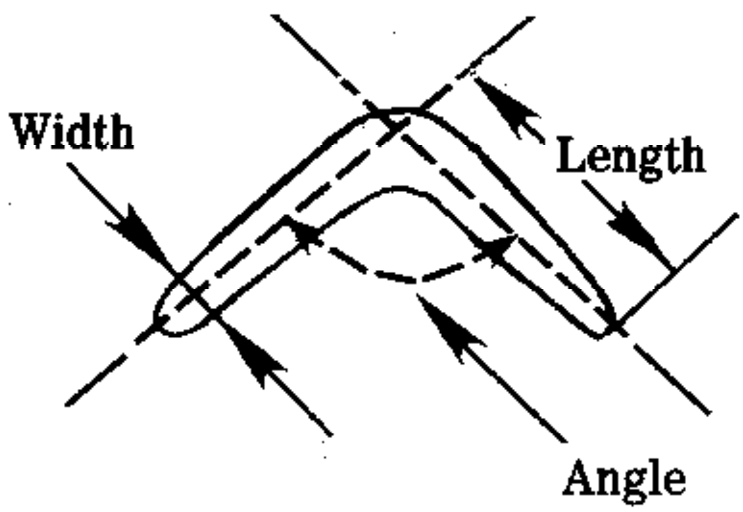
General Dimensions

If you can't seem to get started in constructing the first boomerang, this 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.

A rule you can apply to get you started: usually this applies only to 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.

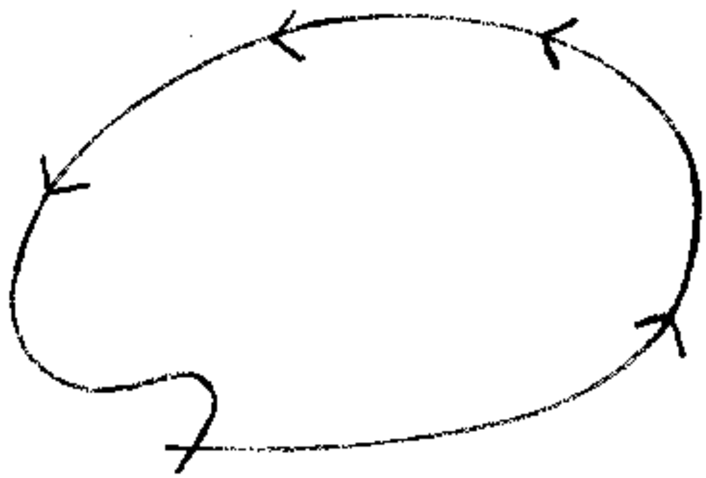
The rule is simple: let the width of the arms be equal to the thickness of the material divided by .16 and the length of the arms be equal to the width divided by .16 or the thickness divided by $.16^2$.

A $^1/_4$" thick plywood would provide a boomerang with arm widths $^1/_4$ / .16 or one and nine sixteenths inches. Length of each arm $^1/_4$ /$.16^2$ or 9 $^3/_4$". A blank designed "L" shaped with these dimensions should produce a well-performing boomerang—properly shaped, of course.



Lift Considerations

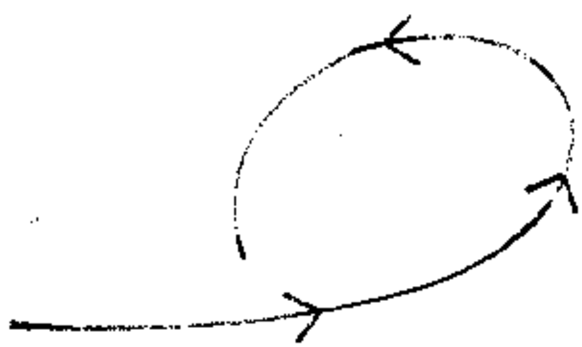
Generally when both arms of a boomerang have equal width, the boomerang (if launched properly) will return well. On its return it will hover top side up and gently drop down at the feet of the thrower.



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

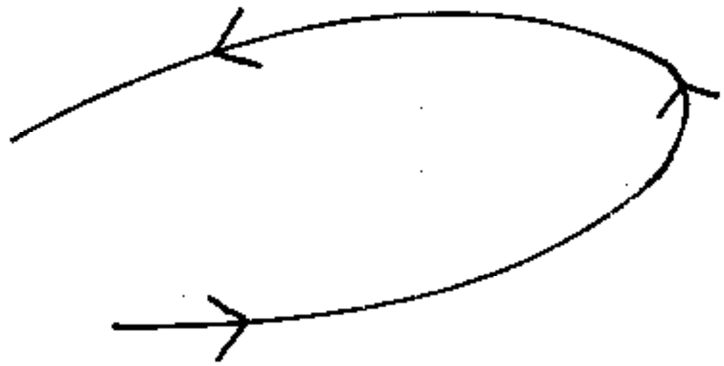
It follows that less lift in relation to the same mass and area will produce a wider circle and would require more launching force or if there is totally insufficient lift, the boomerang will drop to the ground before completing its circle.

Disproportionately more lift on the leading arm usually will result in the boomerang lying down prematurely and returning substantially in front of the thrower.



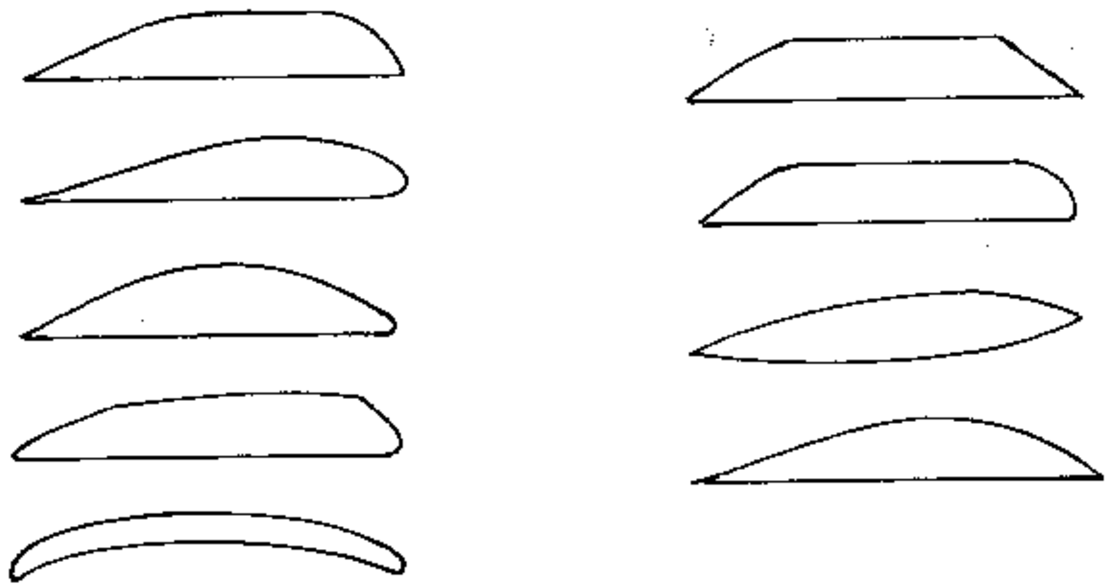
If launched with great force the flight will result in a figure 8 or S-shaped path.

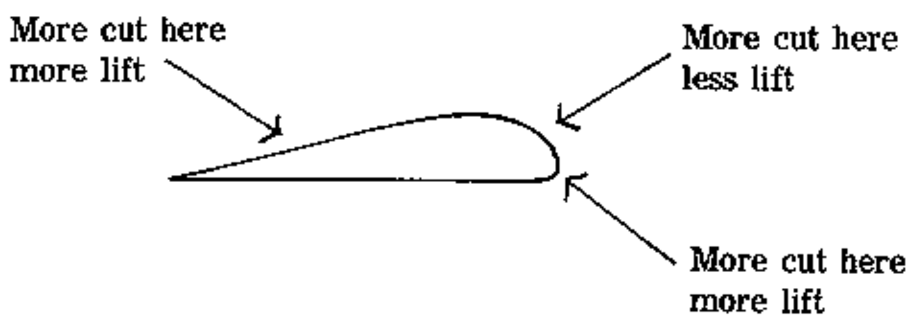
Disproportionately more lift on the trailing arm usually will produce an incomplete return. The boomerang will fall to the left of the thrower.



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 arms.

•Hollow out under part of arms, although the popular concept is to keep underside of arms flat.

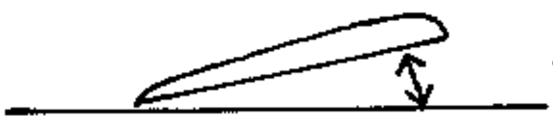
•Thicker arms will generally produce more lift but will also produce more drag causing boomerang either to lose spin prematurely, produce only a partial return, reduce hovering quality, or all three.

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

•Positive dihedral—maximum approximately 15°.

Dihedral

•Positive angle of attack—maximum approximately 15°; more than that will increase drag.



Angle of Attack

•Reduce weight evenly throughout the boomerang.

To Produce Less Lift

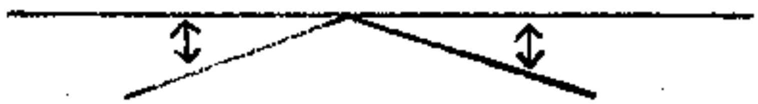
•More cut at the top of leading edge of the arms.

•Thinner arms.

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

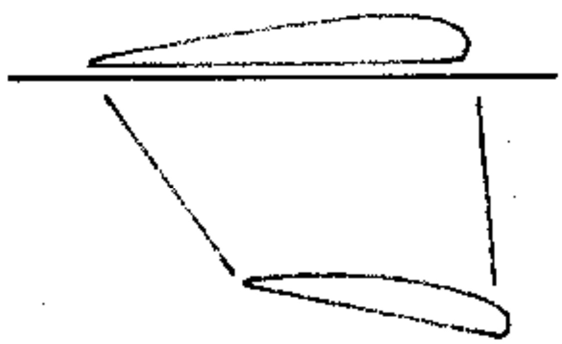
•Smooth upper portion of arms.

•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 than 70° or more than 140° are basically unstable. (Hakansson, 1984).

•A 90° angle seems to produce a reasonably circular flight.

•Generally, reducing the angle between arms will increase the distance a boomerang will travel.

Dimensions of Arms

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

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

•Longer arms usually have less spin retention.

Weight and Weight Distribution

•Generally, weight can be distributed evenly throughout the boomerang by adding heavy paint or some similar covering.

•Weight for a given amount of area is an important factor in determining distance—i.e., more weight in the same design will make a boomerang travel further.

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

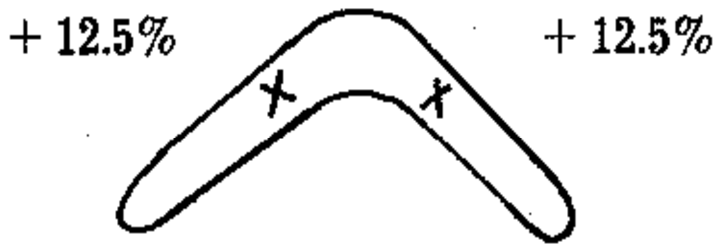
•Shaping usually will reduce the weight of a boomerang blank by about 20%.

•Adding weights without increasing launching force will result in less laydown.

Adding Weights to Produce Desired Effects

Please note that when more weight is added the effects are more pronounced. Adding 25% of the weight of the boomerang should result in the following effects for a V-shaped boomerang.

•To make boomerang more wind resistant without increasing distance, place equal weights on each arm close to elbow.



•Similarly, adding weight in the above positions will reduce its laying down qualities.

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

It will also reduce or eliminate laying down, change its flight so it goes straight out, zoom upward and quickly come down in front of 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.

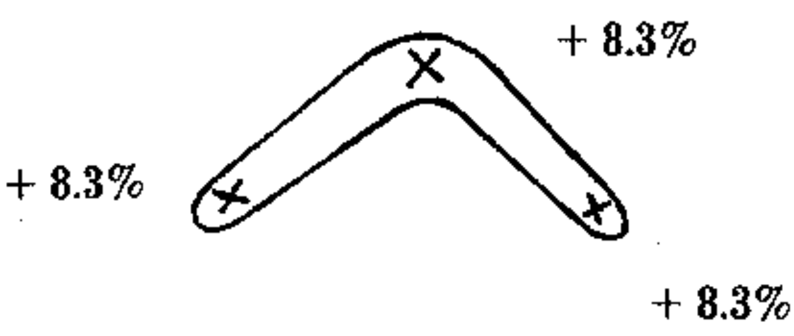
•Adding all the additional weight to the section of the leading arm closer to the elbow produces less laydown. Is likely to retain spin better. Reduces distance by about 20%. Climbs less.

•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. 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 substantially increase distance, produce a fair flight while reducing its laydown.

•Adding one-third of the additional weight at each of the wing tips and elbow will increase distance substantially, produce a similar flight path as the unweighted boomerang. Improves 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. Smaller angle between arms

5. Shorter arm length

6. Narrower arm width (chord)

Factors That Should Increase Spin Retention

1. Shorter arms

2. Wider arms—greater chord

3. Less thickness

4. More weight at elbow and wing tips.

5. More taper at wing tips

N.B. 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 be the same if less dense material were used. 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.

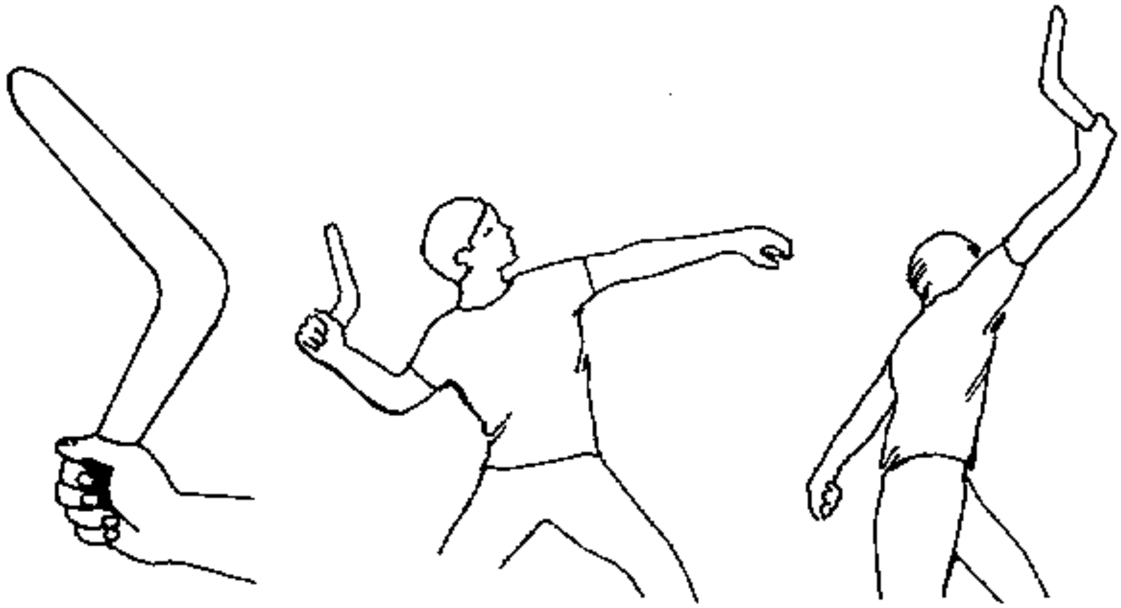
ELEMENTS OF THROWING AND CATCHING

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

Boomerang is held in the manner illustrated here. It is thrown overhand at an angle close to 90° 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. 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, will usually produce a return in front of 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. Generally, the boomerang flight will be level until it completes the first half of flight. On its return, it will usually 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 perform a rocking effect.

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

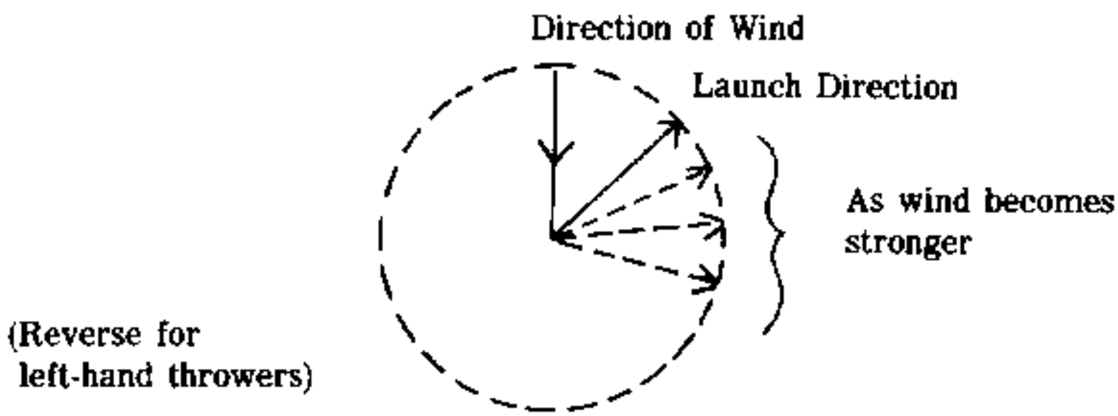
The Throw Relative to the Direction and Speed of Wind

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

•It is usually necessary to adjust the direction of launch more towards 3 o'clock, 4 o'clock or 5 o'clock as the wind becomes stronger.

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

•If a boomerang that ordinarily returns well but returns to the left of the thrower, the throw should be directed more to the right of the wind and vice versa.

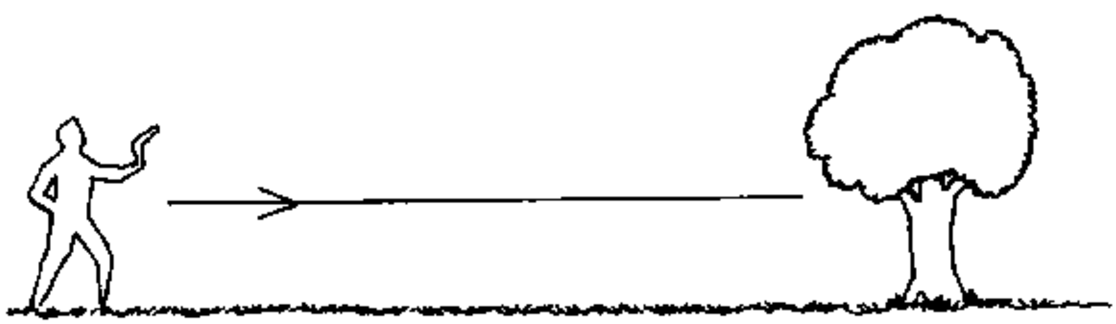


Height of Aim

•Generally, a boomerang is thrown straight out—neither upward nor downward.

•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 lose its hovering qualities.

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

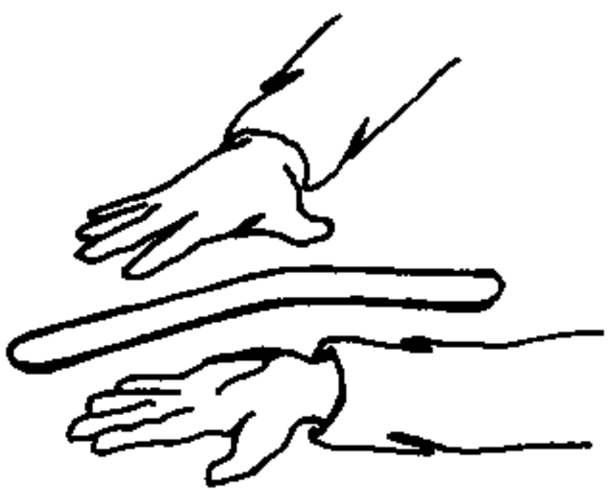
•Trials are often required to adjust to the required amount of force.

Spin

Sufficient spin must be given to complete the flight process. If a boomerang is thrown with little or no spin, it obviously 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 boomerang appears to make when spinning.

EVENTS AND RULES OF COMPETITION

Events and rules of competition have not been totally agreed upon probably because boomeranging is an international sport and there are many notions put forth by many people. Through continuous use, however, the following events have become the most popular and are used in most tournaments.

Types of Events

1. Consecutive catch
2. Maximum time aloft
3. Doubling
4. Fast catch
5. Juggling
6. Distance
7. Accuracy
8. Australian Round

Consecutive Catch

This event is an elimination free-style catching. One drop or no catch eliminates contestants.

1st & 2nd throw:	All contestants in event throw simultaneously. All those who drop or do not catch their own boomerangs are eliminated.
3rd & 4th throw:	Simultaneous throw. One-hand catch. Must be caught with non-throwing hand.
5th & 6th throw:	Simultaneous throw. One-hand catch. Must be caught with throwing hand.
7th & 8th throw:	Simultaneous throw. Behind-the-back catch.
9th & 10th throw:	Simultaneous throw. Catch with feet. (Sometimes optional).
11th throw:	Throw for accuracy. Catch made to nearest center circle wins.

Maximum Time Aloft

Each contestant gets three throws. Winner is judged on length of time boomerang is in air. Catch is required.

Doubling

(Sometimes a Demonstration Event)

Each contestant throws two boomerangs simultaneously. Must catch both for two rounds, then a simultaneous throw round. Lastly, there is a simultaneous throw round when all remaining contestants each throw two boomerangs and are required to catch each with one hand. This round continues until there is a winner.

Fast Catch

Individuals throw from two-meter diameter circle. Twenty-meter distance required. Scored on time it takes to make five catches. Throw must be made from circle (both feet) every time, although contestant may go outside circle to catch. Then must return to circle for next throw. Need to return to circle for last catch. Clock is stopped at last catch, and contestant reaches the circle. First drop eliminates that throw and must be thrown again. Second drop eliminates contestant from event.

Juggling

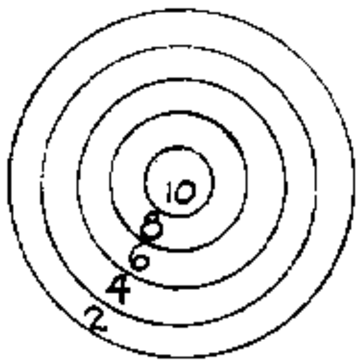
Two boomerangs are thrown one at a time in juggling fashion until one is dropped. Minimum range is 20 meters. Winner is judged on most number of catches.

Distance

Longest qualifying throw—distance boomerang goes out and returns. Forty-meter baseline. Throw is made from center of baseline. On return boomerang must cross baseline between poles to qualify. Three throws per contestant usually.

Accuracy
(Short Range)

Throw from center of a 10-meter radius circle—lines are 2 meters apart, starting from 2-meter radius center. Twenty-meter minimum range. No catch. Scored on where boomerang comes to rest on target. Points awarded on following basis:



(On line: average of two values)

Points

Australian Round or General Championship

Each contestant gets 3 throws plus a sighting throw. Points are awarded for accuracy, catching, and distance. Accuracy on target— same as accuracy above.

Catch:

4 bonus points inside 20-meter radius—2 bonus points outside

Distance: 2 points for 30 meters
Distance: 3 points for 40 meters
Distance: 4 points for 50 meters or more

Rules of Catch

A catch may be scored if boomerang skips off ground on its outward journey. A catch is not scored if the boomerang skips off the ground on its return leg of flight. There is no catch if boomerang hits ground just before catching.

A catch is scored if it is determined that the boomerang was in possession, even if dropped thereafter.

Catch is usually permitted by clasping against body.

One-Hand Catches

Must be legitimate one-handed catches. Clasping against the body is not counted.

Basis for Determining All-Round Champion

Except for Accuracy and the Australian Round (which already have a point system), other events are given points based on performance. Contestant with most points overall becomes all-round champion.

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.

The electronic version of this text is furnished as a service of:

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For more information about boomerangs, email Ted Bailey at tbailey@ic.net or call (734)-971-2970 or write to: Ted Bailey; P. O. Box 6076; Ann Arbor, MI 48106-6076; USA

CREDITS

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