Bow Construction

Understanding the terminology.

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Updates will be added as they become available, e.g., natural bowstrings, home made arrowheads, bow designs, crossbow designs and quills etc.,

Terminology

Stave.

Length of wood, radially split from log, branch or comercially purchased timber from which the bow is to be constructed. (Also refered to as bow-stave.)

Tillering.

The process of working a bow down evenly to reach the required draw weight at the required draw length and to ensure that bow limbs are balanced with respect to each other and ensuring that the "arc" of the drawn bow is even.

Recurve.

Any bow which has the tips of the working limbs bent backwards in the opposite direction from the draw when at rest. This allows the bow to develop extra power when drawn, to store and release energy more efficiently, as well as increasing velocity in the arrow by adding an extra flick in the arrow at the last sec o nd as the arrow starts to leave the string. The amount of recurve can vary from a slight curve at the tips, (similar to a ']' shape) to a total curve whereby the whole working limb of the bow bends backwards from the handgrip, giving a totally reversed 'C ' shape, sometimes curved backwards to the point that the two tips will actually touch when unstrung.(Also known as 'retro-flexed')

Self bow.

A one piece bow, usually made of a single stave of wood, or any other single material (this now includes 'all steel' or 'all fiberglass' bows). Also used to mean a bow which may be made of 2 staves of wood of the same type, jointed at the midpoint (handle), to give a single length of uniform strength and uniform properties. This was often necessary due to the diffi culty of getting a single bowstave of a decent length without knots, warps or other defects. This is the main European/African/American Indian etc style of traditional bow but can be applied to solid fiberglass, steel, horn, etc.

Composite.

A bow made by laminating multiple materials together in thin layers. Materials most commonly

used in traditional bows were different types of wood and layers of horn, often bound together with sinew and glued in layers. Modern bows usually use layers of wood, fiberglass and/or steel. Traditional Asiatic and Arab bows were often horn/wood/sinew recurved composites. The different materials allow the bow to use the best properties in the best location to maximize their efficiency. Manufacture of these types of bows is a slow and painstaking task, as any weakness in any of the joints will give either reduced performance, or a bow which will break under load.

Backed bow.

A bow primarily of wood, but having a thin strip of another material along the back of the bow (see composite bow). Usually the material used was a thin strip of wood (e.g. bamboo or hickory), or a strip of raw hide or even silk glued in place. This backing did not add much (if anything) to the strength or efficiency of the bow, rather it helped the bow to return slowly to straightness. Bows backed with sinew are the exception to this, as the sinew greatly increases the tension of the bow.

Longbow.

Usually a 'Self' or 'Backed' bow, the longbow is effectively a s traight (or slightly curved) length of wood with string on each end. Fiberglass, steel and composite longbows are also often made. It has no recurves, no pulleys or cams, and is the traditional shape associated with the European archers of the middle ages .

Arab/Asiatic traditional bows.

Usually made of thin layers of horn and softened (soaked and softened) sinew glued to a central core of wood. They are often shorter (42"-72" = 107cm-183cm) than their European counterparts (60"-78" = 152cm-198cm) as they were more often used from horseback, whereas the Europea n bows were more often used from the ground. The Japanese bow was different again, being up to 84" (=213 cm) (or more) in length. Many of the Turkish, Asian and Arab races drew the bow using a thumb- ring, a ring worn on the thumb of the drawing hand. The string was hooked behind it (in the palm of the hand) and the thumb closed over the string so that it rested tightly against the middle finger. For heavy bows, the forefinger could also be used to lock the thumb closed. To release, the thumb is opened, a llowing the string to slip off the edge of the ring. (With the heavy bows, the forefinger should be raised first to save undue strain on the thumbnail as it slides free from the forefinger). Using the asian release, the arrow would rest on the opposite side of the bow to that of those using a finger release i.e. for a right handed archer, the arrow would rest on the right side of the handpiece, whereas usually for those using a finger release, a right-handed archer will have the arrow resting on the left side of

Woods other than Yew and Osage orange

Probably one of the most common questions "Is it okay to make a bow from a wood other than yew or Osage orange?"

answer: Not only is it okay, in some cases it is more desirable. Firstly, white woods do not need to be coddled in terms of the sapwood to heartwood ratio. With yew and Osage, bark _and_ outer wood should be removed to produce a good quality bow. For a beginner, this is a daunting task. However, white woods require no special treatment. Once dry, simply remove the bark and the exposed wood instantly becomes the back of the bow.

Secondly, yew staves can cost $120.00 U.S. now, while most people have the ability to go and cut down their own maple, ash, white oak, birch or hickory tree for little or no cost. Often, one can pull two or more staves from a white wood tree. I, personally, refuse to cut down a tree unless it can yield 5 bows. Sometimes this takes a bit of looking, like maybe two hours as opposed to the week or so it could take looking for the "perfect" yew tree - if such a thing exists at all.

In speaking of the virtues of white wood bows, it's impossible to fully appreciate their value without first speaking about bow design and how it can affect performance.

If you're the impatient type, and have already made your first bow of some common wood according to the dimensions given in this FAQ, you will probably have found that the resulting bow has taken a massive "set" or amount of "string-follow". Both of these terms refer to the amount that the bow has bent in the belly direction when unstrung.

String follow or "set" is not a big problem unless the set is extreme (anything over 3"). Again, if you've made a white wood (common wood) bow according to the dimensions in this FAQ, you will probably have constructed a bow with anywhere from 6 to 10" of set. Set robs a bow of arrow speed - a factor that is very important in the construction of bows.

Why? Because a higher arrow speed means that an arrow has a flatter trajectory, thereby making it easier to aim at varying distances. Additionally, if you're a hunter, you'll appreciate that arrow penetration into target is important to ensure a quick, clean kill.

So how can we make a white wood bow with the same weight, arrow speed and poundage as a premier wood bow? Simple. Make your white wood bow wider (in the case of the flatbow) or longer (in the case of the longbow).

Most bowyers agree that white woods need a factor of 20 to 30% increase in width or length to equal the

cast and speed of a premier wood bow. In the case of a flatbow, this amount only applies to the maximum width of the bow. In the case of a longbow, this applies to the entire length.

Although 67" is by far the most efficient length to base a bow at, such a thing is practically impossible if making a D-Style longbow out of a white wood. In my experience, I have found 79 inches to be a good base point. This done, I don't have to adjust any other aspect or dimension of the weapon. With white wood flatbows, I always use 2 1/8" at widest point with handle remaining the same width and thickness as it would in a premier wood bow.

Remember that these increases apply only to the _WIDEST_ point (in terms of flatbow) or _ENTIRE LENGTH_ in the case of a longbow. Adjust no other dimensions ... these changes will do the job.

As a quick review, let's look at the advantages and disadvantages of making bows from "white woods".

Advantages:

Cheap
Easily obtainable
More choice of woods
Outside of tree becomes back of bow. No extra work.

Disadvantages:

Requires wider of longer limbs.
Not as "prestigious" as premier woods.

Seasoning of wood

The main criteria is that the wood has been seasoned (dried) fairly slowly. If you are using commercial stuff (from a timber yard) it has probably been kiln-dried. This is usually OK if done properly, although can sometimes weaken the wood slightly if done too quickly or dried too much. The general opinion amongst bowyers is that air-dried wood is far superior (Some timbers like Osage orange don't like kiln drying.) however, it is often difficult to acquire suitable air-dried timber without doing it yourself (over a long period).
Also, if you have the equipment to be picky about it, the wood should ideally have been dried to suit the region it is being used in. This is sometimes relevant if the wood is imported, kiln-dried in one place and used in a region with a higher or lower humidity. And if kiln-dried too much, (below about 10% Moisture content) this is also likely to weaken the wood. However, as most people don't have the equipment to test, the moisture content is usually just assumed to be correct.

Wood types.

Some of these are well suited to Self-Bows, some better suited to making laminations for composite bows.

(These are all supposed to be the preferences in the Northern Hemisphere, USA, UK, Europe etc. Some or all of these may be available, some may only be available in the USA)
Yew (of course), Osage Orange, Dagame (lemonwood), Elm, Ash (most of them), Hickory, Oak, Birch, Black Locust, Walnut, Cedar, Juniper, Mulberry, Maple, etc. Of the Ash varieties in the US :-
strong ash = white, red, green, texas, & oregon weaker ash = black, blue (both may be adequate for a bow)

The main New Zealand & Australia options include NZ - Tawa, Rewarewa (probably), Manuka/Kanuka (NZ Tea-Tree) OZ - Osage Orange, Acaias (Wattles) (eg Blackapple, Gidgee Myal/Boree etc)

Tasmanian Myrtle, Spotted Gum, Alpine Ash, Silver Ash

Pacific regions :- Bamboo, Lancewood (NB this is *NOT* NZ Lancewood),

Black Palm

Initial preparation of the back of the bow

The back of the bow should be the side which is closest to the outside of the tree or branch if it can be determined (ie. sapwood - particularly for YEW).

In many bows, the back is sometimes made in the sapwood of the timber, with the bulk of the bow in the heavy heartwood. Whether to use the sapwood or not is dependant mainly on the type of timber being used. Yew's sapwood has properties that make it ideal to be left on as the back of the bow. With many species, all of the sapwood is removed and the back of the bow becomes the first layer of hardwood found (See below for a fuller discussion on whitewood bows).
If the sapwood *is* being left on to form the back of the bow, it should be thinned down so that it only comprises up to a maximum of about 1/3 of the thickness of the finished bow. Most of the strength of the bow comes from the heartwood.
Bows can be made totally from sapwood of many tree species, but some slight changes need to be made in the following designs to accomodate whitewood bows. (See "Woods other than Yew and Osage orange" below for details)

To prepare to work the bowstave, the back of the stave should be worked down until the full length of the back is all within a single growth ring i.e there are no rings or 'feathers' showing through on the back. This means following the grain no matter what twisting occurs in the grain and in the stave.

This should be done with handtools, rather than a saw, as it is probably the main reason for weaknesses in a final bow. If the growth rings are cut through anywhere on the back of the bow, it is extremely likely that this will be the place the bow will snap at. Once the back is cleaned down to the same growth ring, the actual bow can be marked out.

Initial process

Initially, wood is rasped evenly from the length of each limb on the bow. After a small amount of wood has been removed, rest the end of the limb on the ground, grasp the other end of the stave in one hand, grasp the centre of the bow and press against the bowgrip. The object is to get the limb starting to flex evenly. Once both limbs have started to flex about 5-6 inches forward from the vertical, we are ready to move on to the more precise tillering. Initial nocks are cut 1/2" in from the end of each limb, sloping at a 45 degree angle from back to belly, using something like a 5/32" circular rasp, pocketknife or 4mm chain saw sharpening file. With practice, floor testing the bow can be used to get to within 20-30 lb of the desired weight, when starting it is advisable to be a bit more cautious. (Floor-testing is resting one end of the stave on the ground and grasping the handgrip and end of the upper limb. Putting pressure on the handgrip causes the limb resting on the floor to flex, the amount of flex is determined by the amount of pressure applied to the handgrip.)

Optional Extras

The completed bow can have the handgrip wrapped in leather, cord or similiar if desired. An arrow shelf (or rest) of wood or leather can also be mounted on the side of the grip. Often a leather, bone or shell arrow plate can be let into the handle or glued to the outside surface of the grip to protect the wood from the arrows sliding past.
The Arrow Shelf (= arrow rest) is a small triangular ledge of any material that the arrow rests on while drawing and firing. Some archers allow the arrow to rest on the top of their forefinger, some prefer the rest.

the grip.

European/African/American Indian traditional bows.

Usually a wooden 'Self' bow of between 60"-78" (=152cm-198cm) and intended for use from the ground, although the American Indian used the shorter versions very effectively from horseback. The American Indian also often used composite (horn/sinew or wood/sinew) or backed bows.

The traditional yew bow of Europe acted as though it were a composite bow, as it was preferably made of a section of yew taken where the sapwood and heartwood joined. The different properties of the two different wood types allowed the bow to act with the best features of each wood type. The properties of the 'Self Bow' are such that the minimum length of the bow is (2x Draw length) ie with a draw length of 28 inches (=71 cm), the minimum length of the bow will be 56 inches (=142 cm). The greater the length of the bow, the more even can be the spread of forces built up.

The short bows of the American Indian probably varied between 20-70 pounds, the European hunting bows normally ranged between 40-100 pounds, with the European war bow (e.g. the Welsh Longbows) ranged from 90-180 pounds.

However, the European war bows were drawn both to the chin an d to the chest. Due to their great draw weight, and the fact that they were often used in ranks of archers and fired at large masses of opponents at long range, they were often drawn to the chest (with the bow-string passing down the cleft of the chin) using a longer arrow (36" = 91cm) the 'cloth-yard' shaft, and fired high into the air in massive volleys to fall almost randomly into their targets. (Hence 'clout' shooting - see competitions listing below)

As the ranges got closer and the archers were more able to pick specific targets, they reverted to a more traditional aiming style, with the long arrow drawn past the side of the chin and the fingers of the nock hand back somewhere around the jawbone or ear and aimed normally. The heavy draw weight of these warbows requires a significantly heavier shafted arrow, usually with some form of bodkin head (see 'Arrowheads' below), which had enough weight to strike its target with frightening power.

Indications are that often many warbows were carried half made (as shaped staves) during prolonged campaigns, and finished as and when they were needed during the campaign.

Normal (European) war tactics involved massed ranks of lightly armed or armoured archers firing large volleys of arrows into formations of target s. It was the Welsh Longbow, in the hands of thousands of archers, which effectively obliterated the cavalry force of thousands of French

knights at both Agincourt and Crecy. Bad weather and mud were major contributing factors in this, as the French caval ry were unable to close to attack effectively, so that massive volleys of arrows wiped out the opposing crossbowmen and then the French Knights (and their horses).

Woods normally used for these bows include :

Europe

Yew, Wytch-Hazel, Elm, Ash

America

Hickory, Osage Orange, Lancewood, Dagame (Lemonwood), Yew, Ash, Juniper, Chokeberry, Maple, Locust

Asia / Pacific Islands

Bamboo, Lancewood

Australia / New Zealand

The local native races down here never had the bow as a hunting or fighting weapon, so there are no traditions

During the reign of England's King Henry VIII, he was concerned enough about the rapidly decreasing availability of Yew wood for longbows, that he made a law stating that for every Yew bow made, there would also be one made of ea ch of the following timbers :- Wytch-Hazel, Brazil, Elm, Ash He also made it a law requiring every male in the kingdom to practice with the longbow, and decreed that it was not murder if anyone killed someone between the target and firing line during practice.

Bow straightening.

Virtually all all-wood (self) bows will slowly develop a constant curve during normal usage. This is termed "following the string" (Yew is one of the few woods which should return fully to its correct shape and even it will usually develop string follow.).

This curving will effectively reduce the draw weight of the bow slightly. This curve can be removed by carefully and slowly heating the complete bow until the wood becomes slightly softer, the wood can then be curved to the desired shape and slowly cooled again. The whole bow should be warmed at the same time, not in stages, so this can be done in a section of pipe

with the ends closed, and the heat applied to the pipe, rather than directly to the bow.

As long as the wood is not overheated or burned at all, it should return to straightness and recover most (if not all) of the lost poundage. This will, of course, not be permanent, but can greatly enhance the effective life of the bow

Because of this and other reasons, it is always a good idea to unstring any all-wood bow any time it is not required for use for more than an hour or so. Many modern composites (recurves and compounds) do not have this problem as much and are often left strung for extended periods, but for any self bow it is important to unstring them after use.

Bowstrings.

These were normally made of hemp, gut or silk and either twisted or plaited with beeswax (for waterproofing) to the desired length. I have heard that steel strings were sometimes used for some of the middle eastern bows, but have not found references for this (and would hate to be using one if it snapped during use. The thought of steel wire under stress snapping close to the check and eye with 50+ pounds of tension on it doesn't inspire me). Often a loop is placed in one end, and the other end left hanging. When the bow is strung, this end was tied using a bowyers knot (now called a 'bowline' knot).

Other methods allowed the maker to plait or twist a loop into either end during construction (e.g the Flemish twist method). Turkish strings were made with separate end loops (tundj) tied to the string with a special knot (same with Chinese, Mongolian, Persian and Tatar, probably others as well too) allowing it to be shortened or made longer to fit a particular bow/archer, the loop added stability to these short recurves.

Recently I was informed that the researchers on the Tudor ship "Mary Rose" have found their first complete bowstring of the period. It was preserved intact under the cap of it's unfortunate owner. The string itself is a very strong variant of English linen, although whether plaited, woven or 'endless string' I am unsure.

Arrows

Spine.

The measure of stiffness in an arrow. Of less importance with 'centre-shot' bows (ie those firing through the centre of the handle), but of major importance with arrows fired past the side of the bow (See 'Archer's Paradox' below)

Although originally made of a single length of wood, many archers used to splice different types of wood together to enhance the properties of the arrow. Hardw oods were often spliced into the head and/or heel (fletching end) of the arrow and softwoods used for the central shaft. Such spliced hardwoods are known as a footing.

The softwoods allow the arrow to retain its flex and lowers the weight of the arrow. The hardwoods in the head and/or heel allow these areas of the arrow to withstand the major stresses in the arrow namely the splitting stress of the string thrusting against the centre of the arrow (if separate nocks aren't used), pushing it forward and pos sibly splitting the wood, and also the compressive stress of the arrow hitting it's target. \par Often nocks would be reinforced by cutting a slot at right angles to the nock and inserting a short section of horn or bone. Hence the stress of the released string is spread across the horn and thence across the whole end of the shaft, rather than being concentrated in the grain directly below the string.

Arrow straightening.

Wooden arrows will often warp slightly in normal usage. This warpage can be removed by gentle heating (usually with steam from a kettle or similar) and carefully bent back to straightness. Fastening the arrow to a straightedge during the process will help to ensure strai ghtness. The ancients used to do this by heating over a fire and then sliding the arrow backwards and forward through a small hole in a piece of bone.

Arrow flights were nearly always made of feather. The stronger and heavier the feather, the better for a flight. Goose and turkey feathers were often used, although many of the middle eastern archers preferred hawk or eagle feathers when available. And wing (pinon) feathers are always preferred over any others although Turkish arrow flights were also made from tail feathers.

Archer's Paradox.

This is not as significant with modern bows, many of which have a shaped handle allowing the arrow to pass through the middle of the handle. It is much more significant in older bows where the arrow is fired past the side of the handle, yet the string actually moves towards the centre of the bow, rather than the edge where the arrow rests. The arrow still manages to fly to the point of aim.

In actual fact, the string moves directly towards the centre of the bow which causes the arrow to curve around the side of the bow and continues to curve and oscillate from side to side in flight. This results in a wavering arrow flight which smooths out as the a rrow travels until this sideways movement has been fully damped out. During this flight, the arrow is actually flexing.

Clout shooting.

A large circle or square (rope, painted etc) is laid out flat on the ground 160-240 yards (146-220 metres) from the archers. The object is to get the maximum number of arrows landing the closest to the center of the circle. The circle is between 8-12 times the size of a standard target face with a light coloured flag marking the center of the target.

Popinjay.

A wooden parrot is placed on the top of a tall pole. The archers fire from directly underneath and score points for how close they get (feathers knocked off etc) and also whether anyone can actually knock the bird off the pole. Modern rules are extended slightly to having a Cock (wooden cylinder 5"x2" (=12.5x5cm)), 4 hens (4"x1.5"(=10x3.8cm)) and up to 24 Chicks (2"x1" (=5x2.5cm)) with feathers attached, all on platforms on the top of a pole up to 85 feet (26 metres) high. Around the base of the pole is a ring 15 feet (4.6 metres) across, in which the archers stand while firing directly upwards. Because the arrows tend to fall straight back downwards again, the arrows used are wo oden with flat ends (3/4"-1" (=1.9-2.5 cm) wide blunts). Scoring is 5 points for the Cock, 3 for each Hen, 1 per Chick. They must be knocked off to score and all are reset as soon as the Cock is dislodged.

Wand shooting.

A peeled willow wand is set up at a specific distance and the archers attempt to split the wand (Robin Hood style). (Aka Prick Shooting)

Butt shooting.

Similar to modern target shooting.

Flight shooting.

Trying to gain the maximum range possible. Hitting a target is not a primary consideration. Early Persians have recorded ranges of up to 900 yards (822 metres) (with documented evidence), and it has been only during the last century with modern technologies that this has been surpassed. The current record is (I believe) somewhere ar ound 1310 yards (=1200 metres).

Speed shooting (aka Shower shooting).

Firing as many arrows as fast as possible, attempting to maintain the maximum number all in mid-air at once. Several recorded attempts have shown archers having 9 in the air at once, The best record I have come across maintains a documented instance of a master Persian archer having 15 arrows all in flight simultaneously, using specially made arrows.

Crossbow

Prod.

Bow section of a crossbow. Can be constructed from fibre glass, sprung steel etc.,

Bow Irons.

Assembly that holds the Prod onto the front of the Crossbow. Can comprise of plates, blocks, wedges and stirrup.

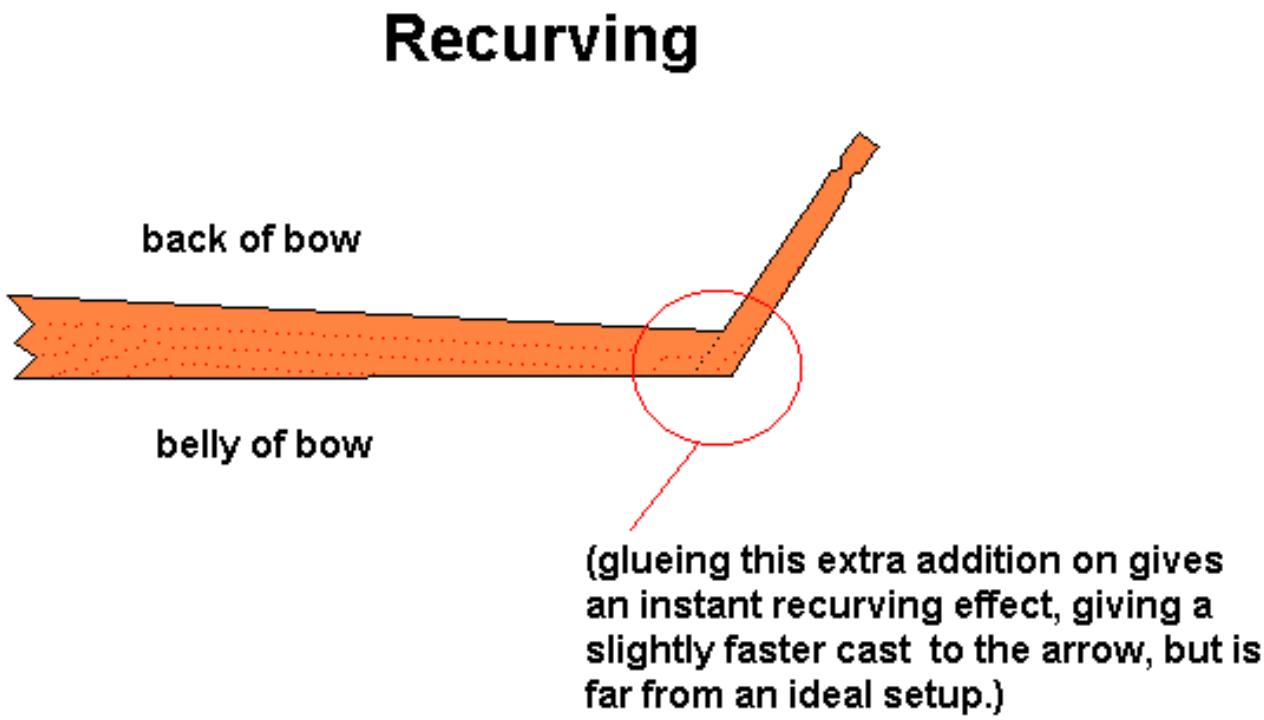
Stirrup.

U shaped clamp or support at the front of a crossbow into which the foot is normally placed, enabling the crossbow to be held down while the bow string is locked into the firing position.

Recurving

Recurving will usually significantly increase the poundage of the bow, without needing a greater drawlength. Recurving is bending the tips of the limb (or the whole limb) backwards in a curve. If this is done while the wood is wet or hot, the wood will retain the curve when relaxed, thus making the bow flex more when drawn.

Recurves can be added to a bow by a variety of methods. One method is to glue extra lengths of wood onto the tips of the bow at an angle to the original stave.



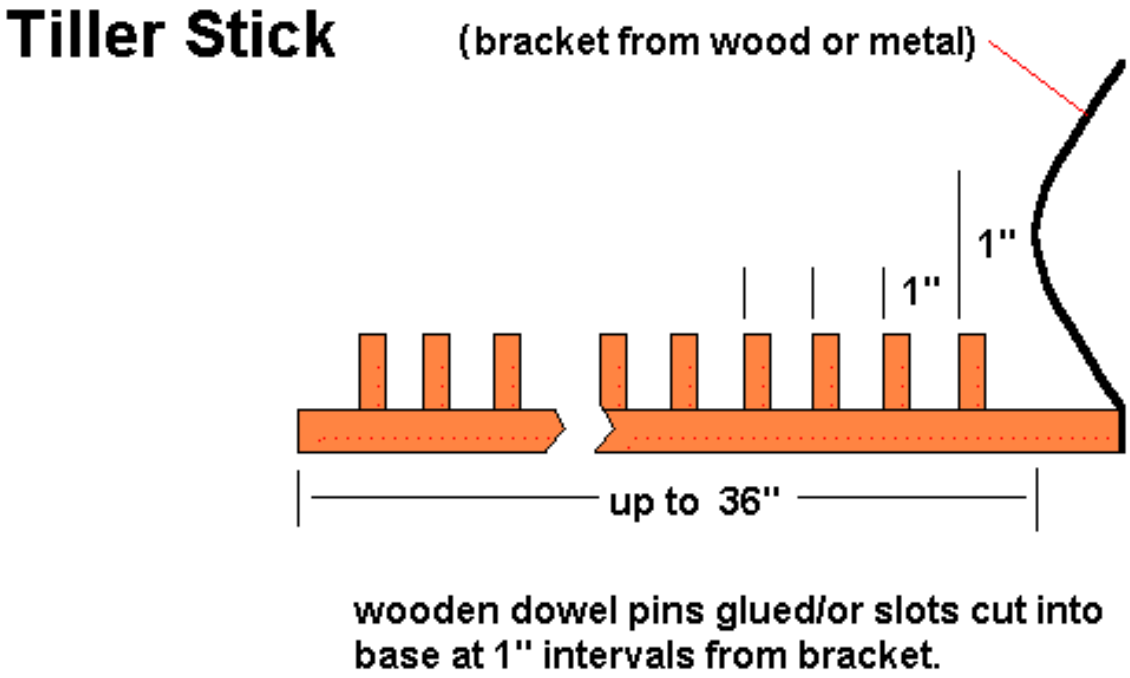
The more normal method to recurve a bow is to hold the area to be recurved over a pot of boiling water for quite some time, so that the steam slowly softens the wood fibres. After a while (20 minutes or more) the wood fibres will have softened enough for the limb to be fairly flexible. Shape it to the desired shape (Usually by wrapping it around something so as to give a uniform curve) then allow it to slowly dry and cool. Ensure that both limbs are recurved to the same extent, again ensuring that the curves in both limbs match at all times. Any mismatch in the flexing of the limbs will place an increased and unbalanced strain elsewhere in the bow, possibly with fatal effects (for the bow).

Straightening

Staves made from twisted timber such as Osage Orange, can be straightened with careful application of heat from a gas stove provided that the timber is protected by application of fat or candle wax or similar to prevent burning.

This method is also used to straighten bows which have developed curves or twists during use. Carefully and slowly heating the complete bow allows the wood to become slightly softer, the wood can then be curved to the desired shape and slowly cooled again. The whole bow should be warmed at the same time, not in stages, so this can be done in a section of pipe with the ends closed, and the heat applied to the pipe, rather than directly to the bow.
As long as the wood is not overheated or burned at all, it should return to straightness and recover most (if not all) of the lost poundage. This will, of course, not be permanent, but can greatly enhance the effective life of the bow.

Tiller stick



The stick is made longer than you intend to draw the bow, up to 36" long is good, with slots cut into one side at every inch mark. The edges of these slots should be rounded so as to not wear the bowstring. The centre of the bow rests in the hollow at the top of the tiller stick and the string is drawn down. This can be used to both show the current draw weight and also the current draw length. If the base of the stick is placed on a set of kitchen scales and the string drawn down level to the slots, the downward pressure on the stick shows as the draw weight on the scales. (The string must be held just clear of the stick to check the draw weight). Also, the string can be slid into any of the slots to hold the bow in a curved state while you stand back and look at it to check the developing curve. It is also useful to trace the shape of the arc on the wall/floor for various draw lengths to check shape/flexing. This is a sensible precaution to set up if you plan on making several different bows.

Once the first (long) bowstring is fitted, the bow is placed in the tiller stick and the string drawn till the bow has a small constant curve. From the first time the bow is bent, the curve must be gradually built up from a small gradual curve to the final state, flexing it slightly further at each stage. And once it starts bending, it should not be drawn to a greater weight than the intended final weight of the bow. (In fact, it should be worked to a couple of pounds higher than intended as it is likely to loose a couple of pounds in the final finishing). Once the nocks of the bow are flexing about 12-14" forward from straight, the normal length bowstring can be fitted and used from then on for testing.

The belly of the bow should show the growth rings meeting in the middle of the bow as the curve develops, and these

should be running steadily out to the tips as the constant taper develops.

As the bow is placed in the tillering stick and drawn slightly, step back and look at both limbs. If they are not both curving equally, mark the places that are not bending enough, take the bow off the stick and work it down further. If there are areas that are bending too much, then don't touch these areas until those on either side are worked down so as to spread the curve more evenly.
Both limbs must develop the same curve, and that curve should be fairly constant and even from grip to nocks.
At every stage, and every time the bow is tested, check the curves of the limbs. Check the curve, get them even, then check the draw weight of the bow. Then draw the bow to the current distance several times (10-15), to exercise the wood. This allows the wood to slowly weaken and get used to bending.
Once the curves are even, take the string down another notch in the tillering stick and repeat the procedure until the desired draw length is reached.

The final weight of the bow should be about 2-4 lb higher than the desired weight. Final finishing (sanding etc) plus initial shooting of the bow will cause it to drop the final 2-4 pounds so as to achieve the desired weight. When the bow is completed, it is usually preferable to glue a thin block of wood along the back of the handgrip, shaped to fit the hand better. Once the bow is sanded, it can be sealed with a decent polyurethane or similiar to waterproof, seal and protect it. Alternatively use a polymerising gun stock oil such as BIRCHWOOD CASEY **TRU-OIL.**

Then fit nocks and handgrips as required. If desired, a backing strip can also be added before the handgrip block is glued in place. The backing strip is likely to raise the draw-weight by a small amount (2-5 pounds).

NB, Once the bow has reached it's desired draw weight, it should *NEVER* be drawn to any greater draw length. To do so, greatly risks snapping the bow. So don't lend it to another archer without carefully supervising them.

Tillering Bows

Tillering is the process of working a bow down evenly to reach the required draw weight at the required draw length and to ensure that bow limbs are balanced with respect to each other and ensuring that the "arc" of the drawn bow is even.
The majority of the work here is simply removing wood from anywhere that is not bending enough, and *not* removing wood from places that bend too much. The final result is a bow that bends evenly throughout it's length (Usually except for the handle section, although in some bows, even the handle section bends slightly).

Tools

To work these, you will need a straight edge (or string-line), pencil, saw, hand rasp and/or drawknife and/or spokeshave, sandpaper. A Vice is also very useful, as long as the bowstave is gripped between blocks of wood etc to reduce damage to it.
The professionals often speed the process up with a bandsaw, but these have a tendancy to waste a lot of bowstaves until you know what you're doing.

Because of this, it is most important to get the correct amount of stiffness (spine) in arrows intended for a non centre-shot bow. If the spine is too high, the arrows cannot flex correctly in flight and hence are less able to correct for the travel of the string. If they are too low, then the arrow is less able to dampen the flex in flight, and hence the flexing continues too long.

The arrow 'spine' must be closely matched to the bow weight, as a heavier bow will induce greater flexion. The shaft of the arrow needs to be thicker (to take the extra stresses) and also stiffer (to dampen out the added flex) for a heavy bow, and thinner and lighter for a light bow.

Arrowheads.

Primitive man started with a arrowhead that was hardened by burning the end of the shaft slightly, then sharpened by shaping the burned end. A 2- blade broadhead (2 cutting edges) was used as the primary hunting and war arrowhead for centuries, either cast from bronze, chipped from flint, or forged in iron/steel.

The arrival of plate steel armour meant that the arrowhead had to change to allow it to punch through rather than cut, so bodkin points were developed in a variety of sizes and shapes. They tend to be very narrow and longer than a hunting broadhead, with little or no cutting edges, in a square or triangular cross-sectional shape to enable it to place the maximum stress on the smallest area of steel plate armour as possible, so as to penetrate as deeply as possible.

Japanese and Chinese arrowheads, on the other hand, have a wide assortment of warheads, each of which have specific effects and intended uses. Amongst these are specially designed heads with hollow channels through them to enable the air to flow through them, giving different sounds in flight. These can be used to scare men and horses in combat. They also have armour piercing alternatives etc.

Turkish flight arrows often had horn tips, thus reducing weight as much as possible.

Armguards.

Simple leather forearm-guards (bracers) with leather thongs were most common, although the more advanced craft of archery amongst some of the middle eastern groups used to make bracers from thin strips of wood, bone or ivory and held in or glued to a leather or cloth body and strapped on. Formal English archers were also kn own to have worn a large glove which extended as far as the elbow, and had pockets fitted for spare strings, wax etc.

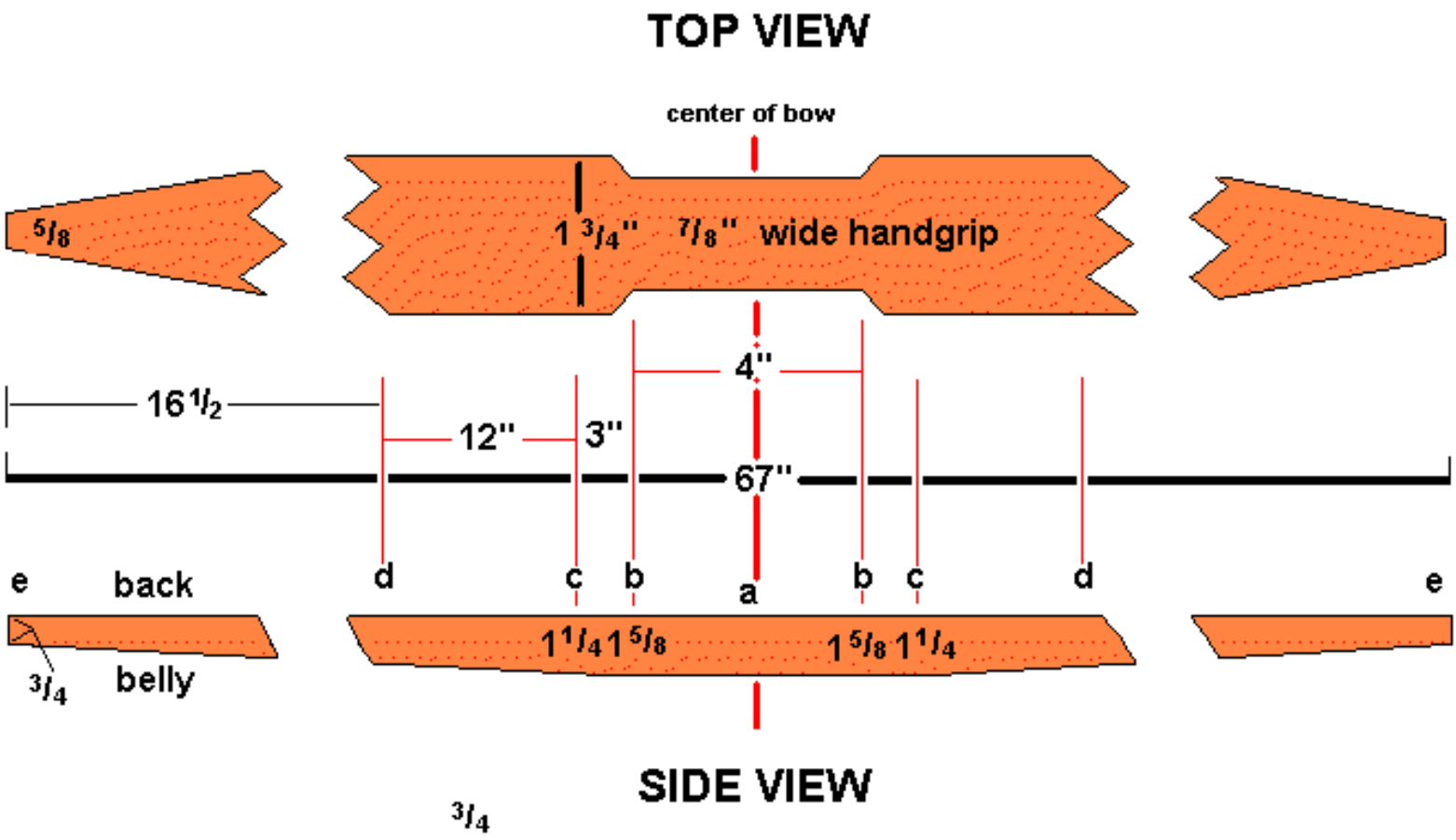
Competitions

Preparation

Ideally, the wood should be split rather than sawn, preferably Bow staves should be radially split from a log/branch which is 4-6 inches diameter plus. This means that it is more likely that the wood will follow the grain, whereas sawing is often more likely to cut across grain. The more the bow-stave follows the grain of the wood, the less likely it is to break, and the stronger it is likely to be. If the grain runs across the bowstave at any sort of an angle, this will weaken the bow to a certain extent, the amount of weakening depending on the degree of the angle of the grain.

Usually the sapwood becomes the back of the bow, particularly in the traditional "D" section longbow. Grain alignment is not as critical when using LEMONWOOD/DAGAME, which is recommended for the beginner.

Self-Flatbow



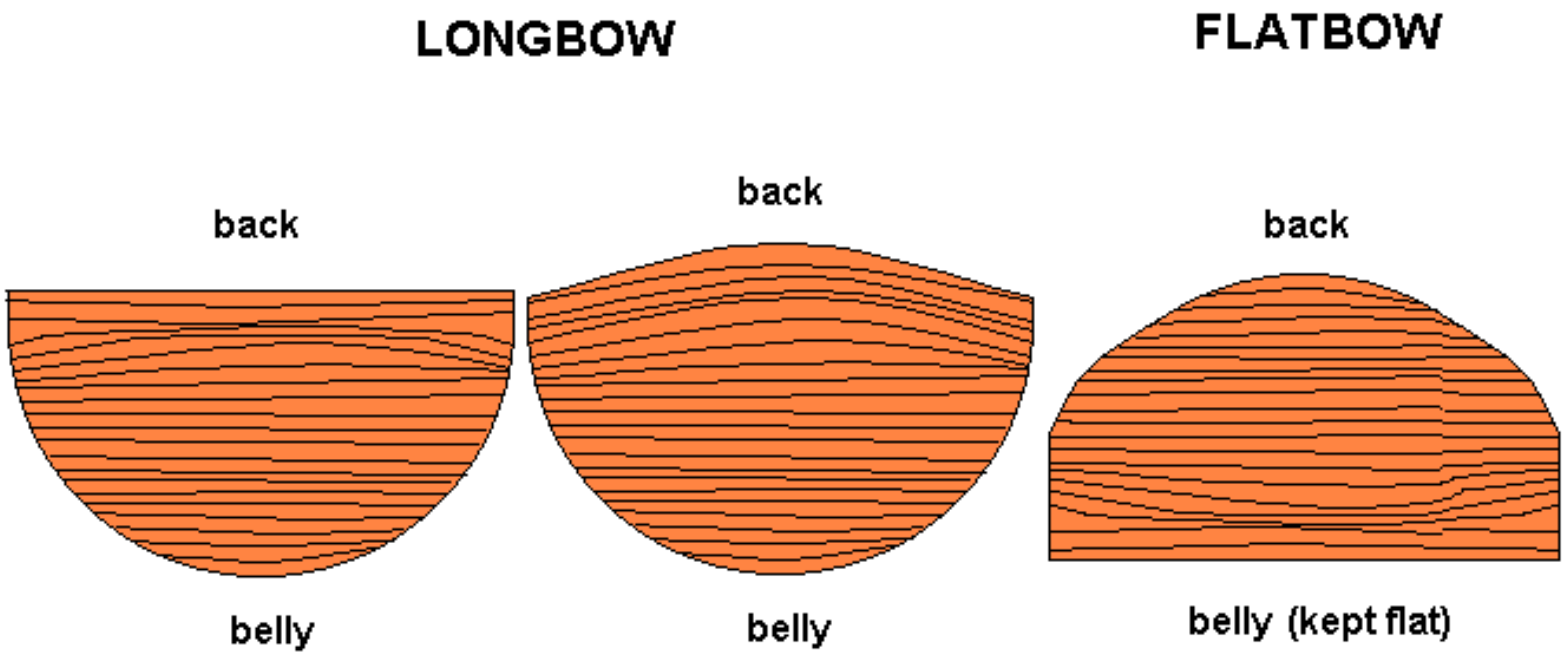
(NB, the bow is drawn to 67" length, designed for a 28" draw length. If your draw length is longer or shorter, alter the total length by 2" for every 1" draw length change (e.g. draw length of 26" gives a length of 63") Handle section (c-c) remains the same, the rest (c-e) should alter in proportion.)
Also, the handgrip on the belly side (c-c) can either be all of one part of the main bow, or else can be a second length of wood glued onto the belly to give the necessary depth.

First, draw a line the full length of the back, directly down the middle of the bow, using a straight edge or string line. Mark the middle of the length of the stave 33.5" from each end. (a) The handgrip will be 2" (a-b) either side of this, (giving a 4" long handgrip b-b) and will then widen over the next 3" (b-c) to the widest part of the bow (c). From c-d (12") the stave remains the same width (1 & 3/4" total width or 7/8" either side of the centre line).

>From d-e, the bow width tapers as a straight line down to a final width of
about 5/8" (5/16" either side of the centre line). Once these are marked on the back, they can be cut to shape and smoothed with plane and sandpaper, giving the rough shape.

>From the side, the depth of the handgrip (b-b) should be about 1&5/8", tapering
off to about 1&1/4" at (c) and then a straight taper down to about 3/4" at (e). Once this basic shape is sawn out, the

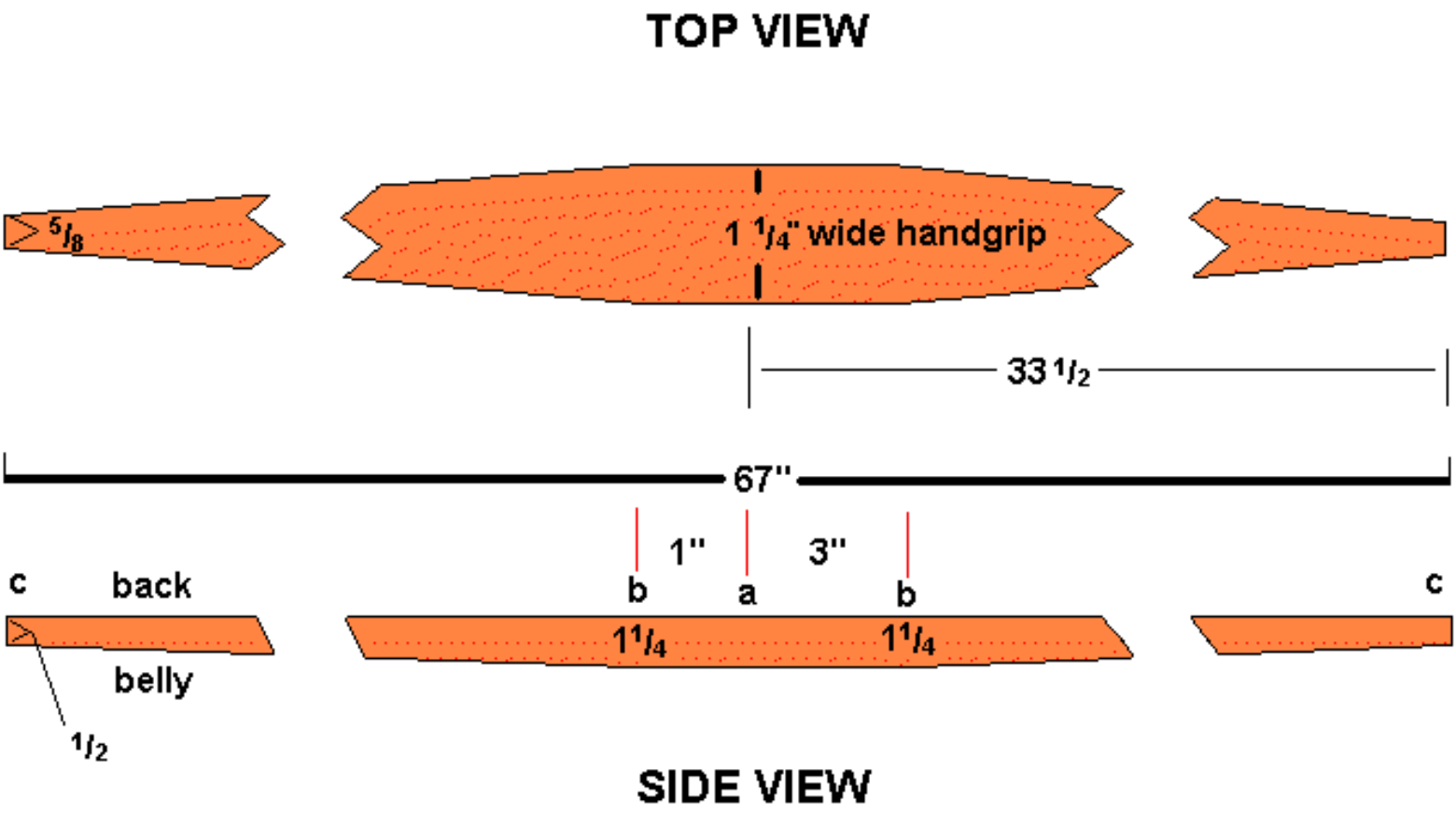
belly can be worked down to meet the required weight using more cautious handtools. The Belly is kept flat throughout it's length and the taper towards the tips kept constant.



(the back remains flat, or slightly convex, following the natural line of the growth rings and the sides and belly slightly rounded into a "D" shape. Wood is shaved off with rasp, spokeshave, drawknife or scraper untill the appropriate tiller is maintained, all the time ensuring that the slope of the taper remains constant from handle to tip.)

(See 'Tillering bows' for details on working to weight)

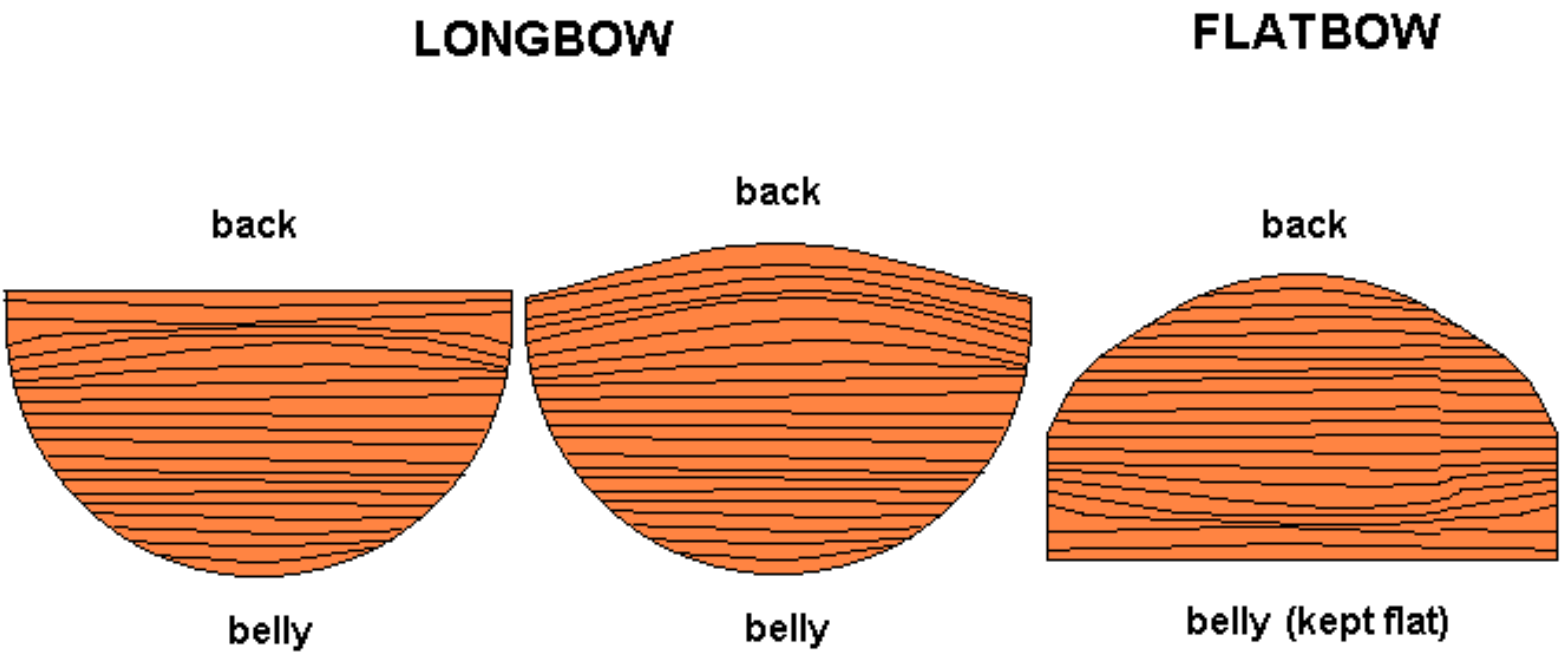
Self-Longbow



To mark the bow out, draw a line the full length of the back, directly down the middle of the bow, using a straight edge or string line. Mark the middle of the length of the stave 33.5" from each end. (a) The handgrip will be 1" from this (a-b) on the upper limb and 3" on the lower limb, (giving a 4" long handgrip b-b but meaning that the upper limb is 1" longer than the lower one). From b-b, the width should be about 1&1/4" wide (5/8 either side of the centre line) and from b-c should taper smoothly down to about 5/8" wide (5/16" either side of the centre line).

Once these are marked on the back, they can be cut to shape (cutting outside of the line to allow slightly extra wood) then smoothed to size with plane and sandpaper, giving the rough shape.

>From the side, the depth of the handgrip (b-b) should be about 1&1/4", tapering
straight down to about 1/2" depth at (c). Once this basic shape is sawn out, the belly can be worked down to meet the required weight using more cautious handtools. This style of bow has the centre of the belly remaining high and the sides and belly completely rounded.

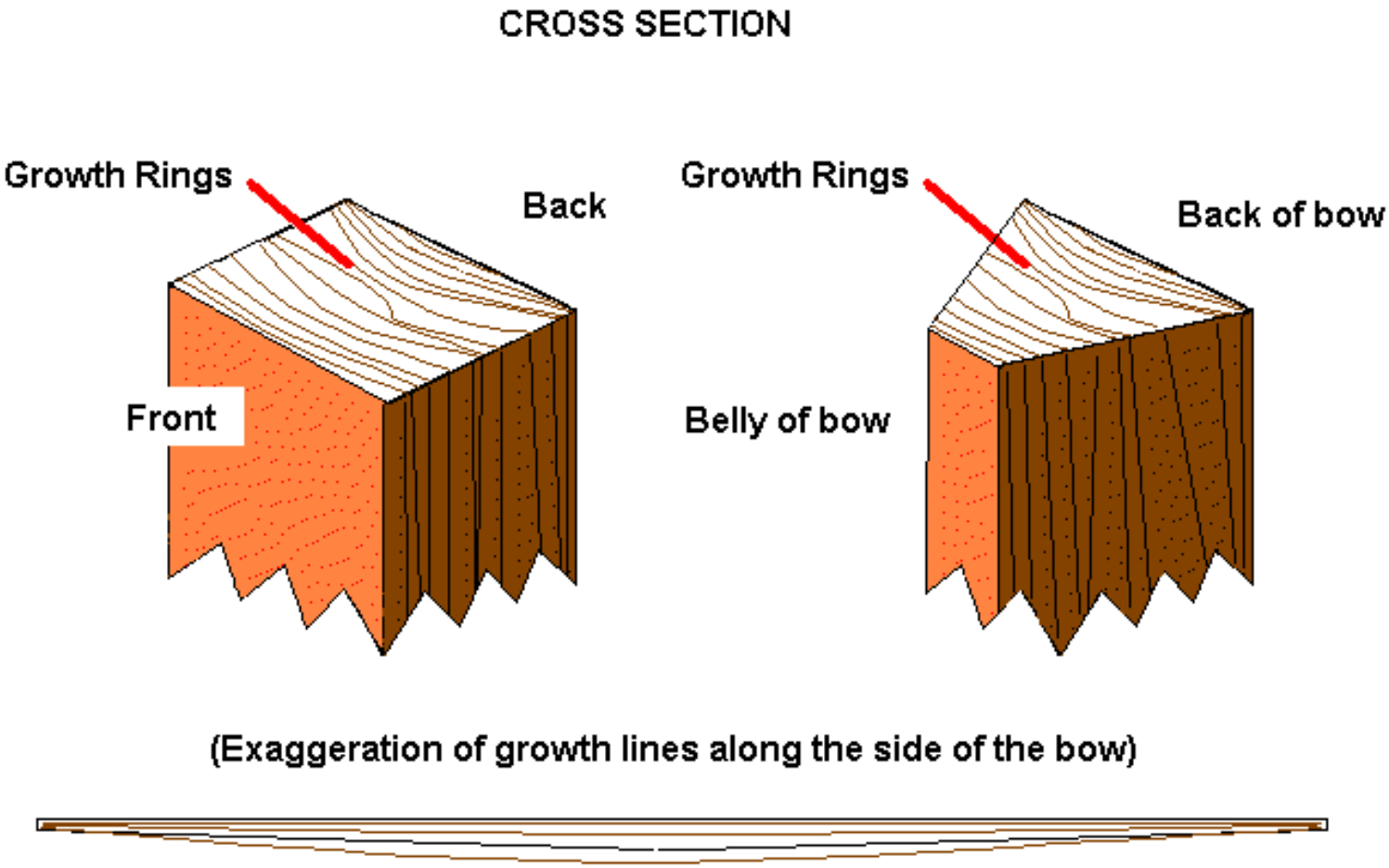


(the back remains flat, or slightly convex, following the natural line of the growth rings and the sides and belly slightly rounded into a "D" shape. Wood is shaved off with rasp, spokeshave, drawknife or scraper untill the appropriate tiller is maintained, all the time ensuring that the slope of the taper remains constant from handle to tip.)

(See 'Tillering bows' for details on working to weight)

Ideal line of grain and wood growth rings

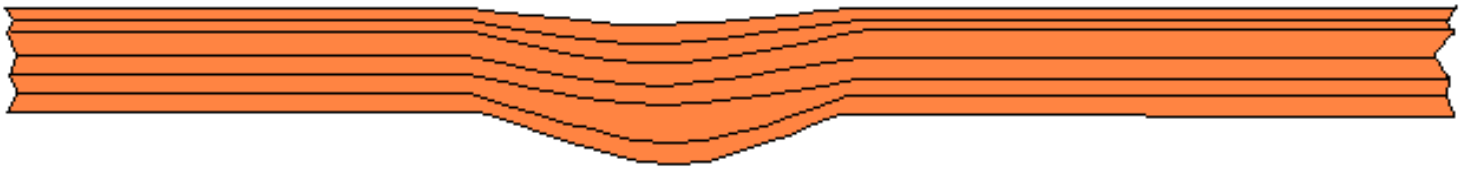
(NB Variations in these are perfectly allowable, but the greater the variation from the ideal, the more likely it will be that the completed bow will be weaker and more prone to breakage in use or in construction)



The grain should also run straight along the length of the stave from end to end. If it curves up and down, then you have to alter the design to follow the grain. At all times, the back of the bow should follow the line of the grain and the front (belly) of the bow should follow the line of the back (with the appropriate tapering required). Likewise if there are any knots in the wood, you have to alter the design to allow slightly extra wood to go around and support the weaker knot wood (or 'pins').

eg if the grain dips down in the bowstave, then the bow should also be shaped to follow that curve
(from a side view of the grain)

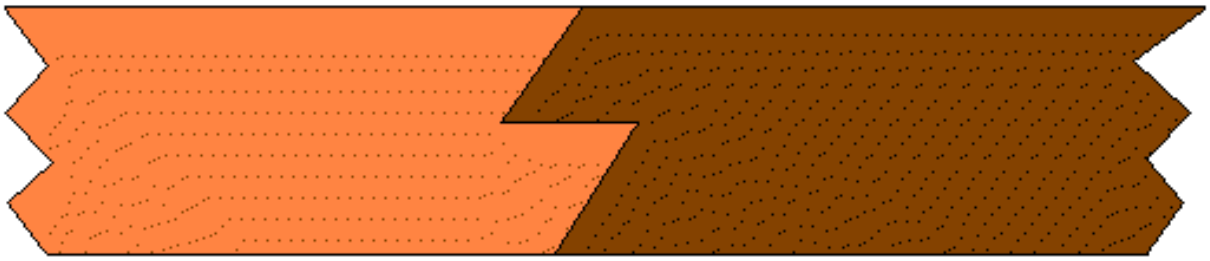
(Side View of grain)



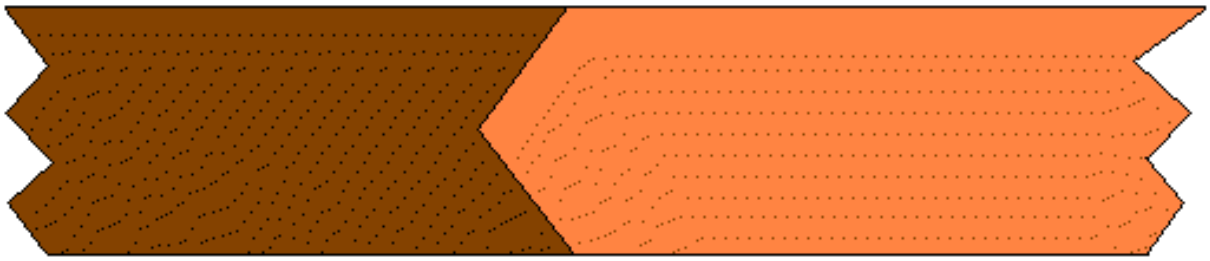
Here the dip in the grain will be followed in the bow, resulting in the bow having a dip in one arm. If not followed the grain will be cut, weakening at this point.

With twisted staves, it is best to joint two "sister" split pieces from the same log (ie two pieces split next to each other from the same log - and which would then have similar twists) and joint them at the handle using a Z- or FISHTAIL SPLICE (as below). This ensures that both limbs are complementary, even if badly twisted.

Z - splice



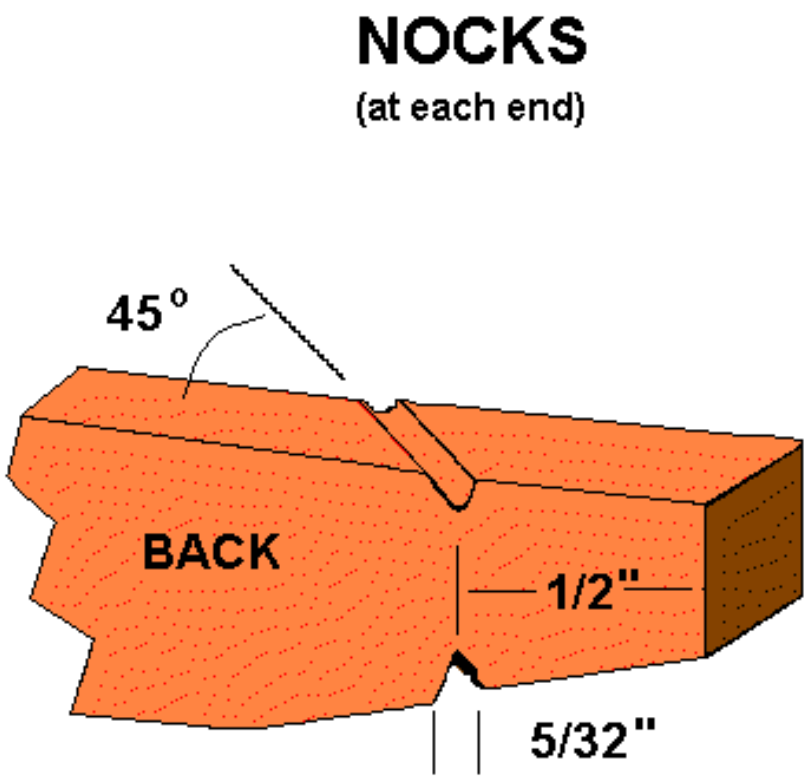
Fishtail - splice



This can also be done if you are unable to find a single length of wood to make a complete stave. 2 half-lengths can be spliced using either of the above splices, such that the spliced section will be in the handle section of the bow and therefore covered by the handle wrapping etc.

Fitting final Nocks

Final nocks can be cut 1/2" in from the end of each limb, sloping at a 45-degree angle from back to belly, using something like a 5/32" circular rasp, pocketknife or 4mm chain saw sharpening file. Care must be taken to keep the back of the bow as clean as possible, ie it should not be cut or worked at all when fitting the nocks. To do so is likely to cut the growth rings, weakening the limb.



As an alternative, many longbows are fitted with antler or horn nocks, slid over the end of each limb and glued in place. This helps protect the wood from abrasion from the bowstring and is also quite decorative. To make these, take a section of antler or horn of up to 4" long and 1/2"-3/4" across at the base. The end of the limb should be shaped into a cone shape for about the end 1/2" of wood, and the base of the antler nock drilled out to fit. File or cut nocks into the antler, then spread a strong waterproof woodworking glue onto the end of the limb and slide the shaped antler nocks on, holding them firmly in position until the glue has set.

Also, as another alternative to cut nocks, it is possible to tightly wrap sinew (or cord) around the nocking points of the bow and glue it in place. The string is then slid over the ends and held in place by the loop of sinew.

Precise tillering

The easiest way of doing this is to have a 'Tiller stick' and a pair of bowstrings. The first bowstring is a very heavy and very long one so the bow can be strung just by slipping the long string on without flexing the bow. The other bowstring is used later once the bow starts to flex evenly to about 12" or so.

The other alternative is to have a pulley rigged up in the workshop, so the bow can be drawn using a pulley and rope with the bow handle clamped down to the floor or bench, set up so that you can hold the rope and still stand back far enough to compare the developing curves.

With a spring scale, this can also be used to determine the draw weight of the bow.

It is also useful to trace the required curves on a section of wall or paper such that the developing bow can be compared against it. As long as both curves are graphed accurately, this helps to ensure that both limbs match perfectly when they are completed.

Rawhide bow backing

I have found a good source of rawhide for backing bows in the local pet shop. They sell rawhide doggy chews that are about 18 inches long, composed of a tube with a knot in each end, looking rather like a shabby femur bone. Other pet shops I have asked knew about these large chews and were prepared to order them for me.

The first task is to choose good material. These chews are a sort of dirty buff color. Reject those with obvious flaws, such as splits, and try and get hold of those with an even coloration. They are translucent, so surface blemishes show through, but I haven't experienced problems, even with quite thin areas in the material.

In order to un-knot them, you have to soak the whole chew in cold water for about 2 days. The knots in the ends then come undone quite easily. My chews consisted of one single piece of rawhide about 36 inches long, 6 inches wide, rolled into a tube and packed with other bits of rawhide about 6 by 11 inches.

Once the pieces of hide have been separated and while they are still soaking wet (they are now white and sort of blubbery), you can smooth the surface. The hair side is usually ok, but the inner surface can be a bit rough. I clamp a steel straight edge in a vise and just draw the surface over the steel edge a few times. This scrapes off a lot of loose-hanging bits.

Next put the rawhide you will be using into a bath containing cold water with about 2 ounces (a scant handful) of washing soda per gallon dissolved in it. Leave for 24 hours to degrease the hide.

Take the hide out of the bath, rinse it quite well under running water and then roll it up in damp sacking for 24 hours. This renders it damp enough to work with, but not wringing wet.

I have backed both board bows and stave bows with rawhide. Stave bows are easier due to their lightly rounded back, so I shall deal with them first.

The best glue to use is hide glue. It works like a charm. Put a handful of hide glue granules in an old tin can and allow it to soak overnight in just enough cold water to cover it. If you don't have a glue pot, cover the bottom of a saucepan with marbles or pebbles so as to support the tin can free of the bottom during heating. Fill the space between tin can and saucepan with water and heat the whole contraption until the glue is fluid. Thin with water to get a syrupy consistency. Stir well. Take the stirring stick out of the glue and watch the glue dribbling off it. If it drips in splashes, the glue's too thin. If it doesn't flow easily - too thick. A thin, consistent stream is about right.

Take your bow and clean up the back with fine sandpaper to give a clean, grease free surface. I usually wipe it over a couple of times with a cloth soaked in acetone to ensure really grease-free conditions.

It helps if the bow is mildly reflexed before backing. Tie a stout cord to the nock ends, take a loop over a screwdriver or other lever in the middle of the cord, and twist the lever to cinch up the bow into about 2 inches of reflex. Tie off the lever to the cord. Mount the bow in a bench vise with the reflexed back uppermost.

As soon as the bow is clean and grease free, paint a thin layer of hot glue over the back surface to seal and prime it. Allow the rpiming coat to cool and set (overnight).

Meanwhile, you can cut the rawhide to shape using a hobby knife. Do this on a clean surface because you don't want dust and grit on your wet rawhide. Allow plenty of overlap over the sides of the bow as the hide shrinks as it dries.

The hide will have to be jointed, preferably under the hand grip. I use a skiving joint.

where the overlap is about 0.3 to 0.4 inch. I've done it in two ways: the proper way, where you bevel the mating edges of the damp hide using a sharp hobby knife before you apply the backing. And the lazy way: Back half the bow. After about a day, bevel the glued down backing at the joint and back the other half of the bow, using a generous (1 inch) overlap. When the backing is dry, you can grind / sand / rasp off the excess, leaving a neat surface.

Backing the bow is a simple operation. Get everything ready before you start. Make sure the glue's nice and warm and running like table syrup. Paint a thin layer on the back of the bow, running down over the sides. Place the backing strips in place on the bow, starting at the centre and smoothing towards the limb tips. Glue the joint. Don't worry that the glue gels almost immediately: the dampness in the hide causes the glue to swell and form a bond.

Now take a bandage, minimum 2 inches wide (as used for first aid) and, starting at the handle, bandage the bow and backing tightly. Overlap the turns of the bandage by about an inch. Fasten off the limb tips tightly with a string whipping. Just to make sure, I now usually use a second layer of bandage over the first.

Restrain your impatience. Remove the bandage layers after 48 hours. Re-whip the joints and the nock ends with string. Allow the bow to dry out for at least a week. A month might be better. Then remove the whippings and the cord used to strain the bow into reflex.

The rawhide is now as hard as finger nail. Carefully trim off the excess using a hook knife (as used by carpet / lino fitters). Rough edges can be trimmed with a Surform, and final trimming is done with a spokeshave, set for a fine cut.

Allow the bow to cure for about another month before finishing it. I sand off the rawhide surface with fine-grit paper, giving a very smooth surface, before decorating and varnishing the bow. I use yacht varnish. Several coats, sanding between coats. Pay particular attention to the sides and the joints, where

rain can seep in.

You can also use the same technique with other parts of the bow. Since my last bow was only 3 millimeters wide at the nock ends, I fashioned nocks from a thin strip of wet rawhide, folded over a thin piece of wooden dowel, then glued and whipped on. Nock-shoes and arrow plates can also be made.

Backing a flat-backed (de-crowned or board) bow is similar, but I have found it useful to use a pressure distributor in the form of a strip of aluminium with a T-shped croos section. I place this with the wide flat area in contact with the bandaged back, then tie up the whole works tightly with cord.

Be aware that, when varnished, the rawhide backing goes almost transparent. So you can see the wood grain through the backing. You can also see any air bubbles and imperfections in your glueing technique!

I have found a rawhide backing to be immensely strong. It also recovers fast: when just unstrung, you can see the bow visibly creeping back to its normal conformation. If it has a drawback, it's that it is relatively heavy and doesn't add to the bow's cast. Set against that, it's like armor plate, and protects the bow against dings and scrapes, as well as other archers who may want to 'have a go' with one's pride and joy.

Recommended reading

The Traditional Bowyers Bible - Volume 1 & Volume 2, Volume 3 Bois d'Arc Press, P.O.Box 233, Azle, Texas 76098 tel.: (817)237-0829. about $25-$29 each

"Longbow - A social and military history", by Robert Hardy,

"The book of the longbow" by R. Elmer and C.A. Smart, published by Doubleday

"Native American Bows" by T.M. Hamilton, edited by Nancy Bagby, published by George Shumway, York, Pennsylvania, 1972.

"Building Robin Hood's Longbow" by Jelen Maciek, a 2-part article fromthe US magazine "Traditional Archery", 1985.

"Basic Bows" by A.S. Clarke, a 2-part article published in the July/August and September/October 1986 issues of the Australian archery magazine "Archery Action".