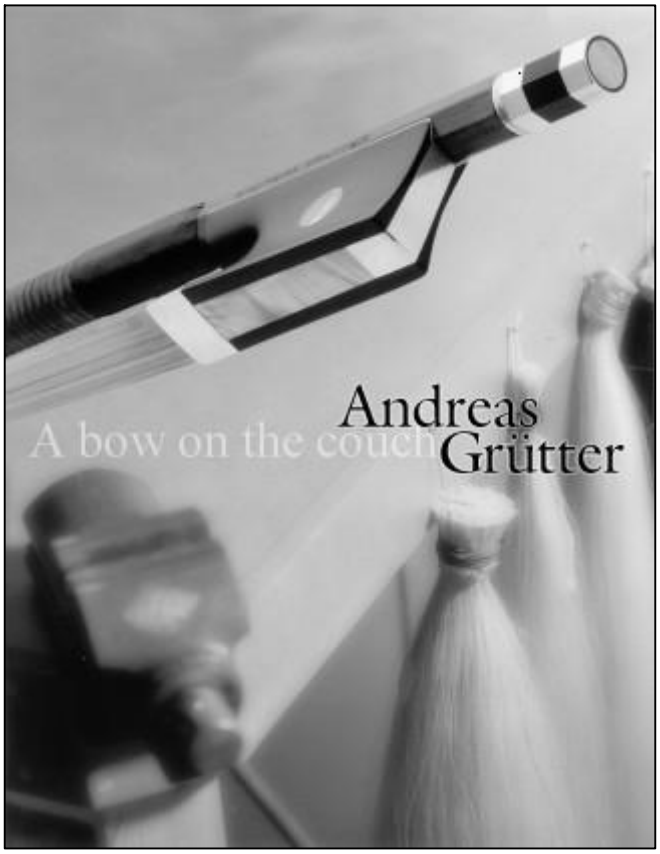
Andreas
Grütter

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Preface

The Chinaman Ein-lei-tung (about 2,000 BC) in his boundless wisdom, concentrated on **one thing** only during his entire life, namely his bamboo stick. After 50 years of deepest meditation, Tung, a man of genius, invented the **bow**, while stretching his bamboo stick with a bundle of horsehair. Even today we still think of him with the greatest respect. Unfortunately the original model, alleged to have had great mythical power, is irretrievably lost, but in spite of this, there are always adventurers who still go in search of the wonderful original.

Concerning the Author

The author - well, that's me. It is possible that you, the reader, don't really care, and just want to get down to business. **But how can you understand the title without reading this introduction?** Besides, I have not written many books, and therefore find it hard to pass up the opportunity to say something about myself.

My parents are psychoanalysts, both of them. But there's no need to pity me on that account, my childhood was no worse than yours. Only different. The question **"why"** had great importance already at that time. And with me, that is still the case.

There are different kinds of bow makers. There are the "what" types, who are often former musicians. There are also the "how" types, who are usually craftspeople. Then there are the "how much" types, who are the dealers. I am clearly of the "why" type, **the psychologists of bow making**.

What I do, so to speak, is lay the bow on the couch and try to analyze it. **Every little detail contains a story.** The interplay of all details results in a particular character. Sometimes I also indulge in the therapy of couples. This concerns the interplay of bow and fiddle. For if the sound post in the violin is in the wrong place, one does not need to fuss around with the bow. It can happen that musicians may themselves wish to have a go at this. But this is not my style.

In accordance with my parents' wishes, I had an academic education. But as I got older, I became more interested in both **craftsmanship and music**. My brother took up music. I lacked the talent for it. So I began making instruments. In fact, I found the craftsmanship part rather **troublesome**. My constant need to know the "why" of things was something of an irritant. As a result, I developed a kind of **sound fetish**. For me, a beautiful sound is an **erotic experience**.

So I flirted with tone production, a rather bewildering phenomenon. In this essay, I am principally concerned with how the bow contributes to the **production of a tone** or several tones. This is already a rather complicated process, as will soon be clear.

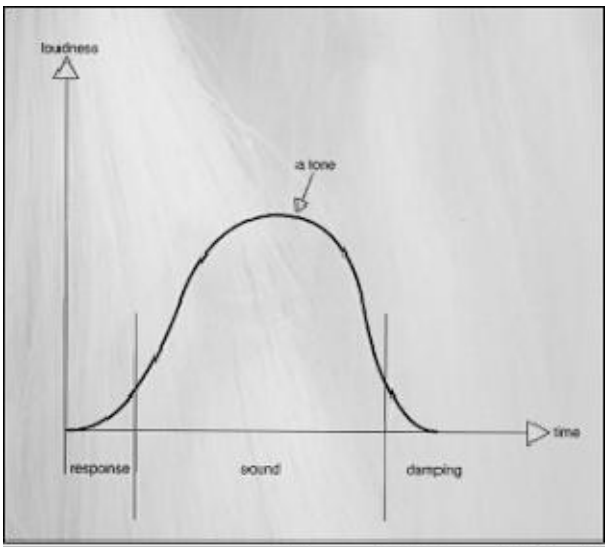
1. The Note

The bow causes the string of a stringed instrument to vibrate. The vibration is transferred to the instrument via the bridge. The instrument causes the **air to vibrate**. We then hear this as a tone.

What we hear depends on many factors. The most important, of course, is the **player**. But this interests us only marginally. In fact, **the player, instrument and bow act as a whole**. Each of the components affects the others. But my visual attention is focussed on the part played by the bow. Not every player appreciates the importance of the bow. It is therefore interesting to try different bows from time to time. I find myself astounded again and again by the huge differences one hears. Not only is the tone different, but so are the dynamics, the whole essence of the music. **It seems as if different bows also invite the musician to play differently.**

My intention is to **analyze** these differences. What is it about the bow that gives it this individual character. My approach is not strictly scientific. As in psychology, empirical and subjective explanations are also accepted. My findings are therefore not completely provable, but I hope they will be understandable.

What complicates this exercise is that **every detail of a bow affects every other detail**. The character of the bow arises from the links and interrelationships of these details. To bring some order into this complicated business, a few definitions are necessary.



Picture one: The three parts of a note

The tone is a sort of wave which swells and diminishes. This wave is divided in three parts. The swell I call the **response**, the diminution the **damping**. What takes place between them is the **sound**.

1.1 The Response

For the sake of clarity, let us first consider a **single note**. It begins with silence. The **bow rests** on the string. Since there is rosin on the bow hair, it adheres to the string. Now the player moves the bow. We can observe this as though it were happening in slow motion.

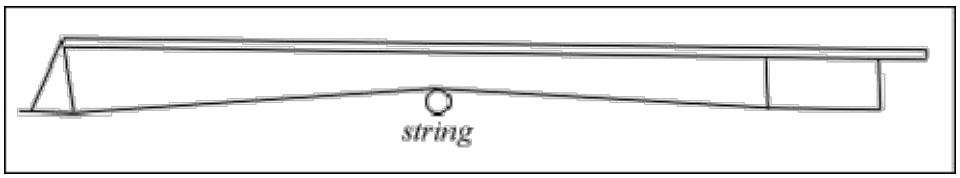
The bow **accelerates**, like a car starting from a full stop. But the hair still adheres to the string. The bow pulls the string in the direction of its movement. The further the string is drawn, the greater its tendency to disengage from the bow hair. The hair also pulls on **the bow, which also yields**, like the bow used to shoot arrows.

But the string's tendency to disengage soon overcomes the bow's adherence to the string. At this point the string snaps back. But the bow continues moving, driving the string along **like a top**. There it is! The **vibration** begins. The way the bow causes the movement of the string to accelerate is what we call its **response**.

At this point a few words need to be said about the **bow hair**, since it is the hair, not the stick, that makes contact with the string. It matters a lot how thick the individual hairs are, how many there are, and whether these are evenly distributed. A bad job of rehairing can affect performance negatively. Reportedly, Mme. Tourte herself washed and selected bow hair with the greatest care.

Every bow has its own response, which is only achieved when the bow is **properly rehaired**. Just as a car needs the right tires, a bow needs more or less, thicker or finer hair. The stronger the bow, the denser the hair that is required, and the more of it that is needed.

Let us now consider how the hair rests on the **string**. The string's surface forms a curve. The **surface** of the hairlint is flat. If the hair is **tight**, the point of contact between the string and the bow hair is very **small**. If the hair is **looser**, and more yielding, it can envelope the string a bit, **increasing the contact surface**. Therefore, a softer bow can set the string in motion more easily. In any case, more effort is needed to move the string with a firmer bow.



The response is almost or entirely **inaudible**, but its effect on the sound is not. The vibration that ensues depends on how aggressively the string is activated. But there is **no ideal response**. The best that can be hoped for is a good compromise. Above all, the bow must be compatible with the

instrument, because the instrument has its own response, which affects the vibration just as much. In addition, a high note has a shorter response than a lower note, because the wave length of the higher note is shorter (Firm bows therefore work usually better for high notes, soft bows for bass notes). It also matters where the bow makes contact with the string.

The string has more room to vibrate over the fingerboard than near the bridge. That affects the relationship between the grip of the bow on the string and the capacity of the string to return to its original position.

The screw makes it possible to tighten or loosen the bow, but what ultimately matters is how the bow is made, and how and where it yields. Usually, it yields the most at its **weakest point**, which is right behind the head. Every time a new vibration is produced, the tip of the bow bends a bit. What matters here is not so much the strength of the wood as the **relationship** of the weakest point to the rest of the stick. There are bows with a short, particularly weak point behind the head, and others where the stick broadens more evenly, leading to a different kind of response.

It is hard to express this in words, but what can be said is that a **short, hard response** generally allows for more **transparency**, but increases the danger of incidental noise. **A softer, slower response** results in a **rounder sound**, but makes it harder to tell exactly when the tone starts. In the end, players have to pick a bow compatible with them and their instrument.

1.2 Damping

A note is a vibration. The next note is another vibration. The bow vibrates each time the string is set in motion. If the bow stops moving, the note sounds a bit longer and dies away. A plucked string vibrates much longer. But the player uses the bow to make the instrument **play the next tone**. It is therefore desirable that the bow addresses the next note as it ought to, rather than continuing happily in the direction it was first asked to move.

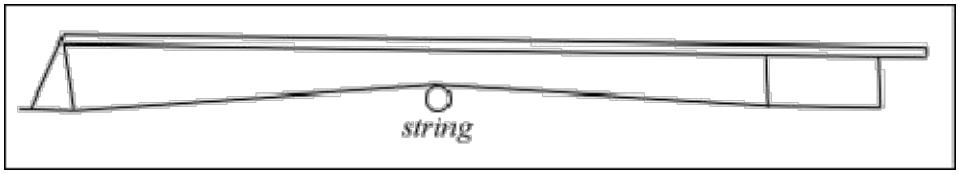
The movement of the bow is a **reciprocal relationship** between the **hair** and the **stick**. The greater the tension on the hair, the more responsive the bow. The less the tension, the more the vibration is damped. The bow must therefore not only activate the string when moved, it must **also stop it**. The damping is actually inaudible, but can be felt as **resistance**. It is the feeling that the player can **shape the note**, that the bow does exactly what is asked of it, **but no more**.

The damping, however, affects not only the end of a note, but also **the sound**. The sound is in fact a specific **combination of overtones**. That some overtones are less strong or even entirely missing, is because they have been **dampened away**. One can imagine this in terms of a colour. If we see a red

colour, this is red because the material absorbs the other colours of the spectrum. It is more or less the same with a note. We hear it as it is, because the other possible overtones become **absorbed** by the instrument and by the bow. Which overtones are absorbed depends on many things, but I will restrict myself to the function of the bow.

Here the **material** is very important, particularly the nature of the wood, its thickness and mass, the length of fibres, the thickness relationships and the tension to which everything is subjected. **There is hardly a detail of the bow which is not engaged in damping**.

It is clear that the bow is a tool for producing a note, but the way it damps the tone is at least as important. That the bow too vibrates with every note can be felt by touching the stick. I will try to analyze these vibrations by concentrating on one **hypothetical oscillation**. This is something like concentrating on a single water molecule in the bathtub. It is very difficult. But it is absolutely certain that water molecules exist and that they move. Our vibration works the same way. It exists, and it moves. The bow rests on the string. There is no sound. When the player moves the bow, the vibration begins at the point where the bow rests on the string.



The vibration can go in **two directions**, forward **toward the head**, and backward **toward the frog**. I will follow the first, which moves toward the head. First, **the hair vibrates**. Of course, this too has a damping effect, as does every material in its respective way. But, under tension, the hair is extremely **elastic**. It transmits the vibration without disturbing it much. Now the vibration reaches the ivory at the tip, then the ebony, then the mass of pernambuco that constitutes the head of the bow. Even if our vibration has a powerful effect on the hair, it can **hardly move the head**. In addition, it has traversed a variety of materials, **each with its own damping effect**. It has therefore already taken something of a beating. What is left of it advances from the head to the thinnest part of the stick. There it can catch its breath, but the further it moves along, the thicker the stick becomes, which damps it again. In fact, there is **not much vibration left**. If we pursue the vibration the other way toward the frog, the effect is similar. The hair meets metal, ebony, metal again, and then has to leap across to the stick. But now it gets an extra weight around his neck, the silverwinding. The effect of which is rather like the damper on a tennis racket.

The two attenuated vibrations meet along the stick like two ripples in water. The ripple from the frog might be slightly stronger, since the stick is thicker at this end. Although I have no way to prove this scientifically, I assume that the **combined wave** moves in the **direction of the head**, because every wave moves in the direction where it meets least resistance. A fraction of the original vibration is

transmitted back through the hair via the head. But this is so minimal as to be overwhelmed by the counter-vibration. **Our vibration has been damped.**

The idea that the **bow's main job** in relation to the instrument has more to do with **damping** the tone than producing it is something that came to me only recently. But a willingness to see things this way is a key to understanding many of a bow's details. It is possible that many makers, who have made made fantastic bows, never thought about damping. But this hardly means that the theory is wrong.

1.3 The Tone

A bow by itself, of course, makes **no sound**. But when tried out on various instruments, it becomes clear that the bow produces a certain tone from each instrument. It might be that the bow produces a better tone from one instrument than another. It can therefore be said that **the bow has a certain tone quality**.

The tone is primarily a **product of response and damping.** If response is understood as thesis, and damping capacity as antithesis, the tone is the synthesis. The synthesis is new, but is subsumed in the thesis and antithesis. But is not quite correct to say that the tonal character of a bow is only determined by its response and damping capacity. Tone is identical with the vibration referred to above, and depends in turn on the player and how the instrument responds. Any reference to a bow's tone is therefore a **theoretical abstraction**. The natural frequency of a violin's top or back can be measured. How these relate to one another is highly important to the tone quality of a violin. The natural frequency of an untightened bow says very little, because a bow needs to be **tightened in order to be played**. Depending on the tension and pressure put on it, the natural frequency of the bow changes significantly. The most that can be said is that one bow has a higher natural frequency than another. The loudspeakers of a stereo system are an analogous case. Each speaker has a particular range of frequencies and a particular character. Every part of the system is important, even the electrical cable. The same applies to the bow. **A good tone is produced when all parts** or qualities of a bow **combine harmoniously**.

Perhaps the most important influences on the quality of the tone are the **quality of wood**, the parameters of its **thickness**, and the relationship of both to the **camber** of the bow. When the proportions are right, the tone is good. On the other hand, the speed of response, springiness and and strength of the bow have little to do with the sound it produces.

On the contrary, it happens only rarely that these qualities combine with a nice tone in a single bow. The maker looks for a middle way that does justice to all the different demands a bow has to satisfy.

2. Differences according to instrument

In principle, the demands placed on an instrument are generally the same. As Shmuel Ashkenasi says, "What I look for in a bow are basically four qualities: sound, articulating qualities (referred to above as "response"), strength and perfect balance." But these take different forms in different instruments. The violin and viola are played in a more or less horizontal position. The cello and bass are played vertically. There are therefore clear **differences in the demands on the bow**. In addition, each group of instruments presents specific structural problems that the bow has to deal with.

For many years I tried to compensate for the weaknesses of the instrument by building bows in a certain way, but without much success. Vice versa works better. What is needed is a bow that goes in the same direction as the instrument. This will emphasize the instrument's strengths and also moderate its weaknesses.

In the remarks that follow I run the risk of over-generalizing. Not all violins are alike. Every instrument has its own complicated character. But there is a certain bow for each group of instruments. In fact, I have seen violists play with cello bows. But this is an exception.

2.1 The bass bow

I myself play the double bass a little, and my wife is a professional bass player. When I go to a concert, I therefore listen to the basses with special care. My impression is that bass entrances are **chronically late** - with the exception of my wife, of course. The bigger the orchestra, the later the basses come in. In fact, if you watch the basses play, it looks as if everything is right. But if you listen, what you get is something like the lag between lightning and thunder. In the latter case, what accounts for the lag is the different speed of light and sound. But so far as I know, the sound of a violin and a bass move at the same speed. Therefore, the **delay** we hear originates **in the instrument itself**. This is no surprise, considering the difference in size between a bass and a violin. The string is about three times longer. When the bow moves across the bass string at the same speed it moves across the violin string, the bass string needs a correspondingly **longer time to start vibrating**.

The vibration must then move past the bridge (four times higher) to the top (with a surface ten times larger). Far **more mass** needs to be moved, and a longer path traveled, before the vibration of the string becomes audible. Therefore, a bass will always be more sluggish compared to the other instruments. This sluggishness is a challenge to the bow's **response**. In the case of the bass, this means that it is especially important that the bow's response fit the instrument. The damping capacity of the bow, on the other hand, is less important, since there is more than enough of this in **the**

instrument itself. It has always surprised me that double basses with more than three hundred cracks and a tangle of badly-executed repairs can still sound so good. This only makes sense if the damping is understood as an important part of the tone. The repairs and cracks are actually dampers.

The instrument's size, of course, is a damper in itself. The damping capacity of a bass bow is therefore not something that needs to be worried much about. The real problem is getting the instrument to vibrate. It is well-known that there is a **French** and a **German** way of holding the bow. The French bow is also constructed differently. Usually the French bow requires more pressure on the strings and near the bridge. This calls for a strong bow with a pronounced response. In the case of the German bow, the string tends to be drawn from the wrist, allowing the bow to be softer and lighter in order to achieve a softer response. There is also a significant difference with respect to balance. The French bow is a bit shorter, and therefore needs a much more massive head. The German bow, on the other hand, needs to be light at the tip, since it needs to cover more distance when changing from one string to another.

It makes no sense to add a German frog to a French bow. Their respective qualities should not be mixed, nor should the character of the bow be modified to compensate for the disadvantages of one or another style of holding the bow. German is German, French French, and a good musician is good, whether German, French or Greek.

In summary, **response** is the **main issue** in bass bows. Tone is largely dependent on response, because the instrument itself offers more than enough damping capacity.

2.2 The cello bow

The cello is the instrument whose range most closely approximates the human voice. Its size, form and the way it is held lead to erotic associations that we will not go into here.

The fact is that most cellos, even very good ones, have **obvious weaknesses**. A **wolf** tone is not unusual. Most cellos have one. Those without one often sound bad over whole registers, producing weak basses or thin trebles. Others sound good over the whole range of the instrument, but produce a small sound. As previously mentioned, it is seldom possible to compensate for an instrument's weaknesses with a particular sort of bow. **Volume is often a problem**. A cello has a hard time making itself heard in a duo or trio with piano. In orchestras too, a few pairs of cellos confront a whole gang of violins, although the cello is no louder than a violin.

A small digression is indicated at this point on the distinction between **carrying power** and **volume**. What I understand by volume is what the player hears. Carrying power is what the audience hears.

Where volume comes from is relatively clear. The more powerfully the instrument is built, and the greater the pressure on the strings, the louder the instrument. Carrying power, on the other hand, has to do with certain sound quality, which is difficult to describe. A baroque instrument, for example, often has the same carrying power as a modern one, without being anywhere near as loud. In my opinion, the bow has little to do with carrying power, save as a bow well suited to an instrument **brings out the best in it**. But the bow has a lot to do with volume. The heavier the bow, and more pronounced the response, the louder the sound. Of course the bow can be too heavy and the response too pronounced, in which case the instrument squeaks and protests.

Although most 19th century cello bows weigh between 76 and 80 grams, 85 grams is not unusual today. In any case, cello bows that are both old and heavy are much in demand. At the same time, heavy bows are a disadvantage in fast passages simply because they require more weight to be moved and kept under control.

An important difference with respect to violins and violas is that **cellos** are played in a **vertical** position. The difference is especially apparent when the bow is played at the tip. As the player approaches the tip of the bow, the pressure from the bow hand diminishes significantly. This has to do with **leverage**. The force exerted at the frog is about four times greater than at the tip. In the case of the violin and viola, gravity, that is, the bow's own weight, helps compensate for this loss of pressure. But gravity is not much help on the cello. This may be a reason why cello bows are about three centimetres **shorter**. In any case, it is especially important that the **tip** of the bow have a **good contact** with the string. The contact has to do with bow **response**.

As with the bass bow, but in a less extreme form, response in cello bows is also more important than damping capacity, and for the same reasons.

2.3 The viola bow

I make a lot of viola bows. This is not because I am especially fond of them, but because they sell well. Although there are a lot of excellent old violin bows available, **fine old viola bows are rare**. In instrument making in general, the viola is something of a stepchild, or was, at least, till the beginning of the 20th century. But all violas suffer from a common problem, which is their size. Size and range correspond in violins and cellos. But the **viola is too small for its range**. Rather than 40 cm., the body of the instrument should really be 54 cm. long , a length even an American basketball player would find unplayable. As a matter of fact, the double bass is also too small for its range. Vuillaume transposed the proportions of the violin and cello to the double bass, resulting in the well-known octobass. This too is totally unusable. I know of no similar experiments with the viola. All playable violas are too small for their range, hence their characteristically **squeezed sound**.

For a time, big violas of 42-46 cm. length were fashionable, but many players now prefer smaller instruments, which are more **comfortable** to play. In any case, violas come in all forms and sizes, but only a very few produce a really convincing tone.

The bowmaker must therefore build **bows for sound**. It has been my experience that most violas react well to a **soft response**, because it reinforces the bass. It also makes the sound warmer and fuller.

In all honesty, I have hardly ever encountered a viola bow I was really enthusiastic about, although I continually run into violin and cello bows that I admire without reservation. The general rule, I would say, is that sound production should have priority over speed of response and springiness. It sometimes helps to modify the camber. There is then less tension on the hair, which produces a softer sound by increasing the damping effect. Using snakewood with its greater damping effect could be an alternative.

2.4 The violin bow

The violin is the **king** of the stringed instruments. Just as one feels attracted to the cello, in the same way one feels overwhelmed by the violin. The violin is perfect, was already **perfect** when the 18th century began, and nothing in particular has been added to it since. The same applies to the bow. **Since Tourte and Peccatte** there has been no **further development**, at least none that I would regard as improvements. Since then there have been bowmakers who did tidier work, but without better results in tone and playability than the bows of the old masters. To be sure, good originals have become **so expensive** that bows made today can be worth their price. A good Tourte is about 20 times more expensive than anything the best contemporary maker dares to ask. This really is disproportionate.

In itself, **the violin is loud enough** relative to the other instruments that a violin bow need not be especially heavy. **Light bows** have the virtue of speedy and nimble response. Violinists often have rapid, virtuoso passages to play. It is therefore important to have a bow adequate to the **technical demands**, that bounces well and has a clear response. Unlike the larger instruments, most violins tolerate a short response without sounding dry.

But what the violin needs above all is a **lot of damping**. On the one hand, the violin has to damp out the **shrill tones**, on the other it needs to shift from a rapid spiccato to a legato without unnecessary vibration, and then come to rest again as quickly as possible.

For a bow to bounce well it needs a big camber and a lot of tension on the hair. For a sweet and quiet legato, it needs the opposite, a **small camber** and less tension. For rapid, rhythmic articulation it needs a short response. But this often results in a harsh tone. The many **contradictory demands** made on bows in general are hardest to reconcile in a violin bow. A good violin bow can only be made of the best and most elastic wood.

3.Weight and Balance

In general, the importance of weight is overestimated because it is so easy to measure how many grams a bow weighs. But for the feel of a bow when played, **balance is more important than weight per se**. Balance too can be measured. I rest the bow on my index finger at the center of gravity, then measure the distance between the middle of my finger and and the frog.

Instrument	Weight	Balance Point
Violin	56 - 65 gr	17 cm - 22 cm
Viola	66 - 76 gr	31 cm - 20.5 cm
Cello	76 - 85 gr	15 cm - 19 cm
Bass	115 - 150 gr	10 cm - 13.5 cm

Of course, there are bows that exceed these values, but in my opinion the ideal measures lie somewhere toward the midpoint of the figures in the table.

As a rule, **heavy bows** are loud, but awkward to handle. This tendency is reinforced when the center of gravity is toward the tip, that is, when the bow is topheavy. This is because weight at the tip is more noticeable than more weight at the frog.

Light bows are usually preferable to heavy bows, provided that they are **not too soft**. These can, even should, have their center of gravity somewhere toward the tip. The advantage of a somewhat **topheavy** bow is that it **tracks well**, that is, that they continue easily in the direction in which they are moved. Their disadvantage is that they make quick string crossings more difficult. Whether more weight at the tip assures more contact is unclear. The contact with the string at the tip of the bow has more to do with the relationship between the camber, the strength of the wood, and possibly the flexibility of the stick, than with the weight of the bow and its distribution.

Weight and balance have little direct effect on the **quality of tone**, it's more a matter of **playing technique**. To be sure, volume and ease of playing have an indirect influence on the sound. It is easier to concentrate on sound production when the player is technically confident, without feeling a need to play as loudly as possible.

What is certain is that the **combination of weight and balance** is impartant in a bow. Weight by itself says little.

4. The Wood

Most bows are made of **pernambuco**, a wood that comes from **Brazil**. In fact, instead of gold, Vespucci (1451-1512) brought home a red wood from Brazil, that the Portuguese called pao brazil. At the time, the wood was used in the production of **red dye**. In Amsterdam we still have the “rasphuis” where female prisoners had to rasp pernambuco. There is an old description of those poor woman with tears running through the dust on their faces.

Originally the wood came from a region still known as **Pernambuco**, although there is no longer a single pernambuco tree there. Today pernambuco comes from other, more humid parts of Brazil. There the wood grows faster, and rarely has the quality that was still common in the 19th century. But when chosen carefully, good pernambuco can still be found.

Other kinds of wood are also used. **Snakewood**, mentioned earlier in connection with viola bows, is primarily used for **baroque bows**. In the transitional peiod between the baroque and the modern, there were experiments with **ironwood**. Actually, this is a generic category for a variety of tropical hardwoods, still known today by a confusing variety of names. I have personally had few good experiences with ironwood, but it is entirely possible that several species have the advantages associated with pernambuco. Cheap bows are often made of **brazilwood**, which is related to pernambuco, but clearly makes for **inferior bows**.

To be sure, pernambuco too **differs** signicantly **in quality**. It is practically impossible to judge a whole trunk. In any case, I have so often been disappointed that I have learned to be careful. When I go through a bundle of wood, I buy 10% at most, usually less. What I first look at is **weight**. If the boards are all cut alike, weight differences are perceptible. The heaviest are the **densest wood**. If the grain is relatively straight, it is worth cutting the board into sticks. The direction of the grain shows how **straight** the wood has grown. There are often different colored stripes in the wood, which can be misleading, because they may not go in the same direction as the grain, but are much more conspicuous, although they have no effect on the quality of the wood.

The first two criteria are therefore **density and linearity**. If one wants to know the density, it suffices to cut off a small piece and throw it in a glass of water. If it sinks, its specific gravity is greater than water, which is cause to rejoice. If it floats, the wood is relatively porous. It can still make a good bow if enough attention is paid to this in the construction. But **a heavy bow can not be made of light wood**. This sounds simple, but it took me some years of practice to learn.

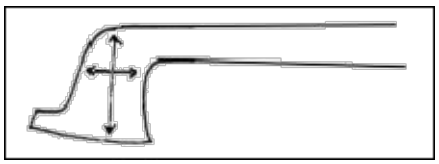
The advantage that porous wood often has is its **greater elasticity**. This is a difficult concept in principle, but it works like this: hold on to a stick firmly at one end, lay the other on a firm surface, e.g., a table, and push on the middle of the stick with the free hand. What matters is not so much the effort

needed to bend the stick - this has more to do with its thickness - as **the way the stick returns to its original state**. This is elasticity. The elasticity of a given bow depends on the **length** of the individual wood fibers, which is hard to judge with the naked eye. A device developed by **G. Lucchi**, my former teacher in Cremona, is useful here. It transmits **ultrasound** at a certain frequency through the wood. The faster the ultrasound passes through the wood, the more elastic it is. This can be misleading, because numbers are always seductive. But given adequate caution in the interpretation of the data, the device is a good thing, even though generations of bow makers managed without it.

If the wood is **very elastic**, care is required to keep the bow from becoming **too nervous**. If the wood is less elastic, it should make a stronger bow, with a full camber. The idea is to compensate for elasticity with more tension. Greater elasticity is surely an advantage. But it is more important that **the concept of the bow correspond to the quality of the wood**.

The way the stick is cut is extremely important. First, the saw has to **follow the grain** of the wood as closely as possible, while avoiding all possible branches and cracks. Second, one needs to be aware of how the **annular rings** are positioned in the stick.

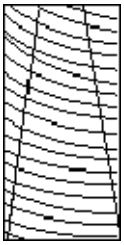
Two considerations are involved here. The first is the **risk of breakage**. All wood splits or cracks at a **right angle to the annual rings**. This can be clearly seen in a bundle of firewood. The cracks all point in a star pattern toward the middle. When wood is split, this is also done at a right angle to the annular rings. The head of every bow is higher than it is wide. If the annular rings are **horizontal** with respect to the head, the bow should split in a **vertical** direction. But that rarely happens, since even a violin bow is two centimeters thick in this direction.



But when the annual rings are vertical with respect to the head, the bow breaks across. The width of the head is only five millimeters thick, therefore the bow breaks more easily in that direction. I can demonstrate this with a practical example. A few years ago I copied a very fine Pfretzschner violin bow. The copy was a great success, save that I overlooked the annular rings. In the original they lay across the head. In my bow they were vertical with respect to the head. After about 10 minutes of playing, the head broke off. The player, a well known violinist, was horrified. Since then I know that, when the annual rings stand upright, the head has to be as massive as possible.

Were the **danger of breakage** the only question, things would be easy. Unfortunately there is another problem. The wood is **strongest in the direction of the annular rings**. Seen in this perspective, it would be an advantage if they were vertical with respect to the head. Or still better, they would

correspond to the angle at which the bow is played, which is not exactly vertical. Violinists and violists tip the bow slightly to the right, cellists and bass players to the left. The ideal position of the annual rings is therefore at an angle to the plane of the bow, with a somewhat horizontal tilt. In this way the danger of breakage can be minimized while, at the same time, the full strength of the wood is brought to bear in the movement of the bow.



Unfortunately, a straight, highly elastic stick of very dense wood with the annular rings in exactly the right place is a **rare exception**. Almost every stick confronts the bowmaker with **imperfect material**. The art is to match the model and design to the wood in such a way as to **minimize the shortcomings of the material**. A small trick, for example: when the annular rings lie at an angle to the string, but in the wrong direction, the stick can be cut so that its cross-section is oval rather than round in the playing direction. This weakens it in the direction of the annular rings, but strengthens it in the direction the bow is played by the musician.

The ultimate quality of a bow depends about 50% on the **quality of the stick**, but the other half is the **use** that is made of a particular piece of wood.

If one buys fresh wood, this is best left to mature, sawn into planks, for about **seven years**. The wood is already dry after about half a year. But the tensions that exist in every piece of wood, take very long to sort themselves out. And when one has sawn the wood into sticks, it has to be lain aiside once again, so that the **tensions can find a new balance**.

If one wishes to ensure that the finished bow will not move any further, one must allow **as much time as possible** between different handlings. The wilder the wood, the longer a stick needs to calm itself down. Looked at in this way, one can say that a bow needs at least ten years before it becomes finally ready for use.

5. Colour and Varnish

Colour and varnish in bows are less complicated than in instruments. Nonetheless it took me many years to attain a clean finish. A bad finish can spoil an attractive piece of wood. A good finish can enhance its appearance. The most attractive finish however is aged, dark wood with a full but thin **shellac polish**. Old wood radiates a warmth unknown in new wood. This has less to do with varnish than the **surface of the wood**, which changes with age. Of course, it becomes darker, but above all the **transparency** changes. The wood grows increasingly **matt**. With less light, the wood is darker. But if held under a lamp, it seems to **glow from inside**. The wilder the growth, the more attractive it is to look at. The flames appear so to speak because the wood fibers run in and out of the stick. According to the angles the light is mirrored differently.

I have tried everything from rabbit dung to an overdose of gamma radiation to **imitate this aging proces**, but with little success. The only useful agent is **nitric acid**. I believe this was already used in the 19th century. The advantage of nitric acid with respect to other coloring agents is that it **reacts** with the dye in the wood, and etches its surface a bit. In the process, the surface becomes a bit uneven, which softens the reflection. Unfortunately, the softer reflection brought about by artificial aging has a different character than natural aging, so the nitric acid treatment remains visible as an imitation. Other coloring agents penetrate the wood less deeply.

If the varnish becomes somewhat damaged, then the treatment with acid does not bring the bright orange wood directly to the fore. But nitric acid conceals its own dangers. If it is not sufficiently **neutralised**, then deep black spots form underneath the varnish, which look very ugly. If a bow has been handled with acid, one can see the pores are very black. This also is optically very disadvantageous.

Unfortunately, customers usually prefer **dark bows** to light. For the most part this is unconscious. Good, old bows are expected to be dark. There is therefore a tendency to confuse dark with good. Actually, the color of the stick has **little** to do with its quality. Dark wood has more coloring material in it, light has less. It is possible that light wood tends to be somewhat more porous, but also more elastic, while dark wood is denser and less resilient. But this is not always the case.

Ordinarily, **pure shellac** is used as varnish. All other resins leave a heavier coat on the stick, which only impedes its movement. Shellac, on the other hand, can be applied in very thin layers and, with a bit of patience and a fine abrasive, the pores can be closed. **"If you want to fill the pores, use a pore filler"**, Roger Hargrave once told me. Since then, I tell myself the same thing everytime I have some polishing to do. Closed pores give the impression of greater compactness. But this is a purely **aesthetic** consideration. What matters to the sound is that there be **as little varnish as possible** on the bow.

On the other hand, shellac is sometimes too glassy, and gives off a hard reflection. I therefore apply a thin layer of **linseed oil** to the raw bow, let it soak in, then polish it. In this way, the varnish is somewhat more matt, the reflection somewhat **softer**. The varnish itself should not be conspicuous. What should be seen is the **wood**.

Synthetic varnish gives off a somewhat harder reflection of light and is often somewhat cold and whitish. On the other hand, it can be quickly applied. I nonetheless advise against it. I need at least two weeks to varnish a bow, often longer. Every layer should be allowed as much time as possible to dry. Then it should be moistened again by polishing with alcohol, and if the previous layer is not totally set, it comes off, which is exasperating.

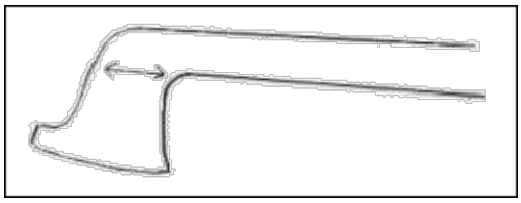
Although polishing is not a creative activity, it is worth the trouble.

6. Distribution of Strength

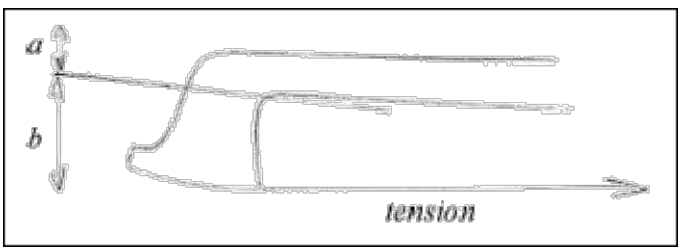
The **bow that shoots arrows** and the bow that plays stringed instruments have **something in common**. The former is also tightened so that it can be used for hunting. When the wild boar breaks out from the thicket, the string is pulled and an arrow is shot. But when the hunter tightens his bow too much and it breaks he has a serious problem. All he can do is climb up a tree. When the violin bow is pulled too tight and breaks during a concert it's also pretty band, and no trees around.

The moment of shooting an arrow corresponds more or less to playing a stringed instrument in a concert, even if the audience facing the player is less dangerous. The comparison could be taken still further, but I will limit myself for the moment to the problem of the breaking point. The tension and force that a bow sustains cannot be greater than the tolerance at the weakest point (for familiar reasons).

Normally, **the head is the weakest point**. The grain of the wood runs along, or more accurately, through the stick and on to the head. But it is unattached to the lower part of the head.



Therefore, the midpoint of the head is usually the weakest point. The extent of the danger has to do in part with the position of the **annual rings** (see the chapter on wood), but also the form of the head. A robust stick requires a larger head. A soft stick will tolerate a finer head, because less force is brought to bear on the vulnerable point. If the risk of a break were all that is involved, the head would be as low as possible. In **baroque bows**, this is actually the case. But over the course of time, bows have been built to produce a bigger sound with as much tension and camber as possible. The vibration of the hair increases the **tension on the head**. The more pressure the player exerts, the greater the tension.



The **higher** the lower part "b" in relation to the upper part "a," the greater the **leverage**. The greater the leverage, the more powerfully the vibrations are transferred to the stick. The **height of the head**

therefore has a major effect on the movement of the stick. Moving a more robust stick requires a more powerful "input." There is otherwise too little amplifier for a too large loudspeaker.

Two **conflicting criteria** must therefore be considered for the function of the head. One is the **risk of breakage**, that can be met by lowering the head. On the other hand, a **higher head transmits vibrations much better**. This makes the bow more sensitive, even when it is powerfully built.

The **strength** of a bow is impossible to express in numbers. Usually a player says that a bow is powerful if the stick remains above the string even when playing forte. But a more flexible bow can also give the sense of power if other relationships are right. The first important point is that the strength of the bow must be **equally distributed** across its length. **Lateral stability** is equally important. A powerful bow that bends laterally is more likely to overplay than a softer bow with lateral stability. To analyze a bow, these characteristics have to be considered.

When a bow is loosened, the strength of the stick in vertical direction can be measured by resting the bow on its ends, and hanging a 250-gram **weight** from the middle. A violin bow will gave way by about one and a half to two centimeters, a cello bow by half of that. Many bowmakers use such a device. **Anything measurable** seems to us nicely objective, but the objectivity should not be **overestimated**. No one plays with a loosened bow.

As soon as the bow is tightened, its **strength** become a function of the **stick's elasticity**, the **thickness** of the wood and the **camber**. The match between wood strength and camber can be tested by tightening the bow until the stick is **straight**. But please **don't do it yourself!** Even if the bow is well-insured, the test is best left to the bowmaker. If the stick is really straight, camber and wood strength are properly matched.

There are various possibilities for distributing the camber and the thickness of the wood along the stick. The bows of the last century (19th) mostly have the most curve in the middle of the bow, but in the course of time, this point has shifted towards the tip. My own impression is that bows with little wood and a lot of camber at the tip respond well, but sound somewhat thin. More camber in the middle produces a fuller sound, although the response is not as accurate. But these are general tendencies, because a bow's sound and response depend on **many factors**. Any concept can work well if the relationship of the camber to the quality and conformation of the wood is right. When this is not the case, the player has the feeling of losing contact with the string at a certain point.

Even when the camber and the quality of the wood are properly coordinated, what matters is **how much bend** there is in the bow. When the loosened bow touches the hair, this is called a **full camber**. The opposite state consists, for example, in a five-millimeter separation between the hair and the stick. The appropriate camber can vary from bow to bow. Too much will make the bow nervous, make it scratch, and cause it to thrust out to the side. Too little makes the bow lame, and causes an irregular

bounce, although it can also make the tone nice and round. A full camber is especially good for the **bounce**, while less camber relaxes the sound and increases the bow's **lateral stability**.

If the bow has too much strength in the vertical direction, **it gives way laterally**, with a loss of energy. The same bow with less camber will be more stable, and therefore more powerful. How much camber is right for any given bow depends on the material, the player's taste, and the instrument. Bows where all conditions match one hundred percent are rare, but most players are so accustomed to their bows' "moods" that they **compensate automatically** by adjusting their technique to the bow. But occasionally the bowmaker can achieve a mini-miracle with a slight change in the camber. Sometimes remarkably little is needed to restore a bow's equilibrium, and it then sounds and works much better.

In the transfer of strength from the hair to the stick, the **tip** naturally is not the only important thing, the **frog** is just as important. In principle, the same considerations apply as to the tip, only the region of the frog is somewhat more complicated.

If the bow is tensed, then the frog sits securely on the stick. The only movement it still has to make is a **slight turning towards the stick** (or revolving in the direction of the hair, or around the brass nut). Even the smallest pressure given the bow by the musician while playing works itself out in this small turning movement.

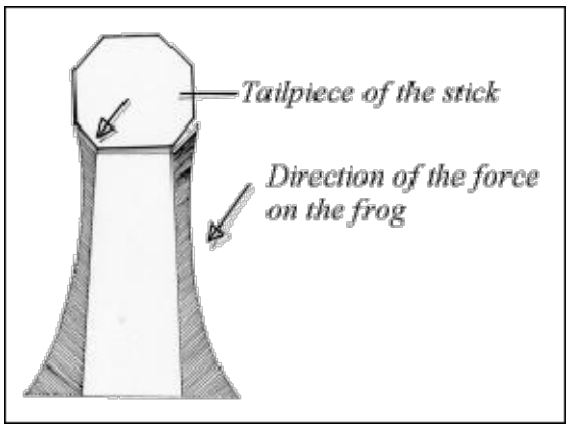
A particularly **tall frog** creates **greater leverage**, and in this way, the situation is exactly the same as for the tip. But with the frog, the strength works itself out from the turning movement at the near end of its base. So the **distance** from the **brass nut**, which holds the frog firmly in place, to the near **end of the base**, also has a part to play. This length is **also a lever**, only the opposite way.

A long base lessens the strength of the leverage. A tall frog with a short base, therefore, makes for the strongest transference of the vibrations of the hair on to the stick.

How strong this **transference** should be, depends upon the opposing **strength of the stick** at this point. The opposing strength given by the stick depends again on the **thickness** of the wood and the **curve** in the region of the frog. A bow that is thinner at the end than in the middle is best matched to a low frog with a long foot. A bow whose thickest point, with much curve at the frog, needs a fairly high frog with a short foot. But very high frogs have another disadvantage, which is that they lose lateral stability.

Many of the old French bowmakers made the **middle track** on the underslide beneath the frog **broader** than the lateral tracks. The reason must be that the player's middle and ring fingers rest on the frog, and thereby exercise some **lateral pressure**. In addition, the bow seldom lies flat on the string, but is **tipped** a bit. This increases the lateral pressure on violins and violas, which tilt to the

right. But in the case of cellos and basses, which tilt to the left, the pressure of the fingers on the bow and the pressure arising from the tilted bow cancel one another out.

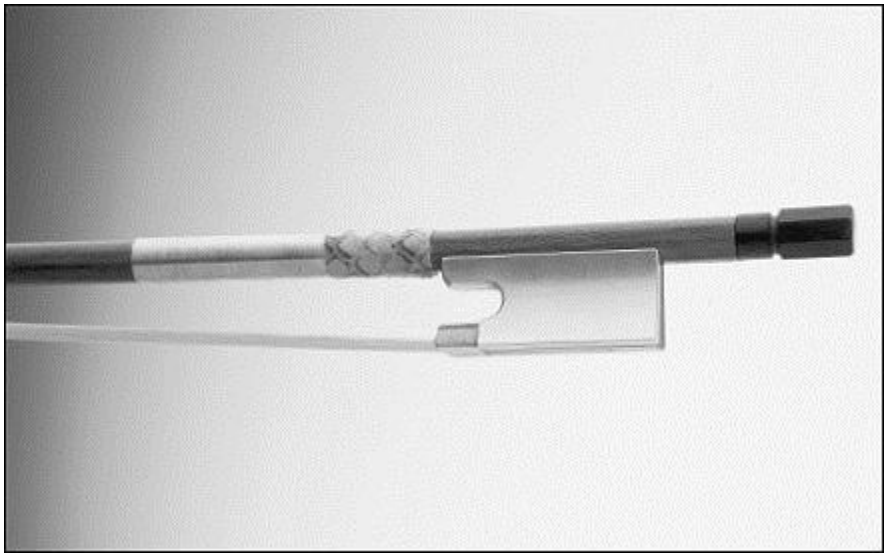


The broader the middle track of the underslide, the more resistant is the frog to lateral pressure. But there is a bit of leverage here too. The breadth of the middle track of the underslide should therefore increase with the height of the frog.

Every detail and measurement of the bow is **functionally related** to every other detail. The smallest change affects the whole bow. Therefore, no two bows are exactly identical, irrespective of differences in the quality of the **wood**, and this is the **basis of every concept**.

7. Aesthetics

There is **no absolute objectivity** in aesthetics. There are only **individual ways** of looking at things. Our brains **compare** everything we see, whether natural or manmade, with familiar objects that are similar. The observer evaluates and classifies the "object" according to his or her experience. It is therefore impossible to look at anything without prior assumptions. Our experience leads **unconsciously** to expectations. If the object meets or exceeds them, we feel secure or are pleasantly surprised. If it fails to meet them, we don't like it or try to ignore it.



While learning the trade I tried as hard as I could to revolutionize bowmaking. I did everything as differently as possible, naturally without much resonance or success. **What we like depends on what we know**, and if novelty deviates too far from this, most people will reject it.

There are nonetheless a lot of people who **agree** on what they like. All we can conclude from this is that they share a **common experience**. This is culturally conditioned, of course. We need to presume this cultural consensus in order to talk and understand one another. Someone from a different culture often understands a given statement quite differently from the way we ordinarily do. He or she finds different things funny or beautiful. Our aesthetic taste is also a matter of cultural conditioning, deriving from our experience and education.

Finding things **beautiful** is also a **culturally determined affair**, since it depends upon our experience and our upbringing. Well, one must now ask oneself just how important it is, how a bow looks. In point of fact, every detail of a bow, every design of its contour has a **functional reason**. The only exception is the nose, the frontal tip of the bow. In the Baroque period, every shape had to end in a flourish. The nose of the bow is a relic from that time of the Baroque bow; it has no functional reason. But one has grown so accustomed to it, that a bow without one would be found extremely ugly.

A bow is not an objet d'art. Its development has been primarily determined **by function**, with the goal of making it louder, stronger, more aggressive. Aesthetic appearance was secondary, equivalent to the spinach served as a side dish to the main course. If the spinach is oversalted, it may be an annoyance. But no one would judge the main course by the spinach.

On the other hand, aesthetics should not be underestimated either. The **magic** that radiates from a master craftsman's **beautiful old bow** is a source of pleasure for the connoisseur. A large part of this has to do with the quality of old wood. An old bow maker once told me, many years ago, that with good pernambuco wood it is like having the feeling one could look into the wood as one would into a lake. This is a romantic description, but I can not think of a better one.

Whereas there is relatively close agreement as to what constitutes good wood, the shaping of the lines of a bow is, to a large extent, **a matter of taste**. Unfortunately, our taste is very dependent on what we are accustomed to, and also on the sheer **price of a bow**. It is much harder for anyone to find a very expensive bow awful, then to disapprove of a cheap one. Nobody likes to admit this to himself. However, it is the case that something which is worth a lot of money inspires us with much respect. When one buys something that clearly oversteps the limits of ones budget, then one loves that thing more, since one has bought something one could not really afford. Musicians normally are not madly keen on having an expensive car, but a too expensive instrument or a too expensive bow gives them much joy. It spurs them on to higher achievements, instead of their just hating the idea, which would be a reasonable reaction. That is a **paradox** from which we all suffer.

Astonishingly enough, connoisseurs are more or less **agreed** on the subject of what constitutes **a good bow**, apart from the wood and the price. It is naturally true that the **longer** one has had to do with bows, the **more details** one can see in them. And the more details one recognises, the nearer one gets to the **essence** of a bow. At the same time, however, the connoisseur is more careful in his judgement. There are bows which one finds beautiful at first sight, but which lose their fascination the more one contemplates them. Others that one had not particularly liked at first gain sympathy with time. What appeals to people straight away probably has to do with the degree of familiarity of the observed shapes. The slowly arising sympathy comes, however, from the more genuine understanding of the object in question. This is the **build-up of a relationship** between object and observer.

The relationship naturally remains **subjective**. But there are objects, in this case bows, which **favor** such relationships, and others which have less appeal to the experienced observer. In my opinion, the intensity of the relationship depends on how much **love**, **time** and **competence** have been invested in a given bow. For the observer, careful craftsmanship or a particular profile are not the issue. On the contrary, less carefully crafted bows may have more appeal for us. Their imperfections can inspire **sympathy**, and may encourage the instinctive understanding needed for a feeling of affinity for a bow. A good bow is a complicated statement, that can subsume an **inner harmony** not always recognizable at first sight. But when it is there, there is a **growing affinity** for the bow, and respect and sympathy increase perceptibly. This happens more often with bows made by well-known makers, not only because they are expensive, but because the makers, each in his or her way, have taken **particular care** with the materials.

Beauty is not an accident, but a result of intense desire plus deep thought and professional skill.