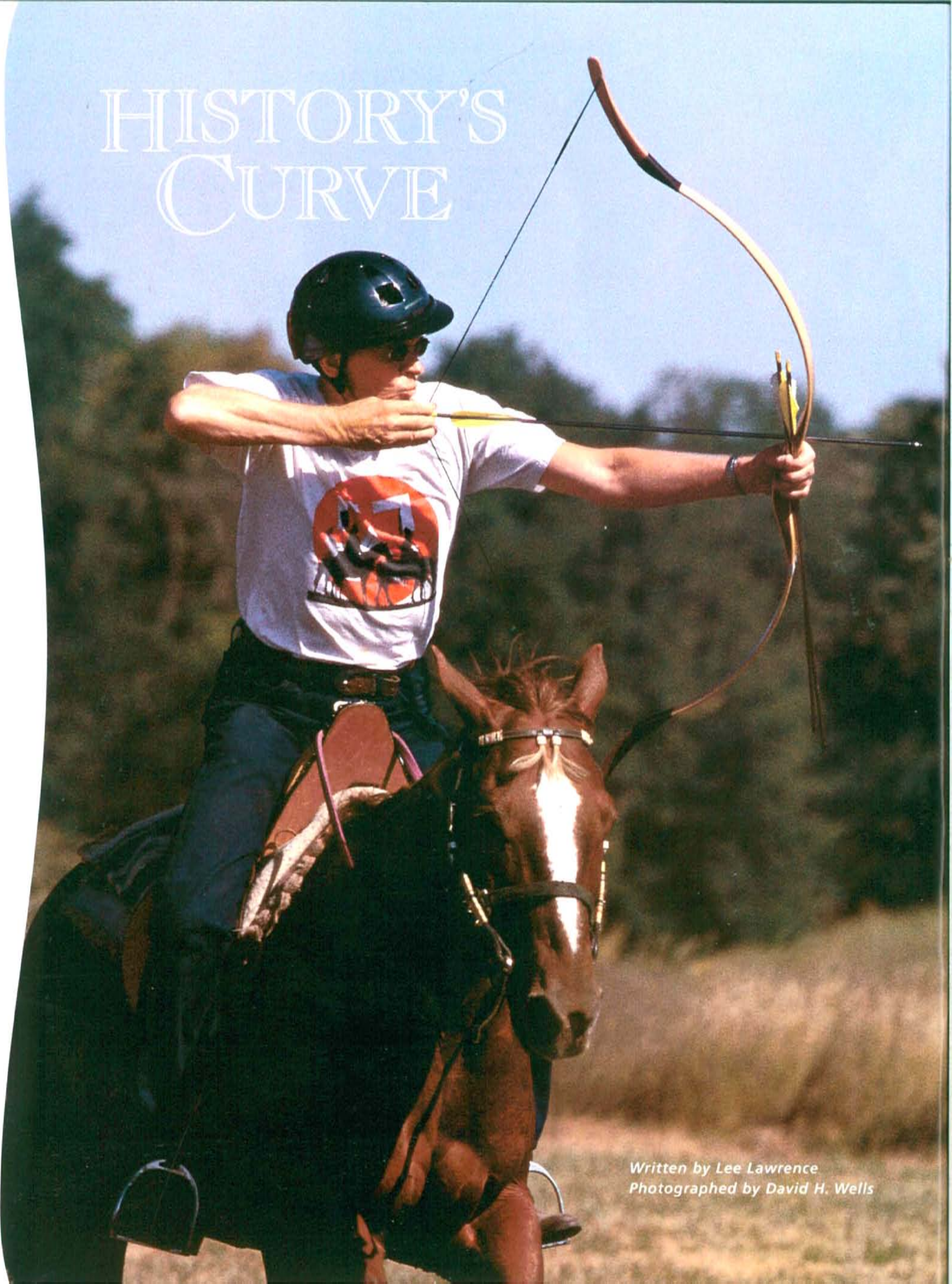
# HISTORY'S CURVE



*Written by Lee Lawrence*
*Photographed by David H. Wells*

An unfinished bow rests in the grip of a vise in a workshop near the small town of Grand Rapids, Ohio. On a nearby work table is a litter of sanding blocks, large-toothed metal combs, wads of steel wool, rolls of masking tape, wrenches, chisels and files. From a pipe overhead hangs a stalactite of orange-tipped clamps. In the center of the chaos sits Bubba, a longhaired gray cat with a body as massive as his appetite for attention.

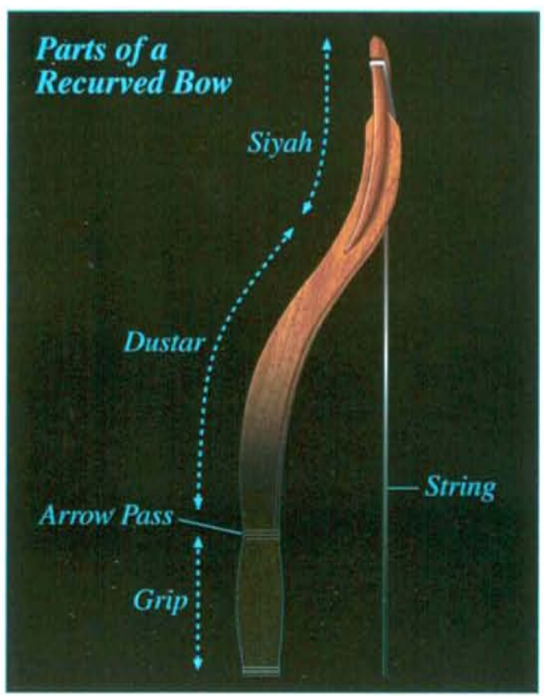
It is here, under Bubba's watchful eye, that Lukas Novotny is crafting what he hopes will be a bow "in which superlative performance is combined with an unsurpassed grace and beauty ... lightness and hardiness"—the dream of modern bowyers. Trained as a glass artisan in the former Czechoslovakia, Novotny emigrated to the United States in 1982; jars of colorful pieces of glass crowd the shelves behind him. Among them, though, are the materials of his present career: a curl of buffalo horn protruding from a top shelf, a slim quiver bristling with arrows standing nearby and, directly in front of the shelves, racks full of row upon row of bows. A slim 32 to 76 millimeters wide (1¼ to 3") but ranging up to 132 centimeters long (52"), they extend as gracefully as a ballerina's arms.

These are Novotny's reconstructions of Asian composite recurved bows, so named because they are composed of several materials and because, when strung, the curve of the limbs reverses at the tips. Elegant and light, they are masterpieces of engineering, contemporary products of an ancient craft that has, time and again, changed the course of history.

In a modern archery contest like the 16th-century one depicted in an Ottoman miniature from the *Divan* of Ali Sir Neva'i at left, a mounted archer, opposite, takes aim with his recurved bow during September's International Horse Archery Festival (IHAF) in Fort Dodge, Iowa. While Ottoman cavalry archers targeted a gourd on top of a pole, today's sport shooters use bull's-eye patterns set at various distances. It was Ottoman bowyers whose technology gave Sultan Selim III a recurved composite bow in 1798 with which the sultan himself shot an arrow 888.80 meters (963 yds), a distance record that modern composite bows have yet to approach.

Like most great inventions, the composite recurved bow was the culmination of a long technological evolution. Humans had been hunting and warring with simple wooden bows for more than 30,000 years when, about the third millennium BC, bowyers from Mesopotamia to Japan independently began experimenting with ways to enhance their bows' springing action by introducing other materials: They applied horn to the side of the bow facing the archer, the side in compression when the bow is drawn, and they applied animal sinew to the outward side, which is in tension. In the process, they reduced the wooden element of the bow to a slim core whose sole role was to keep the sinew and the horn aligned.

The next development was the discovery that, by training the tips of the bow's limbs to curve forward, in the opposite direction of the draw—the "recurve" of the recurved design—both the power and the accuracy of the bow could be increased still more, though at the cost of making it harder to draw. And over the life of the bow, as it gradually lost its spring action, the bowyers found that reheating its limbs



Bowyer Lukas Novotny demonstrates the C-shape of the unstrung recurved bow, which, when strung, takes on its characteristically serpentine, tips-forward shape.

and gently restoring its original curve also restored its original power.

Asia's long-standing preference for the bow over the sword, mace and other weapons favored by Europeans up through the 15th century is credited with helping shape and reshape the political boundaries of the Old World. In 546 BC, Persian archers overcame Lydian mounted lancers and, in battles against Babylonians, Egyptians and Greeks, they often prevailed over the opposition's infantry. Much later, in a famous conflict between the Roman army and the Parthians in 64 BC, it was what military historian E. G. Heath called "the never-failing quiver" that thwarted the eastward advance of the Roman Empire. It was not that the Romans ignored archery—they simply considered it of secondary importance and thus failed to perfect archery equipment or tactics. The Byzantines, on the other hand, valued archery, and this had something to do with the fact that Byzantium outlived the Roman Empire by about 1000 years. When its fall began with the battle of Malazgirt in 1071, it was to the Seljuk Turks, who were true masters of the bow.

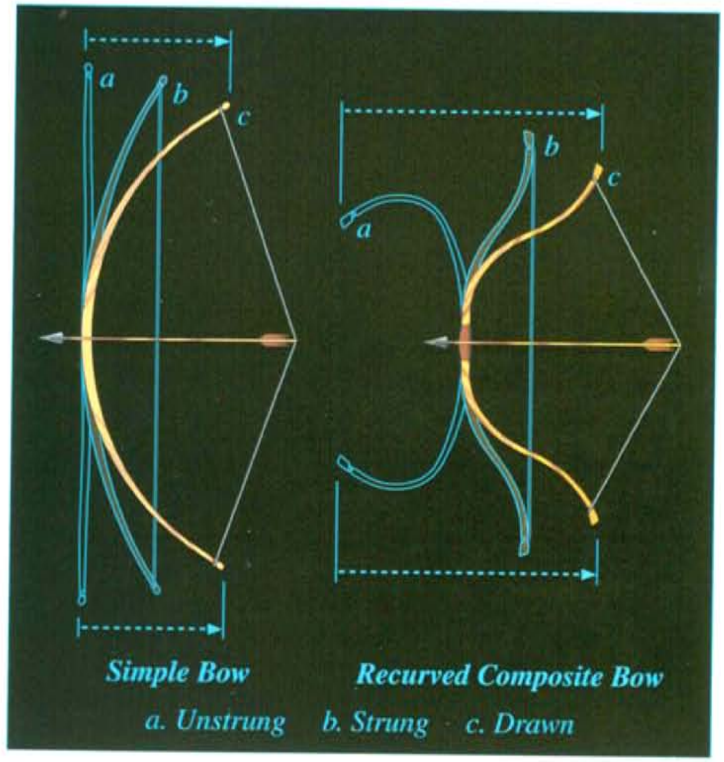
Every historical work on archery speaks of the legendary Persian archer said to have shot an arrow through a five-centimeter (2") thickness of brass, and of Ottoman Sultan Selim III who, in 1788, personally set a still unsurpassed distance record of 888.80 meters, or 963 yards—farther than the best modern bow can shoot. In literature, the bow became associated with great heroes as a virtual extension of their bodies—an idea that is not in fact farfetched, since the archer, in drawing the bow, transfers energy from his body into the body of the bow, where it is stored until he releases it to the arrow. Rustem, the hero of Firdawsi's 11th-century Persian epic the *Shahnama (Book of Kings)*, thus literally uses his final breath to shoot his enemy through the heart.

In Islam, too, the bow holds a special place. It is the weapon the Archangel Gabriel handed down to Adam, the one God commanded the Prophet Muhammad to use. Some 40 *hadith* ("traditions," or recorded sayings and stories about the Prophet) focus on archery as a way to strengthen both body and soul, and while some hadith encourage metaphorical interpretations, others led to the establishment of archery instruction as fundamental to physical fitness. In 1835 the Ottoman ruler Mahmud II had both aspects in mind when he commanded his courtier Kani to set down in writing all available information about archery. He was doing this, he announced, "so that under my royal patronage novices may acquire complete knowledge of the *sunna* [the example] of the Prophet, and by diligence come to possess the degrees of both worlds."

# Bow Facts and Types

***Simple bows** ("self-bows")* are what most people think of when they think of bows. Some 30,000 to 40,000 years ago, humans took a strip of wood and tied its ends together with a taut string to create the first weapon that could store energy. The premise is simple: The archer pulls back on the string, drawing the bow to a smaller radius curve. When the archer lets go of the string, the energy stored in the bow transfers to the arrow, casting it faster and farther than the archer's hand could throw it.

***Longbows*** are made of one or more pieces of wood—typically yew, osage or black walnut—and they are as tall or taller than the archer. The strongest are powerful enough to shoot an arrow through a plate of armor at 365 meters (400 yds), though their more typical range is about half that. To shoot a longbow with accuracy requires great skill and strength. Easy to reload, the longbow was reputedly Robin Hood's weapon as he roamed Sherwood Forest in the 1200's, and it later dominated the battlefields of northern Europe from 1300 to 1500, credited among other things with assuring victory to the




British against the French in 1346 at the Battle of Crécy and again in 1415 at Agincourt. The disadvantage of a longbow is that its size requires that the archer be on foot: It is almost impossible to shoot a longbow while riding a horse.

***Composite bows*** are typically made of wood, horn and

Two hadith specifically mention the Arab bow, commonly interpreted as referring to a composite bow—though some scholars believe that the earliest Muslim warriors from the Arabian Peninsula used simple bows until they gained the know-how to construct composites from conquered lands such as Syria. Indeed, a bow considered to have belonged to Muhammad, now in Istanbul's Topkapı Museum, is made of bamboo. Nevertheless, by the time the hadith were codified in the eighth century, the bow used by Muslims had long been the composite bow, in which the wood was said to correspond to bone, the horn to flesh, the sinews to arteries and the glue to blood.

Just as each of these tissues plays a different role in the workings of the body, each of the bow's elements has a similarly specific function. "The sinew takes the tension," Novotny explains. "The horn on the belly takes the compression, and in the middle, the wood takes the shear stress. It's a simple premise, but if you don't get the details right," he warns, "you'll have problems." After all, when drawn, the bending portions of the bow bear some 175 kilograms of pressure per square centimeter (2400 lb/sq in). If the belly cannot stand the compression, it buckles, and if the back of the bow cannot bear the stretch, it pulls apart. "At first," Novotny confesses, "most of the bows I made broke."

Early bowyers no doubt experienced similar failures in the development of recurved composite designs, but thanks to trade in peacetime and the capture of weapons in wartime, technology was rapidly diffused as bowyers over wide areas influenced each other. "The cultural exchange was incredible," Novotny says with enthusiasm. "We have an idea of what a typical bow

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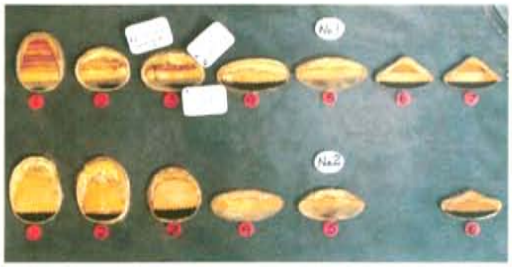
1. Shown unstrung, this modern composite bow uses sheep horn covered with rawhide. 2. Detail of the grip of a replica of a Turkish composite bow. 3.–5. Details of 19th-century Turkish composite bows made of wood, horn and sinew covered with leather and painted.

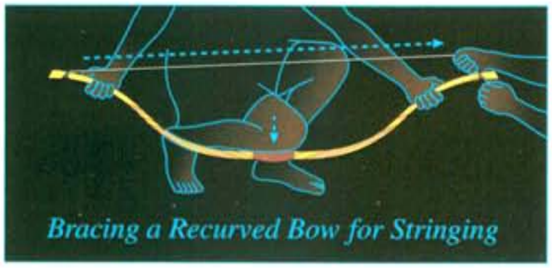
shredded animal sinew. They can pack the same power as a longbow but in a smaller, lighter form usable by a mounted archer.

***Recurved composite bows*** are the most powerful, compact design known. The recurve refers to the tips that curve forward, in the direction of the shot. Each variation of the recurved composite design—Persian, Turkish, Indian or Mongol—excels in a particular area: The Persian bow, for example, trades distance for power; the Turkish bow sacrifices accuracy for distance. Some recurved composite bows use other materials: The Chinese bow, for example, is made with a bamboo core covered with strips of young bamboo on the back (in place of sinew) and dried, year-old bamboo on the belly.

***Crossbows*** are mounted in a metal frame equipped with a crank, which gives the archer a mechanical advantage in drawing the bow. Though it shoots with great power and accuracy, its long "reloading time" made it more useful in sieges than in battles. Crossbows were developed and used in Europe in the 11th to 15th century, and Europeans also deployed them in the Middle East during the Crusades.

Below left: Cross-sections of composite Turkish bows show the layering of materials. Below right: An illustration based on an Assyrian relief shows one method of stringing a recurved bow, a task that usually requires two people in the field, or a specially designed form in the workshop.




PHOTOS 1–5: GRAYSON ARCHERY COLLECTION, UNIVERSITY OF MISSOURI; ILLUSTRATIONS: RIGHT, OPPOSITE AND PREVIOUS SPREAD: TOM MCNEFF; MINIATURE, PREVIOUS SPREAD: BRITISH LIBRARY OR5.846 115r

from each culture looked like, but at the same time, there could be any variation in between."

While Persians, Parthians, Turks, Mongols, Mughals and others all had highly developed traditions, most archers today consider Turkish bows of the late 1700's and 1800's to be the high-water mark of the Asian composite bow. After that time, firearms began to dominate the battlefield, fewer and fewer people had time for archery as sport, and the bowyer's art declined. "There were probably a few people alive who knew how to make composite bows until World War II," Novotny speculates. "But unfortunately, nobody in Turkey today, at least to my knowledge, knows how to build them. It took only one generation to lose the knowledge entirely."

The desire to recover and rediscover that knowledge has turned into an all-consuming passion for Novotny, who over the last decade gradually gave up glass to dedicate himself full-time to researching and making bows professionally. He began by reading a book on North American bows and, being an avid horseman himself, tried his hand at making the short horn-and-sinew bows that Plains Indian tribes used for hunting buffalo. "But always in the back of my mind," he says, "was the history I grew up with in Czechoslovakia—of Turks invading Europe and besieging Vienna."

He said as much to bow expert Tim Baker, whom he met by chance in California in 1992, a time Baker remembers as "the zenith of the reconstruction of Asian composite bows." Their aficionados, he adds, laughing, were "one of the smallest minority groups in the universe."

What the group lacked in numbers, it more than made up for in dedication, as Novotny discovered when Baker put him in touch with Jeff Schmidt, a physicist at the University of Wisconsin. For two years, Schmidt too had been researching Asian composite bows, and he was well known in archery circles for his extensive library of books in English, Russian and Persian and his files bulging with thousands of photocopied papers. But more than that, Novotny says, "he had all the technical know-how."

In Fort Dodge, a young archer draws his bow while sitting on a "steel horse" that simulates the challenge of shooting from the saddle for novices. The 14th-century author of *Essential Archery for Beginners* wrote of young Mamluk archers, "As regards the qualities of the novice, ... the foundations upon which they all rest are humility, hearing attentively and obeying that which is pleasing to God Almighty and His Messenger."

Like Novotny, Schmidt had started out reading books, scouring bibliographies and tracking down every piece of writing he thought might contain useful information. One discovery was a book published in London in 1970, *Saracen Archery: An English Version and Exposition of a Mameluke Work on Archery*, in which authors J. D. Latham and W. F. Paterson explicate a 14th-century Arabic treatise in verse titled *Kitab Ghunyat at-Tullab fi Ma'rifat Ramy al-Nushshab*, loosely translated as *Essential Archery for Beginners*. The text had been written at a time when the Mamluks had convincingly demonstrated the prowess of their archers by repelling the Mongol assault on Egypt and Syria in 1260. It provided basic data on bow construction, supplemented with information gleaned from other early texts and with observations derived from the author's own experimentation.

*Saracen Archery* showed that the wooden core of the composite bow was made of five elements: the handle in the center, two limbs (*dustars*) on either side and the curved tips (*siyahs*) that are either attached to or made as part of the *dustars*. In either case, the tips do not flex; they taper sharply to the nocks, where the string is attached. In many bows, the siyah simply extends the curve of the dustar, but early bowyers introduced the famous recurve that gave the bows their familiar, wave-like shape, their greater capacity for tension and their greater power. These were the bows that Novotny wanted to build.

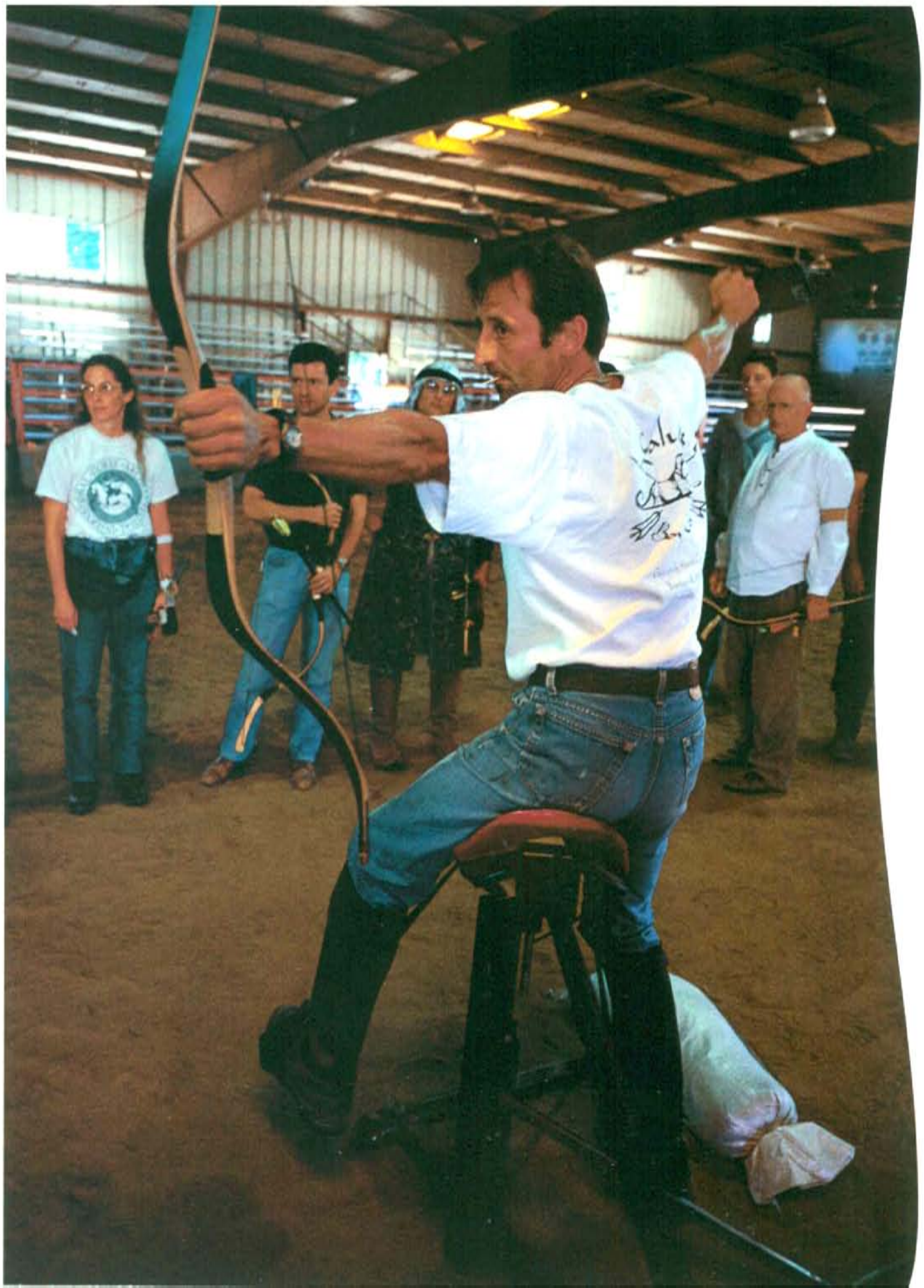
To make the core, Novotny selects pieces of American hard rock maple, the closest match he can find locally for the fine-grained maple favored by Turkish bowyers. Like them, he carves the handle into a gently rounded form, oval in cross-section, that fits comfortably in

the hand, the fingers curling around the swell and back toward the palm. To provide a firm grip, however, the handle must not be so small that the fingers reach around to the palm—that would create, in effect, a bearing in which the bow could swivel.

Most bows made with dustars and siyahs as single elements are Turkish. To make them, Novotny cuts 76-centimeter (30") sections of wood and soaks them in cold water for three days. Then he steams the two pieces into curves of some 60 degrees. For bows in which the dustars and siyahs are separate elements, typically known as Persian five-element bows, he steams the dustars into a gentle curve and finds branches growing at the desired angle for the siyahs. To assemble the parts, he tapers both ends of the handle and, if needed, the ends of the siyahs. He then cuts V-shaped splices into the dustars and, after brushing on glue, fits the pieces snugly to form a strong, undetectable joint.

Next comes the horn; Novotny uses water-buffalo horn. He prepares it by shaving off the surface ridges, cutting it roughly to size, then steaming and flattening it. He can now shave the horn until he has twin strips of uniform thickness the width of the wood core. He glues the horn strips onto the bow's belly so they meet in the center of the handle. Then he winds a rope around the bow using a traditional tool called, in Turkish, a *tepelik*. Unlike modern clamps, the *tepelik* creates an even pressure along the curve, squeezing out excess glue. The bow is now left to dry for several weeks with its ends tied to maintain a soft curve.

The sinew requires even longer preparation. Novotny buys whole tendons from a slaughterhouse and here departs from tradition in that he uses acetone to degrease them instead of the highly carcinogenic naphtha that was used in the past. But he does so only because both are equally effective. "If



At an IHAF workshop, Novotny demonstrates shooting positions: *Essential Archery for Beginners* described 10 primary and seven secondary ones. The Mamluk treatise also had this to say to teachers: "As to a master's duties, he should ... labor to the end that [his pupils] may strive to learn and ever reverence the place dedicated to archery." Top: A thumb ring, believed to have been developed in China and Central Asia by 200 BC, allows an archer a stronger draw.

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**1.** Water-buffalo horns await shaving, cutting, steaming and gluing to a wooden core in Novotny's Ohio workshop. **2.** Building blocks of a Turkish-style composite bow: two strips of horn, two *dustar* limbs, two *siyahs* (attached), a grip and two bundles of sinew; the finished bow at the top shows the final unstrung shape. **3.** After gluing horn to the inside of the core, Novotny lays down sinew on the outside of the *dustar*. **4.** He combs the sinew, which will then dry for weeks, pulling the tips of the bow ever closer together. When the bow is curved back, the sinew will be stretched, giving the bow far more power than if it were made only of wood. **5.** After a year of seasoning, Novotny uses molded forms called *tepeliks* to pull the bow into stringing position.

the glue joint has a speck of grease on it," Novotny explains, "it'll fail, because grease and glue do not mix, and there will be a speck where there is no glue." In highly stressed bows, an unglued speck is enough to introduce a fatal weakness.

Once the sinew is dry, Novotny breaks it up with his fingers and combs through it with a metal brush. The sinew is now a mass of long, thick fibers, which he dips in hot hide glue before laying them on the bow. "I use five different lengths of sinew," he explains. "Through the bending portion, you always use the long fibers; the shorter pieces are for building up around the handle area and along the sides, and they get overlapped and staggered like bricks."

He applies the sinew in two or three courses, each containing three to four layers. After the first course, he lets the bow dry a couple of weeks to allow the sinew to shrink. As the fibers shorten, they force the limbs to curve in on themselves, a process Novotny encourages by tying a string between the siyahs and twisting it as the sinew contracts. This is the beginning of a process that ultimately gives the bow its strength: It is tantamount to instilling the memory of a particular curve into the fibers of the horn, sinew and wood so that, when Novotny later bends the bow in the opposite direction to string it, every cell of the bow will want to spring back. The tension increases when Novotny pulls the bow into full draw, so that upon release the bow's fibers snap back, unleashing an explosion of energy.

But before that happens, there is still much to do. Novotny applies a second course of sinew, after which he again dries the bow, this time in a heat box. When the limbs are malleable, he reflexes them even more sharply, tying the *siyahs* so close together they almost touch. After laying the final course of sinew, he follows the same procedure, this time crossing the limbs all the way over the center until the bow looks like a pretzel. "Then you leave it in that form for about a year, minimum. You see," he explains, "hide glue only reaches its full strength after 10 years."

Novotny draws one of his Turkish-style composite replicas that take some 18 months to produce. "The difference between shooting a composite bow and a fiberglass one is like going to a dinner party and using silverware instead of plastic. It's more supple and sweeter to shoot."

By now the bow has been curved so much that the two pieces of horn on its belly no longer meet in the center of the handle. Novotny cuts a sliver of hardwood or bone—"can't use ivory any more"—and inserts it in the tiny gap. Finally, he covers the sinew side with strips of white birch bark that have been soaked for a year in seawater. Sometimes he uses leather instead, and often he paints on it a decoration appropriate to the type of bow he has made. Jeff Schmidt, on his bows, took this a step further, learning Persian in order to select appropriate verses of poetry to decorate his bows.

From the time Novotny cuts the wood to the day he declares a bow complete, a year and a half has usually elapsed, some of it spent testing the bow, adjusting it, and testing it again. He is often seen astride his horse, bow in hand, and at least twice a day he steps outside his studio to shoot arrows into stacked bales of cornhusks. The setting in rural Ohio is so bucolic, and Novotny's gestures so

assured, that every step looks self-evident, straightforward, easy. Yet nothing could be more deceptive. With no master bowyer to guide them, archers today have had to learn from bows in museums and from old texts, neither of which tell a complete story.

A composite bow can only reveal its full range of secrets if you take it apart, and for the best bows, invariably in museums and private historical collections, this is clearly not an option. Neither is stringing old bows and testing them, since there is no way to assess whether or not they could now withstand the tension. While damaged bows can be taken apart without as many qualms, they yield information only about the final product, and thus there is little to help understand the process. As for the texts, they focus mostly on shooting techniques, and the chapters on construction often prove to be mixed blessings: In some cases, the author was not a bowyer himself and thus did not always understand what the bowyers were telling him. In other cases, the author assumed knowledge that has long disappeared. And like any skilled craftsmen, Novotny points out, bowyers guarded their secrets.

For example, for all its precise pointers on assemblage and materials, *Saracen Archery* does not provide exact dimensions for bows. Its units of measurement are not standardized, and many of the proportions are expressed in terms of a man's anatomy, yet there is no telling just what size that man is.

When Jeff Schmidt, who stands nearly two meters tall (6' 6"), built a bow using measurements based on his own body, it had a "preposterous" draw of 90 kilograms (200 lb): It was impossible to draw. This is because doubling the thickness of the bow increases its stiffness by a factor of eight.

Undeterred, Schmidt kept searching. He found in the second edition of Paul Ernest Klopsteg's self-published 1947 book *Turkish Archery and the Composite Bow* not only the findings Kani compiled for Mahmud II, but also the results of Klopsteg's 15 years of experimentation, which yielded dimensions that "actually worked." Then Schmidt heard about a bowyer named John McPherson, a Kansan who was making highly recurved Native American bows of horn and sinew. Schmidt spent a summer with McPherson learning the ways horn and sinew behave. By trial and error, Schmidt refined his bows' proportions and determined which materials worked best: The Achilles tendons from cattle, he discovered, provided the best sinew, and water buffalo provided the best horn—even though some texts recommended goat and antelope.

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It was just about this time, in the fall of 1992, that Novotny showed up on his doorstep with "some really good North American Indian bows," says Schmidt, who confesses he was "shocked and disappointed because mine were so crude by comparison."

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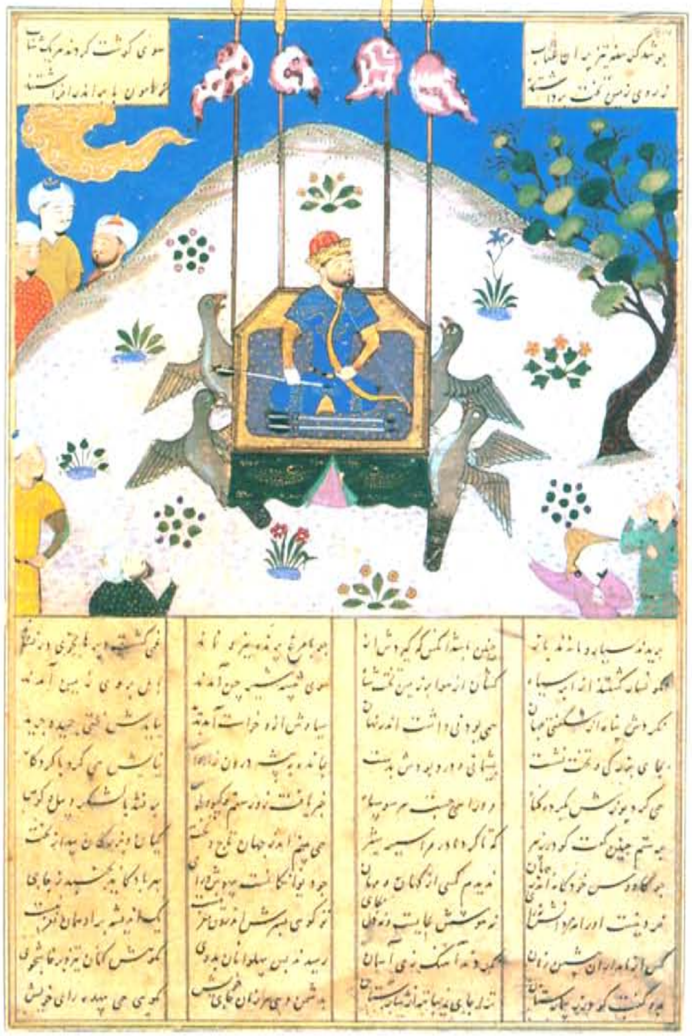
6. He then repeatedly tightens the molds—only an inch or so every two or three hours—after heating the bow to "teach" it proper "tiller," or curvature. 7. The first draws are gentle tests. 8. Rasping away horn can relieve stiff spots and balance the draw. 9. Like other neo-traditional bowyers, Novotny uses decorative patterns from antique bows.



In this painting from the Persian *Shahnama* (*Book of Kings*) dated 1480, the mythical Iranian king Kay Ka'us holds a recurved bow and an arrow. "You always release the arrow at the top of the gallop, meaning that all four hooves are off the ground at that moment," says Novotny, shown here loosing an arrow during IHAF competition. "That is when you are most still and an accurate shot is most possible. But it takes much practice to stand a chance of hitting the target, and years to become really good."

By now, Schmidt recalls, "there was a network of about 20 people working on this. We called each other about once a day." It is impossible to chronicle how this geographically diffuse, informal "bowyer's club" solved each problem its members encountered, but one example imparts their experience of collaboration and dedication. The question was how best to glue the horn to the wood. Fish-bladder glue, they knew, is stronger than hide glue, but according to some texts, Turkish bowyers favored glue made from the roof of a sturgeon's mouth, not its bladder. When this proved unsuccessful, the bowyers decided there might be some ambiguity—intentional or not—in the texts. So, it was back to simmering fish bladders at 65 degrees Celsius (150° F). But these results, too, proved unsatisfactory. "Someone in the group called a chemist in New York who made hide glue," Schmidt recalls. "And the chemist told us that the molecular weight of the fish-bladder glue was high and it was therefore difficult for it to penetrate into horn." The solution was to dilute the stronger fish glue with the weaker but more penetrating hide glue.

Now they faced another conundrum: How thick should the glue line be? Too thin and the seal might not hold. Too thick and the seal might rupture. Enter Wayne Alex, an Alaskan bowyer who knew a collector who had X-rayed bows and reported that the wood and horn bore minute longitudinal grooves. As Novotny subsequently discovered, this grooving is sometimes light, just enough to roughen the surfaces. But on shorter bows that are more highly stressed, the grooving runs deeper, increasing the contact surface for the glue by some 40 percent.

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Schmidt set about constructing scrapers of a type Novotny still uses. Some have short, triangular teeth, with which he roughens up the wood and horn. Others have longer teeth, five to eight per centimeter, with which Novotny scores the horn and wood. It is this "hand control," he says, that Schmidt most admires in Novotny's work. "Lukas," he says, "is by a long shot the most technically skilled when it comes to fabrication."

Today, Novotny also stands out as one of the rare few to remain dedicated to uncovering the secrets of the earliest composite bowyers. While Baker, Schmidt and others have since turned to other pursuits, Novotny has imparted what he knows to engineer Tony Horvat, with whom he established Saluki Bows. To support his passion for traditional bows, he makes and sells less labor-intensive bows of fiberglass and other modern materials. And he continues to research. About four years ago, after examining the cross-section of a bow in a German museum, Novotny changed the shape of his composite bows' cores from flat to rounded, and he built up the sinew at the ends. More recently, he tracked down a copy of an out-of-print Turkish book on archery whose author recently died but whose papers and source materials Novotny believes might be available through his daughter.

He also remains committed to replicating as exactly as possible the materials Persian and Turkish bowyers used. He puzzles over recurring references in texts to the use of neck sinew: Nobody here has been able to make it work. "A truck driver from Florida read an article about me and called to tell me his grandfather taught him to make bows in the 1920's in

Istanbul. He kept mentioning sinew from the neck. Is it faulty memory?" Novotny wonders. "Or is there really some way to use this sinew?" And just as he hunted down a supply of suitable water-buffalo horn in Thailand three years ago, he wants one day to find the exact kind of maple described by Kani and others.

Baker, however, considers such concern over materials "mythologized." Materials, he maintains, "only account for 10 percent of the bow's success"—the rest is design. But while Novotny agrees that design is paramount, he remains curious and respectful of the centuries of experience that went into determining just the best time to cut the sapling and even on which side of a hill to grow it. "I have made some very strong bows," Novotny says, "but I still think I can make them perform much better if I really attain the right materials."

Until then, the quest for the modern equivalent of the recurved composite bows that shaped centuries of history continues, "as much a frustration as a passion."


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www.atarn.org

www.salukibow.com

http://coas.missouri.edu/anthromuseum/grayson/grayson.html

www.intlhorsearchery.org

*Saracen Archery: An English Version and Exposition of a Mameluke Work on Archery*. J. D. Latham and William Paterson. 1970, The Holland Press, 0-90-047004-6.