The Conservation, Restoration, and Repair of Stringed Instruments and Their Bows

EDITED BY TOM WILDER

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GENERAL ISSUES CONCERNING STRINGED INSTRUMENTS AND THEIR BOWS

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STRINGED INSTRUMENTS AND TECHNIQUES FOR THEIR CONSERVATIVE RESTORATION AND REPAIR

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BOWS AND TECHNIQUES FOR THEIR CONSERVATIVE RESTORATION AND REPAIR

Substitute Materials in Bow Making

Benoît Rolland

In the early 1970s the inspiration for making synthetic bows was twofold: it offered a solution to the growing scarcity of pernambuco, and it expressed the prevailing enthusiasm for new materials and new molecules. The classical music community, however, found the idea objectionable, or at best dubious. Cost was not a prime concern; in fact, some of the first composite bows that appeared a decade later were more expensive than good-quality traditional bows. With today's increasing numbers of students receiving musical instruction, particularly those who play stringed instruments at a fairly advanced level, the demand for bows is up, even though most students play for only a few years. Producing good-quality synthetic bows on a larger scale would seem to be an ideal way to provide more musicians with proper tools. Long and complex research has been invested in the design of high-end bows made of composite materials and defining the casting steps. Now that this goal has been achieved, pernambuco can – let us hope – be reserved for creating veritable works of art.

Successful research in the area of alternative materials depends on reconciling a number of parameters: science and technology must of course be coupled with musical practice and production techniques but it is also imperative to consider the cultural and emotional context in which bows are used. In a field as sensitive and historically charged as music, the best bow from a technical standpoint will not necessarily find favour with players unless it is perfectly adapted to the spirit, culture, and references of the music profession. In other words, we are not ready to see a talented classical violinist at an audition for a first violin chair using an odd-shaped, gaudily coloured bow based on a computer-generated design, no matter how superior its proven efficacy.

The world of stringed instrument making is one of references to the past: any innovation in the process of creating new products must take tradition into account. Indeed, imitation has played an important role in developing innovative products. Hindsight has given us a better understanding of how choices were made, how the initial dismissal of the "plastic bow," as it was called, gave way to the thriving market for composite bows that today we take almost for granted. Many years before anyone thought about synthetic materials, it was common to use one natural material to replace another. Substitutes for fittings were often economically motivated: for example, ordinary wood was stained black to imitate ebony. Similarly, early synthetic materials were made to resemble original materials such as whalebone, silver, and so forth, as closely as possible. This firmly entrenched culture of reproduction (or interpretation of a reference model) helped to fix the way in which we envisage the bow. When the concerted effort to find alternative materials began to gather momentum these criteria had to be considered.

Terms such as "imitation," "substitute," or "alternative" imply a prior standard. The reference here is the classical pernambuco bow as it was gradually defined from the Tourte, Peccatte, Tubbs, and Sartory models designed for the repertoire of their time. This bow stands worldwide as the emblematic image of the bow. In the baroque era, however, bows came in

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a variety of shapes. Since much of their value hinged on their individual aesthetics, replacing them with a standardized product would have made no sense. Today's synthetic bow research seems to have a precise objective: to produce an inexpensive, and ideally unbreakable, bow that looks and plays like a good pernambuco bow. Achieving this result has, to date, been an extremely complex process.

Early classical bow makers tried various woods before opting for pernambuco, and sporadic use of these woods has continued, but the choice of pernambuco for first-rate bow making has never been seriously challenged. Alongside great historical bows, makers also churned out a steady stream of ordinary pernambuco bows of uneven quality, some mass-produced. Let us hope that semi-industrial synthetic bows will not, in turn, fill the junkyards of musicdom! But this is unlikely. When the first synthetic bows came out of the moulds, bow making was still an essentially pragmatic craft. The research undertaken to perfect innovative materials and design has answered a number of fundamental questions that had remained unresolved. Synthetic bows now have a place alongside the vigorous practice of traditional bow making.

During the mid-1980s the first workshops to turn out sticks made of alternative materials sprang up in several locations around the world. Various options were proposed, but when played, only a few passed muster and were subsequently developed. The Von Bennigsen, Berg, and Spiccato bows are among these pioneering efforts still in use. Some of the earliest manufacturing concerns were short-lived, and others, such as Coda and Righetti, entered the market later. Today, the competition includes a profusion of brands; major Japanese, Chinese, and American companies are distributing second-generation synthetic bows based largely on precursor models. A turning point came with the move from factory object to professional-quality musical tool. The next step was to match the playing quality of excellent pernambuco bows and to create a versatile bow with personality. Stick-related research has been decisive in the history of bow making. The use of substitutes for peripheral elements – frog (figs. 1, 2), fittings, button, etc. – is nothing new, but it did not involve redefining the bow's playing properties. Casting the stick, however, required a fundamental reinvention of the concept of the bow.

What follows is a chronological review of replacement materials used in bow making. The primary focus is the challenge of making sticks from materials other than wood. But oddly enough the story begins in the 1950s with the explosive popularity of nylon and a desire to replace horsehair. This was followed by numerous imitations of ebony, mother-of-pearl, and whalebone. Substitutions for pernambuco came later. The boundless quest for radically new materials – often inappropriate to music – eventually gave rise to interesting products, some of remarkable quality, that were of sufficient consequence to envisage large-scale production.

Substitute Materials for Bow Components

Hair

There have been many patent applications concerning substitutes for horsehair, but an adequate replacement has yet to be found. The elasticity of horsehair is perfectly suited to the interaction of bow and string: horsehair, when stretched, returns to its initial state with no undesirable recoil effect; its breaking point prevents excessive extension; its porous fibres retain rosin; and its peripheral barbs provide multiple points of contact with the string.

I have examined more than fifteen patents, most of them European, and have witnessed a number of manufacturing attempts, but none come close to the particular qualities of horsehair. A nylon strand may have the same diameter but it snaps back to its original position like a taut spring. A nylon-strung bow is just as unstable as a car with a suspension system but no shock absorbers. The modulus of elasticity is an essential parameter for controlling the stick/hair dynamic.

The most extreme horsehair substitute ever mounted on a stick was a ribbon of aluminum strands – a material inherently lacking the necessary elasticity. This venture remains a testimony to the infinite, un-

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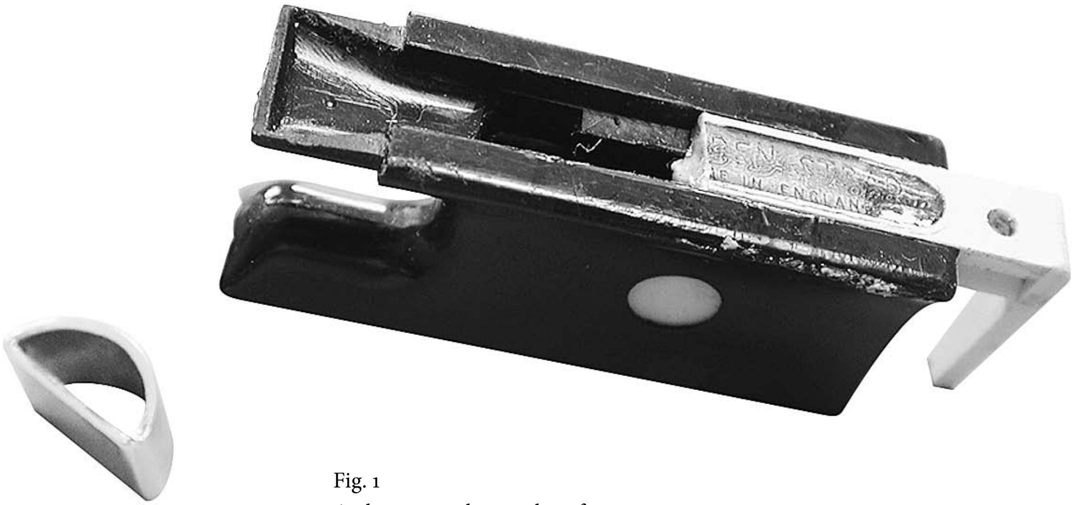

Fig. 1
A plastic or polypropylene frog,
hair-side view.

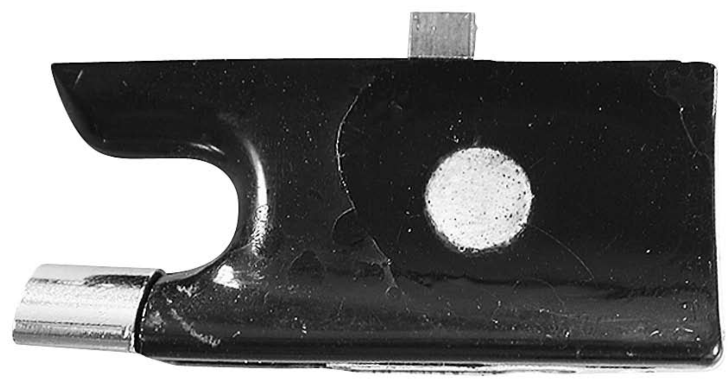

Fig. 2
A plastic or polypropylene frog,
side view.

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bridled ingenuity deployed in the search for substitute materials!

The inescapable question of barbs has excited more than one mind. A patent for a curly nylon thread stated that the twisted loops would hold rosin, but unfortunately, these loops tended to accumulate rosin in a pattern very different from that needed to grip the string.

The idea of substitutes (that is, a substitute for a natural product) has become somewhat commonplace. Some products that at first glance appear to be substitutes are actually standard materials presented in a new context. For example, brightly dyed horsehair suggests a different material that we spontaneously see as fake, or at least amusingly strange. Our momentary confusion is instantly corrected by a glance at the label, demonstrating that even in bow making, "alternative" comes with cultural presuppositions.

Ivory, Mother-of-pearl, Whalebone, Leather, and Metal Mountings

Wildlife conservation concerns have long prompted the use of mammoth instead of elephant ivory. How curious it is that the supply of ivory from the long-extinct mammoth is more plentiful than that which the present elephant population can provide. Piano manufacturers now commonly replace ivory with high-quality plastic polymers, but this practice has not caught on in bow making, where plastic is synonymous with inferiority. Ivoirine, a superb composite resin, has been used for many years in making billiard balls. Some bow makers have tried vegetable ivory, a palm kernel that convincingly imitates elephant ivory, but unfortunately, it is costly, and because it is extremely dense, it is hard on files and difficult to carve with a knife.

It may be that the ivory-faced surface on a bow is too small to create a real need for a replacement. The decision to shun modern materials is cultural (ivory is a prized symbol of quality) and financial (why worry about such a small, reasonably priced piece?), rather than technical.

No satisfactory substitute has been found for mother-of-pearl. As with ivory, the profession has gradually shifted from one source to another. Dwindling European molluscs have been replaced by Pacific Ocean shellfish, which are readily available and repopulate rapidly. While nearly identical, however, the shells are larger and provide thicker nacre that is more wear-resistant but visually less delicate. Nacrolaque, a plastic imitation of mother-of-pearl, comes in sheets that can be cut with a hand chisel. It is available only as white nacre, with grey and white highlights that appear perfectly genuine in spots, albeit in a limited range. Its main disadvantage is that it shrinks with age. Real mother-of-pearl preserves the "jewellery" aspect of the bow.

Plastic imitations of whalebone wrapping have been more successful. Artificial whalebone has good colour and a pleasant feel. Its use has been limited to ordinary bows only by a lack of the refinement expected in such valuable natural ornamental material (figs. 3, 4).

The sole substitution for silver mountings is nickel silver (a copper, nickel, and zinc alloy that first appeared in the 19th century, also known as German silver). Its use, confined to low-end bows, is dictated by economics. Gold and silver – like mother-of-pearl, ivory, and leather (which is rarely replaced by imitations) – give a bow the refinement of a jeweller's touch.

The Frog

While sticks have evolved radically over the past 30 years, frogs have resisted change. Frogs for run-of-the-mill bows are easily machine-made and machine-finished, and the wood is in ample supply. In earlier times, handsome sticks were sometimes embellished with highly decorative frogs that demonstrated the bow maker's free-wheeling imagination; a variety of materials went into these extravagantly ornamental projects. Somewhat less conventional frogs have been made of tortoiseshell, elephant ivory (or more recently, mammoth ivory), and even horn (in rather inelegant attempts).

But ebony has remained the ultimate material of choice. Now that ebony from Mauritius, for decades the source of the loveliest pieces, is protected, frogs are cut from ebony grown in Africa, Madagascar, India, and several Asian countries.

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Fig. 3
Genuine whalebone.

Fig. 4
Imitation whalebone.

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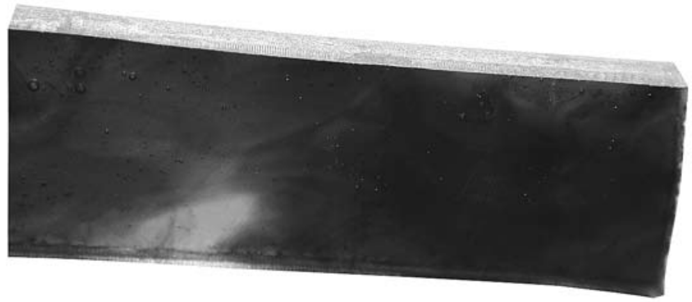

Fig. 5
Imitation tortoiseshell.

No substitute has been able to rival the magic and aesthetic beauty of tortoiseshell (fig. 5), but like elephants, turtles are protected under the Convention on International Trade in Endangered Species (CITES). However, the application of this protection leaves much to be desired on some islands, where turtles are farmed and their eggs and meat sold to bars and restaurants: bow makers would need only a tiny portion of the shells discarded to rot for fashioning a few frogs.

The 1960s enthusiasm for plastic saw the emergence of the polypropylene frogs that are still used today on low-cost bows (figs. 1, 2). Bakelite, a phenolic resin with multiple household uses, was also advanced as a substitute for ebony but failed to win favour. Ebonite, a superior-quality phenolic resin, was favoured for its handsome appearance and could have had a future were it not so fragile: without reinforcement, the tongue of an Ebonite frog cannot withstand the pressure exerted on it when the bow is played. Ultimately, ebony remains a good option.

The Stick

In seeking replacement materials for bow fittings, artisans have focused on imitations of threatened or extremely expensive natural products. Is this to say that imitation has been the watchword of all efforts to find alternative resources? Creative breakthroughs are rare in a field where musicians and dealers adamantly guard the status quo for both musical and marketing reasons. We know how arduous it is to complete an instrument or a bow, and how complex the final product and its tradition are. The introduction of new concepts in stick making involved a revolution of sorts. The following account, while not exhaustive, traces the chronology and logic of the research conducted to achieve an alternative bow of fine quality, particularly the early initiatives.

The Development of New Stick Materials

The fibreglass bow was invented in the United States in 1962. Intended for beginners, these bows were marketed during the mid-1960s and early 1970s, first under the brand name of Roth-Glasser, and later, under Glasser. They are based on an underlying technology of constant principles, and have gradually evolved; they are still sold today.

The Golden Strad was a totally new bow brought out in France in the 1970s. This odd, inexpensive, and interesting object made in part of twisted fibreglass filaments needed serious alterations to make it playable (it bounced to the point that it could not be kept on the string), and from an aesthetic standpoint (it was yellow-orange with brown patches) it left much to be desired. And yet this bold project was full of new ideas: it had nylon "hair," a plastic frog mounted

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with chrome-plated steel, and what's more, a hollow head containing an ingenious patented spring-mounted plug mechanism.

Around 1975 two French engineers – Maigret and Cayuela, whose names are often unjustly forgotten – working for a Bordeaux manufacturer of composite materials patented one of the first formulas for using carbon fibre in a bow stick. Less than ten years later their principles served as the basis for the first carbon bow. While not much to look at, it had interesting playing properties and was apparently unbreakable. The patent was subsequently licensed to a company headed by a well-to-do Swiss cellist who developed the concept and improved the styling. The ebony frogs were machine-made. This bow had playing quality but it lacked evenness and over time it lost camber – a major drawback due to its design. It was introduced as a high-tech product (carbon fibres were still rare and costly) and was more expensive than common wooden models (about US$2,000, compared with US$1,000 to US$1,500 for wood). It was discontinued in the mid-1990s.

Around 1985 a new synthetic bow was created in New Zealand and distributed on the European and American markets at a price comparable to that of good wooden bows (about US$1,200). The fibreglass stick had a remarkably realistic imitation-pernambuco finish. The material still lacked solidity (there were rumours that NASA engineers were involved in its development), the heads were liable to crack, and the machine-made frogs were those available on the market. Despite genuine playing qualities, the first models were also poorly balanced, with an overly heavy head that tired the musician's arm. In addition, they tended to lose camber over time. However, after initial trials, the makers continued to make improvements until they achieved the desired quality. This fibreglass bow is now made and distributed in the United States.

Around the same time, an Italian company introduced a carbon stick made of aligned carbon-fibre bundles. It too was mounted with the machine-made frogs. The bow was reasonably priced (US$1,000), but was initially stiff and produced a rather nasal sound. Different models were named for famous bow makers (Peccatte, Lamy) and marketed with ads touting their appearance and playing quality.

Music teachers of the day joked about "plastic bows for beating students," but soon some of the most renowned soloists began recommending models that had proven their worth at top levels. The endorsement of such musicians was essential for the exhausting research still facing inventors. The turning point came with radical progress in analyzing the vital parameters for casting bows. In fashioning the body of a violin, the choice and preparation of the wood determine whether the instrument will be great, merely acceptable, or unplayable. In much the same way, the shape and camber of a bow, combined with the choice of wood, determine its unique musical character. The multiple interactions of all these inherently complex parameters cannot be directly translated into scanned, computerized profiles. In addition to the fact that there is no obvious recipe for replacing wood with carbon and resin, the intrinsic capacities of these components sometimes run counter to the function of the object. In the late 1980s, with the exception of hand-finished prototypes, no factory had yet turned out a synthetic bow of a quality suitable for concert or recording purposes.

One problem involved defining and stabilizing the camber. The camber of the stick and the resulting versatility of the bow have always been of concern to bow makers because these factors are of utmost importance to the bow's playing quality and musical character. (Around 1950 an American patent was sought for a bow that looked more like a crossbow or a guyed mast. It was supposed to give the musician permanent control of the camber, but it appears to have been unplayable.) The Spiccato was the first fibre bow to solve the camber-loss problem posed by synthetics while still offering professional-level playing quality. This French bow was designed in the early 1980s, and after, ten years of complex technical and scientific research and eleven wooden prototypes, was finally put on the market in 1991. It features an invisible patented stick-tension mechanism that maintains the camber and allows the musician to alter the musical character at will. The hollow stick is a combination of carbon fibres. The style, feel, and

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aesthetics are consistent with traditional wooden master bows, which confirmed the potential value of the new materials, and the adjustment mechanism brought a totally new concept to bow making. The Spiccato has gradually gained acceptance among professionals.

After this revolution, research progressed at a fast clip and the reputation of synthetic bows improved. Interest was focused on two materials: carbon fibres (fig. 6) and glass fibres (fig. 7). The new bows became firmly entrenched in orchestras and conservatories. With various technical options available, entrepreneurs entered the market and the number of shops quickly grew. A few companies took the carbon option to an industrial level, approaching the concept in different ways and interpreting the resistance and weight factors in different manners. The second generation of alternative bows was just around the corner. Large companies bought up and put their own brands on the manufacturing processes for the few synthetic bows that had proved themselves.

At the same time, a number of offbeat inventors were pursuing other avenues: a Parisian bow maker was empirically cutting out bows from carbon blocks; an Austrian inventor was developing a fully customized bow; and a firm in the western United States was producing the cheapest possible fibreglass bow (US$20). In the same low-end category, one French maker offered carbon sticks painted pink, blue, or green, and another company began to specialize in mid-range prices and technical options. Now, in the early 21st century, there are numerous producers.

Fig. 6
Carbon fibres.

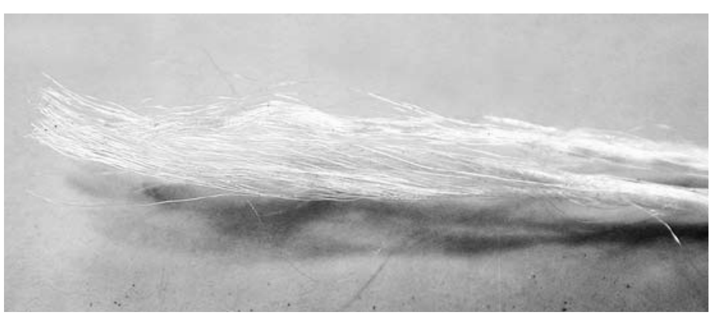

Fig. 7
Glass fibres.

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Technical Features of Synthetic Bow Materials

From this survey of the research conducted in the development of synthetic-material bows, it appears that carbon and glass fibres are the most widely adopted choices, with carbon dominating the market in terms of sales. Since most synthetic bows are cast, current and future progress depends on the rapid development of casting techniques (laser modelling, multiple print moulds, and resin injection) and on the growing availability of fibres and resins resulting from the accelerated creation of new molecules. But the principles remain unchanged.

The following paragraphs provide a rough account of manufacturing techniques. The fibres, which contribute to the structure, after careful selection and arrangement, are disposed in the mould in a particular order. Next, resins are added to bind them together. Proportions and methods for combining these components are trade secrets. As for the fibres themselves, many technical and economic considerations enter into account. For example, fibreglass is more flexible than an equal diameter of carbon fibre. To obtain the same stiffness, a glass bundle must contain more fibres and will thus be heavier. But glass fibres are generally less expensive than carbon fibres. Carbon fibres, which are produced mainly in Japan, come in a wide range of resistance levels; they are indestructible. Resins, on the other hand, are less stable and can deteriorate over time – a characteristic shared by all synthetic bows.

The design of the mould plays a cardinal role, as it determines not only the aesthetics and style (the design of the head, etc.) that are the hallmark of each model of bow, but also the curve of the camber. Like the arrangement of fibres that support the structure, this curve determines the shape and character of the bow. Unlike wooden bows – which are first shaped, then cambered using heat, and repeatedly recambered over their lifetime – synthetic materials do not permit significant alteration of the bow's character once it is shaped.

As noted above, cambering and the loss of camber in synthetic bows remain a core problem that is due mainly to the resinous component. Manufacturers get around this problem by adjusting the composition of the fibre bundle, varying the quantities and properties of the resins (epoxy and polyester are among the most popular types). The range of options is limited by playing requirements; for example, a very hard bow will slacken less but may not be appropriate to the music. Ongoing problems with casting techniques prevent fully automated production. Human intelligence and dexterity are still required at various stages of the bow-making process, to select and arrange the fibres, and to finish the rough stick as it comes out of the mould.

The history of bow making offers many instances of audacious innovation that reflect the scientific thinking of their day – Vuillaume's metal bow is but one example. The most successful inventions take hold and enter tradition, becoming such a normal sight that we no longer see them as innovative; this is borne out by the fundamental bow improvements made by Tourte, Lupot, and Vuillaume. It seems certain that in the 21st century synthetic sticks will not be raising eyebrows much longer.

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