The Armature's Design and Proposed Construction

The armature is the portion of the Giant Crossbow in which Leonardo seems to have shown the most interest, for which the most preliminary studies exist, and on which he starts his handwritten notes on CA 149br, where he estimated the carriage's proportional length and its placement on the sheet. Leonardo refers to the armature or laths across the front end of the Giant Crossbow as the armatura, or armature. He notes this at the end of the third line to the right of CA 149br (Fig. 1.1).

A great crossbow armature normally consists of one or more laths perpendicular to the body of a crossbow, attached to the body's front end, and responsible for applying tension to a string attached at both ends of its lath or laths. This arm or bow flexes back with the pull of the centre of the string, giving a bolt or stone placed at that centre its force and motion when the string is released and the armature springs forward with the string. Around 1494/1495, Leonardo produced a detailed study of the mechanics of a great crossbow with this kind of simple or compound lath armature on CA 142r [51rb] (diagram, Fig. 4.1). The design of the Giant Crossbow armature, however, differs considerably from what one would have seen on great crossbows in the 15th century. The present section of this study will outline some of the possible reasons for the unusual design of this armature.

The giant armature on CA 149br is the crossbow's most decorative feature and thus the most relevant to Leonardo's proposal to make "ordinance of very beautiful and functional design":

7. … I will make cannon, mortar and light ordinance of very beautiful and functional design that are quite out of the ordinary.
8. Where the use of cannon is impracticable, I will assemble catapults, mangonels, trebuchets and other instruments of wonderful efficiency not in general use. (CA 1082r [391ra])

The armature is not a single wooden lath or a simple set of equal-length laminated laths, which was the customary body for "compound" great crossbow armatures, treated with sinew, horn, and an herbal unguent. Instead, it is a complex design of modular laths that conform to an overall appearance of narrow bat wings. Curves at

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1 These preliminary studies would include two armature designs on CA 147av, eight sketches of an armature on CA 147bw, two armatures on CA 57v and possibly various indirectly related studies of armatures.
2 Translated by Kemp and Walker, §612, p 252.
3 Preparation of the armatures of medieval compound crossbows, or "great crossbows", sometimes involved the application of an herbal unguent like spikenard in order to preserve the elasticity of sinew from a bull's neck or a deer's hamstring. The 'two-foot crossbow', so-named for the length of bolt that it shot, had an armature of up to six feet in length, most often made of yew, and treated with goat horn and sinew. As an example, three kinds of great crossbow are documented in France in the 13th century, noted by the scribes of Philip II Augustus in 1204–1206: the crossbow with stirrup (balistam ad estrif), two-foot crossbow (balistam ad duos pedes), and windlass crossbow (balistam ad tornum). E. Audoin (1913) Essai sur l’armée royale au temps de Philippe Auguste, Champion, Paris, pp 187–197.
the centre front and rear of the armature resemble the front and rear curves of most bat wings. Before a discussion of the physical format of these modular laths, an analysis of the possible reasons for its bat wing design immediately follows.

The narrow bat wing design is more obvious when looking at the crossbow from directly above, as in the diagram of Fig. 4.2. Leonardo later used this form for his flying machine designs, such as the examples on CA 70br [22vb] and on CA 846v [309av]. The earliest record of this wing design is among the studies on Manuscript B folio 74r, from the mid 1480s (Fig. 2.1). He designed on CA 149br a large bat-like machine, using a structure that he would have considered a design proven by nature herself. At around the time when he wrote his letter to Ludovico, or shortly thereafter, he produced on MS B 74r his earliest known detailed drawing of the bat wing’s structure. This was drawn at the time when he was copying Valuturio’s De re Militari onto the pages of MS B, producing his first known designs for flying machines in MS B (ff. 73v–80v; 88r–90r) soon after which he designed the Giant Crossbow (the date of which discussed in the previous section of the present study).

A number of Leonardo’s earliest studies offer evidence of his reasons for its massive size and bat wing form. An immediate impression of the Giant Crossbow drawing suggests that it is a formal presentation drawing, intended as a treatise illustration, and therefore to impress a wealthy patron, such as Ludovico Sforza. Unlike CA 147bv [52vb] and 147av [52va], 149br contains complete drawings, and has formal written explanations of its diagrams (written in Leonardo’s reverse script). He likely chose to write alla mancina because his left hand could produce his best looking handwriting. Without reading the text, one can judge the relative size of the machine by observing its proportion to that of the crossbowman on its upper carriage. In the 15th century, great crossbows were considered extra siege weapons, for use in places for which there were not enough cannon, trebuchets, or mangonels for a similar purpose. If a great crossbow design were to impress a wealthy patron who owned many cannon, existing crossbows and presumably a number of trebuchets and mangonels, it had to offer what the rest of the Sforzas’ siege arsenal could not offer. Statements on CA 149br claim that the machine can quietly launch a 100-pound stone. The seventh line of text at the right of the sheet mentions the stone, and the last line on the left refers to the quiet release of the trigger. Although the Giant Crossbow’s practical possibilities are discussed further below, it is worth noting here that its design gives an immediate impression of its proposed capabilities to anyone who understands siege engines. Obviously, the drawing represents a machine capable of the direct thrust of a heavy missile with a relatively quiet trigger. Unlike the expensive bronze cannon, it is mostly composed of wood, it does not require gunpowder, expensive missiles or lead coated stones, and it can launch missiles without much of a sound. Rather than toss a missile less accurately into the air with a trebuchet or mangonel, the Giant Crossbow would make a direct hit at short distances or shoot objects more accurately along a lower trajectory. As for its visual appeance as that of a giant bat, this too would be a significant psychological and memorable advantage at a siege.

Leonardo’s notes suggest that he seriously considered the bat-like structure of the armature. Several times in his notebooks—from the mid 1480s through as late as 1515—he made notes about the bat and its wings. Relevant to the present study is his study

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**Fig. 4.1. Illustration of Leonardo’s drawing of a great crossbow, Codex Atlanticus 142r [51rb], Biblioteca Ambrosiana, Milan**