

A Functional Facsimile
of a
**Chinese Han Dynasty
Crossbow Lock**



Presented by Arqai Ne'urin

Presentation Outline:

Introduction

This project is NOT an attempt at creating an exact replica since it will ultimately be installed in a field ready SCA siege engine. This project IS intended to duplicate the function and approximate the appearance of a period trigger assembly.

Personal

Hello, my name is Arqai and I'm a siegeaholic. I really, really want a siege engine. But I want something different than most. I want mine to be a functional threat on the war field AND I want it to look like an engine my persona might have used.

I came across a website that showed several period catapults, ballistae, and trebuchets. I was so impressed, I bought the book (ref. 5). I began work on one of the engines depicted, the "*San Gong Chuangzi Nu*", three bow little bed crossbow. I began by learning as much as I could about the engine in general (refs. 4-5). In addition to the bows, my trigger went through a long process of development. It is that process that I am presenting here.

Historical Placement

Trigger mechanisms such as presented here (ref. 1) were first used from the Warring States period to the Han Dynasty (435 - 206 BCE). Archeological evidence shows that similar triggers were still in use until crossbows were replaced by reliable gunpowder projectile weapons (~1525 AD). (Ref. 2)

Evolution of my trigger *(see also the Photo Appendix)*

- 1. First Prototype:** Answers the question, "Do I really understand how these pieces work together?"
- 2. Second Prototype:** Answers the questions, "What will it look like with all the pieces?", and "Will it still work the same way?"
- 3. Cast Bronze Model:** Came to me as just the rough cast pieces. After shaping and final fitting, it was determined that this model has a "hair trigger" not suitable to my application. I would have to re-manufacture the trigger lever and sear.
- 4. Cast Bronze/Brass hybrid:** Using the cast bronze nut and pins with cut brass trigger lever and sear. The cast bronze housing is now too small, so components are mounted in a temporary steel frame. This is the first functional trigger, but it became evident that I'd have to modify the nut as well. I wasn't comfortable making further modifications to the nut, so resigned myself to manufacturing a new one out of cut brass.
- 5. Machined Brass components** in the steel frame. The cut brass nut and pins now make the trigger fully usable. But this is the end of the prototype engine development. It's time to make a "for real" housing.
- 6. Completed Trigger:** All the parts assembled of cut brass, including a new housing, ready to install into the Generation 2 Tiller.

Process Details

Trigger Design

There are three primary functional pieces that are held into a cast housing by two cast pins (refs. 1-3). Earlier versions didn't have the cast housing and the moving parts were simply held in place within the wooden stock by the cast pins (ref. 2). My design is based on drawings (ref. 2) and photos (ref. 1) of original triggers as well as a "working model" cast in bronze by a modern artist based on a period original (see side display). Many thanks are due to Archos Arion the Wanderer for his kindness in giving me access and opportunity to work with this model. I have built two prototypes out of wood (see side display) to prove my design.

Materials

The trigger lever, sear, and trigger nut were cut from ½ inch brass bar stock using hack saw, drill press, and die grinder and cleaned up with hand files. The trigger nut is assembled with brass pins, then soldered (for position), then brazed (for strength). The trigger housing is cut from ¼ inch brass bar stock, soldered and pinned. The trigger pins are ½ inch brass round stock set, soldered and pinned into ½ inch flat bar stock.

In period, all of the above would have been cast in bronze, requiring only clean up and fitting with files (ref. 2). However, my trigger is made from cut flat stock and not cast (for reasons explained below).

Machining

Modern tools were used throughout this project. However, many of my modern hand tools would be functionally the same as period tools (hand saws, rasps, mallet, chisels, drills). There are, of course, exceptions. The pin holes, for instance, were done with the help of a motorized drill press.

In period, these pieces were cast in bronze and finished with hand files (which is exactly what I did to get Archos Arion's trigger fitted and functional). The process on my own trigger differed in that I instead used flat stock rather than casting. Most pieces were just cut from bar stock and shaped with hand files. The nut is the exception and draws the most questions. The process of making the nut is better presented in pictures in the Photograph Appendix.

Revisions

"So, why didn't you just enter the cast trigger into the contest?" First, the casting was not done by me, making it substantively "not my work". Also, components of the cast trigger were tested in the Gen 1 engine and they weren't suitable.

My adventure to a trigger went through a number of phases which are outlined in pictures in the Photograph Appendix.

Fig. A. Temporary June Faire (2013) trigger

This was never intended to be final. I wanted to have SOMETHING to present at June Faire and had only just started prototyping. So I came up with a temporary solution. The lever

and pin design is also period, but is very clumsy as the string has to be lifted over the pin for each draw. This wouldn't be a problem on a hand held crossbow, but a siege engine has a whole lot more power.

Fig. B. Prototypes 1 and 2 (see also side display)

The first prototype is based on whatever pictures I could get my hands on. It's only function is to prove that I'm on the right track with how the trigger will work.

The second prototype is much closer to what I could discern from the photographs and drawings I had seen. It's only function is to prove that I had all the parts at least close and that they would work together.

Fig. C. Archos Arion's casting (see also side display)

And of course, once I had it figured out, I get one of the things put in my hand. Archos Arion had ordered his model from a modern craftsman some time ago but never had the opportunity to chase the casting and make it operable. He gave that task to me and it proved VERY educational. I used only hand tools as would have been done in period. This trigger can be seen in a side display, as well as in the Photo Appendix.

But there was a problem. The bronze artist included scale drawings with the castings and I used those as a reference for finishing them. The result was that the relationship between the sear and the trigger lever was such that the trigger would trip from just the weight of the trigger lever. The only way around this issue, short of re-casting, was for me to cut new ones out of flat stock, with more allowance for engagement. This is how I got on the path to making the whole trigger, outright.

From this point on, all revisions have been tested in the Generation 1 prototype engine.

Fig. D. Gen 1 Sear and trigger lever (steel side plates) (see also side display)

With the new trigger and sear, I was able to make a functional trigger for testing by using Arion's nut (most complicated piece) and the parts mounted in steel side plates. This worked well enough for initial testing, but I soon learned that I would also have to modify the nut. I didn't want to make any further changes to the cast nut, so I went about making one of my own.

Fig. E. Nut (manufacturing process)

This was the singular most fun I've had in my shop in ages. The nut is fairly complex to be done with hand tools.

E.1 shows the two "halves" of the nut as they were cut out from 1/2 inch flat stock. You can see that there are still hack saw marks that will be filed out after the nut is fully assembled.

E.2 shows the two halves soldered together. This was done to ensure they stayed aligned during the drilling process.

E.3 shows the soldered halves after drilling. The drilling was done on a modern drill press.

In period, the nut would have been cast with the holes in it already, requiring only some filing to clean it up (which is what I did with Arion's casting).

E.4 shows the trigger with the spreader and sear pivot installed. After splitting the two halves, the inside pieces were cut with a hack saw, shaped with files, and set into position. Then I just heated up the whole thing with my torch and let the already in place solder stick them together once it cooled. After that, I inserted the pins for strength. In this picture you can still see where the pins are.

E.5 back to filing. At this point the finishing process was very much like what I did on the cast bronze original, filing it for final fit and cleaning it up. Patrick the Fool was kind enough to braze the joints for strength. (He has the equipment and I don't. Besides, it's not part of the period process anyway.)

Fig. F. Is of the pins. They are cut from $\frac{1}{2}$ inch round stock and press fit into $\frac{1}{2}$ inch flat bar stock, pinned and soldered.

Fig. G. Is of the sear and trigger. These pieces had to be remade after I had the nut finished. The first set was made to work with Arion's smaller bronze nut. They tended to wobble in the new nut, causing some release failures. These are cut from flat bar stock and kept to the full $\frac{1}{2}$ inch thickness.

Fig. H. The box housing was built from $\frac{1}{4}$ inch flat bar stock, soldered, and pinned. The process was not unlike the manufacture of the nut.

Fig. I. Fitting into the tiller.

What's Next?

The trigger assembly as presented here has been tested in the Gen 1 engine and performed as expected. But still . . .

Further testing. Then some more testing. This trigger mechanism was developed and built with the intention of installing it into a functional siege engine (under development). This engine will be capable of both SCA combat and firing of "live" target munitions through simple field conversion.

The original box housings have a 'top' on the box for the tail of the munition to rest on. I didn't put that on because I wanted to show the pretty insides of the mechanism. I'll put it on if there is reason for it during trials. It would be a simple top plate, shaped with files, soldered and pinned.

While casting bronze is well outside the scope of this particular project, I would dearly love to have the opportunity to use this trigger as a "Master" for casting in bronze. At this point, I'm still far too early on the learning curve to explore that fully.

Resources and References

Special thanks to:

Arion the Wanderer - For many references related to this project as well as ongoing advice on a variety of related components and processes

Theodoric the Scholar - for photography, advice, and ongoing interest in this project

Patrick the Fool - for brazing work on the trigger nut

And lastly, thanks to my late father for instilling in me the joy of creating. He would have loved this project.

1. *Cover Image: Crossbow Lock, 206 B.C.E. - 220 C.E. Bronze, 6 13/16 x 4 1/2 in. (17.3 x 11.5 cm). Brooklyn Museum, Museum Expedition 1912, Museum Collection Fund, 12.73. Creative Commons*

2. "Chinese Crossbow Locks" by Edward McEwen in the "Journal of the Society of Archer-Antiquaries", 2012 pages 35-42

3. *Chinese Archery*, by Stephen Selby, Copyright Hong Kong University Press, 2000, ISBN 962 209 501 1

4. "The Bow of the Ox", by Edward McEwen in the *Journal of the Society of Archer-Antiquaries*, vol. 28, 1985. Mr. McEwen makes further references to scholarly works based on period information. I am including them here, but I don't have ready access to the original references, only Mr. McEwen's excellent article.

2A. 'Ata-Malik Juvaini, *The History of the World Conqueror*, translated by John Andrew Boyle, 1958, Vol. II, pages 630-631

2B. Maulana, Minhaj-ud-Din, Abu-Umar-i-Usman, *Tabakat-i-Masiri*, translated from the Persian by Major H.G. Raverty, Vol. II page 1191

2C. Tseng Kung-Liang, *Wu Ching Tsung Yao* (Collection of the most important Military Techniques) originally written in 1040 AD

5. *Chinese Siege Warfare: Mechanical Artillery & Siege Weapons of Antiquity, An Illustrated History* - Liang Jieming - Copyright 2006, Leong Kit Meng ISBN 981-05-5380-3

Cover Note: The cover image is typical of the photographs to which I had access. One presentation, one perspective. This is why I had to make two prototypes in wood to prove that I understood the mechanism. Then Archos Arion comes along and puts one of the damned things in my hand. Oh well, at least I know I have it right. Also of note, the pins in this example have square heads (as do mine), not pentagonal as in Archos Arion's example. I do NOT know the reason for the difference in the pins. In fact, I don't know which may have been earlier.

Yes, of course this document is set in the Trebuchet font.

Why would you even ask?

Photo Appendix



Figure A.

Temporary trigger for the original project as installed for June Faire 2013. Also a period design, a lever that lifts the bow string over a fixed pin, this was never intended to be final, or even close to it.

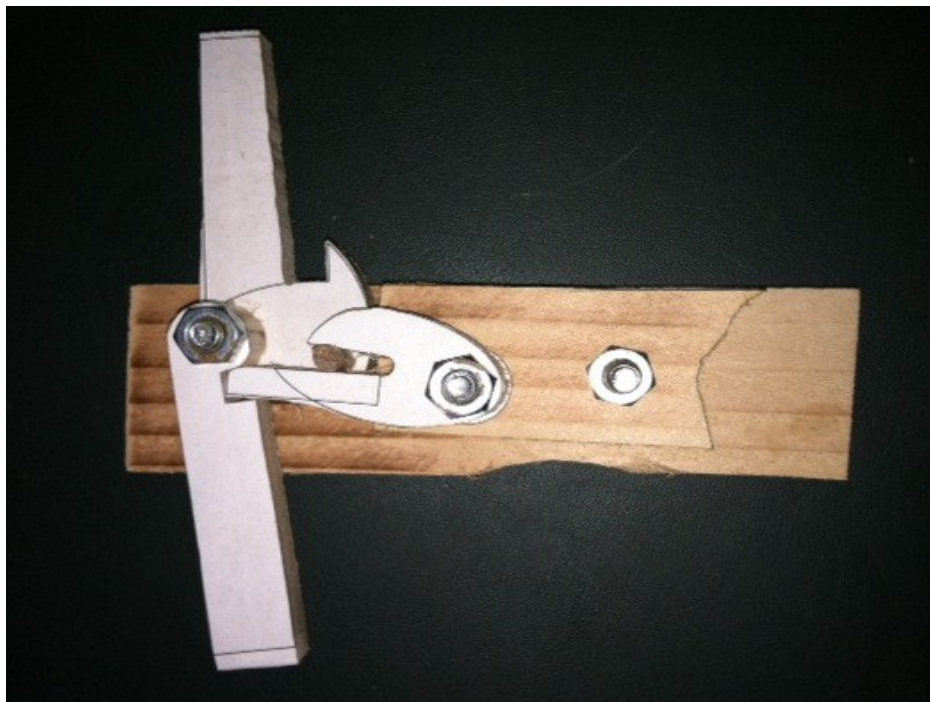


Figure B.1

First prototype trigger, shown in cocked position. (Do I really understand how this thing works? Yes.)

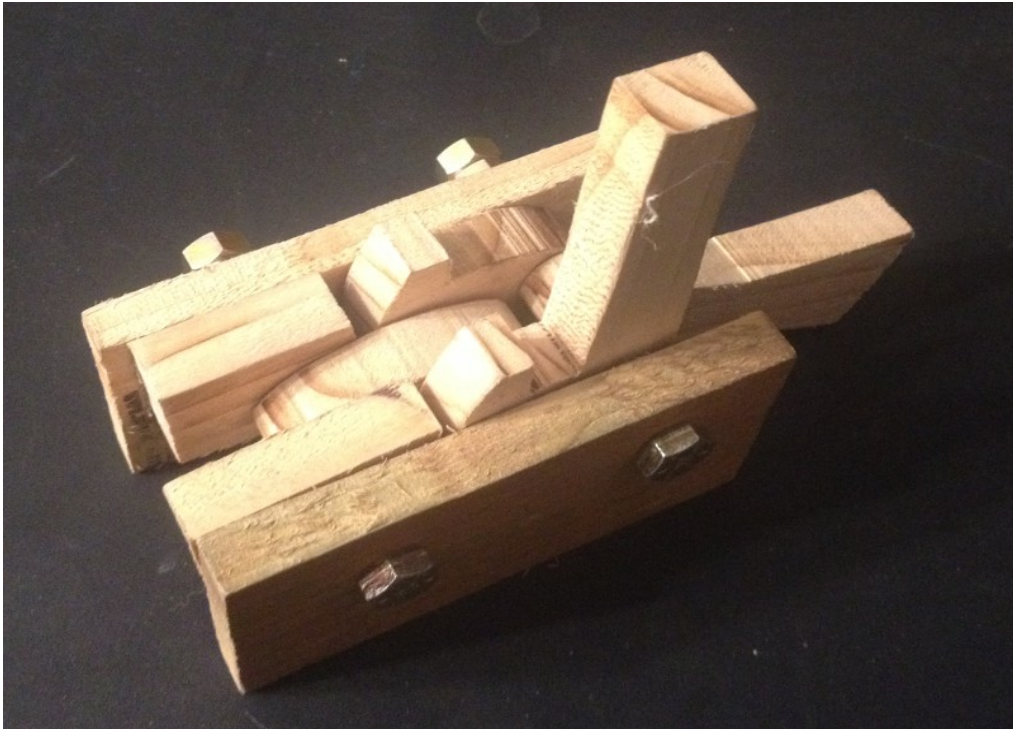


Figure B.2
Second prototype trigger.
This one is a lot closer to the ultimate shape that I had in mind.
(Can I make it work with all the pieces? Yes.)



Figure C.
Bronze cast trigger, modern reproduction, patterned after extant originals.
Shown with the trigger tripped.
(Thanks to Archos Arion for access.)



Figure D. Trigger mounted in tiller (Gen 1)

Note: The two pins and the nut are still borrowed from Arion's cast trigger. Also note the temporary housing. Only the trigger lever and sear are mine at this point (which have also since been replaced). But I have a functional trigger for testing.



Figure E.1
Nut parts roughed out



Figure E.2
Nut pieces soldered together for machining.



Figure E.3
Nut parts drilled.



Figure E.4
Nut final assembly. The two parts have been split and the spreader and sear pivot installed and pinned.



Figure E.5
Nut cleaned up and ready to install.



Figure F.
The pivot pins



Figure G.
The trigger lever and sear.
This is the second set. The first set was cut thinner in
order to fit the narrower cast bronze nut.



Figure H.
The box frame.



Figure I.
Set into the 'roughed in' tiller body (Gen. 2). Ultimately, it will be pinned.
This is a view that I would have liked to have had when trying to figure it out.