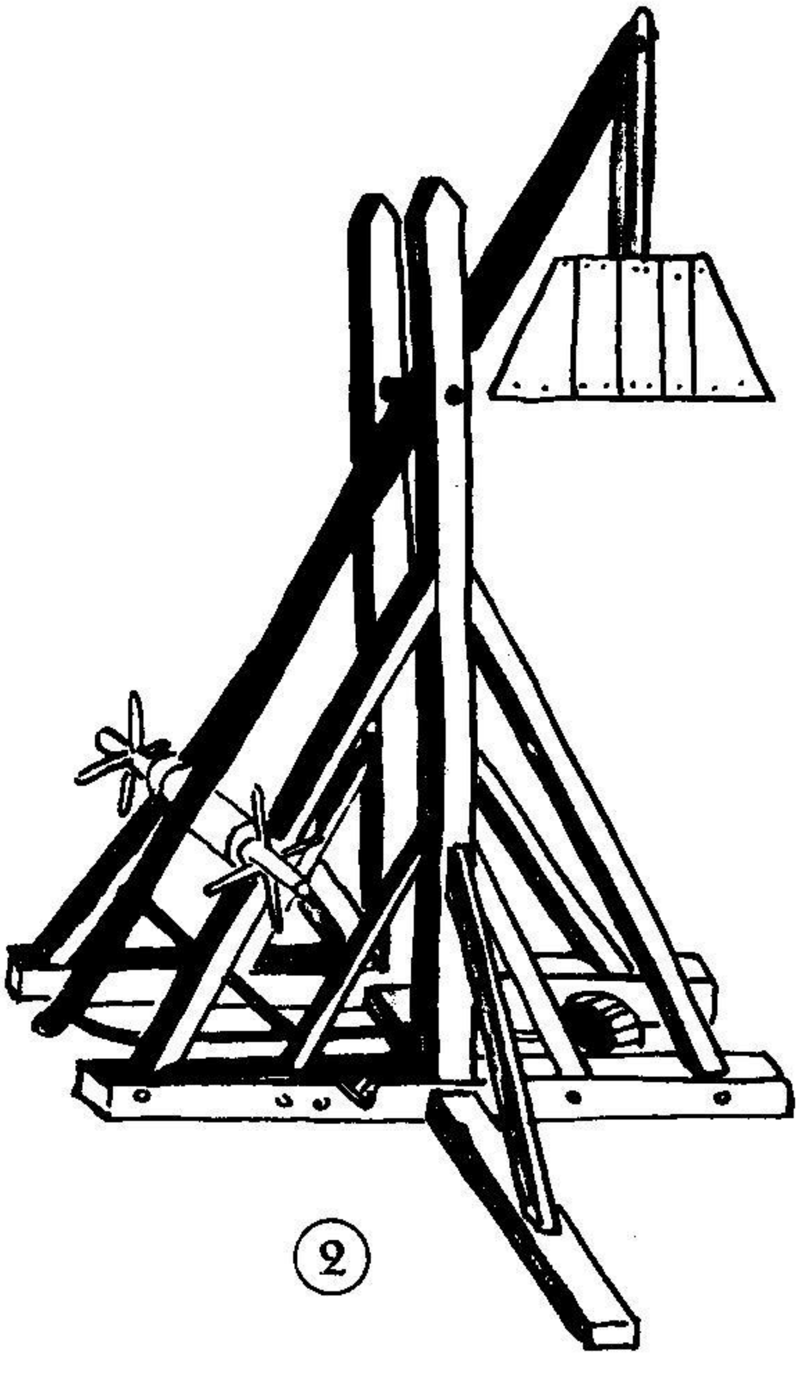
"A Catapult of about 1404"



Eirikr the Eager

Candy Chucker Challenge
Silver Arrow Tournament, December 2007

The Trebuchet – a short history

The trebuchet is often referred to as a variety of catapult, though this word is today generally reserved for a device powered by elastic energy. Trebuchet is derived from Old French, *trebucher* "to throw over" < *tres* "over, beyond" and *buc* "torso". (http://en.wikipedia.org/wiki/Trebuchet).

The counterweight trebuchet was the product of a technological tradition that began in ancient China (traction trebuchet), was further advanced in the technologically sophisticated civilizations of Islam and Byzantium (hybrid trebuchet), and was brought to its fullest development in Western Europe (counterweight trebuchet) (Chevedden 2000).

The introduction of the counterweight trebuchet marked a breakthrough in the development of mechanical artillery. It was the first fully mechanized pivoting-beam artillery weapon powered exclusively by the force of gravity (Cheveddon 2000).

The earliest definitive reference (*trabuchus*) that has been cited by a European source records a counterweight trebuchet used at the siege of Castelnuovo Bocca d'Adda in northern Italy in 1199 AD (Cheveddon 2000). Though earlier accounts, both Byzantine (the sieges of Zevgminon 1165 AD and Nicaea 1184 AD) and Norman (siege of Thessalonike 1185), refer to 'newly invented heavy artillery" without giving a description of the engines in question (Cheveddon 2000).

The earliest extant illustration of a counterweight trebuchet is from an Islamic source, a military manual dated 1187 AD by Murdi ibn Alı ibn Murdi al-Tarsu-sı (Cheveddon 2000). Murdi al-Tarsusi's account describes trebuchets as "machines invented by unbelieving devils", indicating a definite non-Muslim origin (Tarver 1995).

In 1237 AD the 5 year Mongol siege of the Song cities Xiangyang and Fan-ch'eng required the successful intervention of Abakha, the Il-khan of Persia. Who on the request of his uncle Khubilai, sent two renowned engineers, Isma'il of Hilla and Ala al-Din of Mosul, to build the first counterweight trebuchets recorded in China, called hui-hui pao, or "Muslim" trebuchet (Hanson 2006).

Extant images of trebuchets similar to Jahns Trebuchet

Several depictions of trebuchets are reproduced below. The first example (figure 1) is from Iran and is dated to 1306-1314 AD. This trebuchet is similar in design to Jahns's trebuchet (figure 3) though slightly earlier in age (Nicolle p.452).

The operator is using a mallet, presumably to knock the trigger free and release the throwing arm.

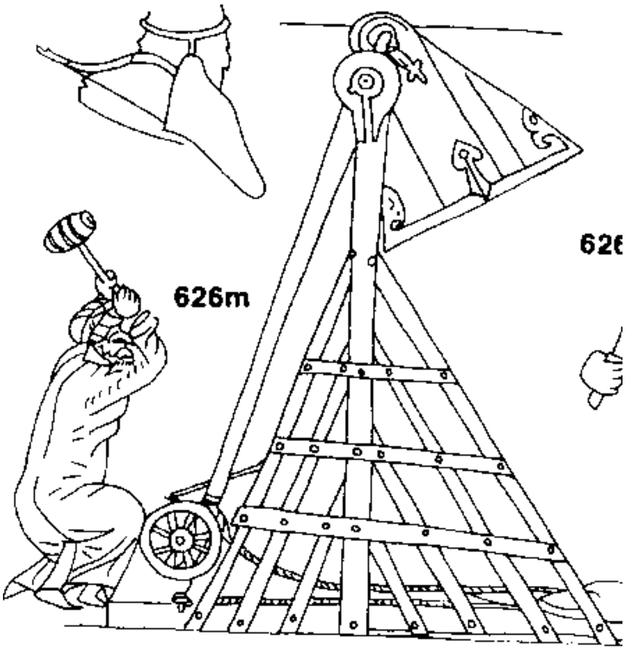


Figure 1. A Muslim trebuchet, early 1300's (Nicolle 1999)

The second example (figure 2) is from early 14th century Western Europe and is depicted with a trough for the pouch carrying the missile to travel along. Though this trebuchet is of a similar period to Jahns trebuchet, it is not depicted with perpendicular side supports.

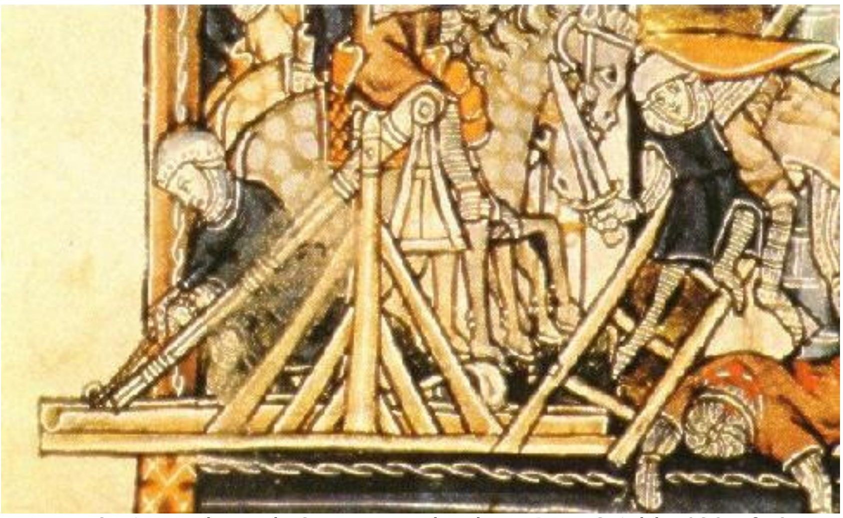


Figure 2. An early 14th Century trebuchet (BM MS Add.10294 f. 81v)

Building the Trebuchet

The Candy Chucking Challenge involved creating a scaled, period, working model of a trebuchet, capable of out-throwing its marshmallow wielding rivals (Challenge rules contained in appendix).

The inspiration for this model (figure 3 below) can be found in Medieval Costume, Armour and Weapons, part VI, plate 24(2), reproduced from Jahns, M (1878) Atlas zur geschichte des kriegswejens von der Urzeit bis Zum Ende des 16. Jhdts, Berlin.

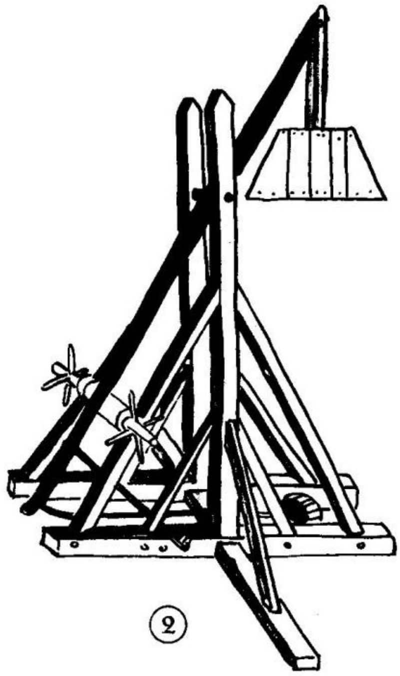


Figure 3. A trebuchet, from Jahns, Atlas zur geschichte des kriegswejens von der Urzeit bis Zum Ende des 16

Assessing the image, a technical problem immediately becomes apparent. There is no tray for the pouch containing the missile to travel along. During firing the pouch would impact the bottom support (crossing perpendicular to the slings direction of movement) upsetting the missile and potentially destroying the engine and injuring its crew.

This is a common difficulty encountered when deciphering historical depictions of siege engines. An artist’s poor scaling, or misunderstanding of the engines technical principles, combined with the intentional depiction of an almost complete engine (removing enough information or covering important features to make the image useless as a blueprint for an enemy to recreate the engine) result in historical images that often require interpretation and testing before their validity can be proven (Payne-Galway 1995).

From the image, Jahns trebuchet would roughly have the following dimensions: (measurements equated to cm)

Base: 57cm
Base perpendicular support: 70cm
Vertical support: 85cm
Throwing Arm: 110cm
Counterweight Arm: 22cm
Width of base: 15cm
Sling: 55cm

The below table shows measurements of 3 different trebuchets and their corresponding ratios as an example of the problems associated with artist's impressions. PB is a smaller, very stable and efficient counterweight trebuchet.

Dimensions	Original Jahns Reproduction (cm)	Final Jahns Reproduction (cm)	PB (cm)
Base length	57	50	15.5
Perpendicular Base	70	50	18
Vertical Upright	85	53	12.5
Arm	110	70	20
Dist between axles	40	14	4
Width of base	15	20	8
Sling	55	53	12
Ratios			
Base vs Vertical Upright supports	0.67	0.94	1.24
Base vs Throwing Arm	0.51	0.71	0.78
Base width vs length	0.26	0.4	0.52
Base width vs Upright	0.17	0.37	0.64
Arm vs sling	2	1.32	1.66
Dist between axles vs arm length	0.36	0.2	0.2
Uprights vs Arm	0.77	0.75	0.63
Uprights vs axle distance	0.47	0.26	0.32
Perpendicular Base vs Arm	0.63	0.71	0.9

Table 1. Comparison of dimensions & ratios between 3 trebuchets.

From the ratios, it is apparent that the base of Jahns trebuchet is very short compared with the throwing arm and overall height of the machine, which suggests instability. The distance between the main and counterweight axles is large, and the sling length is very large.

Having reproduced a working model in the above original ratio (see below for images of the final model) the assumed problems with dimensions scaled directly from the image became apparent.

The distance between the main axle and counterweight axles, combined with the height of the uprights, resulted in a high and forward centre of gravity which in turn resulted in an unstable forward-backward rocking motion during, and immediately after firing. The higher the counterweight is raised the more forward the weight will swing in its downward arc, thus moving the trebuchets centre of balance forward and rocking the trebuchet off its base.

As the weight of the counterweight was increased, the instability became more pronounced, sometimes resulting with the trebuchet tipping over, sometimes forward, but mostly to the rear.

With this instability in mind the below dimensions were reduced (Final Jahns Reproduction). The weight of the counterweight was also reduced.

Vertical uprights shortened by 10cm
Throwing arm shortened by 30 cm
Distance between axles shortened by 4cm
Length of sling reduced by 8cm

Reducing the distance between the main axle and the counterweight axle reduced the instability of the trebuchet during firing. The trebuchets centre of gravity is now closer to the main supporting uprights. Reducing the height of the vertical supports may not have been necessary, but could have added to overall stability. The reduction in length of the throwing arm, and therefore the sling, was necessary to accommodate the reduced height of the vertical supports.

All materials used reflect cost and availability, not historical construction methods. No attempt was made to reproduce winding mechanisms or replicate trigger construction except in the most general of terms.

Figs 3 & 4. The finished trebuchet, at rest and ready to fire.

References

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Appendices

A&S Candy Chucker Competition Rules:

To research and construct a small trebuchet or catapult designed to 'chuck' a regular Pascall marshmallow the furthest, to be pitted against each other at the Silver Arrow 2007 event.

The tabletop siege weapon should be made of materials found in period or reasonable equivalent (i.e. no plastic).

The base of the weapon should be no more than 50 cm in length. The ammunition is to be one regular Pascall marshmallow.