Ancient Greek Artillery Technology from Catapults to the Architronio Canon

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Αρχαία όπλα : καταπέλτες – βαλλίστρες
"Archimedes," said Lucius, "we know that without your war machinery Syracuse wouldn't have held out for a month; as it is, we've had a rough two years because of them. Don't think we soldiers don't appreciate that. They’re superb machines. My congratulations."

Archimedes waved his hand. "Please, they’re nothing really. Ordinary hurling mechanisms—mere toys, that’s all. Scientifically, they have little value. Karel Capek, Apocryphal Tales

Bows (the first machine invented by man?) were used at least since 8000 BC according to cave paintings in 'les Dogues' (Castellón, France). Probably bows were invented much earlier (around 20000 BC). The word Catapult comes from the Greek words *kata* and *peltes*. *Kata* means downward and *peltes* describes a small shield. Catapult means therefore shield piercer. Catapults were first invented about 400 BC under Dionysios I (c. 432-367 BC). The Greek engineers first constructed a comparatively small machine, the *gastraphetes* (belly-bow), a version of a crossbow. The *gastraphetes* is a large bow, end of which rested on the belly of the person using it. When the demands of war were so great that a hand-held weapon, the device was enlarged, and a winch pull-back system and base were added.

Technology of Catapults (*belopoietic* from *belos* (arrow or it is better to say a bolt) and *poiw* make) was a key part of ancient mechanics, a branch of mathematics that also included fortification building, statics, and pneumatics.

Many, though, have begun the construction of weapons of the same size, and have used the same system of rules, the same types of wood, and the same amounts of iron, and have of some of these have made machines that throw their missiles far and with great force, while others have lagged behind their specifications. When asked why this happened, the latter have been at a loss for an answer. So it is appropriate to warn the prospective engineer of the saying of Polykleitos the sculptor: "perfection, he said, comes about little by little [para mikron] through many numbers. And in the same way, as far as concerns our science, it happens that in many of the items that go to make up the machine a tiny deviation is made each time, resulting in a large cumulative error."

Philopoemen

Later, weapons fired by torsion bars powered by horsehair and ox tendon (the Greeks called this material *neuron*) springs could fire arrows, stones, and pots of burning pitch along a parabolic arc. Some of these machines were quite large and heavy and this were thus mounted on wheels to improve tactical mobility and deployment. The production method is not known.

Interesting is also this information:

"When horse-hair and other materials failed, the women in several instances cut it into ropes for the engines (Caes. BC iii.9; Veget. De Re Mil. iv.9). William Smith, D.C.L., LL.D. A Dictionary of Greek and Roman Antiquities, John Murray, London, 1875."

A *palintonon* or palintone translates as "V-spring" and *euthytonon* or euthytone (Ευθύτονος) translates as "straight-spring" from Greek. The "V" or straight spring refers to how siege engines compare to hand-held bows when it comes to how the arms are shaped.

**Main Categories**

- Flexion
- Torsion

**Objects Thrown**
• **Arrows**
• **Stones.** *(lithobolos (Λιθοβόλος) i.e. stone thrower)*
  - **Other.** "When a rampart composed of the trunks of trees is raised opposite to a wall, it may be consumed by discharging red hot iron bars against it from the balistae." — Marcus Vitruvius Pollio: *de Architectura*

**Flexion based Artillery**

• **Arrow**

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The Gastraphetes (γαστραφέτης), a form of primitive crossbow that fired a wooden bolt on a flat trajectory along a slot in the aiming rod. Main components *(syrinx / pipe and diostra / slider)*. Could reach a bow length of 15 feet and could fire a stone of 40 pounds some 200 to 300 yards. Mainly known from Heron of Alexandria references. It was used successfully during the siege of Motya, a Carthaginian island fortress in 397 BC and Greek engineers improved further the capabilities of the device reaching its physical limitations. The army of Dionysius I surprised the Carthaginians with the newly developed gastraphetes with its larger range. The description of Heron of Alexandria is based on an older by Ctesibius.
Oxybeles (Οξυβόλος) (Greek word that means bolt shot)
BITON’S CONSTRUCTION OF WAR MACHINES

(a) Side-elevation

(b) Rear-elevation of base and trestles

(c) Plan

(d) Front-elevation

Mountan gynospho.
Zopyrus's gastraphetes from Zopyrus a specialist in gastraphetes design from Tarentum Southern Italy. A step towards the torsion catapult, including a stand for the heavy gastraphetes:

- Stone
The stone thrower of Charon of Magnesia

Biton addressed his artillery treatise to king Attalus I of Pergamum (241 to 197 B.C.).

The Roman army had stone-throwers capable of hurling projectiles weighing 27 kg across a distance of 150 meters. Archimedes' legendary engines are said to have used stones three times as heavy. Plutarch tells us that it was Hiero, another king of Syracuse, who spurred Archimedes into military engineering. His splendid catapults kept the Roman troops at bay until the besieged city fell in 212 B.C. as a result of treachery.
The engineers saw themselves as an international community: Philo mentions his exchanges with colleagues in Alexandria and Rhodes, Biton his colleagues from Magnesia, Abydos, Macedonia, and Colophon. They also traveled: for instance, Zopyrus, a specialist in belly-bow design from Tarentum in Southern Italy, created one design in Miletus (Asia Minor) and another in Cumae (central Italy).

- **Torsion based Artillery**

The principle of torsion was probably discovered by artificers working in Macedonia under Philip II and Polyidus between 353 and 341 BC. There exists no hint of torsion catapults before Philip's reign. At the siege of Perinthus and Byzantium (340 BC) Philip deployed torsion arrow-shooting catapults. Marsden, Invention of the catapult. Torsion catapults probably around 340 BC. Inscriptions from the Chalkothek on the Acropolis of Athens mentions torsion spring catapults at about 330 BC. Oxybeles could pierce a shield and armor of a warrior in 400 meter distance. It was Philip of Macedon who first organized a special group of artillery engineers with catapults. Philip's use of siegecraft allowed Greek science and engineering an opportunity to contribute to the art of war, and by the time of Demetrios I (305 B.C.), known more commonly by his nickname "Poliorcetes" (the Besieger), Greek inventiveness in military engineering was probably the best in the ancient world.

**Alexander the Great used catapults in a completely different way -- as covering artillery.** He carried prefabricated catapults that weighed only 85 pounds. Larger machines were dismantled and carried along in wagons. Alexander's engineers contributed a number of new ideas. Major Greek cities owned a park of torsion artillery.

210 BC

Philo of Byzantium; refers casually (Pol. 91, 36) to one-armed stone-throwing machines called onager.

**Euthynteronon**

**Light Arrow Catapult**
Euthyntonon, Torsion weapon
(T: Choinikides / Washers)
Palintonon (or Ballista in Roman)
Heavy Artillery Weapon up to 3 tons weight (Transport in pieces). 13 kg stone.
Spherical stones (10-80 pounds)
Palintonon
Palintonon. Plans from "Build Your Own Greek Siege Engine" by Kurt Suleski.
Cheiroballista (Two lever)
Introduction of metal frames.

The Cheiroballista (called Manuballista by the Romans), a device that hurls arrows over a large distance, was introduced around 100 AD (after Heron). As an inventor, Apollodorus of Damascus is proposed working for the Roman army. In this particular engine, the springs are stretched in two separate metal casings. A metal stud was attached to the top of the field frames and the base of the engine to hold them together. Another stud was attached to the bottom of the field frames and the base of the engine (Marsden 209). Heron's cheiroballista represents the most advanced two-armed torsion engine used by the Romans.

Dionysius Repeating Catapult (Polybolo)
The repeating Catapult developed in the 3rd century BC was too complicated to be used widely.

Remarks
Only few metallic parts of catapults survived and projectiles (stones, bolts).
Engineers at Rhodes were known to have produced a palintonon that could shoot stones and also arrows. The use of catapults in the field is evidenced in one of Alexander's early battles in the Northern Marches of Macedon. At Pelion, Alexander, in a rare loss of the initiative had to extract his army from the town and cross a river to a defensive position in the foothills. Surrounded, Alexander lured the barbarian army into watching his phalanx and cavalry maneuver on the plain outside of the city, then he forced a crossing of the river creating a defensive bridgehead. He then set up his catapults and palintona against the wall fortifications. He then crossed the river over the heads of his own troops to cover their rear with a defensive bridgehead. This is the first reported use of siege artillery as an assault weapon (in spite of the fact that it was used defensively). In 334 BC Alexander the Great used at the siege of Halicarnassus heavy palintona catapults and palintona against the wall fortifications. At the siege of Gaza in 332 BC. Alexander was wounded in the neck by a catapult arrow that had pierced both his shield and his breastplate.

Philo of Byzantium, in an artillery manual written in about 200 B.C., stated that a wall had to be at least 4.62 meters thick to withstand catapult stones and that it was a good idea to keep the stone throwers at least 150 meters distant by means of ditches and other obstacles. The palintonon could fire a stone over a range greater than that of a Napoleonic cannon.

It is interesting to note that the largest stone-thrower on record, a three-talent (78 kilogram) machine, was built by Archimedes. In honor of the Greek contributions, to this day the military art of siege warfare is called poliorcetics.

The main catapult significance according to O’Connell is that it: embodied the deliberate exploration of physical and mechanical principles to improve armaments.

The Syracusia probably the largest transport ship designed by Archias of Corinth around 240 BC with the help of Archimedes had eight deck towers including a 18-foot arrow or 180 pound stone catapult build by Archimedes (One if not the largest catapults used on a ship?). Crew that used the Catapults: Katapeltaphetai (Catapultists) equivalent of today naval gunners. Demetrius’s Poliorcetes probably used for the first time catapults on his large warships against the fleet of Ptolemy I at Salamis in Cyprus in 306 BC (His catapults could even use 78 kg stones as projectiles (superheavy category), although a wide range of stone balls have been found, with around 3kg as light category)

The Romans inherited the Catapult Technology from the Greeks and developed new types such as the onager. As many as 10 Catapults and 60 Ballistae were assigned to each legion.

The Steam Canon of Archimedes

![Archimedes Canon, Leonardo Da Vinci:](image-url)
The catapult development started in Sicily with the Greek tyrant Dionysios I providing the financial means required for the experiments that were necessary to find the optimal design. Except in Sicily, Rhodes and Alexandria were the main centers of the development of the catapult technology, in Alexandria advanced by the support of the Greek Ptolemaic kings of Egypt. In the end of the first century AD the Roman engineer Sextus Frontinus wrote in Strategemata that the war devices have reached their [physical] limits a long time ago and there is no hope for improvements.

There were unique devices produced by Archimedes such as a catapult that used steam power and in principle was a canon. It was described by Cicero in a manuscript discovered in a church library. Petrarch collected Greek and Roman manuscripts neglected in various libraries for a collection of "Each famous author of antiquity whom I recover places a new offence and another charge of earlier generations, who, not satisfied with their own disgraceful barren minds, and the writings that their ancestors had produced by toil and application, neglect. Although they had nothing of their own to hand down to those who were posterity of its ancestral heritage"

Leonardo's quotations from books and his lists of titles supply nothing more than literary studies or recreations. It was evidently no part of his ambition to be deep in reading; he expressly states that he did not recognise the authority of the Ancients, on scientific questions was held paramount. Archimedes is the sole exception, and Leonardo frankly owns his admiration for the illustrious Greek to whose genius his own was so much akin.

Architronito e una macchina di fino rame, invenzione d' Archimede. Leonardo Da Vinci: The Cicero manuscript later was used by Leonardo Da Vinci who called the device "Architronito" in honour of Archimedes. He produced only drawings of the steam gun but Ioannis Sakas, a Greek expert of the work of Archimedes used this information to build a test device in 12.5.1981. A vessel was heated and when it reached 400 degrees Celsius 6 g of water was enough to produce in 10 seconds steam that expanding could throw a tennis ball size stone 50 meters. The reconstructed Archimedes steam gun by Sakas was only 1/5 the size of the original.

A Greek newspaper reported 3 days later about the result of the experiment of Sakas. From another Greek website the numbers which are given for the original is that it was able to shoot a 23 kg stone in 1100 meters and it was invented by Archimedes probably around 213 BC one year before his death. The Greek expert Evangolos Stamatis provided even a better performance estimate: 1.2 km for a 36 kg object. As Cicero reports Archimedes experimented with various devices to be used against the Romans is unknown.

Famous Catapult Engineers or Authors
- Polydias, Diades of Pella and Charias (working for Philip and Alexander the Great).
- Diades helped Alexander at the sieges of Halicarnassus (334 BC) and Gaugamela and constructed various siege engines.
- Zopyrus of Tarentum (Ζώπυρος ο Ταραντίνος), Charon of Magnesia (Χάρων ο Μαγνήσιος), Biton (Βίτων), Ctesibius of Alexandria (Κτησίβιος ο Αλεξανδρεύς), Archimedes of Syracuse (Αρχιμήδης ο Συρακούσιος), Dionysius of Alexandria (Διονύσιος ο Αλεξανδρεύς), Hero of Alexandria (Ηρων ο Αλεξανδρεύς), Vitruvius.

Philon of Byzantium c. (280–220) BC
Mechanics treatise "Mechanike syntaxis" (9 books) (250 BC)
1. Introduction
2. On the lever
3. On the building of seaports
4. On catapults *
5. On pneumatics *
6. On automatic theatres
7. On the building of fortresses *
8. On besieging and defending towns

9. On stratagems

- books that survived

**Interesting Remarks**

The word "Bombarde" comes from the Greek *bombos* i.e. bee meaning a loud humming sound.

The word ballistic comes from the Greek *ba'llein*, "throw"

Movement tends to create fire in wood, stone, and iron; and with even more reason should it have that effect on air, a substance which is closer to fire than these. An example is that of missiles, themselves fired so strongly that leaden balls are melted; and if they are fired the surrounding air must be similarly affected. *Aristotle*, On the Heavens Book II Chapter 7

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**References**


Dietwulf Baatz, *Bauten und Katapulte des römischen Heeres*


**A 1740 engraving of Archimedes planning the defenses of Syracuse**

on his cap is *Archimedes the geometer*. This and other higher resolution images from [http://www.mcs.drexel.edu/~crorres/Archimedes/Pictures/ArchimedesPictures.html](http://www.mcs.drexel.edu/~crorres/Archimedes/Pictures/ArchimedesPictures.html)

Roman siege of Syracuse by Marcellus in 214 BC (*Livy 24.33-34 PDF File*);

**Books, References**


(fori students with drawings and explanations)


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**Historical / Fantasy Novels**

*The Arrows of Hercules*
Siege of Tyre and Gaza
The Siege of Tyre
Reports in Greek
Πολεμική Τεχνολογία στην Αρχαία Ελλάδα: Τα Τηλεβόλα και οι Αρχές της Βλητικής

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