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The sinews of war: a brief history of ancient catapults*

Until the discovery of gunpowder, the most powerful weapon available was the catapult. The Roman army had stone-throwers capable of hurling projectiles of 27 kilos at a distance of 150 metres, and Archimedes' legendary engines are said to have used stones three times as big. The construction of catapults or 'belopoietics' (*poietike* - making of – *belos* – projectile, or projectile-throwing devices) was a key part of ancient mechanics, itself a branch of mathematics which also included fortification building, statics and pneumatics.

Belopoietics had a high profile, and attracted the interest and financial support of governments. On an epistemological level, it combined science, in the form of geometry and physics, and technology. Furthermore, ancient engineers saw their knowledge as cumulative and progressive, and themselves as making an important contribution to the welfare of cities and the power of kings and emperors. In sum, the study of catapults challenges familiar historiographical stereotypes, including the idea that science and technology were marginal to ancient society.

Let us go back to Sicily, 399 BC. Dionysius, tyrant of Syracuse, "gathered skilled craftsmen, commandeering them from the cities under his control and attracting them by high wages [...] his purpose was to make weapons in great numbers and every kind of projectile [...] he divided them into groups in accordance with their skills, and appointed over them the most distinguished citizens, offering great gifts to those who made weapons. [...] there was great competition [...] the catapult was invented at this time [...], since the best craftsmen

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had been collected from everywhere into one place. The high wages as well as the numerous prizes offered to the craftsmen who were judged to be the best stimulated their zeal. Moreover, Dionysius circulated daily among the workers [...] and rewarded the most zealous with gifts and invited them to his table."[1]

An inspiring example of policy-driven research, if not of absolute historical accuracy. Catapults in fact seem to figure already in a ninth-century BC relief from Nimrud (Iraq). In the fourth century BC, however, they spread around the Mediterranean like wildfire.

The earliest Greek type was a large bow mounted on a case, whose arms were pulled back with one end of the case resting on the belly of the person using it, hence the name 'belly-bow'. As the demands of war required a faster, stronger weapon, the device was enlarged, and a winch pull-back system and a base added. The next step, achieved perhaps by engineers working for Philip II of Macedonia, consisted in substituting to the arms of the bow two frames, fixed on the case, and in tightly wrapping them up in sinews or ropes. A wooden arm was then inserted through each bundle or 'spring' and a bowstring tied to the ends of the arms. The sinews in the springs were tightly twisted, imparting huge power when the arms were released. The basic torsion catapult was born, either as an arrow-shooter, or a stone-thrower, with a modified spring to allow for heavier projectiles.[2]

Further changes were introduced over time, and the theory of belopoietics established. Philo of Byzantium remarked: "The ancients

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[1] Diodorus of Sicily (1st century BC), *Library of History* 14.41.3-42.2, cf. also 14.50.4; Engl. tr. C.H. Oldfather, Cambridge 1954, with modifications.

[2] Among the best accounts E.W. Marsden, *Greek and Roman Artillery. Historical Development*, Oxford 1969; Y. Garlan, *Recherches de poliorcétique grecque*, Paris 1974; D. Baatz, *Bauten und Katapulte des römischen Heeres*, Stuttgart 1994. For further bibliography, http://home.t-online.de/home/d.baatz/catapult.htm.

[...] did not reach a conclusion [...], because their experience did not arise from many facts; but they did reach the heart of the matter they were looking for. Those after them examined the question on the basis of former mistakes, [used] subsequent experiments as a guide, and introduced the basic principle of construction."[3] That is, they realized that all the parts of a catapult, including the weight or length of the projectile, were proportional to the size of the torsion springs.

Fig. 1: Copper alloy washer, probably 1st century AD. Placed on top of the twisted sinew- or rope-bundle in the spring carrier, it would have been pinned into place through the small holes on its rim (Bath, Roman Museum)

Whereas in the old days of trial-and-error procedures, results could never be guaranteed, the introduction of proportionality and thus mathematics made catapult-construction almost standardized - tables of specifications were compiled for quick and easy reference. From a geometrical point of view, proportional construction required the modification of a cylinder, and was thus reducible to the problem of doubling the cube. Philo is our earliest direct source for a solution to this problem; Hero of Alexandria provides an alternative proof; both present an interesting combination of deductive style and mechanical procedure, relying as they do on the use of a moving ruler.[4]

According to a still current view, in antiquity theory and practice were on opposite sides of an unbridgeable divide. Yet, in the belopoietics treatises we find a combination of science and technology, experience and reflection. Philo, for instance, underpins his account with theoretical explanations based on mathematics and physics, but he also punctuates it with references to cost, expediency, durability and

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[3] Philo (ca. 200 BC), *Belopoietics* 50. Unless otherwise indicated, translations are taken, with modifications, from E.W. Marsden, *Greek and Roman Artillery. Technical Treatises*, Oxford 1971.

[4] Philo, *Belop.* 52; Hero of Alexandria (1st century AD), *Belopoietics* 117-9.

structural strain. He identifies demands in the market and suggests corresponding improvements to old designs. For instance, he proposes an engine that provides long-range shots, because shooting far is something "which they display the greatest enthusiasm over and would exchange anything for", but he does not recommend a repeat arrow-shooter, because he sees "no advance" in it.[5]

The 'they' whose enthusiasm Philo courts may have been powerful political figures. He tells us that the technicians in Alexandria were "heavily subsidized because they had ambitious kings who fostered craftsmanship."[6] Biton's artillery treatise was addressed to king Attalus I of Pergamum (241-197 BC), Vitruvius' ten books on architecture to the emperor Octavian Augustus, and the treatise on catapults by Athenaeus (late 1st century BC?) to a Marcellus, usually identified with a member of the powerful Roman family. Demetrius Poliorketes (the Besieger) king of Macedonia (336-282 BC) loved building his own war ships and siege towers, and was so good at it that even his enemies admired the beauty of his creations. Plutarch tells us that (after Dionysius) it was another king of Syracuse, Hiero, to spur Archimedes into military engineering. His splendid catapults kept at bay the Roman troops, led by another Marcellus, until 212 BC, when the besieged city fell by treachery. By the first century AD the technical expertise of the Romans was such that Sextus Julius Frontinus proudly and somewhat prematurely wrote: "The invention of [machines of war] has long ago been completed and I don't see anything surpassing the state of the art".[7]

The remains of two first-century AD catapults in Cremona suggest that engines could be in service to a legion for more than twenty years, and

[5] Philo, *Belop.* 56, 76-7.
[6] Philo, *Belop.* 50.
[7] Frontinus, *Stratagems* 3.Preface; Engl. tr. C.E. Bennett, Cambridge 1925, with modifications.

that their production and allocation were controlled by the upper levels of command. Catapults appear as a normal part of the landscape of military life on the column erected to celebrate Trajan's victories in Dacia. More humbly, a catapult has also been found to mark the grave of a soldier. The epitaph tells us that Vedennius was an *architectus* with the army, was honourably discharged after 18 years, and was then retained, probably because of his technical expertise, for 23 more years. Funerary art was an important means of self-expression, and tombs of soldiers were often decorated with a portrait of the deceased in full military garb, or simply with weapons, a cuirass, and greaves. Vedennius, or whoever commissioned his tombstone, must have seen the catapult as the emblem of his life. The engine points at the viewer, face-on, as if to protect and defend the dead in his eternal rest.

The washer in fig. 1 has an interesting story too. It was found at Bath, England, still home to a Roman temple dedicated to Sulis (a local Celtic goddess, assimilated to Minerva), and equipped with a natural hot water spring where pilgrims would cast votive objects. When archaeologists drained the sacred pool in 1979, along with coins, statuettes, and curse tablets, they found a piece of a catapult. Its size suggests a small arrow-shooter. What is it doing there? The washer must have been a prized, significant possession for the person who offered it to the goddess. Was it the ex-voto of an engineer, come to thank the divinity (Minerva was the goddess of war) for having survived many campaigns?

Much has been made of the alleged ancient bias against technical knowledge, and of the social marginality of its practitioners. Both the texts we have briefly sketched, and the objects illustrated here tell a different story, of pride in one's artefacts and identification with them. By the end of the fourth century BC, any state with political aspirations needed a semi-professional army, any army machines, and any city a fortified wall. The change of tune in ancient warfare is well encapsulated by a saying attributed to king Archidamus of Sparta (338-331 BC). "On seeing the missile shot by a catapult which had been brought then for the first time from Sicily, he cried out, 'By Heracles, this is the end of man's valour!'"[8]

The military ideals epitomized by Homeric heroes and Spartan kings were being threatened by different notions of leadership: more technical, knowledge- rather than virtue-based, acquired rather than simply innate. The necessity for the leader to acquire a new type of expertise is evidenced by the treatises addressed to kings, but also by documents such as a third-century BC inscription from the island of Ceos in the Cyclades which regulates catapult shooting competitions for the young. They are to take place in the gymnasium, along with the other traditional Greek sports which were originally also meant as military training, and are rewarded with prizes.[9]

In parallel to the rise of advanced catapults, better fortifications, and of manuals on artillery and tactics, we see a rise in visibility and status of engineers, in reality polymath figures who also worked as architects and surveyors. They were proud of their achievements: "Though very many years have passed since the design [of the catapult] was discovered and established, and there have naturally been many machine- and artillery-makers, no one has dared to depart from the established method. We were the first to do so and we have passed on many excellent ideas".[10] They saw themselves as an international community: Philo mentions his own exchanges with colleagues in Alexandria and Rhodes; Biton mentions colleagues from Magnesia,

[8] Plutarch, *Sayings of kings and commanders* 191e; identical story at *Sayings of Spartans* 219a; Engl. tr. F.C. Babbitt, Cambridge 1927, with modifications.
[9] *IG* 12.5.647, 1.24-6 (*Syll.*^{3} 958), mentioned in Garlan, *cit.*, 218.
[10] Philo, *Belop.* 58-9.

Abydos, Macedonia, Colophon. Engineers travelled: for instance, a specialist in belly-bow design, Zopyrus, was from Tarentum (Southern Italy) but created one design in Miletus (Asia Minor) and another in Cumae (central Italy).[11] With the ascent of Rome, technicians became if anything more vocal and bolder in their statements. Vitruvius affirmed that the architect/engineer, as well as being a military expert, should know about history, law, medicine, embodying an aristocratic ideal of all-rounded education. Hero started his *Belopoietics* by claiming that catapults are necessary to the well-being and security of a city - the philosophy of machines compares favourably to the philosophy of mere speeches.

The importance of catapults for our view of ancient science and technology, and of ancient society in general, has not yet been fully investigated. Texts like Philo's or Hero's, although known for years, are only now being brought to wider attention, while better knowledge is being gained of the archaeological evidence, with more items from excavations or museum stores identified as parts of catapults. From sharpened stones to Patriot missiles, humans have sought powerful and accurate ways to hurl projectiles against the enemy and their cities. In exploring the early chapters of this story, we are gradually reconstructing a portrait of ancient engineers, their role in society and their often ambivalent relationship with political power. After all, the most interesting question is still, who are the people behind the machine.

[11] Philo, *Belop.* 50. Biton, *Belop.* 62, 65.