Military Technology

TO THE TEACHER

OBJECTIVES OF THIS UNIT: To help students think about warfare from the perspective of the technology used, thus linking military history to economic history and the history of science.

TEACHING STRATEGIES: This unit can be used to help students grasp the long-term military confrontation between Chinese dynasties and the northern steppe societies. This unit lends itself to a comparative approach as many of the weapons and techniques have close counterparts in other parts of the world.

Most of the images in this unit were taken from wood block illustrations in traditional Chinese books. To make this unit more challenging, teachers could raise questions about the advantages and limits of such sources.

WHEN TO TEACH: Although the material in this unit derives primarily from Song dynasty sources, it deals with weapons and defensive systems in use for many centuries, and even in a chronologically-organized course could be used earlier or later to good effect. If used as part of instruction on the Song period, students would get more from the unit if they have already been introduced to the struggle between the Song and its northern neighbors, culminating with the Mongols. This unit would also be appropriate for use in teaching comparative military history.

siegecraft

crossbows and armor

The Song period is a good point to take stock of China's military technology. First, warfare was central to the history of the period. The confrontation between the Song and the three successive non-Chinese states to the north (Liao, Jin, and Yuan) made warfare not only a major preoccupation for those in government service, but also a stimulus to rethinking major intellectual issues. Second, we have illustrated sources for the military arts of the period, in particular, *The Essentials of the Military Arts* [in this Teacher's Guide this link is below], published in the eleventh century. Most of the illustrations in this section have been drawn from this book. Third, the military

technology of the Song-Yuan era can be compared to that of Europe in the same period. In this era, although China did not win all the wars, it had surprisingly advanced military technology.

The Essentials of the Military Arts (Wujing zongyao) **was completed in the early Song (1043) by Zeng Gongliang, Ding Du, and others at the order of Emperor Renzong. The book has four parts, including institutions, frontier defense, campaign anecdotes, and divination. The book can be seen as an encyclopaedia of Chinese military arts till the Song time. Its topics range from military strategy and organization to infantry and cavalry training, the production and employment of weapons, and famous campaigns of earlier periods. The large number of illustrations in the book make it especially valuable as a source for the military technology of the time.**

spears, clubs, and swords

catapults

Warfare in this period usually aimed to capture cities, which were the centers of both commerce and government. Therefore, this unit deals primarily with the type of weapons, implements, and strategies used in attacking and defending cities. Before firearms were invented, crossbows and catapults were the most important of these weapons.

warships

gunpowder and firearms

Think about the following issues as you view the sections on the right.

- ***Given the military technology of the period, how much of an advantage went to the side that could afford lots of expensive weapons?***
- ***In what ways was siege warfare in China similar to siege warfare in medieval Europe? What sorts of differences are significant?***
- ***Why would the Chinese publish guides to the construction of weapons? What if they fell into the hands of the enemy?***
- ***Would the nomads of the north, such as the Mongols, have any particular advantage in siege warfare?***

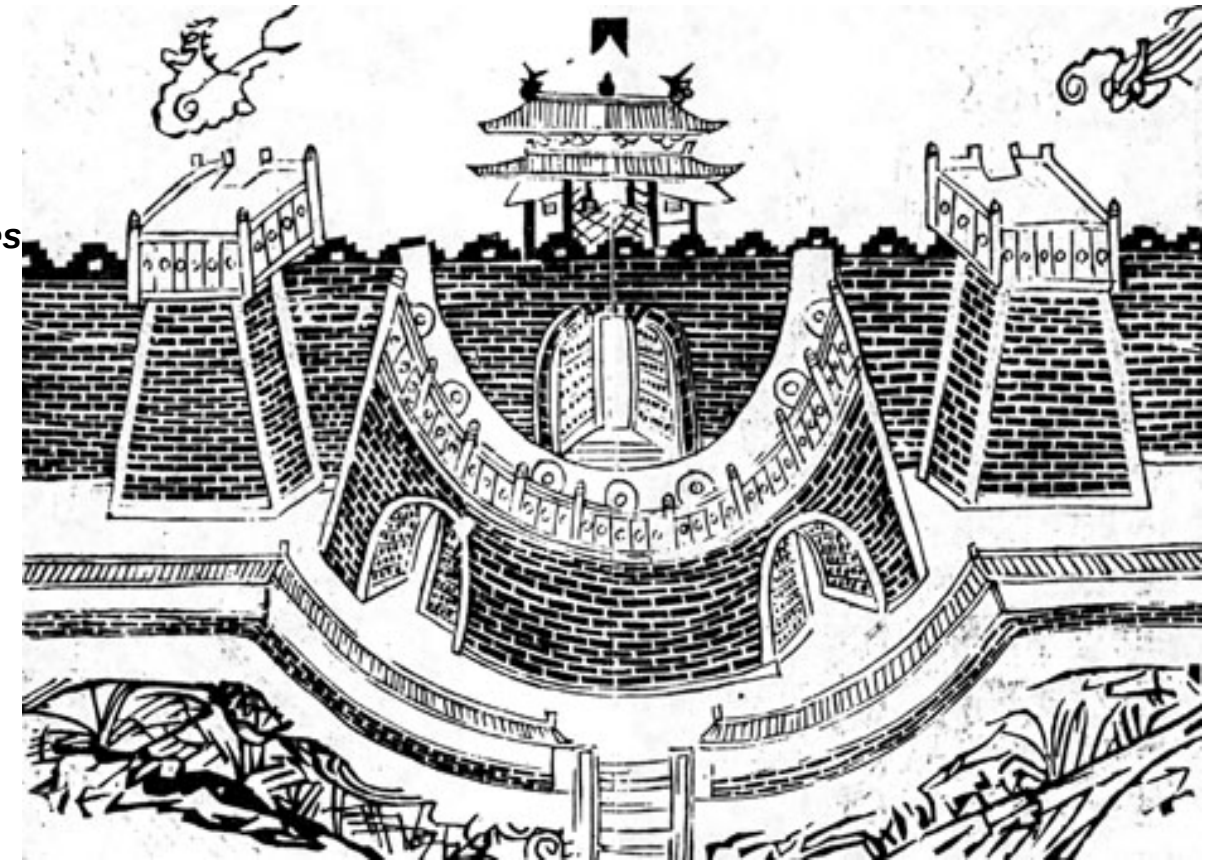
Suggested Reading

Siegecraft

The Chinese have been building walls to defend cities since the Neolithic period. Walls were usually built with pounded earth, but often, in later periods, faced with brick.

Can you identify defensive measures in the design of the "wall system" shown here?

Are they similar to ones used in Europe of the period?



Gateway of a city wall, seen from outside

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12: 4 (p. 529).

In the picture above, notice the small wall immediately behind the moat. Known as a "sheep-horse" wall, it created a space in front of the main walls where animals could be corralled when the area around a city was evacuated. It was also another barrier to attacks.

Cities isolated on a plain were less vulnerable than ones in rougher terrain, where the enemy would have more places to hide and rocks offered ammunition for catapults. When an attack seemed likely, one defensive measure was to evacuate nearby residents, both to protect them and to protect the city against the possibility that they might reveal information to enemy forces.

Attacking a fortification

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu*, Ming edition (Beijing: Renmin meishu chubanshe, 1955), p.88.

This illustration of the enemy attacking a fortification is from a novel, *The Water Margin*.

***The Water Margin* is a long episodic novel that narrates the legend of a rebellion in North China in the Song period. The stories had become rather famous by the Yuan period, mostly popularized by the storytellers. The woodblock illustrations used here were created in the Ming dynasty by Liu Junyu.**

What kinds of weapons do you think would have been the most effective in the circumstances depicted? Do you see them being used in this image?

Defenders would also generally clear a space around the city to gain an open view of an approaching army's activities, and at the same time deny the enemy access to firewood, ammunition, or cover. This sometimes meant that the enemy would run out of food, firewood or fodder long before a well-stocked city would exhaust its supplies.

One of the ways to begin defending a city was to send out troops to attack an encroaching army before it got to the walls, as seen in the illustrations below from the novel, *Romance of the Three Kingdoms*. After a siege was well under way, garrisons often mounted sorties outside the walls to destroy enemy siege engines or supplies and raise morale within the city.

The Three Kingdoms **is a long saga of the wars between contenders for the throne at the end of the Han dynasty. This novel was written in the Yuan Dynasty, and drew on a cycle of tales used by storytellers in Song times. The illustrated version used here dates from the late nineteenth century.**

Attacking horsemen

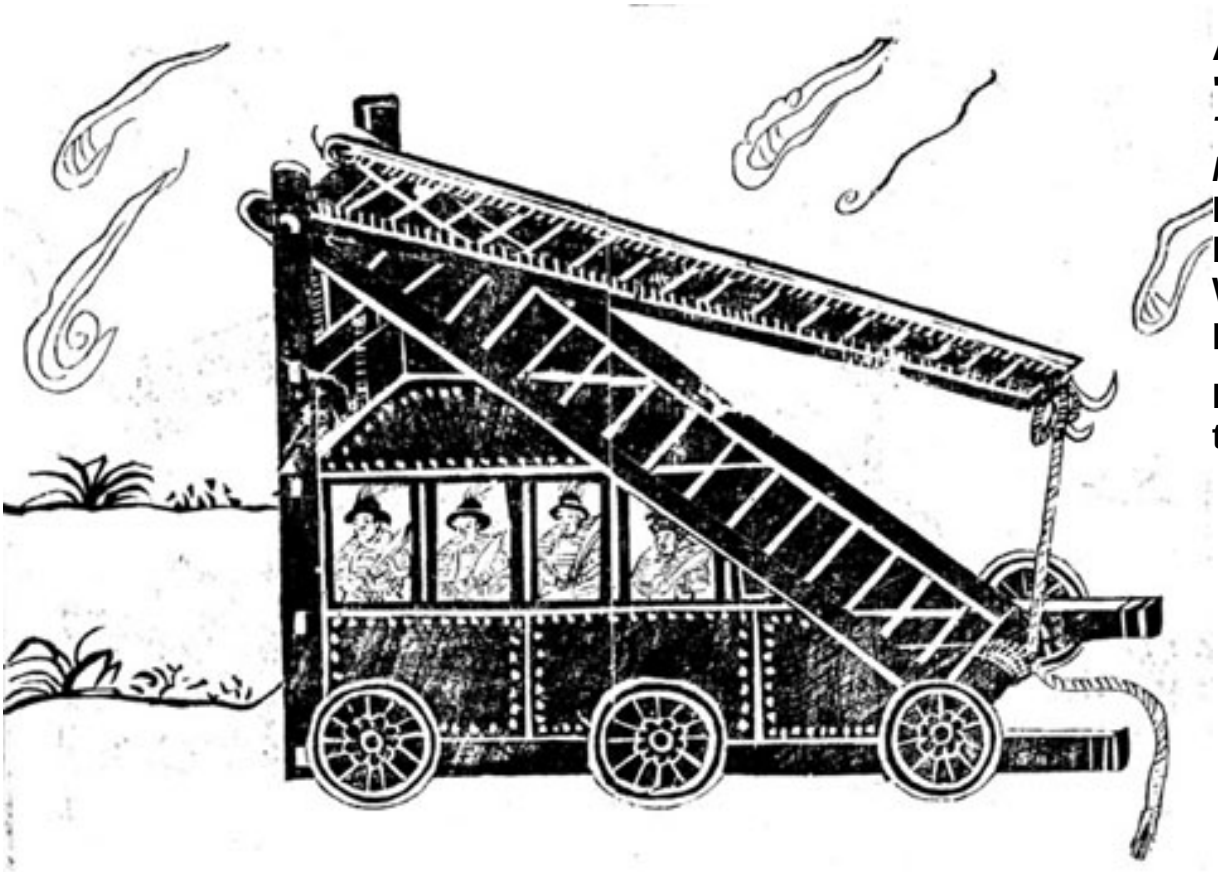
SOURCE: Luo Guanzhong, *Quantu xiuxiang xanguo xanyi* (Shanghai: Feihong ge, 1896), 5: illustration before page 1.

Felling an enemy

SOURCE: Luo Guanzhong, *Quantu xiuxiang xanguo xanyi* (Shanghai: Feihong ge, 1896), 27: illustration before page 1.

After surrounding a city, attackers would begin by delivering leaflets via arrows to explain the consequences of resistance or the rewards to be given to those who surrendered. When that failed, as it usually did, the attackers would bombard the city with crossbows and catapults, then attempt to scale the walls. They would bring in equipment such as bridges, ladders, carts, and towers, many on wheels, to help in breaching the walls. The illustrations below show six types of tools from *The Essentials of Military Art*s and *The Water Margin*.

From the pictures below, can you guess why city officials would have had plenty of time to prepare for the attack of an oncoming army?

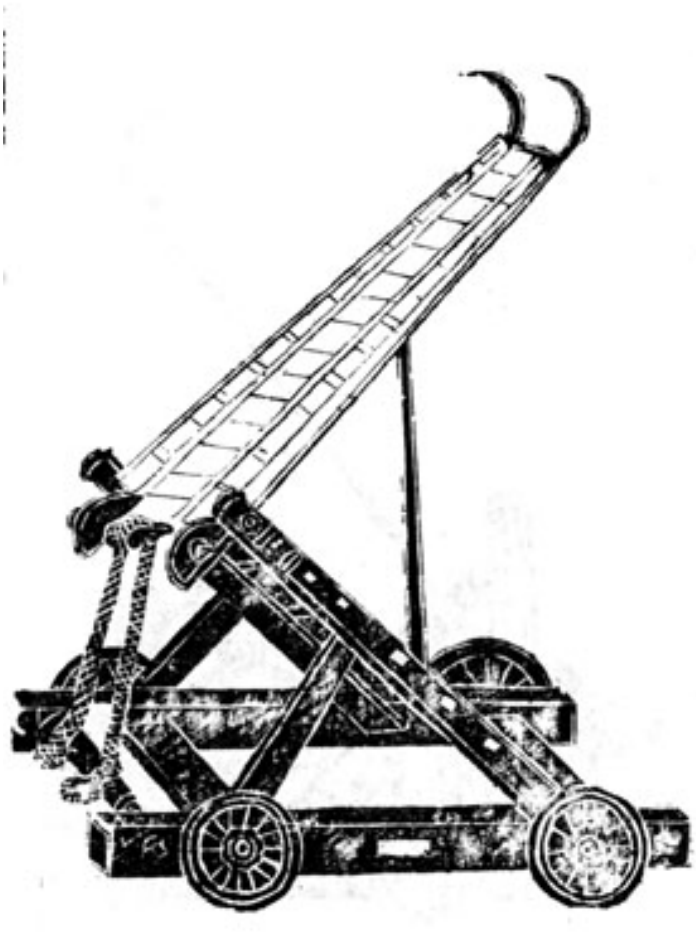


"Cloud ladder"

At left is a "cloud-ladder" from *The Essentials of the Military Arts*. Scaling ladders were already being used in the Warring States period.

Notice the helmets on the soldiers.

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10: 17 (p. 437).



"Hang-over-the-sky" ladder

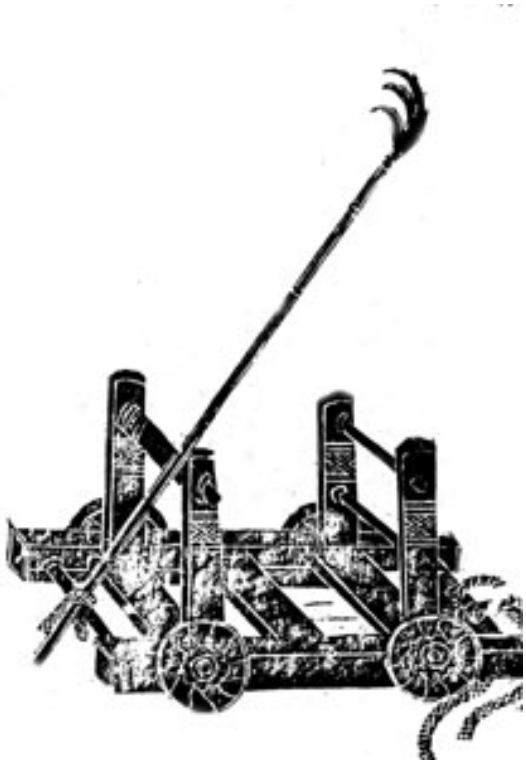
The "hang-over-the-sky" ladder shown at left was another version of scaling implement.

Can you think of a way to counteract ladders like the ones at left and above?

ANSWER: One method was for those on the city wall to pour or throw down a wide variety of things at the attackers. Another was to try to chop off the hands of those who reached for the top of a wall.

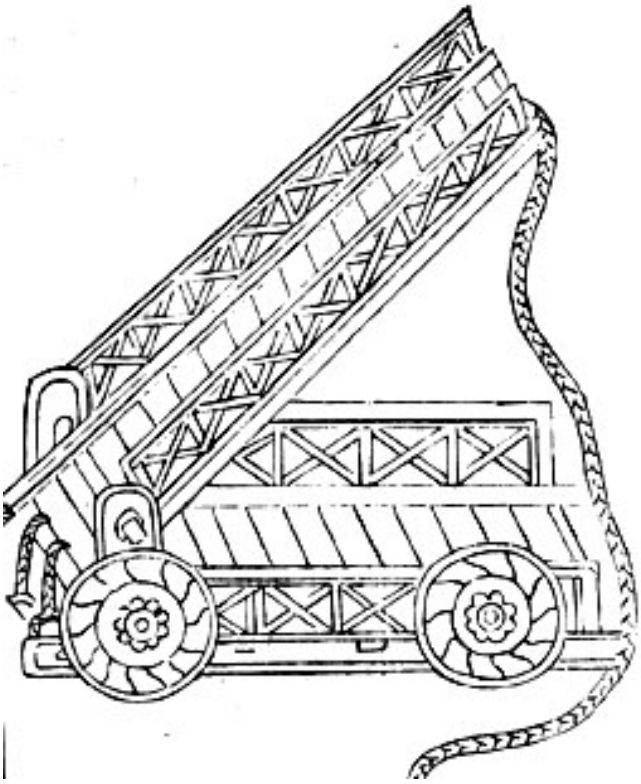
SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10: 34 (p. 471).

The "fork" cart to the right, another movable weapon, would have been used by the attackers to chop at the walls. The pivoting beam terminating in long claws would sometimes have been attached to a long ladder for extra height. When a wall's integrity was breached, other implements such as "buildings in the void," "flying ladders" and "cloud ladders" would be moved into the holes thus created to allow invaders access beyond the walls.



"Fork" cart

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10: 34 (p. 472).



When the attacking side was close to the moat and the walled city, folding bridges could be used by both the attackers and the defenders.

Why would an army bring their own bridges with them?

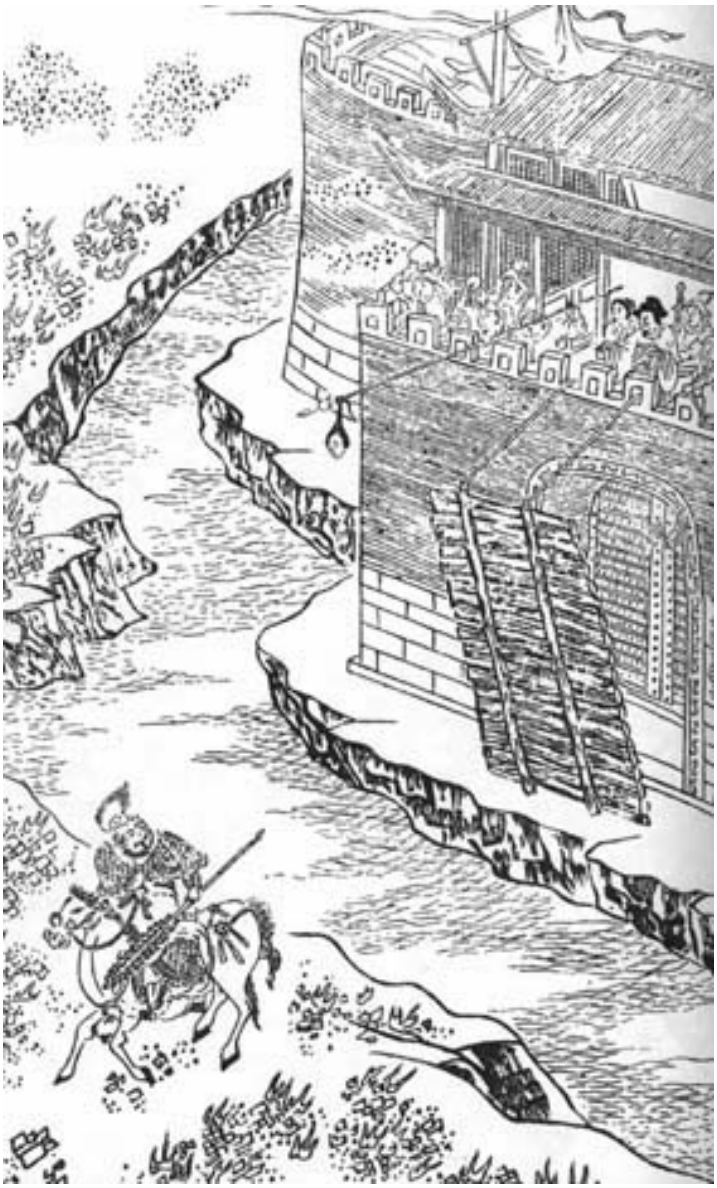
Folding bridge

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10: 16 (p. 435).

To the right is a suspension bridge from *The Water Margin*.

Can you see from the picture how the bridge would have worked? How vulnerable was it?

Other types of bridges included revolving bridges, connected underground to a mechanism inside the gates. When the connecting pin was disengaged, the bridge would turn over and anyone on the bridge would fall into the moat.



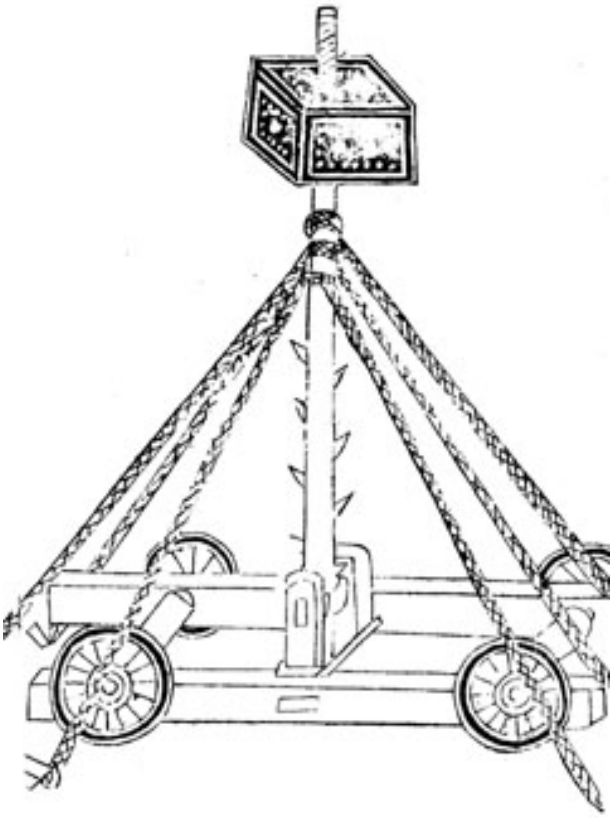
Suspension bridge or "fishing" bridge

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu*, Ming edition (Beijing: Renmin meishu chubanshe, 1955), p. 29.

Below are a watch tower and a striking cart from *The Essentials of the Military Arts*. The three ropes on either side of the pole are attached to either side of the cart, keeping the pole upright.

How do you imagine these were used?

ANSWER: The watchtower allows a view over the walls. The box at top, for the watcher, is enclosed to protect him from enemy fire. The striking cart could also be known as a battering ram.



"Watchtower cart"

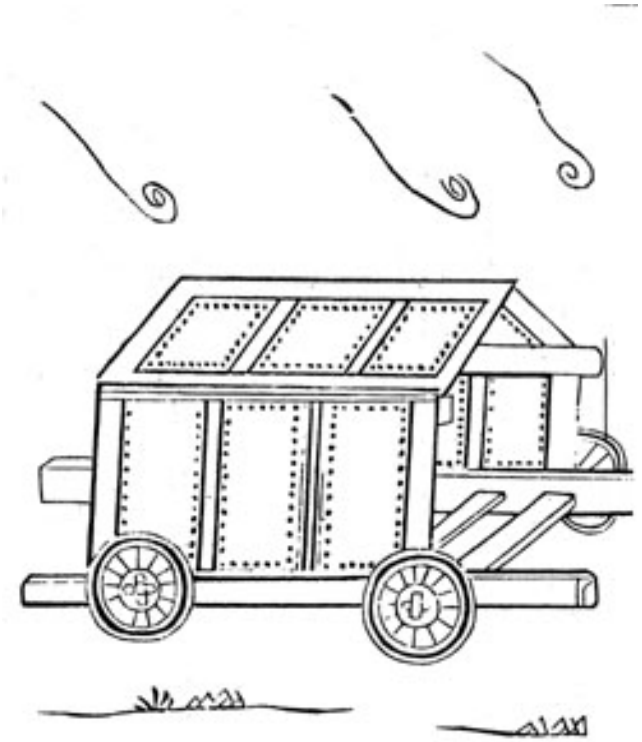
SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10:23 (p. 449).

"Striking cart"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:22 (p. 565).

An early version of the tank, at the right, had a rigid spine and was covered like a tent with oxhide. It was designed to protect men as they were brought close to the wall. Incendiary arrows could be shot at the cart, but if the oxhide was fresh enough, it provided some protection.

How do you think this tank would have been propelled?



"Tank" cart

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10: 34 (p. 444).

At left, an army that had approached a city's walls is bombarded by items dropped from above -- one of the major lines of defense.

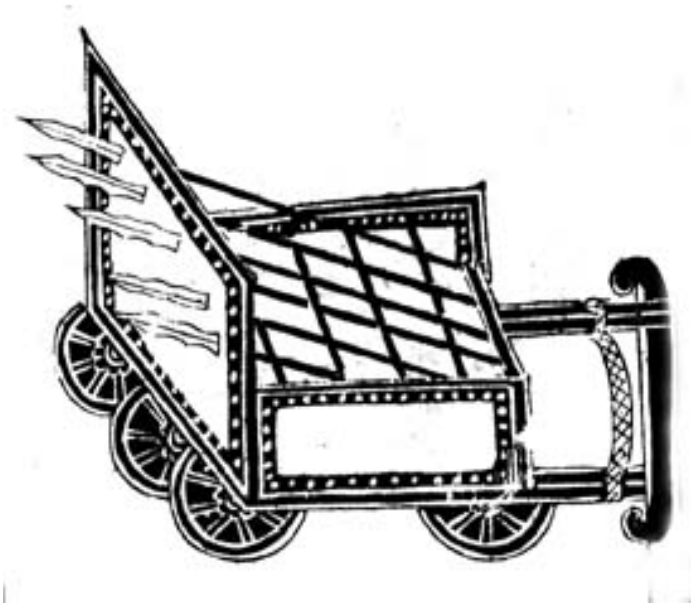
Can you identify some of the objects raining down -- especially after viewing the next sections?

City defenders attacking

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu,* Ming edition (Beijing: Renmin meishu chubanshe, 1955), p. 98.

In the eventuality that the gates failed to hold, defenders would have implements such as the one on the right, a "knife cart for blocking up gates," to roll into place.

When a city did fall, civilians were encouraged to flee, but soldiers were expected to stay and fight. The sack of a city was usually gruesome, with indiscriminate slaughter and desperate attempts to buy mercy.



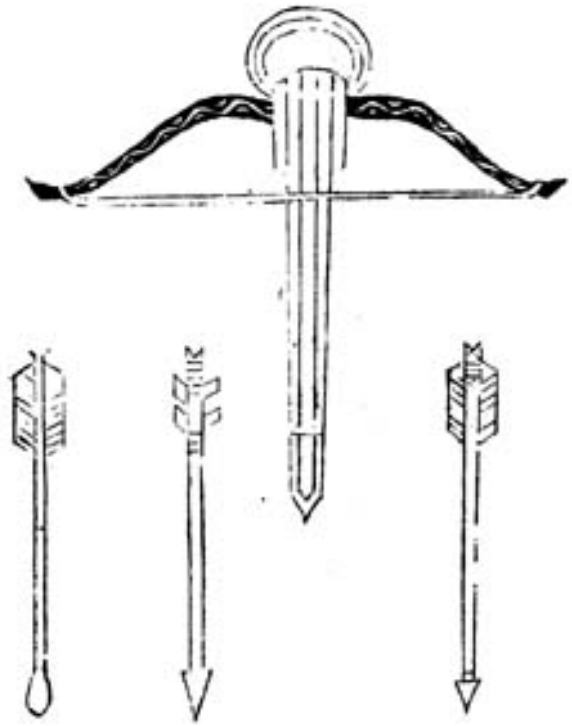
"Knife cart for blocking up gates"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12: 28 (p. 19).

Move on to Crossbows

Crossbows

Crossbows were in use in China by the fifth century BCE and quickly became an important element in the warfare of the Warring States period. Where other bows rely on the strength of the archer, the crossbow has a mechanical trigger, so that many releases could be made without tiring the crossbowman. The Chinese development of the crossbow depended on bronze technology advanced enough to allow manufacture of accurately machined trigger-mechanisms. Early crossbows were portable and mostly operated by one archer. They became popular for the defense of royal entourages and for hunting; the later multiple-firing crossbows were intended for military campaigns.



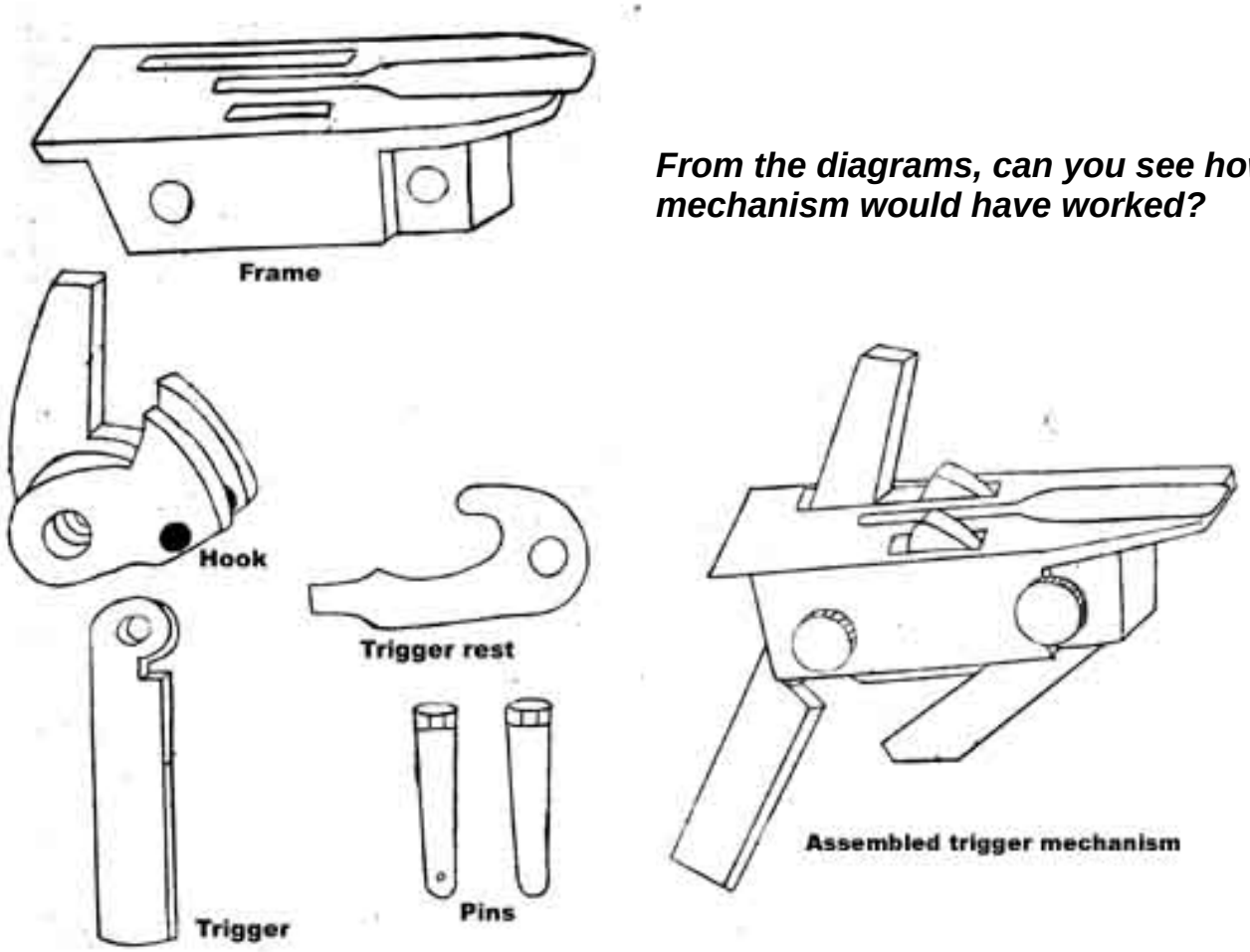
Crossbow and arrows

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 13:12 (p. 679).

Crossbows were also used in the West. They were known to the ancient Greeks and Romans, and by medieval times in Europe, the crossbow had evolved into a powerful weapon capable of penetrating armor. Chinese crossbows could pierce several layers of iron armor, but in China, where the defense and attack of walled cities was the primary focus of military campaigns, the crossbow was valued for its ability to deliver volleys of bolts even more than for its power to penetrate.

Crossbows remained one of the major weapons in Song times. In the eleventh century, Shen Gua argued that the crossbow is to the Chinese what the horse was to the Khitan -- the asset that gave them their advantage. In field battles against foreign cavalry, the Chinese infantry would have a row of pikemen with shields, rows of archers, and a row of crossbowmen. When the cavalry approached, the crossbowmen would shoot first above the crouching pikemen and bowmen. The pikemen and archers would shield the slower-firing crossbowmen, who, however, could inflict more damage.

Below is a schematic drawing of the bronze trigger mechanism, including both an assembled one and the component parts.



From the diagrams, can you see how this mechanism would have worked?

Trigger mechanism from a 17th century book

SOURCE: ***Rongzhen dian,*** **Congshu jicheng edition, 2:18, 2:28.**

Illustration from *The Romance of the Three Kingdoms*

SOURCE: Luo Guanzhong, *Quantu xiuxiang xanguo xanyi,* (Shanghai: Feihong ge, 1896), 46:0 (illustration before p. 1).

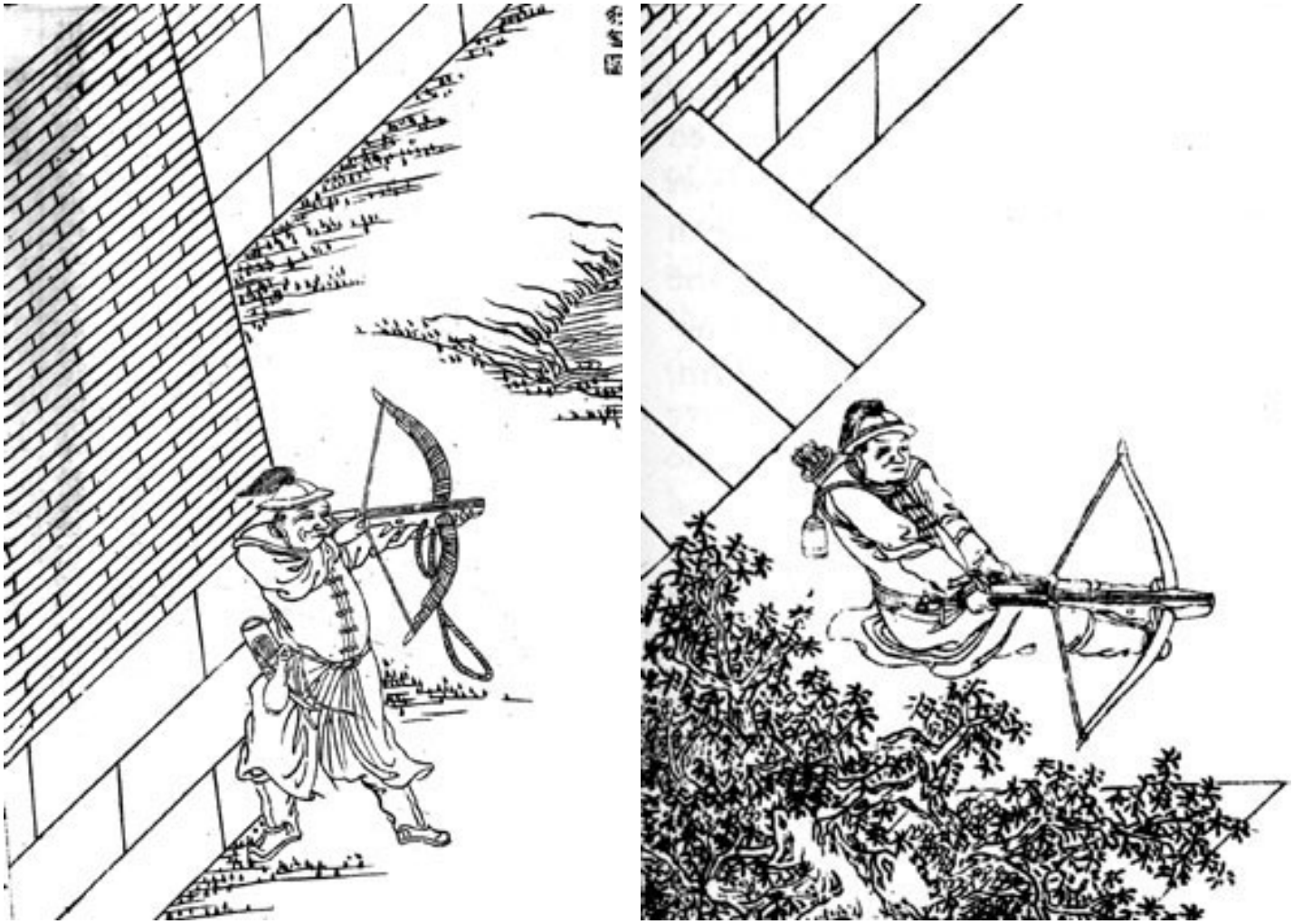
The scene on the left shows a famous story from *The Romance of the Three Kingdoms*. The Shu strategist, Zhuge Liang, successively "borrowed" 100,000 arrows from the rival state, Wu. With his arrows in short supply, he covered the Shu boats with hay, so that the arrows from Wu would stick and could be collected later.

Although the crossbow was a very effective weapon, using one took training. Below are two crossbows that are armed in different ways.

On the left, notice the loop hanging from the armed bow. By inserting his foot into the loop, the soldier could pull down the bow as he pulled up on the string until it caught in the trigger mechanism.

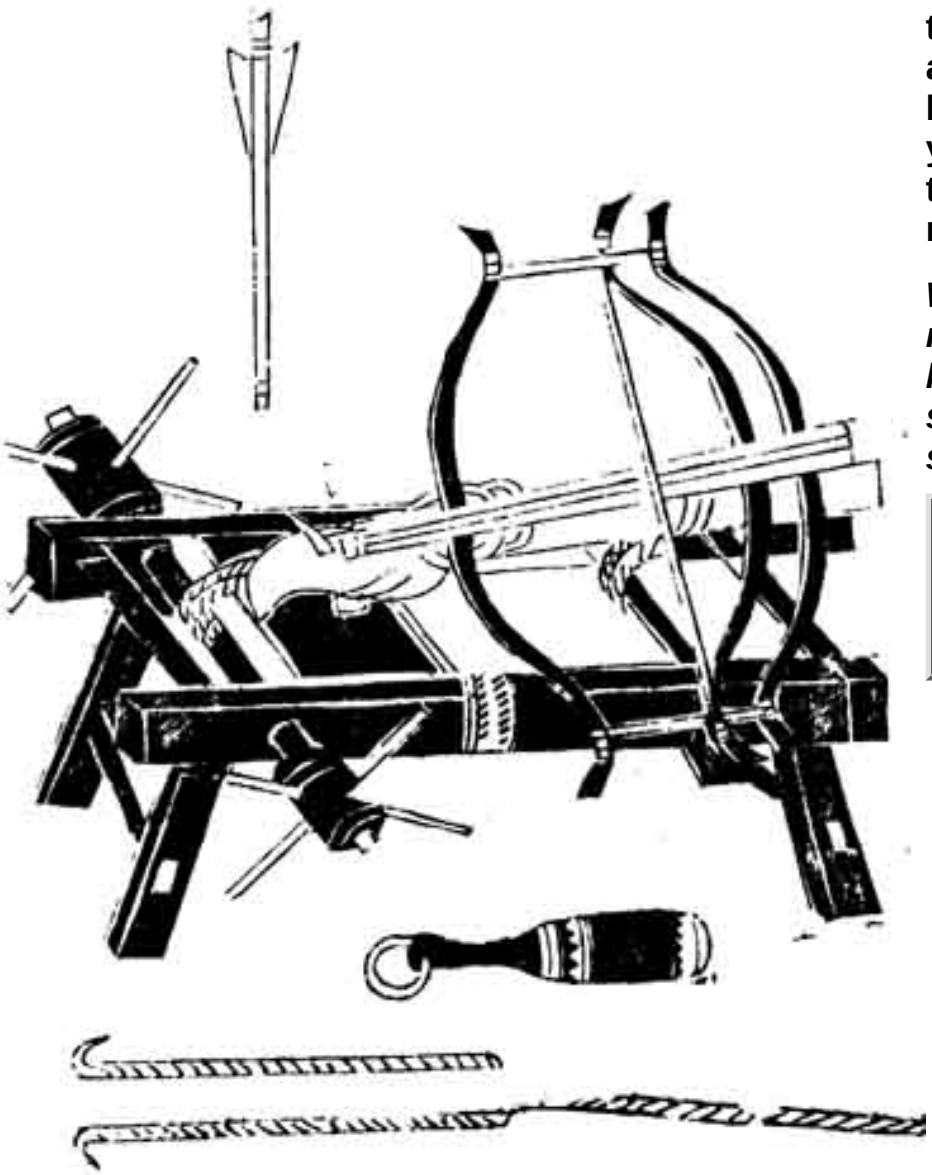
On the right, the soldier uses a "belt-claw," which hooks onto the bowstring so he can pull it back into the trigger mechanism while pushing the bow away with his feet.

Why would one method be preferred to another?



Crossbow arming methods

SOURCE: *Rongzhen dian, Congshu jicheng* edition, 284 juan, Nubu huikao, 2:18, 2:27.



Triple crossbow

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 13:12 (p. 679).

To the left is a triple crossbow from the Song period. It would have taken as many as 20 men to operate and had an effective range up to 125 yards. The heaviest one was said to take 100 men to operate and had a range of 175 yards.

Why would a composite crossbow requiring 100 men's strength but only having a range of 175 yards make sense if the one using 20 men's strength had a range of 125 yards?

HINT: Think about situations, such as defending a city, in which manpower may not be in short supply but keeping attackers too far out to use catapults effectively might be very important.

How could the effectiveness of bows be further increased?

ANSWER: By the Song, gunpowder packets with oiled paper fuses would be attached to many projectiles. Gunpowder is discussed in the last of the sections in this unit.

ARMOR

From very early times, soldiers wore armor and used shields to protect themselves from arrows. Horses, which were more important than ever when the Song was coping with the Liao, Jin and Yuan, were also armored.

Note the elaborate armor worn by the two generals below. Armor was often made from the hide of a rhinoceros and then lacquered. So many rhinoceros were slaughtered for this purpose that the animal was largely wiped out in China and rhinoceros hide had to be imported.

General with bow

SOURCE: Luo Guanzhong, *Quantu xiuxiang sanguo xanyi,chatu ji* (Shanghai: Feihong ge, 1896), p. 17.

General in suit of armor with shield

SOURCE: Luo Guanzhong, *Quantu xiuxiang sanguo xanyi,chatu ji* (Shanghai: Feihong ge, 1896), p. 31.

Can you tell from these pictures what other kind of materials were used to make armor and shields?

ANSWER: Iron chain mail and hard lacquered leather were commonly used. Less expensive (but also less effective) materials included layers of thick cloth and sometimes bamboo.

As in Medieval and Renaissance Europe, military equipment was often embellished in ways that served no utilitarian functions.

What can you infer from the style and craftsmanship of the armor, shields, and quivers shown below?

To the left is an illustration of a general wearing a helmet and armor and carrying a quiver.

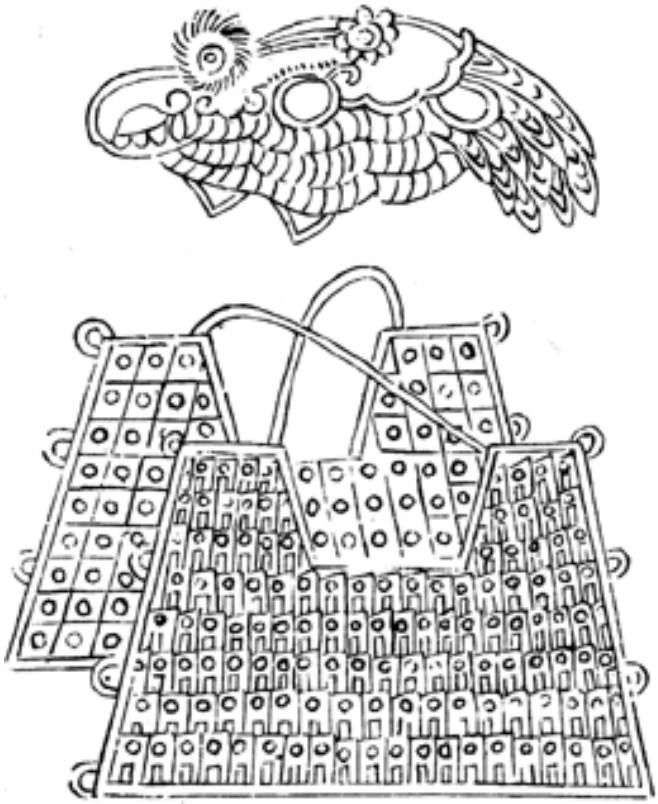
Armored officer seen from rear

SOURCE: Luo Guanzhong, *Quantu xiuxiang sanguo xanyi,chatu ji* (Shanghai: Feihong ge, 1896), p. 6.

Below are diagrams of the front and back of a shield (left) and armor for horses (right). The face on the shield depicts a demon king.

Shield, front and back

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 13:23 (p. 702).



Horse armor

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 13:30 (p. 716).

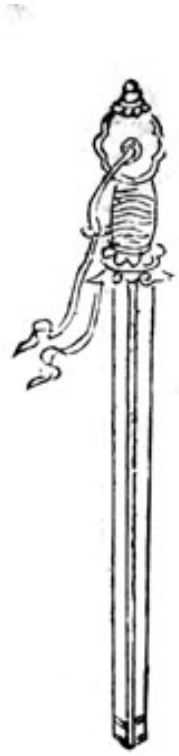
Move on to Spears and Clubs

Spears and Clubs

Traditional weapons such as spears, axes, clubs and swords remained in use into the twentieth century, never fully supplanted by firearms.

Below are samples of some long-handled weapons from *Essentials of the Military Arts*. The handles of clubs, maces, and axes could be up to three or four meters long.

In what situations would long-handled weapons be preferred over ones with short handles?



Two-edged sword

"Iron whip"

"Wolf-tooth mace"

Big axe

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 13:13-16 (p. 687-89).

ANSWER: Short-handled weapons were used in close combat. Some weapons with longer handles were used in cavalry fighting, others were necessary to reach enemies trying to scale walls.

The general to the left, from *The Romance of the Three Kingdoms*, is holding under his arm a long-handled halberd with a long blade

Armored general with halberd

SOURCE: Luo Guanzhong, *Quantu xiuxiang sanguo xanyi,chatu ji* (Shanghai: Feihong ge, 1896), p. 20.

Below are three scenes from *The Water Margin* showing various weapons in use.

Cavalry fighting

Bombarding attackers

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu*, Ming edition (Beijing: Renmin meishu chubanshe, 1955), p. 55, 98.

How many weapons in these pictures can you identify ?

What kind of comparisons and contrasts can be drawn between this army and a medieval European army on parade?

On parade

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu*, Ming edition (Beijing: Renmin meishu chubanshe, 1955), p. 77.

Move on to Catapults

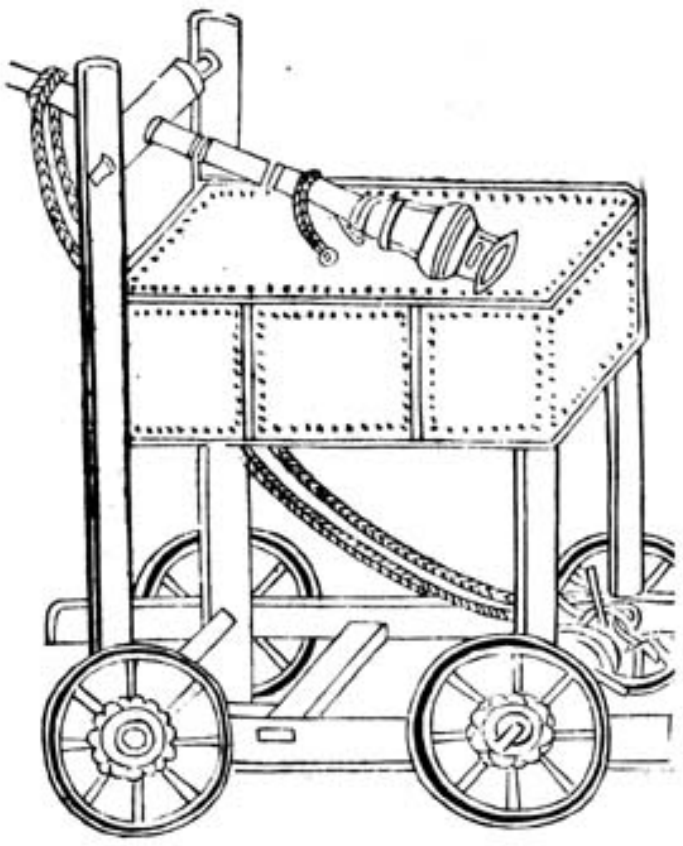
Catapults

By the Sui-Tang period, catapults were used by both attackers and defenders, in both siege warfare and field operations.

A catapult is a device for hurling stones or other objects. The basic principle in a catapult's operation is a central lever mounted in counterpoise, like a see-saw. Song catapults could throw objects several hundred feet. Deploying catapults required a large number of soldiers, but could cause serious damage. *The Essentials of the Military Arts* lists 18 types of catapults, including both movable and fixed ones.

MORE: It took a lot of manpower to operate catapults. A fifty-man team could hurl five-pound rocks or bombs 85 yards. The largest catapults, requiring a 250-man team, could fling a 125-pound object the same distance.

Chinese were not the only ones to use catapults. When the Jurchen set siege to the Song capital of Kaifeng, the Song defenders were bombarded with rocks and gunpowder bombs flung from over a hundred catapults outside the city walls. Mongols employed Arab engineers who redesigned the catapults so that only ten men were required to hurl projectiles as large as 200 pounds. These were crucial in their five-year siege of Xiangyang, 1267-1272.



On this page are three different types of catapults.

Which type do you think would be best for use by defenders on top of city walls, and which seem more likely to have been used by an assaulting army?

Counterweighted catapult

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10:10 (p. 424).

Above is a counterweighted catapult. The arm extends in front at the left, and the wide ring around the bottom of the arm is probably a sliding weight. The large box is the counterweight and could be removed from the rear supports.

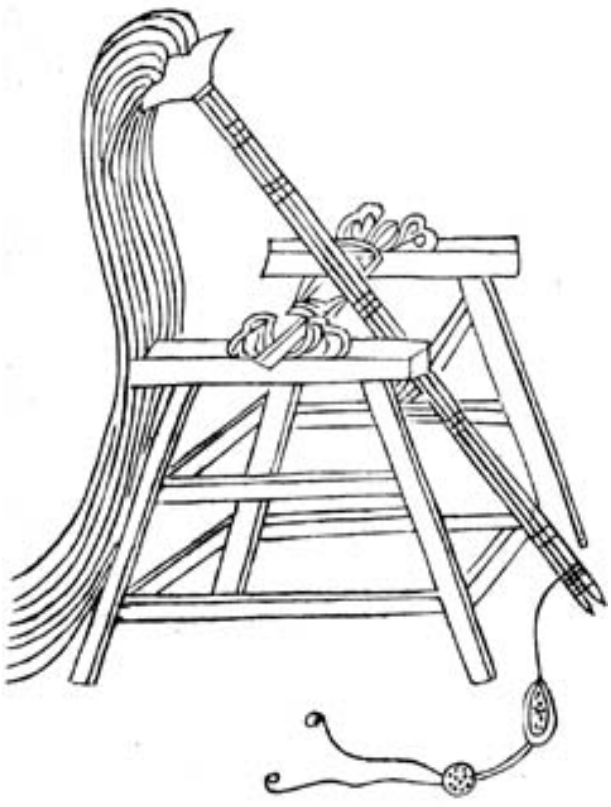
What might have been some ways to counteract the damage caused by catapults?

ANSWER: In cities, nets could catch certain kinds of ammunition. Another strategy was to drape joined ropes of rice straw over buildings and cover these with wet clay to protect from fire and penetration.

Below are two variations on a fixed catapult.

Can you figure out what the different parts are and how they worked?

To the left is a "one-lever" catapult, to the right a "seven-lever" one (seven lengths of wood tied together). The thicker lever is stronger, and so had a greater range.



"One-lever" catapult

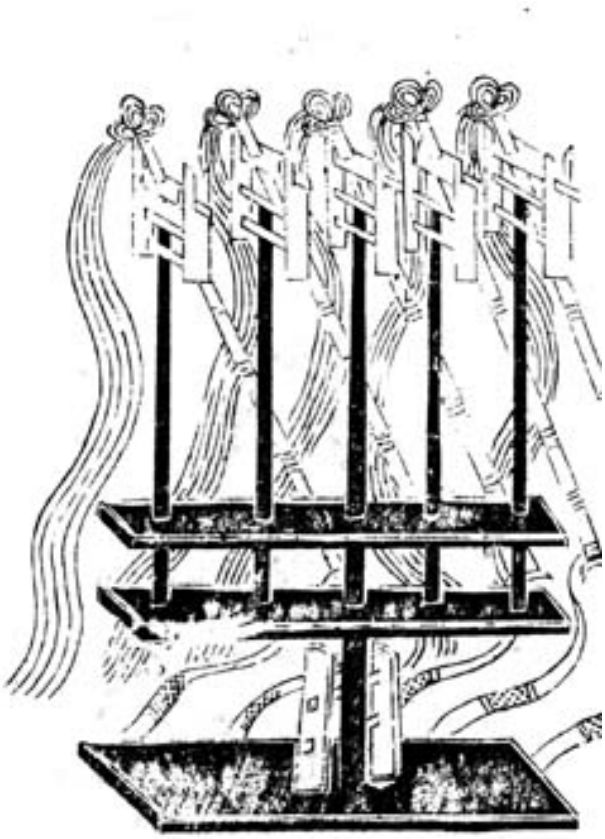
SSOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:37 (p. 595).

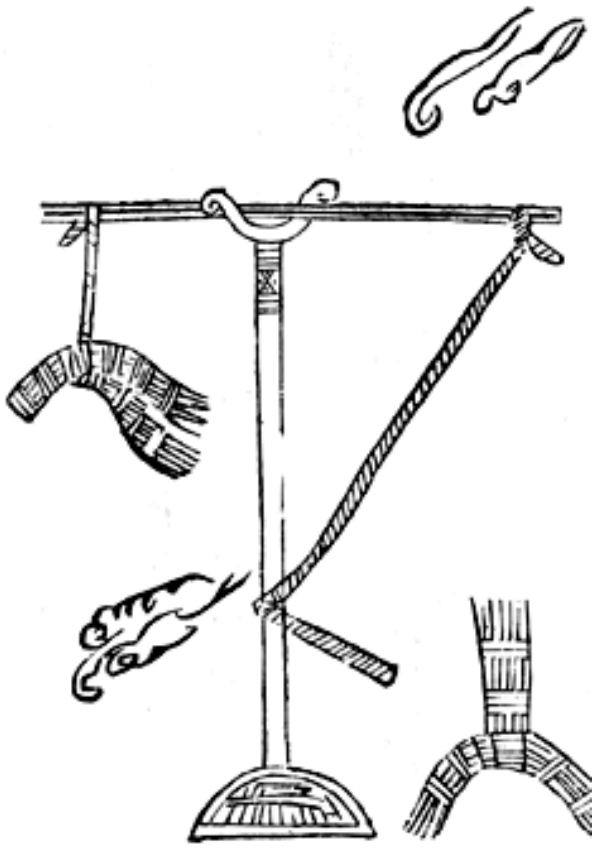
"Seven-lever" catapult

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:41 (p. 604).

Below are two different types of "whirlwind" catapults from *The Essentials of Military Arts*. With these, projectiles could be hurled in any direction.

Can you figure out why they were called "whirlwind" catapults?



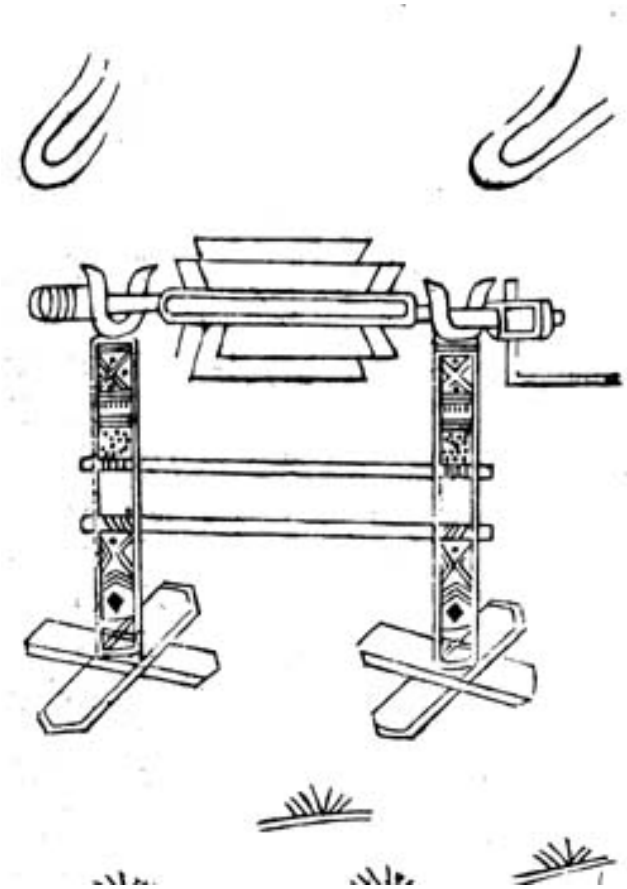


"Whirlwind" catapults

SOURCE: SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:48 (pp. 618; 625).

Against what kinds of structures do you think catapults would be most effective?

SOME THOUGHTS: On wooden buildings, catapults were very effective, to the point that wooden watchtowers on walls were no longer used in the twelfth century.



"Fan cart"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:28 (p.577).

The enemy's approach to city walls was often severely restricted by the many items raining down on them from above. Underground warfare was therefore a significant part of siege warfare, and is one of several reasons for moats.

One of the methods to push back invading miners was to set up fans, such as that shown at left, which would propel smoke (sometimes poisonous), fireballs, and various types of shrapnel forward into tunnels.

Move on to Warships

Warships

China has one of the longest histories of shipbuilding. The square ship in the Warring States era was already double-bodied and made up of two junks secured together side by side. Third century warships had eight compartments. Paddle-wheel boats were invented in the late Tang and widely used in the Song.

Small boat approaching a walled river city

SOURCE: Luo Guanzhong, *Quantu xiuxiang sanguo yanyi* (Shanghai: Feihong ge, 1896), 35:0 (illustration before p. 1).

The Song period saw major advances in shipbuilding with improvement in speed, security against foundering, adaptability to marine conditions, and steadiness.

The Southern Song navy was much larger and comparatively stronger than that of the Northern Song, mainly because it needed to keep northern armies from crossing the Huai and Yangtze Rivers. The navy had both small ships such as those on the left and larger vessels like those shown below. A strong navy of an attacking army could come right up to a riverside city. If a ship's deck was high enough, soldiers could step from it to the top of the city's wall.

What might be other advantages and disadvantages of large and small ships?

ANSWER: Large ships could hold more men, and from the high top deck, archers could rain down arrows. However, large ships had deep draughts, and so needed deep water to maneuver. They were also slower. Smaller ships could navigate quickly, making them useful for close combat.

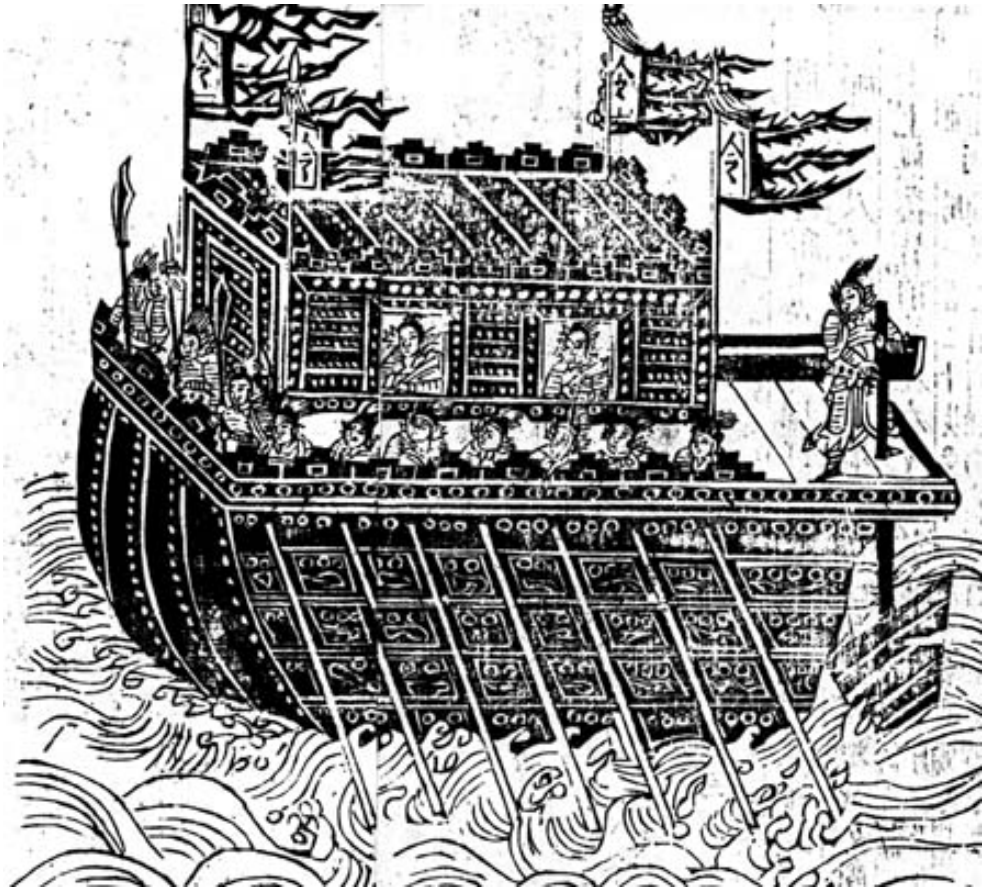
"Sea hawks," as the type of ship below was called, were invented in the Tang and had floating boards on each side to stabilize the ship. By the Song, sea hawks usually had four to six boards on each side. (In the picture below, it is difficult to distinguish the oars from these boards.) Song ships were also strengthened with iron in the hull. Some had several decks to keep the ship steady.

What role do you think ships might have had in siege warfare?

"Sea hawk" warship

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:10 (p. 495).

Compare the "sea hawk" ship above with the warship depicted below. What would be the advantage of the ship below?



Warship

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:9 (p. 493).

Song battleships were equipped with fire-bomb catapults and incendiary arrows that used gunpowder (discussed in other sections). Sometimes protected stations on upper decks were created for crossbowmen who also played the role of watchmen.

Scene from *The Water Margin*

SOURCE: Liu Junyu, *Shuihu quanzhuan chatu*, Ming edition (Beijing: Renmin meishu chubanshe, 1955), p. 16.

To the left is a naval battle depicted in *The Water Margin*.

Can you identify the weapons used here?

What is different about the boats used here and those seen above? What about this scene might suggest a reason for the difference?

To the right is another type of warship from *The Essentials of Military Arts*. The word on the flag reads, "commander." Notice also the huge rudder.

What do you think is the purpose of the drums?

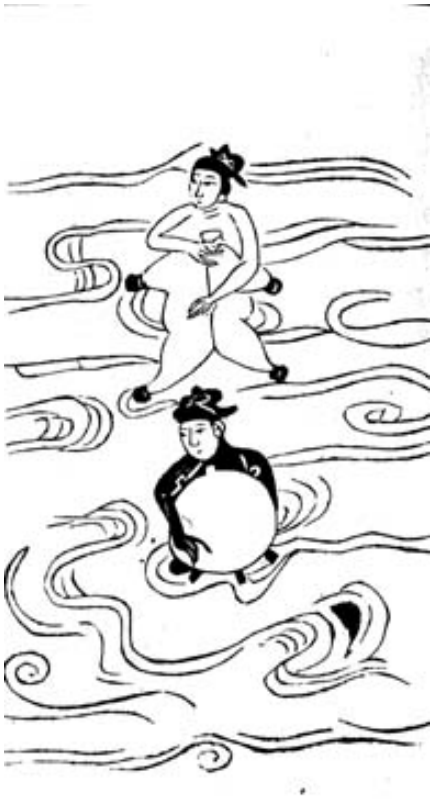
Warship

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:8 (p. 491).

Below to the left is a raft, to the right a floating bag.

Bamboo raft

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:13 (p. 501).



Floating bags

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:14 (p. 503).

What would have been the military purposes of these items?

What do you think they were made of?

ANSWER: These floating bags would likely have been made of sheep or goat skin. With the raft, they would have been used to float men close to enemy walls or ships to undermine them or gain access to them in some way.

Another use of these bags was to hold water that could be squirted out in measured proportions against fires in underground mines

Move on to Gunpowder and Firearms

FURTHER READING FOR MILITARY TECHNOLOGY

The Institute of the History of Natural Sciences, The Chinese Academy of Sciences, ed. *Ancient China's Technology and Science*. Beijing: Foreign Languages Press, 1983.

Kierman, Frank A., Jr., and John K. Fairbank eds. *Chinese Ways in Warfare*. Cambridge, MA: Harvard University Press, 1974.

Needham, Joseph, and Robin D. S. Yates. *Science and Civilization in China, Volume 5: Chemistry and Chemical Technology VI: Military Technology*. London: Cambridge University Press, 1994.

Yates, Robin D. S. "Siege Engines and Late Zhou Military Technology," Li Guohao, Zhang Mengwen, and Cao Tianqin, eds. *Exploration in the History of Science and Technology in China, Collections of Essays on Chinese Literature and History.* Shanghai: Shanghai Chinese Classics Publishing House, 1982. 409-452.

Gunpowder and Firearms

In China, military strategy focused on outsmarting the enemy, by whatever means possible. Fire was used as a weapon of war since it inspired great fear and confusion among the enemy. Those in charge of defense had to keep the danger of fire in mind and military guidebooks outline in detail the ways to prevent fires from spreading rapidly during attacks.

As an offensive weapon, fire was delivered to enemy camps in a variety of ways. Animals with unpredictable behavior, such as birds, were frequently used. To the left are oxen stampeding with burning hemp lashed onto their tails, and below is a fire cart. When used in combination with ladder carts, hook carts, battering rams and tanks, fire could be a particularly useful weapon.

Can you think of ways to counteract attacks by fire?

Fire oxen

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 11:21 (p. 517).

ANSWER: Since many offensive techniques such as fire attacks required time to prepare, defensive tactics could include disrupting enemy camp stability. For example, tunneling could undermine the earth on which an enemy stood, and fire or smoke could be sent upwards into enemy camps.

How effective do you think it would be to send burning hemp attached to animals into enemy ranks?

Fire cart

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 10:19 (p. 441).

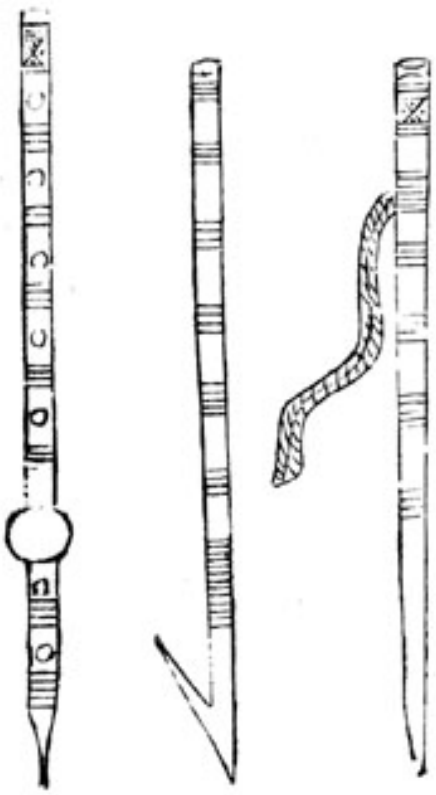
Gunpowder

Chinese military strategists sought ways to create effects from a distance. For example, by Song times they had sophisticated methods for producing smoke. Gunpowder's potential to move objects therefore made it attractive to military strategists designing weapons.

Gunpowder was first used by people seeking immortality (though this esoteric use of it was probably not known to most Chinese). The first textual evidence of a proto-gunpowder formula is contained in a work dated about 850. So far as we know, *Essentials of the Military Arts* records the first true gunpowder formula and describes how to produce it on a large

scale. Its first use in warfare was as an incendiary, or fire-producing, compound.

Gunpowder was of many different types. Chinese texts identify blinding powder, flying powder, violent powder, poison powder, bruising and burning powder and smoke-screen powder.



Starting from the Tang or the beginning of the Song, small packages of gunpowder wrapped in paper or bamboo were attached to arrows, which marked the first use of gunpowder in war (see the illustration at left). These would be lit with a fuse of some kind, so that the arrow became an incendiary, intended to set targets afire.

In the group of projectiles at left, the different styles correspond to two different types of javelin-propulsion methods. Note the arrow with the gunpowder chamber.

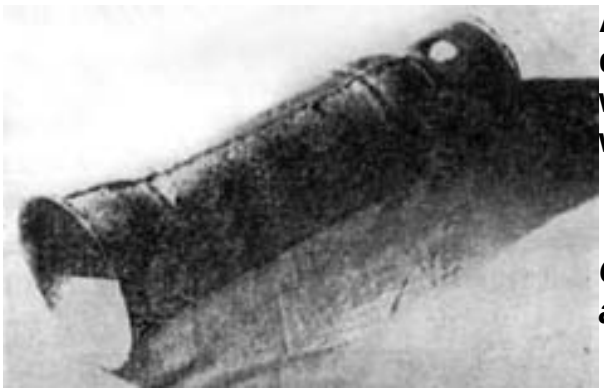
Far left, "fire-medicine whip arrow"

Far right, "whip arrow"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:52 (p. 626).

Two crucial innovations were needed before the Chinese developed rockets propelled by gunpowder. First, the idea of a counter-balance had to be conceived. A counter-balance would allow the rocket to move on a straight trajectory. The second innovation was a hole bored into the exact center of the gunpowder in the missile tube. This would allow the gunpowder to burn evenly and provide efficient thrust. This process of boring into the gunpowder was extremely dangerous. Both of these developments occurred during the 12th and 13th centuries.

Evidence of the first bronze hand-held gun dates to the early Yuan dynasty, but metal barrels were used as early as the Tang dynasty for fire lances that propelled gunpowder bombs intended to burn targets.



At left is the earliest excavated gun, from the early Yuan dynasty. A wooden tube would have been inserted in the wide mouth for extra range. The gun was mounted on a wooden housing.

Can you think of any similarities between this gun barrel and the "arrows" pictured above?

The earliest known bronze gun, ca 1332

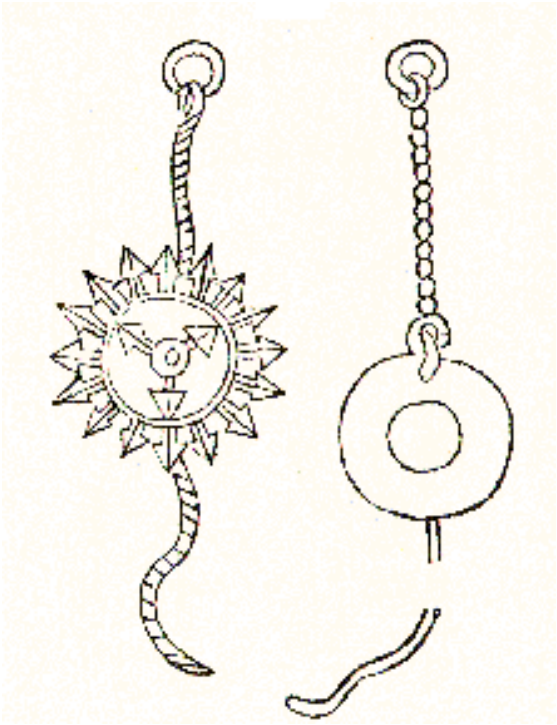
SOURCE: Shu Zhenfu et al, *Zhongguo junshi shi* (*Chinese Military History*), 1: Arms/Weaponry (fig. 92, p. 117).

ANSWER: In both weapons, the bulbous area, where the shell was thickened, held the gunpowder. This is also the shape of the bombs pictured later.

Bombs

During the Song, smoke bombs, incendiary bombs, gunpowder grenades, and the usual shrapnel objects such as rocks were used in siege warfare. Hemp or cotton would be soaked in oil, ignited, and catapulted outward. Bombs made of iron shells resembling gourds in shape could shatter a city wall. Gunpowder bombs were a mixture of gunpowder and shrapnel such as charcoal and iron scraps. The range of such "firing balls," or bombs, could be from ten to a hundred yards.

***The Essentials of the Military Arts* also lists the formula of a gas bomb, which could contain poisonous elements. This would have been used in tunnel warfare, a significant aspect of siege activity. It was also in the 13th century that bombs started to be used as land mines.**

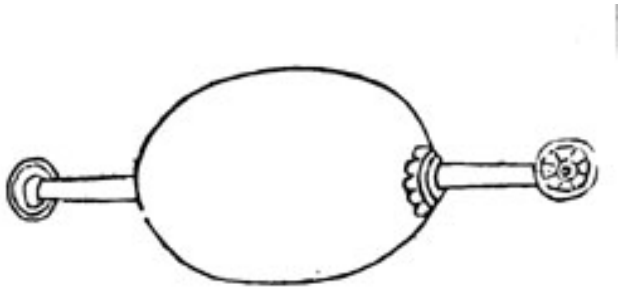


Raised "flower" and ball bombs

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:56 (p. 633).

Of the different types of bombs discussed above, which ones are pictured here?

The "thunderbolt-ball," right, was a package of gunpowder and iron scraps attached to a bamboo core. A small amount of gunpowder left outside the ball would explode the contents inside.

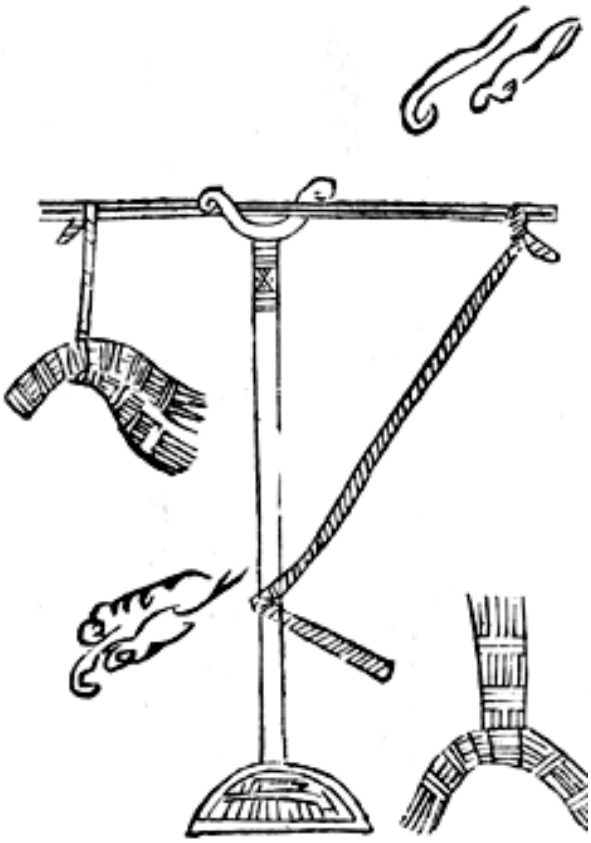


"Thunderbolt-ball"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:59 (p. 640).

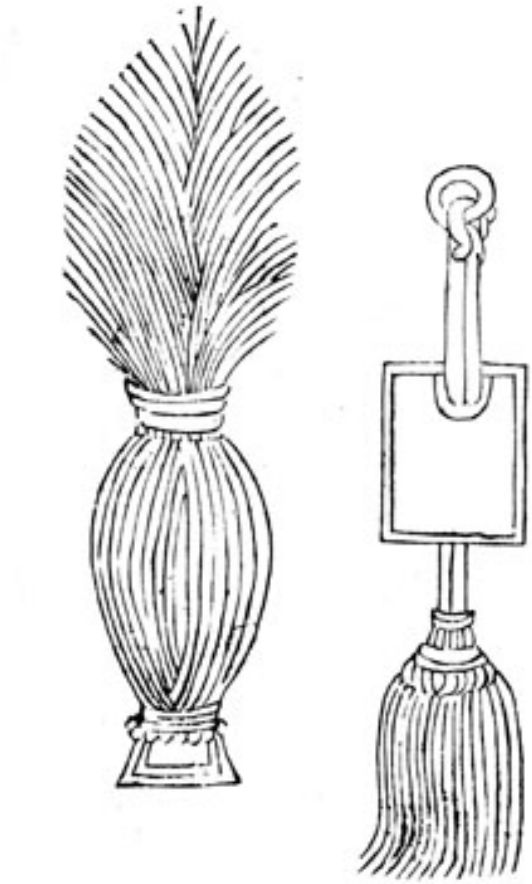
Below is a whirlwind catapult, one of several designs that could hurl bombs.

Can you visualize which of the bomb types would be best to use in the "whirlwind catapult"? Can you think of any other methods that could transport a bomb?



"Whirlwind" catapult

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:52 (p. 625).



"Bamboo fire hawk"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:56 (p. 634).

Non-explosive smoke bombs had been in use since antiquity. Pictured above to the right is an example of a "thunderclap" bomb of the eleventh century. This one, known as the "bamboo fire hawk," had gunpowder and small stones wrapped inside bamboo and hay.

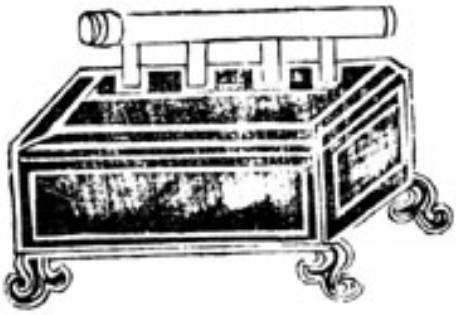
Why would the gunpowder mixture be wrapped in hay?

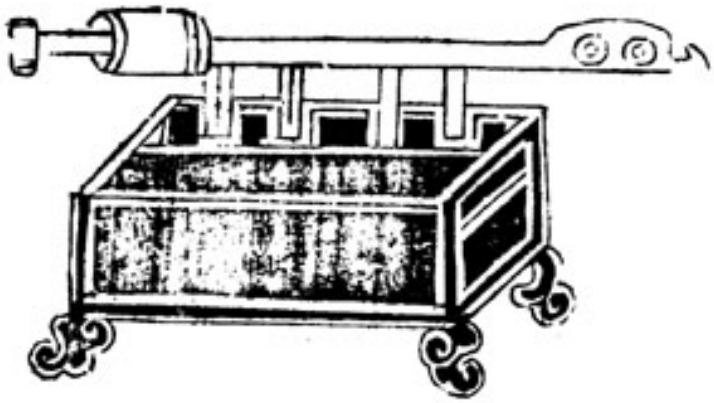
Flame-throwers

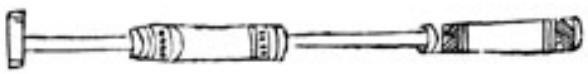
While Europe, by 675, had a single-acting force-pump contraption that could spurt flames, much like a syringe shoots liquids, it was not a true flame-thrower. For a true flame-thrower a continuous streaming of flames has to be achieved. The Chinese were able to do this by the use of a double-action piston-bellow, which would force the kerosene out of the barrel on both the forward and backward strokes of the pump handle.

Below is an illustration of a flame-thrower from *The Essentials of the Military Arts*. We see a tank, a pump, and an ejector. A continuous stream could be maintained because of the use of a double-acting piston-bellows.

Can you figure out the structure of the flame-thrower from the illustrations? Where do you think the kerosene would have been put?







The components of, and an assembled, "fierce fire oil cabinet"

SOURCE: Zeng Gongliang and Ding Du, *Wujing zongyao (Zhongguo bingshu jicheng* 1988 ed.), 12:58 (p. 637).

"Fire-spurting lances" were also invented in the Song. Bamboo was used as a barrel to hold the gunpowder, though by the Song, metal barrels were also used. Some had narrow barrels and could be held by one person. Others were mounted on wooden frames and can be understood to precede the modern cannon; these were called eruptors.

The "eruptor" to the right fired cast-iron shelled gunpowder bombs, some of which would explode only on contact, hence its name, the "flying-cloud thunderclap eruptor."

What are some of the things you notice about this fire-lance that make it different from modern cannons?

ANSWER: The main difference, aside from the type of ammunition used, is that the size of the shells emerging from the cannon mouth do not match the width of the barrel, or the bore.

"Flying-cloud thunderclap eruptor"

SOURCE: Shu Zhenfu et al, *Zhongguo junshi shi* (*Chinese Military History*), 1: Arms/Weaponry (fig. 106, p. 124).