

# 運河

## Waterways

Imperial China's construction of waterways to connect different parts of its vast territory produced some of the world's greatest civil hydraulic (water) engineering projects. One of the most impressive was the building of the Grand Canal. Construction of the first Grand Canal began in the early 600s to connect the Yellow River in the north with the Yangzi River in the south. Tens of thousands of Chinese were forced under threat of death to work on the canal system, a project that lasted for many centuries. Once the Grand Canal was complete, people carrying messages and ships carrying rice and silk were able to travel back and forth from far away parts of China. The gigantic, 1100-mile-long waterway had to be rebuilt after 1340 when the Yellow River flooded, spilling into the Grand Canal and destroying it. A Chinese engineer and 150,000 civilians and 20,000 soldiers worked successfully to construct the new channel. This extraordinary accomplishment of water technology came at the cost of much money and resources taken from both the government and the Chinese people.

# 長城

## Rebuilding of the Great Wall

The building of the Great Wall of China, one of the legendary seven wonders of the world, began in 221 B.C. Eight hundred years later, the Sui Emperor Yang Di began a huge project of repairing the ancient wall. The costs and benefits of building and rebuilding the wall were enormous. The Great Wall's construction involved the forced labor of hundreds of thousands of Chinese, many of whom died from the harsh working conditions and were buried in the wall itself. Another 700 years later, in 1368, Ming Emperor Tai Zu decided to rebuild the ancient wall yet again. Tai Zu's project focused on the use of the wall for defense against attackers. Fifteen-thousand defense towers and forts along the wall that had become old and weak were reconstructed. Peasant army troops were stationed at different points behind the wall to provide additional security against attack. During the Ming dynasty, much of the 3,665-mile wall—which stretches from Inner Mongolia to the sea—was strengthened and rebuilt. It remains the largest structure ever built anywhere in the world, and is the only human made work on earth visible to the naked eye from the moon.



## Ships

For centuries, Chinese ships, or junks, and sailing techniques were far in advance of the rest of the world. One Chinese shipbuilding invention was the bamboo-and-mat sail, a mast that could be easily raised and lowered. European sails at the time were made of canvas and were difficult to raise and lower when the wind changed. The Chinese also developed a new shape for sails, which had previously been square. These new sails, called fore and aft rigs, were curved and triangular shaped and allowed boats to sail into the wind. These and other discoveries, such as watertight compartments, made it possible for the Chinese ambassador and explorer Zheng He to take seven trips to the Middle East and East Africa between 1403 and 1433. On his voyages, Zheng He brought Chinese porcelain vases and pearls to the rulers and people of foreign countries. When he returned to China, he brought giraffes, zebras, tigers, and ostriches. Overseas exploration was impossible for the Europeans until understanding of ancient Chinese rigging was adopted 1300 years after the Chinese had begun inventing and using their shipbuilding technology.

# 指南針

## Magnetic Compass

The Chinese were using compasses to chart their course at sea almost two centuries before news of the Chinese invention reached Europe. As early as 500 B.C., both the Chinese and the ancient Greeks had discovered that a mineral called lodestone was magnetically attracted to iron. To create a south-pointing compass, the Chinese used a pointer—in the shape of a spoon or ladle—made of magnetic lodestone and a bronze plate with directions on it. The spoon was placed on the center of the plate, where it rotated and pointed south. The device was adapted for navigation as sea, as well as for “geomancy,” a way of laying out buildings to conform to the earth’s energy. By the ninth century, the spoon of the early compass was replaced by figures in the shape of a fish, or tortoise, and then later by magnetized needles. Eventually, the fish-shaped magnetized needle was placed on the surface of a bowl of water and was an effective navigation technique. The earliest European reference to a magnetic compass similar to the Chinese was in 1187.



## Music

The Chinese developed a sophisticated understanding of the musical quality of timbre during the Song Dynasty. *Timbre* is the particular quality of sound each instrument makes. The Chinese discovered that the timbre of string instruments could be changed depending on how the strings were touched. Strings could be plucked, brushed, hit, scraped, or rubbed to produce different sounds. The Chinese composed music on the *Qin*, a long, wooden board with strings. The song you hear, “Parting at Yang Kwan,” is performed on a seven-string *Qin*. The song commemorates the parting between Wang Wei, the celebrated poet of the Tang Dynasty, and the poet’s friends at a gate leading out of the Kansu province. Listen as the timbre, or quality of the sound, changes in different parts of the song. While many cultures understood the idea of timbre at this time, the Chinese developed the idea as a complex musical practice and art form.

# 紡車

## Spinning Wheel

To meet the increasing demand for silk, China's greatest export, the Chinese developed the spinning wheel in A.D. 1035.

Processing silk fibers was difficult because silk strands can run for hundreds of yards and can withstand the weight of 65,000 pounds per square inch. Chinese silk winders needed a machine to deal with the tough, long fibers. The answer was the spinning wheel, a simple circular machine—easily operated by one person—for winding fibers of silk into thread. The invention had two rimless wheels that were laced together with a criss-cross pattern of string (cat's cradle). A drive belt made the wheels spin. Italians who traveled to China during the Mongol dynasty brought the clever invention to Europe. The earliest picture of a spinning wheel in Europe dates from the fourteenth century; later, it came to America with early immigrants. The spinning wheel is still in use in China.

# 活字版

## Movable-Type Printing

Printing was one of the most significant inventions of the Chinese during the Tang and Song dynasties. Though woodblock printing—a time-consuming process done by hand—had been invented in China in the eighth century, a Chinese commoner named Bi Sheng created a faster way of printing, using movable type, around the year 1045. The movable-type method used reusable blocks of Chinese characters (words) that could be moved around on a page. Bi Sheng made his movable type by carving Chinese characters from clay and then baking the clay forms until they were hard. Each page of a text was printed after the necessary forms of the characters were placed into an iron frame, in which they were held with wax. Bi Sheng's invention and other Chinese developments in printing made printing books faster and easier, making more books available to more people. It wasn't until 200 years later that moveable-type printing was used in Korea, and 400 years later that it was developed in Europe.



## Porcelain

Ceramics made of porcelain was a Chinese invention that reached perfection during the Song and Ming dynasties. The Chinese had made pottery for centuries, but during the Tang Dynasty Chinese artists learned that a mineral, feldspar, could be added to white clay to make white porcelain. When the special clay, called *kaolin*, is fired at a high temperature it becomes translucent (partially see-through), water resistant, and extremely hard. During the Song and Ming dynasties, porcelain artistry reached new heights as hundreds of thousands of workers crafted the clay into porcelain statues and art objects that were the envy of many foreigners. Some porcelain statues and vases remained white, while others were decorated with patterns or painted. Chinese artists had been making ceramics from porcelain for 1400 years before Europeans finally developed the art in the eighteenth century.



# 驛站

## Roads and Relay Hostels

Roads and relay hostels, or inns, built during the Tang and Song dynasties greatly improved communication and trade throughout the vast land of China. By the late 700s, relay hostels, which offered horses and food for travelers, had been built along the main travel routes of China and provided places for government officials to stay for the night during long journeys. The roads allowed official inspectors, tax collectors, and messengers to more easily move throughout China. Some messengers traveled on horseback, while others were trained to run on foot, delivering government mail across hundreds of miles. The new roads also increased trade by providing a way for merchants selling rice, tea, silk, and seafood from the coast to trade their goods all over China.

# 飛錢

## Paper Money

The Chinese invented paper money in the ninth century. Paper money was originally called “flying money” because it was so light and could “fly” out of one’s hand. In previous centuries, the Chinese had used copper and sometimes iron as currency. However, this metal money was difficult to carry and transport because it was so heavy. When copper became scarce and printing on paper became more widespread, merchants began to issue their own bills of exchange and letters of credit—paper certificates that could be exchanged for cash—to customers and other merchants. In 1024, the Song government took over the printing of paper money and began to issue official certificates, which were used as currency. The idea of paper representing metal money led the Islamic money changers in the marketplaces to develop a checking system. Gradually, paper money and checking systems spread to the rest of the world.

# 天花

## Smallpox Inoculation

The first breakthrough in inoculation (introducing a weak form of a disease to treat or prevent a disease) against the small pox disease was made in China. Smallpox, or *Variola*—a deadly virus disease characterized by skin blisters drying to scab-coated pustules and leaving crater like scars—existed in Europe, Asia, and Africa from the tenth century onward. The technique of inoculation, or variolation, was first publically recognized in China when the eldest son of Prime Minister Wang Dan (A.D. 957–1017) died of smallpox. Hoping to prevent the same thing from happening to other family members, Wang Dan summoned physicians and other specialists from all over China. A Daoist monk brought the technique of inoculation to Wang Dan and introduced it to Chinese physicians in the capital. They continued to experiment with inoculation, and by the sixteenth century it was widely practiced against smallpox in China.

# 火藥

## Gunpowder

Gunpowder was invented in China and used to develop weapons like the cannon long before the substance was heard of in Europe. Chinese alchemists (scientists who study chemicals) first discovered gunpowder in the third century by mixing sulphur, saltpeter, and charcoal and then exposing the mixture to intense heat. By the time of the Song Dynasty, which began in A.D. 960, military manuals discussed gunpowder's ingredients and its uses for military purposes. Other documents warned soldiers of fatal accidents caused by the misuse of the weapon. Chinese soldiers used gunpowder to make fire arrows and to make the catapult more dangerous to their enemies. By 1259, the Chinese had made a gun barrel of bamboo with fiber wrappings. Just a few years later, the first metal gun barrel recorded in history was used in China. The Europeans and the Arabs later copied the Chinese model of the gun.



## Abacus

The Chinese developed the abacus, a counting device, during the Song Dynasty. By the fourteenth century, the Chinese *suanpan*, or abacus, was perfected and given the form it still has today. The instrument consisted of a rectangular wooden frame with parallel rods or wires, each of which has strung on it seven flattened beads, or counters. The rods are separated into upper and lower parts by a crossbar. Two beads on each rod are above the bar, and five are below it. On a standard abacus, each bead above the crosspiece is worth five units, and each below is worth one. The rungs from right to left indicate units—tens, hundreds, and so on. With this instrument the Chinese could easily add, subtract, multiply, and divide. Brilliantly simple in design, this instrument makes addition, subtraction, multiplication, and division remarkably fast. The abacus became the basic calculating device in Asia and the Near East, and it is still widely used for commercial purposes.

# 漏

## Mechanical Clock

One of the greatest inventions of the medieval world was the mechanical clock, developed in China. Yi Xing, a Buddhist monk and mathematician, made the first model of a mechanical clock in A.D. 725. This clock—really an astronomical instrument that served as a clock—operated by dripping water that powered a wheel that made one full revolution in 24 hours. An iron and bronze system of wheels, shafts, hooks, pins, locks, and interconnected rods made the clock work. This system caused the automatic chiming of a bell on the hour and the beating of a drum every quarter hour. Yi Xing’s first clock was called the “Water-driven Spherical Birds’-Eye-View Map of the Heavens.” Three centuries later, the inventor Su Song made an even more sophisticated mechanical, or astronomical, clock. This clock, called the Cosmic Empire, included several floors housed in a tower over 35 feet high. It was also made of bronze and powered by water. On top was a platform with a sphere that kept time with the motion of the planets. Su Song developed his clock in 1092, two centuries before the mechanical clock was developed in Europe.

# 煤

## Coal and Iron Production

The scale of production of iron and coal in China during the Tang and Northern Song dynasties (A.D. 618—1127) was vastly greater than anywhere else in the world until the nineteenth century. In the fourth century B.C., the Chinese had discovered the use of coal—which they called “black earth”—as fuel. It wasn’t until 300 years after Marco Polo observed the Chinese using coal that the fuel was commonly used in England. Using coal to melt iron, the Chinese began mass production of cast iron goods by the second century A.D. Later, by taking the carbon out of cast iron, the Chinese were able to manufacture steel. By the seventh century, much of the iron and steel produced in China went to equip the Song army of well over one million men, providing them with swords, steel-tipped arrows, and armor. Iron was also forged to make tools for farmers and carpenters, and consumer items, such as nails, needles, and stoves. By 1078, 125,000 tons of iron were being produced each year to make such common items as ship anchors, bridges, gates, pagodas, and Buddhist statues.