The Four Great Inventions

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1 Lecture 1 Invention, Development, and Influences of Papermaking Technology

The invention of papermaking technology is one of the most outstanding contributions made by the Chinese people to the world civilization. It is not only a revolution in writing materials, but also a perquisite for the subsequent invention of typography.

1.1 Character Carriers Before the Invention of Papermaking Technology

Over its long history, the Chinese nation has created brilliant ancient cultures. In the early ages, the ancient Chinese successively used the ancient Chinese character system in animal shells and bones, bronze, pottery, stones, bamboo, wood, silk, and other materials to extensively record incidents in their life. After exploration for more than centuries, the Chinese finally invented "paper," a character carrier of good quality and low cost. To trace the origin and development of papermaking technology, first it is necessary to briefly introduce the major writing materials previously used in China and the regions of other ancient civilizations.

1.1.1 Shell and Bone Inscriptions

So far, archaeological discovery of the earliest documented data is the shell and bone inscriptions of Shang Dynasty. Bone and shell inscriptions derive their name from the carriers: Shell refers to tortoise shells and bone refers to animal bones.

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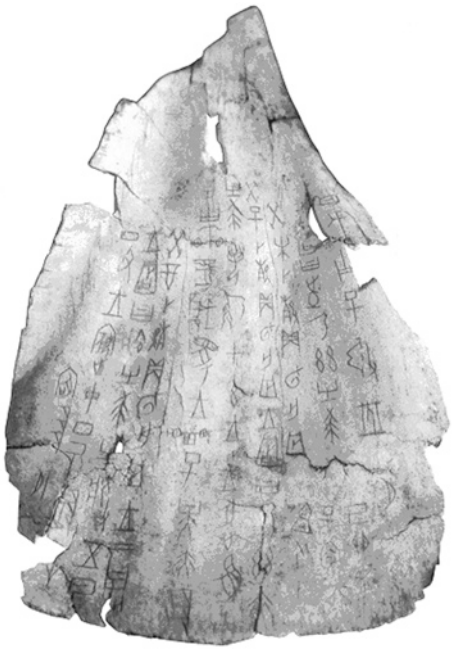

Fig. 1 Shell and bone relics from Yin Ruins

Therefore, shell and bone inscriptions are characters engraved on tortoise shells and animal bones. Shell and bone inscriptions are in use from about fourteenth century BC to twelfth century BC, current for about two centuries.

In the late Shang Dynasty, Yin the capital was subjected to the warfare of Duke Wu of Zhou Dynasty crusaded against Emperor Zhou of Shang Dynasty, and turned into ruins. This incident in history was recorded on shells and bones, was buried for about 3,000 years, and was known to few in the while. In late nineteenth century, farmers from Anyang, Henan Province, accidentally bumped into shell and bone fragments (see Fig. 1) while working in the field. In 1899, Wang Yirong, an epigrapher from Fushan, Shandong Province, recognized for the first time that shell and bone inscriptions were characters used in the Shang Dynasty.[1] From then on, shell and bone relics became the subject of antique collectors, and research in shell and bone inscriptions gradually attracts people's attention.

Aside from Yin Ruins, shell and bone relics are successively unearthed in Qijia of Fufeng, Fengxi of Xi'an, and Fengchu of Qishan in Shaanxi Province; shell and bone relics of the Western Zhou Period are also unearthed at Fangdui Village, Hongzhao County, Shanxi Province, as well as Changping District in Beijing, since the 1950s. Some inscriptions on shell and bone relics of the Western Zhou Period are as small as millets and can only be intelligible with the help of magnifying glass.

[1] Bai Shouli (General Chief Editor), Xu Xichen, Si Weizhi, Yang Zhao (Chief Editor). General History of China Volume 3 [M]. Shanghai: Shanghai People's Publishing House, 1994:116.

Shell and bone inscriptions are mainly oracle texts, interspersed with independent records of historical facts. According to the "*Book of Rites-A Token*," "The rulers of Yin hold the deities in high esteem; they [always] lead the people to wait upon the gods, and put the ghost [of deceased ancestors] before rites." In the Shang Dynasty, people believed in gods and put the gods before rites in the order of obedience. Whenever an important event occurs, they would practice divination to ask for the opinion of the gods and record the divining results. Most of the texts in the bones or shells are directly engraved without writing first, but there are also texts engraved after they were written.

1.1.2 Bronze and Pottery Inscriptions

With the invention and application of pottery making and metal smelting technologies, some ceramic wares and metal utensils were made carriers of characters.

Previously known as bell and tripod scripts, bronze inscriptions refer to epigraphs engraved on ancient bronze objects or other bronze utensils. Archaeological findings show that ancient Chinese had mastered bronze-founding technology back in as early as 3000 BC to 2300 BC. The Shang and Zhou Dynasties mark a period of considerable development of bronze ware in China. The earliest bronze ware unearthed with epigraphs can be traced back to the Shang Dynasty, concurring with shell and bone inscriptions. Statistics has found that about 6,000–7,000 bronze ware unearthed prior to 1950 are with epigraphs, among which 1,000 are made in Qin and Han Dynasties, 1,000 are made in Shang Dynasty, while the rest 4,000 odd pieces are from the Zhou Dynasty.[2] This betrays the fact that bronze wares are the most common character carriers in the Zhou Dynasty.

Epigraphs of the Shang and Western Zhou Dynasties were mainly cast on bronze ware, while it was being made, while later epigraphs were engraved after the ware took shape. It is noteworthy that some epigraphs on bronze ware of Zhou Dynasty adopt molds pieced together, with each mold consisting of one or several characters. This is very similar to the movable types used later on and thus can be deemed as ushering in the application of movable types.

Although concise, epigraphs are greater in length and complete, when compared with shell and bone inscriptions. The longest bronze epigraph in existence is the Maogong Tripod (see Fig. 2) unearthed in Qishan, Shaanxi Province, during Daoguang Era (1821–1850) of the Qing Dynasty. Manufactured in the reign of Emperor Xuan of Western Zhou Dynasty, the tripod has a 499-character epigraph, which can be termed a masterpiece among epigraphs of Western Zhou Dynasty.

In addition to the bronze inscriptions, the seal which appeared in the Shang and Zhou Dynasties has a special significance. The use of the seal is essentially

[2] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988.

Fig. 2 Maogong tripod currently kept in "National Palace Museum" in Taipei

mechanic replication of characters, thus the engraving and use of seal technology, especially the use of bulk seal, can be seen as the forerunner of woodblock printing.

Epigraphs engraved on pottery ware fired from clay are called pottery inscriptions. Pottery ware with epigraphs falls into three categories, i.e., pottery utensils, brick and tiles, and mud caps. Pottery inscriptions have a lot in common with bronze inscriptions. However, pottery utensils are fragile and unfit for long-term preservation, while bronze utensils are strong and durable. Therefore, pottery inscriptions are not used for recording long historic facts like bronze inscriptions are. Instead, they are mainly short texts.

Early pottery ware in China, like painted pottery unearthed in northeast China and north China, emerged approximately in late Neolithic period. There are decoration patterns, pictures, and character-like signs on those potteries.

1.1.3 Boulder Inscriptions

Fabrication of bronze inscriptions requires a complicated casting procedure, while engraving on stones has proven more convenient in comparison. The above-mentioned stone inscriptions of ancient times show that the use of stones as character carries has a long history. However, so far we know that the use of boulders to record feats and recall the ancestors first started in the Qin Dynasty.

It is generally acknowledged in the academia that the 10 stone drums are as the earliest stone engravings extant in the real sense of the word (see Fig. 3). Originally located in Tianxing (now Fengxiang County of Shaanxi Province), those stone drums were rediscovered in the Tang Dynasty, and men of letters like Du Fu, Wei Yingwu, and Han Yu had poems or odes in praise of them. Externally

Fig. 3 Stone drum "*Luanche*" of the warring states period currently kept in the palace museum in Beijng

drum-shaped, the stone drums are irregular in shape and size. The rocks used have a dull color but high rigidity, ranging from 45 to 90 cm in height, and averaging 210 cm in the circumference of cross sections. With wide and flat bottoms, and round yet slightly smaller tops, they look very much alike sections of a cylinder. Texts are engraved around them, in the style of the seal, or Zhou Wen, which is used before Qin Shi Huang unified character. The content is singing praise of the emperors of Qin hunting, and thus, they are also known as "hunting stone tablet." Due to long-term natural erosion and artificial destruction, most of the texts have become obscure, while the text on one of the drums has already vanished completely.

Investigations by modern scholars in the style of the characters and the place of excavation have lead to different opinions regarding the specific time of their engraving: Duke Wen, Duke Mu, Duke Xiang, Duke Xian, and etc. However, it can be basically determined that those stone inscriptions are made in the Kingdom of Qin in eighth century BC to seventh century BC in the Spring and Autumn Period.

After annexing, the six kingdoms of Qi, Chu, Zhao, Wei, Han, and Yan, Emperor Qinshihuang made many visits eastward between 219 BC and 211 BC and established seven stone tablets in Mountain Yishan, Mountain Taishan, etc. in Shandong Province in extolment of his achievements. After his death, his son Qin Ershi circumambulated the country and added "Complementary Remarks" to the stone tablets, to sing eulogy to his virtuous policies.[3]

[3] Sima Qian of the Han Dynasty, Records of the Grand Historian-Biographic Sketch of Emperor Qinshihuang.

After the Han Dynasty, inscribed stones turned into rectangular *bei* from cylindrical *jie*. Usually, rectangular in shape, *bei,* is polished in the exterior to facilitate inscription and thus is far more elaborate than *jie* with its coarse surfaces.

Aside from *bei* and *jie*, the poems of personages and literati, as well as the tribute of visitors, are also carved on the cliffs of famous mountains or places of interest, resulting in cliff carvings. In the fifth and sixth centuries, when Buddhism prevailed in China, cliff carving became so popular that Buddhist gashes and segment of Buddhist classics could be found on cliffs everywhere. The characters were usually large to show the stateliness of the religion. In addition, characters are also carved on the stone materials of various architectures.

Stone classics are another type of stone inscription with great importance after the Han Dynasty. After the Emperor Wu of the Han Dynasty adopted Dong Zhongshu's proposal of "respecting Confucianism as the only doctrine," Confucian classics became the major courses studied by scholars and to be handed down generations after generations. However, "It has been a long time since the emergence of Confucian classics, and mistakes abound. Worse still, worldly scholars tend to give farfetched interpretations, thus misleading future scholars." To avoid mistakes stemming from manual transcription, all Confucian classics were engraved onto stone tablets as the definitive edition. From Xiping Era of the Eastern Han Dynasty to the Wei Dynasty established by Cao Cao, to the Qing Dynasty, Confucian classics were inscribed on stones for seven times. Inscribing on stones has considerable influence on the subsequent invention of typography.

1.1.4 Bamboo Slips and Wooden Tablets

Mo Di (BC 486–BC 367), an important thinker of the Warring States Period, listed in his book *Mo Zi* many character carriers used in ancient times. It is said in *Mo Zi-Ming Gui Xia* that "The wise kings of ancient times customarily consider serving ghosts and gods as their duties and hold ghosts and gods in high respect. Afraid that later generations would fail to observe this custom, they wrote it down on bamboo and silk so as to hand it down. However, the worry over the loss of record due to the corrosion of bamboo and silk caused them to engrave it on boulders and jars or carve it on bronze ware and rocks for assurance."[4]

"Bamboo and silk" mentioned by Mo Zi are bamboo slips and fine silks, which are used as a major writing material in the long era between the Warring States Period and Qin and Han Dynasties, even after the emergence of paper. The characters on the above-mentioned shells and bones, and bronze and boulders are "engraved," instead of being "written" with pens. Strictly speaking, those materials are not "writing" materials. The earliest writing material in China is bamboo slips, and the earliest books are bamboo slips strung together with ropes, also called strung bamboo slips.

[4] Mo Zi. Volume 8. *The Twenty-two Masters*. Shanghai: Shanghai Classics Publishing House, 1986: 249.

It is now difficult to determine the exact time of origin for bamboo slips. The Chinese character "册" in the oracles on the Shang Dynasty shells and bones looks very much like a bunch of bamboo slips strung together with two strings, while the character "典," which is relevant to "册," denotes a book on the table. It is also seen in the bronze inscriptions of Western and Eastern Zhou Dynasties. Therefore, it is believed that the use of bamboo slips began back in the Shang Dynasty. Slips made of animal bones can still be found now. For instance, a tiger bone is kept at the Royal Ontario Museum of Canada. About 22 cm in length and containing 22 characters, the bone slip is made in the third year (1152 BC) of Dixin (i.e., Emperor Zhou of Shang Dynasty). Another bone slip fragment dates back to twelfth century BC. Both of the two can be seen as the beginning of using slips for writing. So far the earliest bamboo slips discovered are the Warring States bamboo slips unearthed in the Tomb of Zenghou Yi of the early Warring States Period (443 BC) in Sui County, Hubei Province, in 1978. The slips are about 72–75 cm in length and 1 cm in width, and characters are written on both sides. The form of the characters is the same as the characters on other utensils of the Warring States Period. The time for bamboo slips to come into use should be earlier than this slip.

"简" (slip) is a collective name for "bamboo slips" and "wooden slips," which are collectively referred to as "bamboo and wooden slips." The emergence of wooden slips may be later than the bamboo slips, probably as their replacement. Wooden slips appeared in the Han Dynasty and became the prevalent writing material during the years before and after the Christian era.[5] First, both bamboo and wooden slips are usually narrow slips straight in form to contain one row of characters from top to bottom only. This shows that in bamboo slips, the material determines its long and narrow shape; after wood replaced bamboo in making slips, the long and narrow shape is naturally preserved. Second, the word "简" has a radical of "竹" (bamboo); concurrence of Bamboo and Silk is often found in the pre-Qin classics, while the use of "wooden slips" in the literature did not appear until the Han Dynasty. Third, just as in literature records, books of the Warring States and early Han Dynasty unearthed in recent years are all bamboo slips, while wooden slips unearthed over the years are from around the Eastern Han Dynasty, mostly in remote regions in the northwest where no bamboo was available.

Slip is the basic unit of ancient books, equivalent to one page of a modern book. Slips sequentially bound together with a string form a book, equivalent to the modern forms of a book. In some cases, characters are written on the slips which are then strung together into a book; in other cases, empty slips are bound into a book, and then, characters are written. In "*Yongyuan Military Materials Register*" unearthed in Dunhuang, some characters are covered by the string, pointing to the fact that characters were written on the slips which are then bound together. In "*Etiquette*" of Han Dynasty unearthed in Wuwei, there were no characters in places covered by the string, showing that the book was made before

[5] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988:60.

any characters were written on the slips. Bamboo slips, unearthed in Zenghou Yi Tombs in Sui County, Hubei Province, are bound with two strings, and the characters immediately above and under the strings are wider spaced, bespeaking the fact that binding comes before writing.

Hemp strings are the most commonly used in binding slips, while silk sash and hide stripes are also used. Liu Xiang mentioned in his book Bie Lu (Abstracts): "Sun Zi's book is written on dried bamboo slips which are bound together with light blue silk cord," referring to the use of "light blue silk cord." Sima Qian remarked in "Records of the Great Historian—the Confucius Family" that elderly Confucius "had read the Book of Changes to such extent that he wore out the cowhide string for three times." This indicates that the Book of Changes read by Confucius had been bound with cowhide cords.

1.1.5 Silk

While it is much easier writing on slips than engraving on stones and metals, the writing space is limited, especially for drawing which requires much greater space. About from 7 BC to 6 BC, the Chinese people began to use silk as a writing material. Silk is light in weight and smooth in texture and can be cut into various shapes and sizes. Therefore, it can be used not only as a text carrier, but also as the solution to the problem rising from the limited spaces of bamboo slips in certain cases of special uses.

It is now impossible to trace when silk was first used as a writing material. In 1934, a silk book ("Chu Zeng book") was unearthed in a Chu Tomb in Changsha. 47 cm in wide and 38.7 cm in length, the book contains characters written with black ink and brush. The characters are flat in font, resembling those on the slips of the Warring States. Research found that it belonged to the Kingdom of Chu during the Warring States Period.[6] Silk manuscripts of the Warring States period are also unearthed in many other places, while those from periods after the Qin and Han Dynasties are even greater in number. No. 3 Han Tomb of Mawangdui, Changsha unearthed in 1973 a large number of silk manuscripts, which were written on full sheets of silk 48 cm in width, or on half sheets 24 cm in width. At the time of excavation, all of them have been severely damaged (see Fig. 4). After restoration, collation and examination, the batch was found to contain a total of 28 books, encompassing 120,000 characters. According to research, earliest of these silk manuscripts was replicated in the 25th year of Qinzheng (222 BC), while the latest was made in the burial time in the 12th year of Emperor Wen of Han Dynasty (167 BC). The transcription years of most of the silk manuscripts should be between Emperor Gaozu and the early years of Emperor Wen of Han Dynasty, i.e., in the 30 years around the beginning of the second century BC.[7]

[6] Qian Cunxun, Book and Script Records in China Before Invention of Printing [M]. Beijing: Print Industry Press, 1988:81–82.

[7] Encyclopedia of China (Volume of Archaeology) [M] Beijing: Encyclopedia of China Publishing House, 1986:307.

Fig. 4 Silk book *Book of Warring-States Strategic Advisors* (partial), unearthed in No. 3 Tomb at Mawangdui

In the Qin and Han Dynasties, both slips and silks were used. Due to the fact that slips are relatively inexpensive and allow easier modification, drafts were often made on slips before final versions were copied onto silk while writing important documents. In addition, silk is greater in width and is often used to draw the illustrations and other figures for bamboo slips.

The silk manuscripts were stored mainly in two ways. One way is to fold and store them in a pouch or wooden box. For example, silk manuscripts found in Changsha Mawangdui were folded and put in lacquer boxes. The other is to roll them on round sticks made of wood or other materials in the fashion of silk reels. Later, the reels are inherited by paper books. The trend of writing material change can also be seen from the directory of history books from the ancient Chinese dynasties: The nearer the era, the greater the use of "volume," a unit denoting silk and paper, and the less the use of "chapter," a unit denoting bamboo slips.

When used as a writing material, silk is clearly superior over slips. It is not only light, soft, easy to carry, but also "easily tailor-made in accordance with the length

Fig. 5 Parchment manuscript, from the monograph of Dard Hunter

of the book."[8] In addition, being white and clear in surface, and awarded with good ink absorption properties, silk is the ideal writing material. Even in Tang Dynasty when papermaking was well developed, people were still writing on silk. Paintings before the Tang Dynasty mostly used silk rather than paper. However, silk is expensive and thus is difficult to popularize.

1.1.6 Writing Materials Used in Other Countries Before Papermaking

Ancient Egyptians and some other peoples of the world carved texts in stone tablets. In ancient Assyria, Babylonia and the Middle East people engrave texts in clay billets, which were then fired to become a hard bricks. In ancient Rome and other European nations, people casted words in brass, bronze, lead plates, and other metal materials. Westerners had also used wood in writing chronicles. All these materials are not different from the writing materials used by the Chinese before the invention of papermaking.

In ancient times, some countries had also used other writing materials, which were not used or popularized in China. Among them, the most noteworthy ones are as follows:

First are animal hides, mainly parchment (see Fig. 5) and vellum. Made of sheep skins and calf hides, those thin sheets were the writing materials in Western countries for a long time.

Second is papyrus. In the Nile basin, there grows a perennial cyperaceous herb (Cyperus papyrus). Egyptians cut of the stem, removed the roots and top, segmented the middle part into two-foot pieces, cleaved the pieces into halves, and flattened them. Then, the flattened sedge stalks were laid out in two layers on a plank, with the upper and lower layer vertically staggered, and vinegar was dropped onto them. After that, they were pounded until completely flat, resulting in the so-called papyrus sheet.

[8] Tang Xu Jian. Initial Learning. Volume 21.

Third, leaves. India, Pakistan, and other countries in ancient times used broad leafs of palm trees for writing, after which two holes were punched in each leaf and then a cord was used to string it together with other leaves. Buddhist scriptures written in such leaves were introduced during the Tang Dynasty to China and called by the Chinese people "Pattra." India had also used in writing the large leaves of fan coconut trees of the Palmae family. Use of leaves as writing material is also found in other regions in ancient times.

Fourth, bark felt. Long before the Europeans arrived in the Americas, the Mayans and Aztecs used thin slices made of bark for writing and painting. Its production method is as follows: removing the colored outer layer of the epidermis from the bark stripped off, tear the endothelial torn into one inch wide strips, put the stripes into a pot, add plant ash, and heat to boil. Then, like production of papyrus piece, lay the boiled bark crisscross on a plank, hammer them into thin slices, dry the slices, and hammer with polished stones. Indigenous peoples on many Pacific islands beat barks to make tapa or kapa. Seen from the principle and production process, the product also belongs to the scope of bark felt.

It is worth noting that the above writing material can be used as text carriers. Some looks like paper externally, while others are dubbed "paper." However, seen from production principles none of them is real paper made through recombination of broken fiber. Yet application of these written materials has continually promoted the development of the writing systems of various nationalities. The writing systems, in turn, put forward higher requirements for writing materials, laying the basis for the invention of paper, a better writing material. About the era before Christ, the Chinese first made a breakthrough. Back then, the widely used writing materials were slips and fine silk, which had major defects as writing materials, although they were far more suitable than stone and other materials for the purpose. Slips are bulky. "*Records of the Great Historian • Imperial Biographies of Qin Shi Huang*" said, "All things in the world of things, big and small, are judged by the emperor himself. Slips are submitted continuously to the emperor, day and night. The slips submitted amount to hundreds of kilograms each day. The emperor cannot take a break unless [officials] stopped submitting." In other words, the bamboo slips marked by Qin Shi Huang during his reign are often weighed in Dan (60 kg). Had these submissions been written on paper, 1 kg of paper might have been more than enough. Silk is expensive, and only a handful of the rich and powerful aristocracy can afford to it. Therefore, silk cannot meet the needs of a rapidly developing society. It was in this context that papermaking came into being.

1.2 Invention and Development of Papermaking

1.2.1 Invention of Papermaking

It is still a controversial issue regarding when papermaking was invented. For a long time, people think that it is Cai Lun (?~AD 121) of the Eastern Han Dynasty that invented papermaking according to the following record from "*Book of Eastern Han Dynasty •The Legend of Cai Lun.*"

Since ancient times, books and documents have been written on slips, and later silk came into use, under the name of paper. Neither silk nor slips are convenient because the former is expensive and the latter cumbersome. Cai Lun creatively used bark, hemp, rags, and used fish nets in producing quality paper, and submitted his invention to the emperor in the first year of Yuanxing (AD 105). The emperor spoke highly of Cai's talents. From then on, people followed suit and began to use the paper invented by Cai Lun, hence the name CaiHou Paper.[9]

In this regard, doubts rose as early as the Tang and Song Dynasties. Some believed that there had been paper before the invention of Cai Lun, who was just proficient in the art handed down by predecessors, just as Zhang Huaiguan of the Tang Dynasty said in Volume 2 "Judgment of Calligraphy," "With the rise of the Han Dynasty, paper began to be used as a substitute for slips. During the reign of Emperor He, Cai Lun dedicated himself to papermaking and improved it."[10]

The above view did not attract much attention until the twentieth century, when archaeologists in China successively discovered some ancient papers ascertained to be made before Cai Lun, such as the Lop Nur Paper, the Baqiao Paper, Jinguan Paper, Fufeng Zhongyan Paper, Majuanwan Paper, Fangmatan Paper, and Xuanquan Paper, which were found to be relics of the Western Han Dynasty. After that, the situation began to change for the better.[11] Now, a growing number of scholars believe that papermaking craft began before Cailun, who was the first to use bark, hemp offal and rags, fishing nets and other raw materials to make paper. Cai also revolutionized papermaking technology and significantly improved the quality of the paper, playing an irreplaceable position in the history of papermaking.

1.2.2 Development of Papermaking in the Early Stages

Shortly after the advent of the "Caihou paper," people moved toward to began to use paper in writing documents and letters. Yu Shinan of the Sui Dynasty (AD 630) remarked in the Volume 104 *Beitang Shuchao* that Cui Yuan (78–143), a scholar of Eastern Han Dynasty, wrote in a letter to his close friend Ge Gong (styled Yuan Fu, 73–143) "I am sending you ten volumes of *Xuzi Shu*, in paper, because I'm too poor to afford to even plain silk," meaning that he could not afford plain silk paper and had no choice but to write on paper. Yu also remarked that Yan Du said in replying to a letter from Zhang Huan, "I thought about you a lot since we parted 3 years ago. Last month I received your letter in care of Boying. Reading the four pages time and again gave me such delight." Boying is the style of Zhang Zhi, who lived from 117 to 192.

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[9] Book of the Later Han. Volume 108. Biography of Cai Lun. The Twenty-five Histories. Book 2 [M]. Shanghai: Shanghai Classics Publishing House, 1986:1022.

[10] Tang • Zhang Huaiguan. Judgment of Calligraphy. Volume 1. On Three Kinds of Fu's. Volume 87: 4016.

[11] Collection of Traditional Chinese Crafts • Papermaking and Printing [M]. Zhengzhou: Elephant Press, 2005.

In the late Eastern Han Dynasty, with the gradually expansion of papermaking places, paper technology witnessed continuous improvement and development. In Donglai Shandong (now Huangxian County Shandong), there appeared a famous papermaker Zuobo (styled Ziyi, 165–226). Zhang Huaiguan said in *Shu Duan*, "Ziyi is exceedingly proficient in papermaking,"[12] praising that Zuobo Paper was superior to Caihou Paper. Historically, there are many men of letters full of praise for Zuobo Paper. For example, "*Xiao Ziliang's Reply to Wang Sengqian's Letter*" said: "Ziyi's paper is smooth and glossy. Characters written on it with Zhongjiang's ink are readily intelligible. One can keep Boyin's brush dancing on the paper until his thoughts are exhausted. However, now the three are gone forever, never to return." One more example: *Sanfu Juelu* recorded: Wei Dan wrote in a memorial submitted to the emperor: "… Artisans should hone their instruments first if they want to do a good job. Zhang Zhi Brush, Zuobo Paper and my ink, are established classics. With the three combined, I can write thousands of words at one sitting."[13] Wei Dan (179–253), styled Zhongjiang, noted calligrapher of the Three Kingdoms Period, the fame of the ink made by him. The ink, pitch black in color, had a fame on a par with Zhang Zhi Brush and Zuobo Paper. It is not difficult to see that extensive use of paper promoted the advances in brush and ink production technology, which went on to promote the development of calligraphy and painting.

Ode to Paper by Fu Xian (234–294) of Jin Dynasty is the earliest essay existing in praise of paper. The original text goes in Chinese classical style of writing.

It says to the effect that in various historical periods, characters have different carriers. First, inscriptions on turtle shells, bones, metals, and stones were used in place of making rope knots for recording incidents. Later, paper replaced slips. Paper is not only suitable for writing, but also low in price, white in color, pure in texture, and exquisite in form. Men of letters are fond of paper and have written many a fabulous essay. Brand-new paper is made from rags and old ropes. Papers can be folded and unfolded, allowing convenient use. Those away from their hometown can use paper to write letters home and convey their feelings.[14]

Although the use of paper had become increasingly common in as early as the Three Kingdoms Period, silk and bamboo as the old writing materials were not fully replaced. A variety of writing materials were used at the same period. After the Jin Dynasty, with the continuous improvement in the quality of paper, people got gradually accustomed to the use of paper and no longer wanted to use expensive silk or cumbersome bamboo slips. In conformity with the historical trend, the government banned use of bamboo slips in the palace. For example, in the later

[12] Tang Zhang Huaiguan. Judgment of Calligraphy. Volume 1. On Three Kinds of Fu's. Volume 87: 4016.

[13] Song Su Yijian. Notes on the Four [Tools] of the Study. (Volume 4). Collection of Series. Book 1493: 50.

[14] Jin Fu Xian. Ode to Paper. In Qing Yan Kejun (eds.) Anthology of Ancient, The Three Dynasties, Qin, Han, Three Kingdoms and Six Dynasties Anthology of Jin (Volume 51) Beijing: China Book Store, 1985:5.

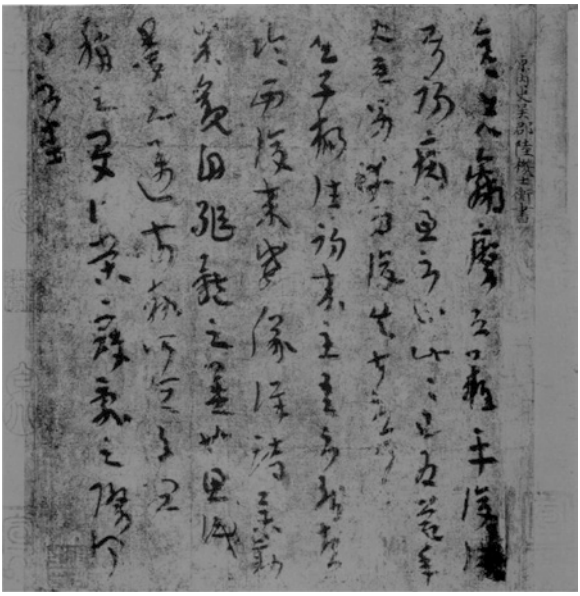

Fig. 6 Pingfu Tie (the calligraphy model)

Eastern Jin Dynasty, Huan Xuan (369–404) dethroned Emperor An of Jin Dynasty and styled himself emperor. After ascended the throne, he ordered that yellow paper be used in the palace, instead of bamboo slips. Volume 605 *Tianping YuLan* cited "*Huan Xuan Usurpation*" "In ancient times, there was no paper, so bamboo slips were used for writing. There was no element of showing respect to predecessors. Now all those who use slips should switch to yellow paper instead."

During this period, papermaking spread to all places in the south and north. The north was dominated by Luoyang, Chang'an, Shanxi, Hebei, Shandong, etc. Papermaking centers in the south were located in Jiangning, Kuaiji, Yangzhou, south Anhui, Guangzhou, etc. Gaochang (now Turpan, Xinjiang) probably started making hemp papers in the 16 Kingdoms Period (304–349). With expanded production areas, paper turnout continued to increase, satisfying social demands to some extent.

The extensive use of the paper also promoted the progress of writing art for Chinese characters and changes in the font. Chinese character fonts changed from the official script and Xiaozhuan popular in the Han Dynasty to Kaili with the features of both official script and regular script, both of which formed in the Period of Wei, Jin and Southern and Northern Dynasties, and Kaili gradually evolved into the regular script. Meanwhile, Caoli (Zhangcao), rising in the later Han Dynasty, continued in use until the Wei and Jin Dynasties and became more characteristic. For example, Pingfu Tie, the Calligraphy Model on hemp paper written by Lu Ji (261–303) of the Western Jin Dynasty and kept in the Beijing Palace Museum (as shown in Fig. 6) is a representative masterpiece. Since then, the cursive Kaili gradually developed into Xingcao, and then to cursive style. Without paper, all those transition would be hard to imagine.

On the other hand, ever new requirements for paper supply spurred by social and cultural developments, and extensive use of paper in official documents, school textbooks, Buddhist, and Taoist classics greatly promoted the prosperity of paper industry and development of papermaking. After Buddhism was introduced to China, in order to meet the needs for the spread of Buddhism, the monks came up with a fast book replication method, at the time when woodblock printing was not yet invented, that is, by encouraging believers to extensively copy Buddhist scriptures, or to buy from monasteries scriptures copied by professional Buddhist scripture transcribers, saying that copying and buying Buddhist scriptures can earn bless of the deities, or afterlife salvation according to the wish of the believers. A large number of Buddhist scriptures found in the Dunhuang Grottoes were handed down by believers who bought and stored them in the temple grotto for worship.

1.2.3 Emergence of Bark Paper in the Tang Dynasty

Sui and Tang Dynasties witnessed considerable prosperity in science and technology, culture and art, and religion. Social demand for paper soared, promoting the vigorous development of papermaking technology, ushering in the first peak mainly featuring the rapid rise of bark paper.

Bark paper first appeared in Cai Lun's period. However, seen from the unearthed material objects, turnout of bark paper before the Tang Dynasty was far less than that of hemp paper, and this scenario did not change until the Northern and Southern Dynasties. Since the Tang Dynasty, bark paper gradually prevailed to become the most important kind of paper, with three main strains, i.e., rattan paper, mulberry bark paper, and mulberry paper.

Rattan paper appeared in the Jin Dynasty and reached its peak in the Tang Dynasty. Wuzhou, and Yuhang County, Xinzhou, and Quzhou of Hangzhou submit rattan paper to the royal palace.

Rattan paper of the Tang Dynasty boasts high quality. Li Zhao of the Tang Dynasty put "Yanxi Rattan paper of Yue first," while listing quality papers at that time in *Guoshi Bu* (Supplementary National History). Rattan paper was used as the high-class paper for official documents and was privileged for the royal family and the royal Taoist temples.

After reaching its peak in the Tang Dynasty, rattan paper soon declined. Rattan was limited in growing areas, slow in growth and long in regeneration cycle, overharvesting inevitably lead to its depletion. Shu Yuanyu, a scholar of Tang Dynasty, indignantly wrote the article *Obituary to the Ancient Rattans in Yanxi*,[15] warning people that moderation should be exerted in development and utilization of natural resources and objective law should be followed, and that sole demand for immediate benefits should be avoided; otherwise, sustainable development would be impossible.

[15] Song Gao Sisun. Yan Records. Volume 5.

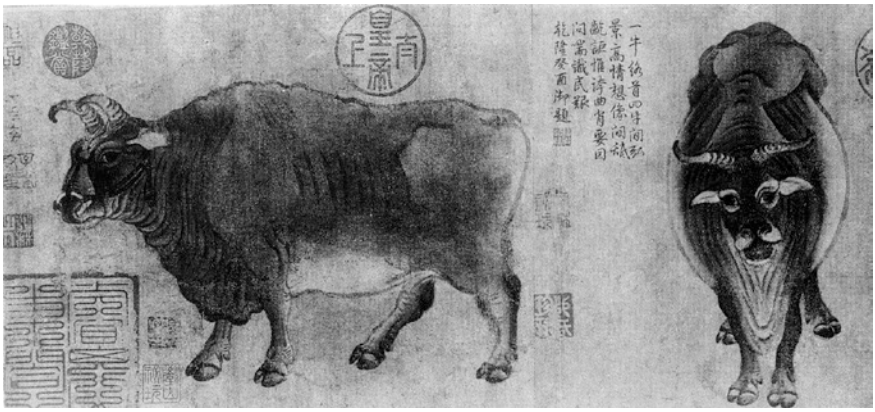

Fig. 7 Wuniu Tu (Five Ox Painting) painted by Han Huang (partial) this is the earliest painting in existence on paper by famous painters. Taken from *Collected Pictures of Ancient Chinese Civilization*

The sudden plummet in rattan paper production put a higher demand for other types of bark paper production. The mulberry bark paper and mulberry paper developed very quickly during this period. Many a bark paper work produced in the Sui and Tang Dynasties has been handed down. The well-known "*Lanting Xu*" copied by Feng Chengsu of the Tang Dynasty is on mulberry bark paper. Wuniu Tu (Five Ox Painting) (Fig. 7) painted by Han Huang (723–787), a painter of the Tang Dynasty, and now kept in Palace Museum, used mulberry bark paper.[16]

Based on the heritage of technology in Tang Dynasty, bark paper production reached a second peak in the Five Dynasties and Ten Kingdoms Period, witnessing the appearance of the most prestigious paper in history—the Chengxintang (Clear Heart House) Paper. According to the records of *Houshan Tancong*, a book by Chen Shidao (1053–1103) of the Northern Song Dynasty, Chengxintang was originally the hall name of Li Lei (888–943) the founding father of Southern Tang. During the reign of Emperor Li Yu in the Southern Tang (961–975), an official bureau was set to make quality paper exclusively for imperial use, and the paper was named the Chengxintang Paper.

The Chengxintang Paper was solely intended for imperial use and occasionally presented to the courtiers. Therefore, it was rarely seen by the outside. After the demise of the Southern Tang Dynasty, the Northern Song Dynasty literati obtained some from the imperial warehouse through palace attendants of the Southern Tang Dynasty and began to chant poetry in its praise, thus making it known and valued by the public. Liu Chang (styled Yuanfu), a scholar of Song Dynasty, presented ten sheets of the Chengxintang Paper he had got to Ouyang Xiu (styled Yongshu, 1007–1068). On seeing the paper, Ouyang Xiu could not hold his praise and made

[16] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M] Beijing: Science Press, 1998:143.

the poem "In Gratitude to Liu Yuanfu for Chengxintang Paper": "Don't you see that talents like Manqing and Zimei had been long-buried in the earth? … Since the departure of those two talents, the mountains have taken a gloomy appearance and low morale. Even if I have Chengxintang Paper, whose praise should I sing for?" Ouyang gasped in admiration, "from where to did you get this paper, so pure, so shiny, so elaborate, so smooth, and so elastic?"[17]

Chengxintang Paper rose to fame, with repeatedly praise from the thinkers of the Northern Song Dynasty. Due to the rarity of original pieces, Chengxintang Paper became very precious and plainly unattainable for ordinary literati. Therefore, imitations kept appearing from the Northern Song Dynasty to the reign of Emperor Qianlong of Qing Dynasty. Only five types of Chengxintang Paper mentioned in the literature of subsequent generations are genuine, while the majority are more likely to be later imitations.

1.2.4 Technical Achievement in Fine Letter Paper in the Tang Dynasty

Tang Dynasty also attained high achievements in letter-paper craftsmanship. The so-called letter-paper refinement techniques refer to finishing process of the original paper through calendering, applying glue, applying wax, dyeing, etc. to make it more elaborate or to meet specific needs.

Refined letter paper appeared only slightly later than the invention of papermaking. The previously mentioned Zuobo Paper with "elaborate glow" is the result of calendering. By the Jin and Southern and Northern Dynasties, dyed paper became generally used in writing edict and documents, and the five classics and Zi Shi, due to rapid development in paper-dying technology. In the Eastern Jin Dynasty, there were multiple colored papers, including blue, red, light blue, and pink, reflecting significant increase over the previous era in the variety of dyed paper.

After the Tang Dynasty, refined letter-paper skills saw all round development, as witnessed by the appearance of surface wax application, gold sprinkling, and other methods. Various methods combined to create a number of new varieties of letter paper.

Hardened yellow paper of the Tang Dynasty is the most valuable. Also known as "Yellow Hard" it is often referred by subsequent generations as "Yellow Wax Letter Paper" (as shown in Fig. 8). This kind of paper assumes a yellow or light yellow appearance, has a hard and smooth texture, and gives off a crisp sound while being shaken. Based on the wax letter-paper production process, people of the Tang Dynasty combined the coating and powdering techniques of the Wei, Jin and Southern and Northern Dynasties with wax application technique to make flour wax letter paper: At first, white mineral fine powder is coated on the paper; wax is applied, before the final process of calendering. The resultant paper has the advantages of both letter paper and waxes letter paper. People from later generations applied gilt on the powder wax paper to produce gilt wax paper.

[17] Northern Song Ouyang Xiu. Complete Works of Ouyang Xiu. Volume 5.

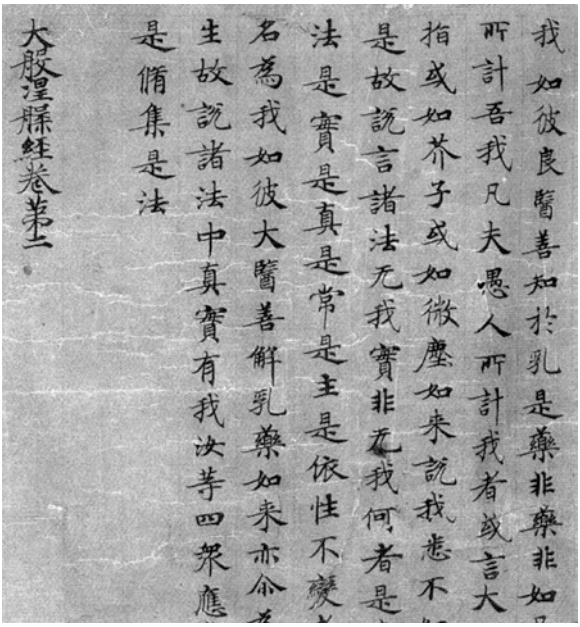

Fig. 8 Hardened yellow thin paper of Tang Dynasty

Among the dyed papers of the Tang Dynasty, Xue Tao paper is the most famous. The paper was named after its maker Xue Tao (styled Hongdu, about 781–832). Xue was good at writing short poems, so she specifically asked the paper technician to make smaller-sized papers in order to solve the problem of unduly waste in normal-sized paper. The resultant paper was well received by people, partly because of its pleasant color. Li Shangyin (ca. 813–ca. 858) of the late Tang Dynasty wrote in her poem *Seeing Cui Jue off to Xichuan,* "Huanhua letter paper has the color of peach blossoms, and deserves good inscriptions in praise of the crescent moon."[18]

1.2.5 The Sudden Emergence of Bamboo Paper in the Song Dynasty

With the continuous development of papermaking technology, the quality of paper was continuously improved and the consumption of paper also incessantly increased. The original linens and barks could not meet the needs of the paper industry for materials, and the development of new raw materials became urgent. The maturity of hemp paper and bark paper manufacturing technology also made the technical preparations for the development and use of new raw materials, and the production of new kinds of paper. It is under such conditions that bamboo paper, which uses bamboo fiber as raw material, came into being.

[18] Complete Poems of Tang Dynasty. Book 2[M] Shanghai: Shanghai Classics Publishing House, 1986: 1361.

Fig. 9 Bamboo paper version of calligraphy of "Coral Note" by Mi Fu

Techniques for making bamboo paper was invented in a time no later than the Tang Dynasty and came to maturity in the Song Dynsty. Mi Fu said in "*History of Books,*" "I once processed bamboo [paper] of Yuezhou by hammering, and found it smooth as the gold plates, and better than Youquan Paper. I resized it to make scrolls, which were stored in a book case. The process was repeated and I could make dozens of scrolls a day." Mi Fu added in his *Paper Assessment Note*, "After processed via innumerous hammering the bamboo paper from Yue became lovely tight and thin, and better than Youquan Paper. I began to make this paper at the age of fifty, and named it gold version." Mi believes that bamboo paper of Yuezhou is superior to Youquan Paper of Hangzhou.

Mi Fu's Coral Note (as shown in Fig. 9) is now kept in the Palace Museum in Beijing. Examination has found that it had used bamboo paper, which is yellow, contains many fiber bundles, and its smooth surface bespeaks processing though calendering.[19] In the Southern Song Dynasty, bamboo paper manufacturing technology became greatly improved, and refined bamboo paper was gradually able to compete with rattan paper and bark paper for its low price.

Shi Su recorded in *Jiatai Kuaiji Annals*, "Now bamboo paper becomes the only paper with worldwide fame, and no imitation has succeeded so far. Thus it has eclipsed rattan paper. There are three types of superior bamboo papers, i.e., Yaohuang, Xueshi, and Shaogong—the three are equal." Shi also summed up the five advantages of Kuaiji bamboo paper as "first, smooth; second, displaying the advantages of ink; third, suitable for stunts with the tip of writing brush; fourth, maintaining the ink well despite repeated folding and unfolding; fifth, resistant to worms."[20] Chen You in "*Fuxuan Yelu*" (1210) also spoke highly of bamboo paper from Zhejiang "Currently, the bamboo paper of Yue is superior to that of other places."[21]

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[19] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M] Beijing: Science Press, 1998:187.

[20] Southern Song Shi Su. Jiatai Kuaiji Records. Volume 17, Records of Produce. Complete Library in Four Branches of Literature.

[21] Southern Song Dynasty Chen You. Fuxuan Yelu. Volume 2. Complete Library in Four Branches of Literature.

In the Song Dynasty, book printing industry was well developed, and there were five book printing centers of Hangzhou Jianyang, Meishan, Kaifeng, and Pingyang (Now Linfen, Shanxi). "Jianben" (also known as "Mashaben") engraved in Jianyang Fujian won out and became most popular due to its lower price, just as recorded in Volume 11 of *Fangyu Shenglan* by Zhu Mu of the Southern Song Dynasty, "Masha and Chonghua are book producers and known as the House of Books." Jianben primarily used bamboo paper. Later, Zhejiang, Jiangxi, and other areas with developed book printing industry became main producing areas of bamboo paper, and block-printed books often used locally manufactured paper.

1.2.6 Achievement of Bark Paper in Song, Yuan, Ming, and Qing Dynasties

The masterpiece of bark paper craft in the Song and Yuan Dynasties is Pizhi. "*Wenfang Sipu*" recorded that "Yi and Xi produce many varieties of quality paper, including Ningshuang, Chengxin, and etc. In some cases the large-sized paper can reach 50 Chi (1 Chi = 33.33 cm) in length." Manufacturing paper of such size not only requires special papermaking facilities, but also superb operating skills. Precision is required in each step. Before the advent of papermaking machines in the nineteenth century, Western countries never mastered the technology for production of large-size paper.

Mulberry paper still developed after the Song, Jin, and Yuan Dynasties. During Jin and Yuan period, it was continued to use the system of Song Dynasty for issuing paper money, which uses mulberry paper from the north (as shown in Fig. 10). According to "*The History of the Jin • Shihuozhi*" recorded, "In May the system of paper money repeatedly changed—new systems became invalid soon after they were promulgated. The mulberry bark and old paper used in papermaking were levied on the people, and the levy became very difficult. So the government ordered to have mulberry bark and old paper priced, on used this as a basis to collect Mulberry-bark-and-old-paper tax in the form of Weibaoquan and Tongbao, on the ground that such a tax can free people from the ordeal of transporting and save costs."[22] Paper money has high requirements on the quality of the paper, so the fact that mulberry bark paper in north China was used in the Jin and Yuan Dynasties to make money reflects its superior quality at that time.

Ming and Qing Dynasties epitomized papermaking technologies and is the third peak of the development of bark paper technology. The highest achievement of bark paper in the Ming Dynasty is Xuande Paper produced in Xuande years (1426–1435). The Xuande Paper is the general term for a series of refined letter papers, whose main varieties include white letter paper, gold-sprinkled letter paper, five-toner pink letter paper, five-toner letter paper with golden flowers, five-toner curtain paper, and porcelain green paper. These papers were submitted for imperial use for their superior quality and thus the name Xuande Paper.

[22] History of Jin. Volume 48. A Record of Food and Commodities 3. The Twenty-five Histories. Book 9: 7036.

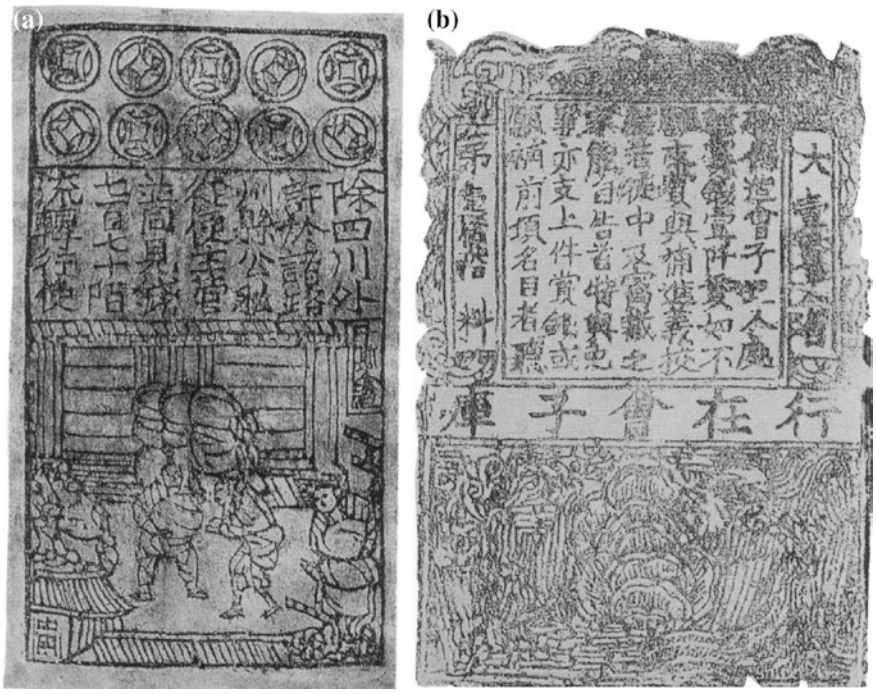

Fig. 10 Paper money of the Song Dynasties. **a** Jiaozi of the Northern Song Dynasty, **b** Huizi of the Southern Song Dynasty

The last peak in development for bark paper is the advent of Rice Paper Era. The term "Xuanzhi" (rice paper) is first seen in Volume III of *Famous Paintings of All Periods* compiled by Zhang Yanyuan of the Tang Dynasty, "Good families should set aside hundreds of Xuanzhi sheets, and wax them for counter-drawing." "Xuanzhi" is the abbreviation for "Xuanzhou Gongzhi" (the tribute papers from Xuanzhou). From the Tang Dynasty to the Qing Dynasty, making technique for Xuanzhi witnessed a series of development stages, with changes in raw materials, production process, and even product name. "Xuanzhi" is the general term for the tribute papers produced in Xuanzhou, and the name derived from "Xuanzhou Gongzhi" of the Tang Dynasty. In its development process, Xuanzhi inherited the bark paper manufacturing technology of Wannan—as represented by Chengxintang Paper—in the Song Dynasty and the advanced technology of Xuande Paper, with continuous improvement in the long period of Yuan and Ming Dynasties. By the middle and late Ming Dynasty, Xuanzhi had become perfected and the outstanding representative of handmade paper in China.[23] In compilation of *Complete Library in Four Branches of Literature* in the Qing Dynasty (as

[23] Fan Xilu, Zhang Binglun and Fang Xiaoyang, Connotations of Xuanzhi Concept from the Perspective of Its Technological Origin [J]. Historical Research in Auhui, 2009: 2.

Fig. 11 *Complete library in four branches of literature* compiled in the Qing Dynasty

shown in Fig. 11), Xuanzhi was used. Just as Hu Yunyu (styled Pu'an, 1879–1947), the scholar from Jing County in late Qing Dynasty had remarked in "*On Papers • Xuanzhi,*" "Jing County was known as Xuanzhou in ancient times. Across the country produces the largest amount of papers, called Xuanzhi, which is produced in Xuancheng, Ningguo Jingxian and Taiping, hence the name Xuanzhi. The paper produced in Jing County is especially elaborate. Now Xuanzhi is produced in Jing County only, and thus is also known as Jingxian paper."[24]

1.2.7 Manual Papermaking Since the Late Qing Dynasty

After the Opium War, the influx of Western machine-made paper into market had an impact on sales of handmade paper. Since the late Qing Dynasty the papermaking equipment began to be introduced for production of machine-made paper, efforts were made to imitate Lianshi Paper and MaoBian Paper in response to market demands. A variety of papers including Yanglianshi and Jilianshi were produced, resulting in increasingly serious impact on handmade paper. With the continued development of the paper industry, the handmade paper production was generally in the state of contraction. In addition, there were war and chaos, so papermaking shops in many areas had to shut down or turn away.

During the Anti-Japanese War, material supply in the rear was in shortage. Some manual papermaking workshops restored production to meet the demand for paper, and traditional paper industry flourished once again. For instance, bamboo paper production in Jiajiang, Sichuan made considerable progress in this period.

After the founding of the People's Republic of China, manual bamboo papermaking in other war-torn areas soon revived and developed, aside from Jiajiang which continued the development of bamboo paper. In the early days of the nation, the paper industry was still relatively backward. And with economic blockade,

[24] Hu Yunyu. On Paper. Puxuezhai Series, Volume. 4.

China's import of wood pulp was once cut off, and machine-made paper could not meet the needs of the society. Paper-producing areas took active measure of self-help production, not only furnishing an important supplement to the paper market, but also contributed to the rapid rise papermaking industry in China by turning many workshop of lower-class bamboo paper into bamboo pulp boards for machine paper factories in the context of originally backward domestic paper industry suffering shortage of raw materials.[25]

After the 1980s, the Chinese government adopted the policy of reform and opening. Traditional calligraphy and Chinese painting picked up vitality. With the revival of the ancient classics printing industry, the demand for handmade paper increased, lending vitality to handmade paper production. According to our investigation in recent years, Jingxian County of Anhui Province, Jiajiang of Sichuan Province, and Fuyang of Zhejiang Province are still major producing areas for handmade papers with relatively larger numbers of workshops and greater turnout. In addition, there are many manual papermaking workshops of varying scales in places in Yunnan, Guizhou, Guangxi, Anhui, Hebei, Shaanxi, Shandong, Shanxi, and other provinces.

1.3 Dissemination of Papermaking and Its Influences on Modern Papermaking Technology

1.3.1 Dissemination of Papermaking in Countries Adjacent to China

Dissemination of papermaking overseas started with regions adjacent to China.

Korean Peninsula adjoins China. Lelang County (now the Pyongyang area) in the north was established in the 3rd year (108 BC) of Yuamfeng during reign of Emperor Wu of Han Dynasty, under the jurisdiction of Department of Youzhou Prefectural Governor of Western Han Dynasty. Since the Western Han Dynasty, many Chinese had settled down here and in the Eastern Han Dynasty, and Wei and Jin Dynasties, Lelang County was governed by the Han ethnic group, who not only used paper made in China, but also brought the papermaking technology there. In about third century AD to fourth century AD, artisans from northern China began making paper there. Goguryeo, bordering Lelang and Liaodong, started making paper roughly at the same time. Baekje and Silla might be a little later in papermaking, but no later than the fifth century AD.[26]

In the early states, the Korean peninsula produced hemp paper, which were thick in texture and which had the characteristics of paper from north China. In the later half ninth century, Wang's Koryo Dynasty rose, overthrew Silla in 935 AD,

[25] Wang Shiwen. Historical Review of Traditional Chinese Bamboo Paper and Treat of the Features of Its Manufacturing Technology [J]. Paper History Research: (15).

[26] Pan Jixing. The Four Ancient Great Inventions in China—Origin, Dissemination Overseas and Global Influences [M]. Beijing: University of Science and Technology of China Press, 2002:361–367.

and established a unified peninsula feudal dynasty. Papermaking skills of Korea witnessed further development, with the progress in bark papermaking especially significant. After the Song Dynasty, Koryo paper entered China as a tribute paper and was appreciated by the literati. Han Ju, a poet of the Song Dynasty (ca. 1086–1153), had the expression of "The Koryo paper you sent me are white like tallow and moonlight sprinkled on the tea table,"[27] and so on in his poem "*Gratitude to Qian Xunzhong for the Koryo Ink.*" In the late fourteenth century, Koryo Dynasty came to an end, ushering in the era of Li Dynasty, under the title of Korea. Li Dynasty and its Chinese contemporary Ming and Qing Dynasties continued to maintain friendly relations and cultural exchanges. Chinese still inappropriately called the Korean paper "Koryo paper." Like China, Korea entered a period of outstanding papermaking technology during this period, further improving the quality of the paper. Shen Defu (1578–1642) of the Ming Dynasty even remarked that "Among all papers currently in use around the world, Koryo paper is the best."[28] Despite the partiality in Shen's comment, the quality of Koryo paper is evident.

Japan, overlooking China across the sea, started economic and cultural exchanges with China early on. According to the research of Pan Jixing, the starting time of Japanese papermaking should be the fifth century when Wang Ren, Gong Yuejun, Azhi Shizhu, and many other Chinese people came to settle down in Japan from the Korean peninsula. This era is equivalent to the Jin and the Sixteen Kingdoms period in China. After entering the Nara Dynasty (710–794), Japan enjoyed social stability, economic prosperity, and booming cultural and educational undertakings. All those brought about a surge in the demand for paper, and the fast increasing demand greatly stimulated the development of local paper industry. Mino, Musashi, and many places in Honshu Island and Awa of Shikoku Island were sending paper as tribute to central government. Broken burlap, mulberry bark, and gampi were the main raw materials. Over time, papermaking in Japan gradually formed its own characteristics in process.

Bordering China in the south, Vietnam and Chinese mainland were under the reign of the same government in the 1,000 years between the Han Dynasty and Song Dynasty and used the same reign title and characters. Papermaking in Vietnam started in about the early third century, when Shi Xie (137–226) was in office of the prefect of Cochin.

Despite the fact that India borders with China and started direct economic and cultural exchanges with it since the Western Han Dynasty, and the fact that Buddhism was introduced from India to China in as early as the first century, we can see from currently available information that papermaking entered India might not be earlier than the seventh century. The route was probably from Xinjiang via Kashmir, or from Tibet via Nepal. Pakistan and Bangladesh started making paper slightly later than India, but reached a high level in no later than the thirteenth century to fourteenth century.

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[27] Song Han Ju. Collected Poems of Lingyang.

[28] Ming Shen Defu. Feifu Yulüe. Collected Series. Book 1559. Shanghai: Commercial press, 1937.

1.3.2 Dissemination of Papermaking to Europe

It is in the Tianbao years (AD 751) during the reign of emperor Xuanzong in the Tang Dynasty that the Chinese papermaking was introduced to the West and Arab. Prior to this, "in early eighth century, the Arabs ruled the region equivalent to Turkestan of the former Soviet Union. This situation is well documented in the Arab history books. Back then Turkic civil war broke out, and one of the leaders asked for assistance from China, while another sought help from the Arabs. Arabs defeated the Chinese army and drove the latter to the frontier of China. Among the captives there were paper workers who later teach papermaking art in Samarkand."[29]

Dissemination of papermaking to Europe can be divided into two phases: the first phase is from twelfth century to thirteenth century, when papermaking was introduced to Europe by the Arabs from the Tang Dynasty. The second phase is from the eighteenth century to the nineteenth century, when the Chinese papermaking technology was directly introduced to Europe by Europeans and eventually led to revolution in the papermaking technology. In Europe, Spain is the earliest to make paper locally, and one of the reasons is that it was once under rule of the Arabs. Previously, European had to import paper mainly from Arabia for use. The Arabian paper was transported from Damascus via the Byzantine Constantinople to Europe. An alternative route is from Egypt and Morocco in North Africa via Sicily in the Mediterranean. Introduction of papermaking to Italy might have been achieved via the same two sea routes. The first paper workshop in Italy was established in 1276 in Monte Fano in central Italy, and it produced hemp paper.

Since then, France introduced papermaking from bordering Spain in the mid-fourteenth century, while Germany established a paper workshop in the latter half of the fourteenth century with several Italian paper workers brought to the country by a businessman named Strom back to his hometown Nuremberg. Nuremberg later became famous for papermaking, and the center of the printing industry in Germany. Since then, Switzerland, the Netherlands, the United Kingdom, Denmark, Norway, and other European countries successively imported technology from neighboring countries to establish paper factories.

In the New World in America, the Spaniards established in 1575 the first papermaking field in Mexico. More than one century later, that is, in 1690, Rit House an immigrant from Germany built the first-hand paper company in Germantown, a city near Philadelphia within the boundary of the USA. By 1776 when the USA became independent, paper factories had been widely distributed in many states.

In the eighth century, it was papermaking process of the Tang Dynasty that got introduced from China to the West. When Europe and the USA successively established their own paper factories, papermaking in China continued to develop. After

[29] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West [M]. Beijing: Commercial press, 1957: 112.

development over the 1,000-odd years spanning the Song, Yuan, Ming, and Qing Dynasties, the overall level of papermaking had exceeded that in the Tang Dynasty. Although Europe also contributed to the development of the traditional papermaking artistry—for example, the Dutch invented the beater in 1680, and the Germans first started using a screw press in the sixteenth century—the overall level lagged far behind China. This is especially true in variety of paper materials, use of paper drugs (viscous additives used in papermaking), and manufacturing of large-format papers where Europe had a significant gap to bridge in order to catch up with China. Learning the situation from Jesuits sent to China, Europeans began introducing paper technology from China for the second time from the middle of the eighteenth century.[30]

1.3.3 Influences of Traditional Papermaking Techniques on Mechanical Papermaking

Modern paper machine was invented in 1798 by French named Robert. Originally, it was just a small-sized machine established in Eisenach paper mill, with a lot to be improved. After many years, a really practical machine was set up by Gerber and Don King in England. From then on, papermaking entered the modern mechanized process.

The modern paper machine is composed of three main parts, i.e., the wire section, the press section, and the dryer section, all of which adopt the principles of papermaking in China. Therefore, just as Carter put it, "it is a most irrefutable and absolute truth that papermaking has been invented by the Chinese. Other countries might be able to contend with China for being the originator of other discoveries. They might be justified in arguing that those discoveries germinated in China but depended on the West for development and utilization. However, the Chinese papermaking spread abroad as a well developed process. Actually there is no substantial difference between the paper used today and the paper back then. Even in today, China still wants further improvements in papermaking. The thin printing paper and tough paper we used now spread from China to the West in the nineteenth century."[31]

Papermaking made unparalleled contributions to world civilization. It not only provides mankind with a new and convenient textual and graphic carrier, promotes the spread and development of human culture, but also lays the foundation for the invention of printing. It can be said that without papermaking, there would be no printing, because without paper as the cheap material, printing would lose its meaning of existence. In addition, it also created painting and calligraphy unique to the Chinese. At this point, mechanical papermaking so far has not completely replaced the traditional papermaking technique.

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[30] Pan Jixing. The Four Ancient Great Inventions in China—Origin, Dissemination Overseas and Global Influences [M]. Beijing: University of Science and Technology of China Press, 2002:392–397.

[31] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West. [M] Beijing: Commercial press, 1957:17.

1.4 Evolution of Traditional Papermaking from the Perspective of Dongba Paper of Naxi Ethnic Groups

The time of papermaking origin has been a hot topic in research of papermaking history. However, research in the evolution of the papermaking process is still insufficient. The current academia cannot give definite answers to many problems, including which process was used in the early stages of papermaking, when it began to use paper drugs, and when was papermaking process used. The reason is lack of sufficient evidence. In recent years, more and more data gradually emerge with the deepening of survey in intangible cultural heritage, making it possible for us to further explore these issues. According to the information available, we had questioned the view of Cai Lun inventing paper drug and put forward a new view.[32] Recently, we find that traditional papermaking processes in some places carry important information, which can help us construct the evolutionary process of paper craft.

1.4.1 Production Technique for Dongba Paper of Naxi Ethnic Group

Naxi Ethnic Groups in Daju of Yulong County and Baidi, Shangri-La County, Diqing Tibetan Autonomous Prefecture, Lijiang City, Yunnan Province still retain the original Dongba paper production process. In recent years, Li Xiaocen, Zhu Xia, Chen Dengyu, and many other scholars have successively been to the place of origin for fieldwork. According to the investigation report, the bark of a shrub in the family of Wikstroemia Thymelaeaceae is used as the materials for production of Dongba Paper. The production process includes acquiring raw materials, drying materials, soaking, cooking, rinsing, pulping, making paper, drying the paper, calendering the paper. Compared with the process of mulberry bark paper and mulberry paper, the set of processes have many features, but the most noteworthy is the process of making paper.

The uniqueness of the finishing technique for Dongba paper lies in that the technique is not only different from ordinary papermaking, but also different from pouring paper. Therefore, it can be seen as a third technique. To facilitate discussion, we will briefly introduce this process.

Papermaking tool used in Chinese mainland is shown in Fig. 12. It is constituted by two parts: the bamboo curtain and curtain frame. Similarly, Dongba paper papermaking tool is composed of two parts: the curtain and frame (as shown in Fig. 13). The curtain "is made of rows of thin bamboo strips connected with twines." Curtain frame "is shaped after the drawer and its inner space is spacious enough to contain the paper curtain. Thus, its size matches that of the paper curtain. On the bottom, there are two to three horizontal rungs used to support the

[32] Jialu Fan, Fang Xiaoyang. Several Issues Relevant to Paper Drug Invention [J]. Journal of Nanchang University (Humanities and Social Sciences), 2000(2) 132–136.

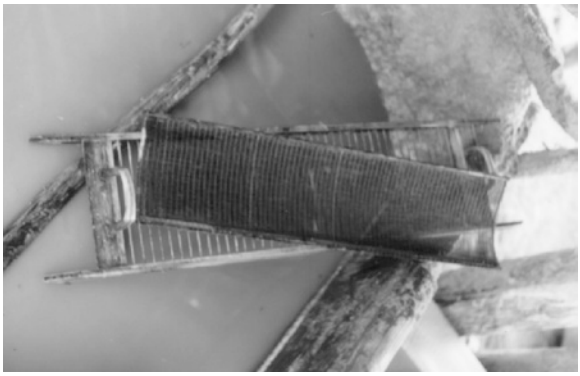

Fig. 12 Paper curtain and curtain support for papermaking in Chinese mainland

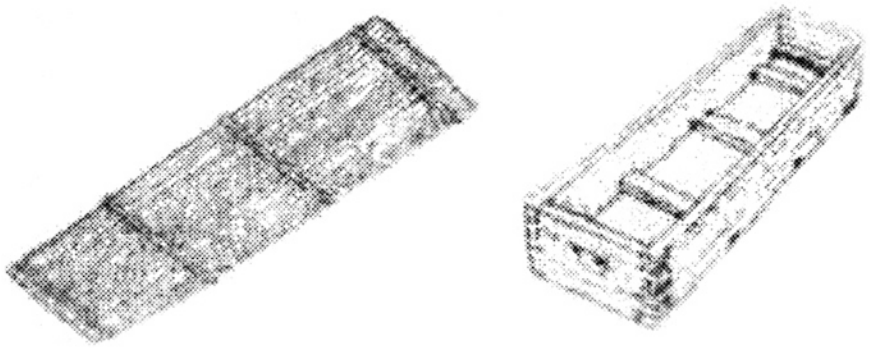

Fig. 13 Tools for making Dongba paper by Naxi ethnic groups

paper curtain." We have noticed that there are significant differences between the curtain used in Dongba and that in the Chinese mainland. First, the latter can be rolled up, and unfolded, while former is like a fixed bamboo fence which cannot be rolled up. Second, the wires in the latter are very thin, generally below 1 mm in diameter. In some cases, they are only 0.3 mm. In comparison, those in the former are much thicker. There is also a significant difference in curtain frame between the two. The curtain frame used in papermaking in Chinese mainland is thin, equivalent to a screen for fixating papers. Smaller curtain frames are no thicker than 3 cm, and those used for 4-Chi (1 Chi = 33.33 cm) rice papers are normally no thicker than 6 cm. Here, the curtain frame "is shaped like a drawer" and can reach 20 cm in thickness.

In fact, the differences in tool reflect that in process. The papermaking process in Chinese mainland is as follows: secure curtain on the curtain frame, hold both ends of the curtain frame with hands, plug the curtain into the groove, lift the pulp and make it evenly distributed on the paper screen, and then peel the curtain off from

Fig. 14 Lift the curtain after putting the lift paper upside down on the paper stack

the frame and turn it over on the paper stack, lift the curtain (as shown in Fig. 14). The process can be repeated again to make thousands of sheets of paper as drain the paper stack, lift the paper sheet by sheet, and then begin the drying treatment.

For Dongba paper, the process is different. The first step is to put curtain into the curtain frame, immerse it in water, place the beaten pulp on the curtain, and shake the curtain to make the pulp even. Then take out the paper curtain, directly flip it over on the wall or board for drying paper, pat the wet paper slightly so that the wet paper can get stuck to the wall or board, and then remove the curtain, and make the second sheet.

Although in making Dongba paper, removable curtain is used, which is similar to the tool used in papermaking method. However, seen from the above procedure, it has much in common with pouring paper.

Pouring papermaking method is a process different from papermaking, in that the curtain is stationary, i.e., the curtain and the curtain frame are combined into one, and that homespun rather than bamboo filament is used in the curtain. While pouring paper, sprinkle the pulp on the paper curtain, and shake the curtain so that the pulp becomes evenly distributed. Lift the curtain, dry the paper in the sun, and peel it off. The Tibetan manual papermaking technique currently kept in Dege Sutra Printing House in Sichuan is the pouring method. In addition, pouring method is still in existence in Mannzhaozhai, Mengkun Township, Menghai County, Yunnan Province, etc.

Removable bamboo curtain and independent curtain are repeatedly used in Dongba paper, similar to the papermaking process. However, the process of making Dongba paper shares some common ground with pouring method in that its curtain cannot be rolled up and the pulp is poured instead of being lift up. So it is a paper manufacturing process between pouring paper and papermaking.

1.4.2 Technical Origins of Dongba Paper Process

The fact that the manufacturing technique of Dongba paper between pouring paper and papermaking carries important historical information, which attracts the attention of researchers far and wide.

Most of the relevant research that the author has learnt believe that it results from the merge of pouring paper method and papermaking process. For instance, Mr. Chen Dengyu believed that The Naxi ethnic group absorbed the strengths of papermaking method and pouring paper method to create a unique Dongba paper during their exchanges with the adjacent Bai ethnic groups and Tibetan ethnic group.[33]

The reason for them to come to this conclusion is that "in China, there are two distinct systems in traditional paper manufacturing technique: one is the traditional papermaking system, and the other is pouring paper." Seen from the existing situation, this is an objective fact. However, different understandings of the fact will lead to very different inferences.

Li Xiaoceng and Zhu Xia believe that the birthplaces of papermaking method and pouring paper method are different. The reasons are as follows: Firstly, the two methods have significantly different characteristics: the papermaking process is mainly found in the East Asian continent, while pouring paper method is mainly seen in the Indo-Pakistan subcontinent and Southeast Asia; papermaking process is mainly used in the Chinese cultural area for production of papers for cultural purposes and sanitary paper, while pouring paper method is mainly used in Buddhist cultural district in India for the production of papers for Buddhist scriptures; technically both are two distinct systems; Secondly, some literatures have relevant records. For instance, the *Condition of Plants in the South* recorded "Honey-scent paper" as "tough handmade paper produced in ancient India using daphne bark as the raw material via pouring paper method." The final conclusion is the papermaking process originated in Chinese mainland and is related to silk whitening by the ancient Chinese; pouring paper may have originated in areas beyond Chinese mainland, including the vast areas of the Indo-Pakistan subcontinent and Southeast Asia, and is related to clothing and bark cloth, while its dissemination and use is closely related to the Buddhist culture of India.[34]

Although this argument is not entirely unfounded, the evidence is far from being able to necessarily lead to this conclusion. In fact, now there is no direct evidence showing which is used at the beginning of the invention of papermaking—the pouring paper method, the papermaking method, or another method. The question is, how we understand the several different processes we see today? You can think of each process as having its own unique origin. You can also believe

[33] Chen Dengyu. Exploration of New Methods in Dongba Paper of Naxi Ethnic Group [J] Ethnic Art Studies, 2004(6):70–78.

[34] Li Xiaocen, Zhuxia. Manual Papermaking in Ethnic Groups in Yunnan Province [M]. Kunming: Yunnan Fine Arts Press, 1999:88–94.

that the various processes are not mutually independent; instead, they are the remains of the same process in different evolutionary stages. Changes result in diversity, just as the case of evolution of animals. When we say that man evolved from apes, we mean that only some of the apes evolved into human beings, not that all the apes evolved into human beings. As a result, there are the two species of human and ape. If we say that humans and apes have always been two species with their respective origins, logically there is no problem. Otherwise, people would not have believed so before Darwin.

It stands to reason that all kinds of process are evolving in varying degrees. It is hard to imagine people from the time of Cai Lun can produce paper so uniformed and so thin with the thin curtain see today. It is equally difficult to imagine that a certain process would stay constant without improvement in the long years. The manual papermaking processes that we see at different places are different. Can we say that these processes have their own respective origins? If the papermaking process did not exist in Cai Lun's era, how did people make paper? Mr. Pan Jixing in the early 1970s proposed that the first paper should have been produced by pouring paper.[35] The reason for him to think so is that he only knew these two methods and that pouring paper is more backward than the papermaking method. We believe that, if there were no more primitive method, then the inference is correct. Of course, if Cai Lun really used pouring paper method, the method should be far more primitive than what we see today. Since it is considered that the papermaking method comes from pouring paper method, how exactly does the evolution occur? Which intermediate forms are involved? Before we see the papermaking skills in Dongba, we have been confused by these issues.

While undertaking review at the Ministry of Culture in the first session of intangible cultural heritage projects, the author had access to data of Dongba paper production technology in Yunnan Province. In videotapes, the author clearly saw the entire production process of Dongba paper. Seeing the paper worker lifting (strictly speaking, should be "pouring") the paper curtain with wet paper and securing on the drying wall, and then softly sticking the paper to the wall, I cannot help but exclaim, isn't it the transition between pouring paper and papermaking process that I've been looking for?

The repeated use of one curtain in Dongba paper craft, rather than preparation of hundred of curtains as does the pouring paper method, helped saving costs. But compared to the papermaking process, it puts one sheet to dry every time it lifts one—i.e., the two processes of lifting and drying are not separated—and productivity is lower. Therefore, it should be an intermediate form in transition from pouring paper method to the papermaking process. If the case were like what Mr. Chen Dengyu said, i.e., absorption of the advantages of pouring paper and papermaking method, it is clearly difficult to understand from the perspective of technology evolution.

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[35] Pan Jixing. History of Science and Technology in China Volume of Papermaking and Printing [M]. Beijing: Cultural Relics Publishing House 1979:47–51.

1.4.3 Relevant Deductions

Following this line of thoughts, we can reach a series of deductions.

First, if the earlier paper is manufactured by pouring paper method, then, the early paper should not be so uniformly thin and with curtain pattern, as the paper from later generations are. Instead, there should be no curtain patterns and might also be thicker. The era of pouring paper method in common use should be the Wei and Jin Dynasties. Approximately in the middle and late stages of Northern and Southern Dynasties, transition to the papermaking process began in the Central Plains, and the transition basically completed in the Sui and Tang Dynasties. Papermaking methods adopted by the transition period should be an intermediate form like that for Dongba paper—the paper produced should have curtain patterns, but should not be so thin as that produced by later generations of papermaking.

Second, since the craft of Dongba paper of the Naxi Ethnic Groups is an intermediate form during the transition from pouring paper to the mature papermaking method, it could not have been introduced from Tibet, but from the cultural circles of the Central Plains instead. The level of the craft is equivalent to that in the Central Plains region in the early Tang Dynasty. Admittedly, the Naxi manual paper craft as we see today is not necessarily the same as what it was initially.

Third, the time of pouring paper introduced to Tibet should be earlier than the appearance of the papermaking process, at least earlier than the popularization of papermaking method in the Central Plains region. Judged temporally it should be before the Tang Dynasty. The academia mostly agrees with the conclusion of the American scholar Carter, i.e., Chinese papermaking was introduced to the West and Arab in the 10th year of Tianbao (AD 751) during the reign of Xuanzong of the Tang Dynasty. In a battle with the Chinese army, Arabs captured some paper workers who later began to teach papermaking process in Samarkand.[36] Now the manual paper craft at the same stage of evolution as the Dongba paper craft is still preserved in the West. The American scholar Hunt made quite a comprehensive study of handmade papers around the world in the first half of the twentieth century. In his book, Hunt introduced manual paper production in England at that time: paper drugs were not used and the curtain used could not be rolled up. Instead, felts were used to separate the wet papers (as shown in Fig. 15), in a way somewhat like making tofu skin.[37] Like Dongba paper craft, this set of process does not use paper drugs and thus can be considered to be at the same stage. Upon further comparison, it is found to be more advanced than Dongba paper, in that it directly attaches the wet paper to felts instead of the wall, improving work efficiency, and product quality. Now that pouring paper is the more primitive method,

[36] [US] Carter. Tr. Wu Zeyan. Invention of Printing in China and Its Spread to the West [M]. Beijing: Commercial press, 1957:112.

[37] Dard Hunter, Papermaking: The History and Technique of an Ancient Craft, 1949, Alfred A. Knopf, New York, p. 441.

Fig. 15 Papermaking without paper drugs, from Dard Hunter's *the history and technique of an ancient craft*

its widespread use should have happened before this craft. Therefore, we believe that the time for pouring paper to be introduced into Tibet should be before the Tianbao years of the Tang Dynasty, probably before the Tang Dynasty or in early Tang Dynasty.

Fourth is on the issue of time and route for papermaking to be introduced to India. Mr. Ji Xianlin has conducted in-depth explorations on the issue in the 1950s. According to his research, in the middle of the second century AD, papermaking already entered China's western region, and Indians living in the Ancient Xinjiang region may have accessed paper at that time. There is evidence in literature that in no later than the seventh century there were people using paper in the mainland of India.[38] As for the time of papermaking introduced to India, Mr. Ji did not give any specific conclusion. We believe that it should be at roughly the same time when papermaking spread to Tibet, that is, before the Tang Dynasty. This, of course, is a corollary of this article, without much direct evidence.

[38] Ji Xianlin. On the Time and Location for Introduction of Chinese Paper and Papermaking from China to India. Wang Shuying (eds.) Ji Xianlin on Cultural Exchanges between China and India [M]. Beijing: New World Press, 2006-1. The book also included two other relevant theses, i.e., Was Chinese Paper and Papermaking Introduced to India via Maritime Routes, and Supplemented Studies of the Introduction of Chinese Paper and Papermaking to India.

Finally, about why pouring paper method persisted in the region for a long period of time, we believe that religious use is a relevant factor. In accordance with the Mr. Li Xiaocen's theory, products of papermaking process were mainly used for cultural purposes and sanitary paper, and those of pouring paper method mainly for Buddhist scriptures. He treated the differences in product use as the essential difference between the two processes. Thus, his theory does not make sense logically. However, we can find the answer to a question through it. The reason for those regions to preserve the relatively backward production technology is perhaps the religious culture has more stringent requirements on inheritance. The paper made by pouring paper method is used to write Buddhist scriptures, and paper used for Buddhist scripts over generations has been made this way. So this method can go on and on. Although there were other methods for making paper, the paper had not been used for scriptures. Therefore, they were not worth learning. Much like the Tibetan Ethnic Groups managed to preserve the process of pouring paper method, the Naxi Ethnic Group was able to save the original process, probably because of its direct relationship with the unique Dongba cultural traditions. In fact, after the modern times, pouring paper method was still in use in many areas. D • Hunt's book recorded pouring paper scenarios he had seen in Guangdong Province, China in the mid-twentieth century.

Of course, there may be other reasons. For example, while surveying the manual paper-producing areas in Jiajiang, we found that in Macun Tonwship, which is not far from the county seat, manual paper craft had evolved very quickly over recent years. All the paper mills basically produced calligraphy paper, but it was impossible to find throughout the township a mill still using traditional methods for making pulps. In relatively secluded Huatou Village, whose average elevation exceeds 1,000 meters, many papermaking households solely using the original process had been preserved. This shows that the evolution of the process is not synchronized in slightly larger ranges. There are always some places to stick with the original process. Naxi papermaking process may not have been directly introduced from the Central Plains and is likely to have arrived at a later period from an adjacent place which happened to have retained the original process.

2 Lecture 2 Printing

Qi Han

Printing, gunpowder, and compass are known to the Westerners as the three great inventions of China. The British Francis Bacon once said in the seventeenth century, "Printing, gunpowder and the compass: These three have changed the whole face and state of things throughout the world; the first in literature, the second in warfare, the third in navigation; and they have all played significant roles, whence have followed innumerable changes, in so much that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries." We now know very clearly that those inventions are from China. Add papermaking, and we will have what is well known today as the four

great inventions of ancient China, which are great contributions to human society made by the Chinese nation, and which has also had extremely far-reaching impact.

Printing is called "a sacred art" and also known as "the mother of civilization." Its importance is well known. It is often said that "knowledge is power," and one of the sources of this power is printed books. Woodblock printing was invented during the Zhenguan years, the early of the Tang Dynasty in the seventh century, about 700 years earlier than that in Europe. During the Qingli years of Northern Song Dynasty in the eleventh century, Bisheng invented movable type, about 400 years ahead of Gutenburg from Germany. Over the 1,300 years, due to the widespread adoption of printing, the Chinese civilization has managed to continue in a continuous line, making an indelible contribution to the world.

2.1 Block Printing

2.1.1 Origin and Development of Block Printing During the Tang and Song Dynasties

The time of invention of woodblock printing is an old issue of controversy over hundreds of years. There are many theories proposed by scholars from home and abroad, ancient and modern and those theories can be divided into seven categories, namely the Han Dynasty Theory, Eastern Jin Dynasty Theory, Six Dynasties Theory, Sui Dynasty Theory, Tang Dynasty Theory, Five Dynasties Theory, and the Northern Song Dynasty Theory. According to archaeological data currently available, the Han Dynasty Theory, the Eastern Jin Dynasty Theory, and the Six Dynasty Theory are faulty in that they are too premature, while Northern Song Dynasty Theory is feeble in for being too late. The Five Dynasties Theory, though popular in the Qing Dynasty, has been overthrown by Xiantong-version "*Vajracchedikapra-jnaparamitaSutra*" of the Tang Dynasty found in Dunhuang. The Sui Dynasty Theory has few followers due to its misunderstanding of literature. Therefore, the only theory with relatively higher credibility is the Tang Dynasty Theory. Since the Tang Dynasty ruled for about 300 years (618–907), there are a variety of different arguments for the specific era of invention of printing, including the early Tang Dynasty Theory, middle Tang Dynasty Theory, and late Tang Dynasty Theory, with the third theory having the most followers. Some have proposed the Zhenguan Theory (early Tang Dynasty Theory) in the seventh century, according to the "*Hong Jian Lu*" by Shao Jingbang (1491–1565) a historian from Hangzhou in the Ming Dynasty. These data first appeared in "*Collected Essays of Reading in Shizhuzha*i" a book written by Zheng Ji (died in ca. 1880) of the Qing Dynasty. The original text in Volume 46 of *Hong Jian Lu* says: "太宗后长孙氏，洛阳人。……遂崩,年三十六。上为之恸。及宫司上其所撰《女则》十篇,采古妇人善事。……帝览而嘉叹,以后此书足垂后代,令梓行之" (Empress Zhangsun, wife of Emperor Taizong of the Tang Dynasty, is a native of Luoyang, passed away at the age of 36, and the emperor grieved her death. The

Inner Palace Secretary relegated the ten essays of "*Important Principles for Girls*" which recorded the virtuous deeds of ancient women… The Emperor read them and sighed in admiration. Convinced that the book by the empress sets an example for future generations, the emperor ordered to have it printed).

"梓行" is equivalent to engraving and printing, thus the meaning is very clear. The Empress Zhangsun died in the 10th year of Zhenguan (636). Therefore, the book should have been published in the same year or slightly later. At that time, there might have been civil print of the book, before Emperor Taizong wanted to have it published. The problem is that Shao Jingbang is a historian of the sixteenth century, and his book is second-hand historical data. However, the sentence "令梓行之" (ordered to have it printed) is nowhere to be found in *The Old Book of Tang, New Book of Tang*, *Comprehensive Mirror for Aid in Government* or *The Imperial Readings of the Taiping Era*. Yet "*Hong Jian Lu*" is an official general history, which was proclaimed by Shao to be comparable to *Tongzhi* (General Records) by Zheng Qiao of the Song Dynasty, and which took 15 years of his effort, and underwent four drafts. From this, we can see how cautious and careful Shao had been. In addition, Shao also proclaimed "I transmit but do not innovate." Therefore, his record should not have been concocted out of thin air.

Buddhist disciple Xuanzang of the Tang Dynasty once printed and distributed images of the Budda, providing circumstantial evidence to the Zhenguan Theory. In his "*Yunxian Sanlu*" (Random Record of Immortals), Feng Zhi of Tang Dynasty cited "*Sengyuan Yilu*" (Anecdotes of Monk) as saying "Xuanzang printed images of Samantabhadra on Huifeng Paper, for distribution across the nation, exhausting five camel loads each year." Xuanzang made a journey westward to the India in the 3rd year of Zhenguan (629 AD), returned in 645, and passed away in the first year (664 AD) of Linde. Therefore, printing of Buddha images should have occurred after his return. He produced five camel loads of images of Samantabhadra each year—that is a large quantity—yet unfortunately none has been handed down. The single width large images of Samantabhadra with Monju and Avalokitesvara of the Five Dynasties found in Dunhuang may be similar to the image printed by Xuanzang.

Lu Shen, the scholar of Hongzhi-Zhengde Era in Ming Dynasty, is the first one to propose that book printing began in Kaihuang years of Sui Dynasty. Lu's "*Hefenyan Xianlu*" (Idle Record of Hefenyan) recorded, "On December 8 of 13th Year (January 5th, 594) of Kaihuang during reign of Emperor Wen of Sui Dynasty, edict came requesting complete restoring or recarving of shelved Buddha statues and remaining Buddhist scriptures, thus marking the beginning of printed book. This happened before Emperor Feng Yingwang."

The material cited by Lu is seen in "*Chronicles of The Three Treasures Over Generations*": because the Northern Zhou Dynasty abolished Buddhism, "destroying statues and damaging Buddhist scriptures, treating monks with scorn and smashing temples," "Buddhist towers and other buildings were ruined and scriptures and images plunged into degeneration." Yang Jian, Emperor Wen of Sui Dynasty, strongly advocated Buddhism soon after he acceded to the throne and promulgated in the first year of Kaihuang (581) a decree, ordering that everyone

in the country should be free to choose to become a monk or nun and that money should be levied on the basis of population for the restoration of Buddhist scriptures and statues. In the 13th year of Kaiwang, he "Respectfully donated one hundred and twenty thousand rolls of silk for renovation of all damaged statues and images" "to re-solemnize the true images of Buddha, to make the destroyed facilities more stately, and to restore all the ruined statues and scriptures." However, the article mentioned "the ruined statues and scriptures," which includes scriptures and statues, and the two are obviously different. Therefore, "restore all the ruined statues and scriptures 'means' carving the statues that have been destroyed, and gathering and collating remnant Buddhist scriptures." Wang Shizhen of the early Qing Dynasty said "Upon detailed study of the context, I found that carving applies to the statures, while gathering and collating applies to Buddhist scriptures. This is a slip of tongue on the part of Yanshan (i.e., Lu Shen)." Hence, the theory of Kaihang in Sui Dynasty rose from Lu's misunderstood of the context. Later generations in quoting Lu Shen changed "悉令雕撰" to "悉令雕版," or even to "雕造," inevitably resulting in repeated baseless assertions, which has now few believers.

Based on existing literature and archaeological objects, we cannot prove it is a historical fact that block printing appeared in the Eastern Han Dynasty, the Six Dynasties, Later Zhao Dynasty, Northern Qi and Sui Dynasties. Actually only a few of them can be as the corroboration of the Zhenguan (early Tang) Theory. Of course, the final settlement of this issue is pending on the discovery of new historical and archaeological objects.

Verifiable book-carving locations in the Tang Dynasty including Chang'an the capital, and Luoyang the eastern capital, Yuezhou, Yangzhou, Jiangdong, Jiangxi, and with Yizhou (Chengdu) were well developed. Bookshops appeared in the eighth century in Chang'an. In the Dunhuang Photo of Tang Dynasty manuscript *New Compendium of Works on Moxibustion for Emergencies* in the collections of the National Library of China, there is a note "京中李家于东市印" (printed by the Li Family of the Capital City in the East Market). On the back of photograph, we can see the yin and yang scripts written in the 2nd year of Xiantong (861AD). From the prescription written 3 years before that we can conclude that the book had been printed before Xiantong, and this "*Moxibustion*" manuscript had been copied from a printed version. In addition, Dadiao Fmaily of East Market of Shangdu printed "*Almanac*." Xi'an is now in possession of a printed version of *Dharani Mantra* unearthed in a late Tang Dynasty tomb in the western suburbs of Chang'an, which features a seemingly colored Buddha in the middle, surrounded spell texts in Chinese in a square. It is similar to the spell book sold by the Bian Family of Chengdu in the Tang Dynasty, thus is probably a product of Chang'an. The printed book is originally kept in a copper box, with inscription of Xiantong reign of the Tang Dynasty. Therefore, it must have been printed in Xiantong years or before that and thus is the oldest existing printed book of the Tang Dynasty.

"*Vajracchedikapra-jnaparamita Sutra*" found in Dunhuang has a line of remark "Reverently printed and distributed by Wang Jie for his parents on April 15, the 9th year of Xiantong (868)." This volume of the sutras is acknowledged to be the world's most ancient printed book in existence. Wang Jie, an ordinary folk-turned

Fig. 16 Picture of Sakyamuni preaching in frontispiece of "Vajracchedikapra-jnaparamita Sutras"

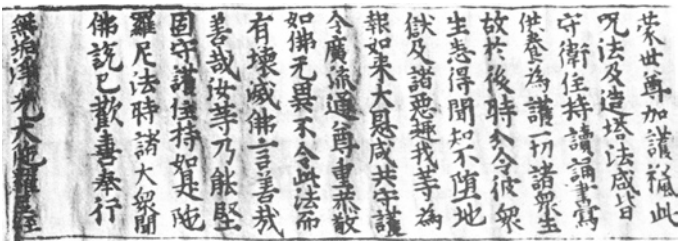

Fig. 17 *Spotless pure light Dharani Sutra* found in Bulguksa temple, South Korea

Buddhist disciple, funded printing of sutras. And the motivation is to pray for his parents and repel misfortunes, thus the expression "printed and distributed… for his parents." In the frontispiece, there is a picture of Sakyamuni preaching Buddhism (as shown in Fig. 16). The image is solemn and stately, and the carvings elaborate. It is a mature work and the crown of printing history in the world. Now it is kept in London.

In 1966, woodblock print *Spotless Pure Light Dharani Sutra* (as shown in Fig. 17) was found in the stone spire of Sakya Tower, in Bulguksa Temple in Gyeongju, South Korea. Upon examination and collation, scholars believed that it had been printed between 704 AD and 751 AD (the third year of King Seongdeok—the 10th year of King Gyeongdeok, equivalent to the 4th year of Changan in the reign of Empress Wu Zetian–10th year of Tianbao in the reign of Xuanzong during the Tang Dynasty). The volume of the sutras is four feet longer than the Xiantong-version Vajracchedikapra-jnaparamita Sutra, about one hundred years earlier, and decades older than the Hoki versions of *Spotless Pure Light Dharani Sutra,* and three others published in 770 AD. Thus, it is known as the treasures of the world's oldest surviving woodblock printing. This sutras used four characters made by Empress Wu Zetian (i.e., 证、授、地、初). However, those

new characters made by Empress Wu cannot prove that it to be a Silla printing, but can prove it to be engraved in the Tang Dynasty. In the first year (689 AD) of Zaichu, Empress Wu created a dozen new characters, which were used by translators and engravers in compliance with her decree or because they have become popular in the society. Even if they reached Silla, those characters could only be used by a few men of letters and were unlikely to be very popular, because Silla had no reason to comply with the decree of Empress Wu. As for the general writing or book engraving, commonly used characters were naturally preferred over complicated hieroglyphics with multiple strokes causing difficulty in engraving.

Tang Dynasty had frequent cultural exchanges with Silla. In the 13th year of Zhenguan (639 AD), Silla, Goguryeo, Baekje each dispatched students into national schools of Tang for study. Over a decade, the Silla adopted the dress of Tang. The Silla monk Chajang took over four hundred copies of the "*Sanzo*" from the Tang Dynasty and won nationwide welcome. Monk Hong Kyung brought home a set of the *Tripitaka* from Fuzhow of Tang. Since the entire voluminous "*Tripitaka*" was brought to Korea several times by monks, it is only naturally reasonable for rolls of printed copies of Buddhist scriptures to be taken with them. Therefore, scholars believe that *Spotless Pure Light Dharani Sutra* is the printed version of the Tang Dynasty in the early eighth century, not published by Silla. Decades after this, there in Japan emerged the Hoki-version dharani. Said to have been hidden in millions of small wooden pagodas, they may have been Japan's own creation because of the large number, but the influences from engraving in China are irrefutable.

After the Tang Dynasty, China entered the period of the Five Dynasties and Ten Kingdoms. During this short period of only 50–60 years, the alteration of dynasties was frequent. Separatist warlords seized their won strongholds, leading to the formation of a dozen local regimes. Coupled with massacre and looting from the Khitan and tribes, hundreds of square miles surrounding the Central Plains including Kaifeng and Luoyang became deserted. Sovereignty was retained in the more remote areas such as Sichuan, Southern Tang, Wu and Yue, and Kingdom of Min, which became cultural centers, with economic prosperity, and relatively developed printing industry. The government published official version of the scriptures, marking the beginning of official versions. Therefore, those scriptures occupy an important position in printing of this period. Book engraving locations in the Five Dynasties include Kaifeng, Jiangning, Hangzhou, Qingzhou, Guazhou, Shazhou, Fujian, and Sichuan, among which Kaifeng, Chengdu, and Hangzhou are most active.

After the establishment of the Song Dynasty, the government became not only eager to supplement the collection of the National Library, but also more strongly advocated book engraving. Imperial Colleges engraved Confucian classics, history, philosophy, and medical books, which were distributed around the country and licensed them for sale. The monarch of the Song Dynasty followed Buddhism and Daoism therefore is also engraved scriptures of the two religions. In this situation, the private interest in books engraving and compiling witnessed significant increase, and it became a trend among local officials of the Southern

Song Dynasty to get engaged in book engraving. Lu You said: “Modern scholars are obsessed with book carving.” Wang Mingqing said: “most of the county seats I visited in recent years took to book carving.” Over 100 scholars, including Lu You and his son, Fan Chengda, Yang Wanli, Zhu Xi and Zhang Shi, took book engraving with them wherever they took an official post. Via carving, they published their own writings, or those of their ancestors, or those of local personages and celebrities. As for scholars publishing the writing of their mentors and friends, or rare books in their family collection, they are simply too numerous to mention.

Local governmental agencies of the Song Dynasty, including the Military Commission, Tea and Salt Commission, Judicial Commission, Transportation Commission, Provincial Official Residence, County Official Residence, Provincial School, Prefectural School, County School, Academies, Colleges, all took to books engraving, making them the official books. Among the agencies, Provincial Official Residence and District Schools were more productive. In addition, there were envoy bursaries: Song set envoy bursaries in all counties to provide board and lodging for officials going to the capital. Envoy bursaries have envoy expenditure, bursary vinegar tax, and funds under other names. The money was used for catering to the officials, and the balance for engraving books. Some bursaries also set up book printing bureaus. Local officials sometimes also use public funds to engrave books.

The books engraved were printed and sold at a profit, thus Kaifeng, Lin’an, Wuzhou, Quzhou, Jianning, Zhangzhou, Changsha, Chengdu, and Meishan successively set up bookshops, just as in the saying “All the common folks followed suit and started carving books (so as to make money), for food and clothing.” Private schools, as well as temples, all took to book engraving, creating an unprecedented prosperity in official and private engraving in the Song Dynasty, marking the golden age in the history of woodblock printing. In the Song Dynasty, engraved versions replaced manual copying, offering great convenience to the reader, and enabling the substantial scientific and technological culture development. The book engraving of Song Dynasty has three characteristics: First, the government attaches importance to and local officials advocate book carving. Second, block-printed books are rich in content, complete in category, and exquisite in outlook, which are beyond the reach of future generations. Third, book engraving places gradually increase. In the Northern Song Dynasty, the number of book-carving centers does not exceed three dozen, while that in the Southern Song Dynasty reaches nearly two hundred. In the Southern Song Dynasty virtually all the 15 routes (equivalent to present-day provinces) were engaged in book carving, with Zhejiang, Fujian, and Sichuan particularly representative.

Hangzhou already boasted bookstores in the Northern Song Dynasty. After the court fled south, the number of private book houses mushroomed, under the name of classics shop, classics mill or classics workshop, shop for classics, book shop or characters shop. Twenty of those can ascertained, some of which were moved to Hangzhou from Bianjing. Books engraved in Hangzhou are sophisticated, with renown at home and abroad. Ye Mengde, the bibliophile of Song Dynasty, said: “in

the world printed books of Hangzhou are supreme, followed by those of Sichuan, while those of Fujian are inferior."

Jianyang County and Jian'an County which shares an outer city wall with Jianning Mansion are one of the centers of the publishing industry in the Southern Song Dynasty. Block-printed editions of Fujian were called "Min Edition," "Jian Edition" or "Jian'an Edition," and those of Masha Township Jianyang were called "Masha Edition." Masha Editions were shoddy products designed to speed sale; containing many errors they almost become synonymous with inferior or notorious editions. In addition, because soft wood was used in carving, the calligraphy and painting were prone to blurring and damages; locally produced bamboo papers were mostly used for printing, and the papers were crisp and thin in texture and the yellow black in color. Neither the content nor the material was good, and they gave a bad impression. But because "Fujian Editions almost swept the nation" for their rich variety and low cost, books currently handed down from the Song Dynasty are mostly Jian Editions. Admittedly, there are also works with elaborate design and academic values. In the Southern Song Dynasty, even the remote Qiongzhou also published a medical book. It can be said that in the Southern Song Dynasty woodblock printing had spread to almost all parts of the country.

Most of the books before the Tang Dynasty have succumbed to generations of warfare, while many books of the Song Dynasty are handed down, and even some ancient works have been handed down in the form of printed copies made in the Song Dynasty. Therefore, the block printing of Song Dynasties has been meritorious in preservation of ancient Chinese culture. The Song Dynasty not only for the first time engraved the philosophical works of thinkers in the pre-Qin and Han Dynasties, but also published a lot of science and technology books. Due to the government's attention, medicine witnessed particularly development, and official and private medical books published were greatest in number. Books of the ancient times and present day have multiple versions; books of entertainment and fun also appeared.

In Kaibao 4 years (971 AD), Emperor Songtaizu sent people to Chengdu to carve *Buddha Treasure*. This is the first time for China to engrave *Tripitaka*, which is also the ancestral version of a variety of domestic and foreign versions of *Buddha Treasures*, and which known as "the Yizhou Edition." Due to the fact that publication started in Kaibao years, it is also called *Kaibao Treasure*. Later monks and common folks in Fujian carved a set of *Tripitaka* blocks in Dongchan Dengjueyuan in Fuzhou, called "*Chongning Wanshou Tripitaka*" or "Dongchan Temple Edition." In Kaiyuan Monastery within Fuzhou city carved a version of *Pilu Tripitaka*, called Kaiyuan Temple Edition. Starting his path on officialdom as Observation Missionary of Mizhou in Guian County, Huzhou, Liangzhe Xilu Route in the middle of Xuanhe Era, Wang Yongcong donated his family wealth in the 2nd year of Shaoxing (1132) for engraving "*Tripitaka*" in Yuanjue Monastery in Sixi, and the resultant sutras was called "*Sixi Yuanjue Tripitaka.*" In the third year of Jiaxi, Fabao Zifu Monastery in Sixi Anjizhou (Huzhou) published a Buddhist scripture, called "*Sixi Zifu Tripitaka.*" Monks and common

folks from Jiangsu Region set up a Tripitaka Bureau in Qisha Yanshengyuan, in Chenhuzhong, Pingjiang government mansion. The bureau started carving in July, the 4th year of Shaoding during the reign of Emperor Lizong of the Song Dynasty, and completed the undertaking successfully in the 2nd year of Emperor Yingzong of the Yuan Dynasty. The resultant work is called *Qisha Tripitaka*.

In the Liao Dynasty, two sets of *Khitan Tripitaka* were also carved. In the Jin and Western Xia Dynasties, there were many carved books. Book carving in the Yuan Dynasty gradually declined, in comparison with the Song Dynasty, but it prospered again in the Ming Dynasty. In the Qing Dynasty, woodblock printing took a downward turn, and wood type became popular. After the Daoguang Era, Western printing was introduced to China, and woodblock printing was gradually eliminated.

2.1.2 Overprint, Woodblock Print, and Color Print

The earliest extant overprint object should be of the "*Annotations on the Vajracchedikapra-jnaparamita Sutra*" (as shown in Fig. 18) published by Zifu Temple in Zhongxing Route (present-day Hubei Jiangling) in the Yuan Dynasty. In the frontispiece, there sits Wuwen the senior monk annotating the sutras,

Fig. 18 *Annotations on the Vajracchedikapra-jnaparamita Sutra* published by Zifu Temple in the Yuan Dynasty

waited upon by a boy. Beside the boy there stands a third person. The book case, square table, clouds, and Ganoderma are all red, while the pine nearby is black. The body of the text and the notes are red and black, respectively, while the title "*Vajracchedikapra-jnaparamita Sutra*" is red. The printing time should be between 1,340 and 1,341. The engraving creatively adopted for the first time two colors, marking a major event in the history of printing.

1. Overprint in Huzhou

In late Ming Dynasty, the two families of Min and Ling in Huzhou managed to carry forward the overprint technology, developing by the two colors, three colors, four colors, and even five colors on the basis of two colors, marking a big step forward in the history of color printing. Overprint in Huzhou began in approximately the 9th year (1581) of Wanli, represented by Ling Yingchu's publication of "*A New Account of Tales of the World*". Another theory believed that it began in the 44th year (1616) of Wanli, represented by Min Qi Ji's publication of "*Mr. Zuo's Spring and Autumn Annals.*" Both of the books are products of Wanli, Tianqi and Chongzhen Eras. Hu Yinglin of the Ming Dynasty said "Like engraving in Huzhou, engraving in Xi witnessed rapid progress" adding "In printing, the color red, black and indigo are used, sometimes independently, sometimes combination of two. Two-color printing would be more precious if red is used." The reason for Huzhou engraving to be exquisite is the adoption of two-color printing, i.e., overprinting. Min Qiji was a scholar of a wealthy family in Wucheng County. He engraved Lao Zi, Zhuang Zi, Lie Zi, the collected poems of various schools and *Chu Ci* (Songs of the South). His brothers and nephews were also engaged in book engraving. The Ling Family had Ling Yingchu and Ling Mengchu as the representatives. Ling Mengchu engraved "*The Collected Poems of Meng Haoran,*" and his family engraved many books which have been handed down.

Overprint edition put a variety of bright colors on the snow-white Liansi paper, producing pleasant and satiating books to attract the reader's affection. The craft is most suitable for works and maps with commentaries and a variety of punctuation marks in that it can make them clear. Criticism is recorded above the body of the text and annotations and punctuation marks are placed between lines to make the meaning of each word readily intelligible and all paragraphs clearly separated so as to make the books easier to read for beginners. The characters in each line are widely spaced to facilitate overprint, and there are no lines within the box for text on each page. Each box normally contains 8 or 9 lines, to embrace 19 characters each. Such printed copies, particularly the three- or four-colored copies, are costly and time-consuming, since each of them would require the cost of several ordinary books. In addition, subject certain printing techniques are required, so that the colors will not get mixed. The Min and Ling Families turned out 144 overprint books in total, and most of them are red and black, 13 three-colored, 4 four-colored, and 1 five-colored.

2. Woodblock Print

One of the features of printing in the Ming Dynasty is well developed woodblock print. The number of pictures in illustrated books ranges from several or dozens in the least to one or two hundred in the most. Woodblock print of the period is not only great in quantity but superior to Song and Yuan Dynasties in quality, marking a peak of graphic art. Illustrations can either be placed under the diagrams to form comic books, or inserted in the middle of the body or a section, while in most cases, they are attached to the frontispiece. After the Chenghua and Honghua Eras of the Ming Dynasty, folk rap, poetry, fiction, and drama became widely popular. To cater to the preferences of the reader and to promote sales, the publishing houses started everything they print with pictures, just as the saying "All of the legends, ancient and modern, are illustrated with pictures." Illustrations can increase the taste of books, facilitate understanding of the texts, enhance the reader interests, and appeal to both the vulgar and refined. Therefore, illustrated books became a momentary fashion in the Ming Dynasty. The woodblocks are so elaborately carved and intricate that they make the viewers mesmerized, thus catering to the preference of the time and invite a broader scope of buyers. Woodblock print is most popular in Wanli, Tianqi, and Chongzhen years, attaining full flourish. Woodblock print can be roughly divided into four schools: Beijing, Nanjing, Jianyang (the three factions feature bold and simple lines, and abundant antiquity), and Huizhou. Huizhou prints are elaborate and meticulous, gorgeous, and inviting. The figures carved are vivid and lifelike, while the curtain patterns carved are reflective of all nuances. Reflecting arts and techniques to the extreme, they deserve the name of embroidered images. Open the book and the reader is bound to be pleased and fascinated. Most of the workers come from Qiu Village (or as Qiuchuan Village) in She County. Surnamed Huang, they claim themselves to be the Huangs of Xinan, or the Huangs of ancient She. "At that time, people would certainly seek workers from She for engraving undertakings." Those workers were often invited to carve books away from their hometown, and sometimes moved houses to facilitate life and work.

3. Color Print

After the Wanli years of the Ming Dynasty, Huizhou woodblock printing technology reached its peak, with the popularization of common fiction and drama. So some people came up with the idea of adding colors to the pictures. "*Moyuan*" (Collection of Chinese Ink Stick Images, ca.1605), engraved by Zilantang of the Cheng Family from Shexian Anhui, has nearly 50 colored images, most of which are four- or five-colored. All colors were applied to the engraved block and then printed out on paper. Each block contains a number of colors, presenting a rich and luxuriant appearance, and grabbing the eyes of the onlooker. In "*Tianlao Duiting Tu*" (Picture of Heavenly Elders in the Court, as shown in Fig. 19) in *Moyuan*, there are red and yellow phoenixes and green bamboos. Using colored ink, the block

Fig. 19 *Tianlao Duiting Tu* in *Moyuan*

can be used to print dozens of pictures at one sitting. In the following year, the Xin'an Huang Yiming carved "*Fengliu Juechang Tu*" (Picture of Perfectly Matched Merriness and Smoothness), turning out ink-printed copies, as well as color-printed copies, in which character's clothing and footwear, and their skin color and eyes, and window curtains are extraordinarily printed. In *Huashi* (History of Flowers) printed in about 1600, there are red lotuses and green leaves. Originally, several colors were applied to the corresponding sections of the block, for instance, red to the flowers, green to leaves, and ocher to the branches. However, the resultant prints are easily confused. Therefore, a further step was taken: each color was engraved on a separate woodblock, and woodblocks were used in the order of colors to be printed. Because smaller blocks were engraved first and then used in different combinations, like Douding the assorted snacks, therefore it was called "Douban" (assorted block) by the people of the Ming Dynasty.

The Douban is a very delicate and complex job. At first, the worker has to sketch the outlines of the entire picture and then divided it into several units according to the painting itself. This step is called "Zhaitao" (frame-removing). A picture often requires the engraving of three dozen to four dozen smaller blocks, and sixty to seventy times of printing of varying shades. To commit to paper the different shades and position and direction of a flower or a leaf is like

the boneless painting used by artists of the Northern Song Dynasty. Paintings produced this way are best at maintaining the character and spirit of Chinese painting, because the pigment and rice paper used are identical to those in the original painting, with the same features of Chinese national art. Douban color printing, a great leap forward in the printing history, had become very successful in the early years of the seventeenth century. The most prominent representative work is "*Luoxuan Biangu Jianpu*" (Trumpetvine Pavilion's stationery catalogue) carved by Wu Faxiang of Jiangning. The landscapes, plants, and animals in the book are printed using Douban and Gonghua overprinting. Yanji Zu of Zhangzhou commented in the Foreword "My friend Wu Faxiang told me that the slightest detail has been completed meticulously and ingenuously. Therefore, it is wonder among imperial scholars and the ultimate treasure of the study." *Luoxuan Biangu Jianpu* was printed in the 6th year of Tianqi (1626), 19 years earlier than Hu Zhengyan's "*Shizhuzhai Jianpu*" ("Ten Bamboo Decorated Album," but only 1 year earlier "*Shizhuzhai Shuhua Pu*" ("Ten Bamboo Studio Manual of Painting and Calligraphy"), which was completed in the 7th year of Tianqi.

Hu Zheng Yan, of Xiuning Anhui origin, moved house to the side of Jilongshan Mountain in Nanjing to live together with his wife Wu and work together in engaged album engraving and printing. With more than 10 bamboos in front of his house Nanjingzhai, he named it "Ten Bamboo Studio," and styled himself "Master of Ten Bamboo Studio." He was well versed in the six categories of Chinese characters and unrivaled in calligraphy such as seal script, official script, cursive script, and running hand. He could also make quality paper and quality ink. In addition, he was skilled in engraving and good at painting. "*Shizhuzhai Shuhua Pu*" printed by Hu consists of 16 books and 8 albums, including bamboo album, ink book, stone album, feather album, plum album, orchid album, fruit album. "*Shizhuzhai Jianpu*" includes 32 categories, like ancient utensils, figures, flowers, and stones (as shown in Fig. 20). The originals are well painted and engraving vivid, aptly reproducing the spirit of the originals. While printing a palm brush is used instead of a writing brush, the motions are applied appropriately and to the point. Hu discussed day and night with skilled workers for a long time without getting tired. Finally, he was able to carry ingenious designs and became equally proficient with painting, engraving, and printing. Flowers and plants, feathers, and worms—they all come to life under the brush of Hu. No wonder his friend Yang Longyou would say that Hu "has dexterous hands and a clever mind far beyond the previous generations… and is unprecedented." His works were immediately warmly received by people to the north and south of the Changjiang River. Beginners in painting used them as templates for copying. Thus, Hu has played an important role in painting education.

Wu and Hu used Gonghua craft (blanked stamping), i.e., pressing the engraved block on white paper to produce protruding patterns (see Fig. 21), in the same way we use the stamp now. It can be said to be a colorless printing, used to set off the water, white clouds, mosaic veins in the leaves and flowers to make them simpler yet more elegant.

Color printing of Douban of the Ming Dynasty was also imitated in the Qing Dynasty. For instance, two drawings in "*Compendium of Materia Medica,*"

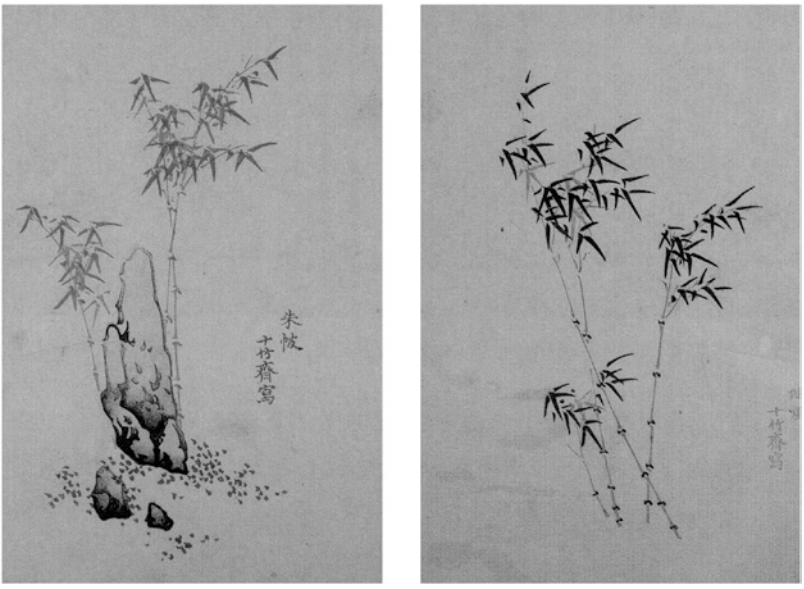

Fig. 20 "*Shizhuzhai Jianpu*" printed by Hu Zhengyan

Fig. 21 Gonghua printing of Hu's

Peach Garden Oath picture in "*Romance of the Three Kingdoms*" and Emperor Kangxi's "*Ploughing-weaving Picture*" carved in Suzhou had been produced via color overprint. The full landscape of Westlake and the ten scenic spots of Westlake in "*Stories of the West Lake*" published by Wang Ya in Jinling during Emperor Kangxi's Reign and "*Mountains and Rivers in Ancient She*" Volume One

published by Wu Yi during Emperor Qianlong's reign were produced via multi-colored overprint. Qing Zaitang imitated Hu's *Ten Bamboo Studio* in drawing flowers, plants, and feathers. "*Shizhuzhai Shuhua Pu*" was recommitted to engraving in the 22nd year of Jiaqing (1817) by Jie Ziyuan (Mustard Seed Garden), and in Guangxu Years, Jiao Jing Shan Fang (studio for collation of classics) had yet another engraving. However, the verve and color of that color overprint were inferior to those of the original. Multicolored "*Painted History of Jieziyuan*" was painted by Wang Gai and his two brothers in Jiaxing; and the first episode was color-printed using Douban in the 18th year of Kangxi (1679). Three more episodes were printed in the fortieth year of Kangxi (1701), to be followed by four more episodes printed in the 20th year of Jiaqing (1818). Gorgeous and pleasing to the eye, the book underwent repeated re-carving after the Jiaqing years and was made textbook for beginner painters. Therefore, it was more popular and more influential than the "*Shizhuzhai Shuhua Pu.*"

During the reign of Emperor Qianlong, Ding Liangxian and Ding Yingzong from Suzhou printed many flower-and-bird paintings (as shown in Fig. 22) by using Douban. Using exquisitely carved blocks and Gonghua technology, the prints used white paper and presented a dazzling colorful appearance. They are of rare quality in chromatic printing. Ding Liangxian was a Catholic living in the middle of Qianlong's reign. Constantly rubbing shoulders with European missionaries in regions south of the Yangtze River, Ding was engaged not only in printing, but also trading of foreign paintings. His works might have been sold to Europe through the missionaries. In Suzhou during the reign of Emperor Qianlong, there were people imitating Western perspective in making New Year pictures and printed materials of other literature, some of which are still kept in the museums of Europe and Japan.

In the 28th year (1848) of Daoguang, Yingying Shuwu (photocopying house) edition of "*Goldfish Album*" was published, including paintings of 56 different types of goldfish, each with a protruding belly and goggling eyes and a vivid posture. The original color of each type was painted, and the margins of each paper were decorated with pale green patterns of pines, bamboos, and plum blossoms. "*Zhedong Zhenhai Desheng Quantu*" (Panorama of Victorious Zhenhai Zhedong) was the result of color printing. In the 7th year of Guangxu, "*No. 1 Genius Book*

Fig. 22 Flower-and-bird painting printed by Ding Liangxian in Qianlong years using Douban

Romance of the Three Kingdoms" was printed in Shanghai, with each frontispiece illustration colored, setting an example of woodcut overprint combining the new method of letterpress.

2.1.3 Wax Block Printing and Movable Tin Type

In the Song Dynasty, people not only used various woodblocks and copperplates as printing tools but also invented application of wax in printing. In the first year (1094) of Shaosheng, the messenger in Kaifeng the capital was so eager to publicize the list of new No.1 Scholar and the Runner-up Scholar that he could not wait to carve a woodblock. Instead, he used wax blocks. Records of this incident can be found in Volume II of "*Chunzhu Jiwen*" (News from the Water's Edge on a Spring Day) written in the Song Dynasty by He Yuan: "Bi Jian was the No. 1 Scholar and Zhao Shen the runner-up." Soon after the list was announced, the messenger in the capital was eager to spread the news. So he carved a wax block for printing. There was water on the radical of the character "澥" and ink failed to adhere. As a result, "澥" became "斩" (meaning "behead"). The messenger shouted the erroneous message at the top of his lungs "状元毕斩第二人赵谂" (literally, No. 1 Scholar will in the end behead the runner-up Zhao Shen. The correct message should be No. 1 Scholar Bi Jian; Runner-up Zhao Shen.—translator), those who heard the news considered it ominous. Later, Zhao Shen was killed for rebellion, echoing to the message of "in the end the runner-up will be beheaded." At that time, the No. 1 Scholar was Bi Jian. However, since the oily wax could not mix with water, the radical "氵" denoting three drops of water did not accept ink and failed to come out in the print. The messenger shouted "状元毕斩第二人赵谂." Eventually Zhao Shen was beheaded. This wax printing is suitable for works urgently needed and demanded at short notice. There is no record whether it was used in the Yuan and Ming Dynasties. However in the Qing Dynasty, it was commonly used to print newspapers (as shown in Fig. 23).

In the early Ming Dynasty, tin type was used to print counterfeit notes and the perpetrator was subjected to capital punishment. In the 52nd year (1787) of Qianlong in the Qing Dynasty, Cheng Dunwei from Shexian printed a volume

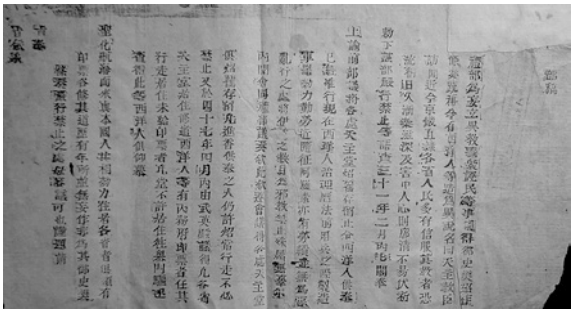

Fig. 23 Wax-printed newspaper in the Qing Dynasty

of "*Texts on the Eaves Tiles in Qin and Han Dynasties*": "In the beginning data wood was used for carving. However, upon proofreading against the original mistakes persist. Later seal casting and foundry method used by the Hans was applied: molten tin was poured into the tile-turned mould to produce tin types." Cheng opened a new chapter in printing by using molten pewter to cast mold for reprographic printing.

2.2 Movable-Type Printing

2.2.1 Invention of Movable-Type Printing by Bi Sheng and Its Use in the Song Dynasty

The invention of movable-type printing is a great technical revolution in the history of printing. The world's first inventor of movable type is Bi Sheng, a civilian in the Song Dynasty, specifically in the Qingli reign of Emperor Renzong (1041–1048) in the Northern Song Dynasty. Bi's invention is four hundred years earlier than the first use of movable type in Europe by Gutenburg to print the Bible. The fact of Bi Sheng's invention is recorded in "MengXi Bitan" (*Brush Discussions of the Dream Creek*) (Fig. 24) by Shen Kuo (1031–1095, or 1030–1094) and is irrefutable. "MengXi Bitan" said in Volume 18:

Woodblock printing had yet to become prevalent in the Tang Dynasty. After Feng Yingwang printed the Five Classics, woodblock came into use for printing by subsequent generations of classics. During Qingli reign Bi Sheng created movable type.

Fig. 24 The dream pool essays

The method: carve characters out of clay, as thin as a coin and each character occupies one block; set fire to the clay characters and hardern them. Set up an iron block, and cover it with pine resin, wax, paper ash or the like. While printing, place an iron frame on the iron block, and arrange the fired clay characters on it as necessary. After the frame is filled with characters, heat it until the pine resin slightly melts, and place a lithographic on their surface and the printed characters are as smooth as a whetstone. It would not be convenient if only several copies are printed. If dozens of or hundreds of thousands copies are printed, the speed is unrivaled. Often, two iron frames are used, so that while one is used in printing, characters can be set on the other. When the first block is printed, the second block is ready. Such an alteration occurs in virtually the split of a second. Each character has several spare copies. Characters like '之'and'也' have more than 20 spare copies each, so as to meet the demand of repetition in one block. Characters left idle are stuck with paper and stored in a wooden grid in the order of rhyme. Rare characters are usually not carved beforehand, but are improvised on the spot, fired with straw, and presently prepared for use. The reason for using clay in stead of wood is that wood has different degrees of grain density, and water is likely to make wooden characters uneven in height. In addition, wood characters are undesirable in that they get stuck with paper drugs. In comparison, clay type is easily recovered after use, by heating the paper drug until it melts. After that, whisk the clay type with hand and it will come off by itself, without catching any impurities. After death of Bi Sheng, his clay type is obtained by my cousins and nephews and kept to this day.

In Bi Sheng's method, clay types were hardened through firing and then arranged in an iron frame for printing though primitive; it fundamentally shares the same principle as the prevailing type typography, just like Shen Kuo said "It would not be convenient if only several copies are printed. If dozens of or hundreds of thousands copies are printed, the speed is unrivaled." From Shen Kuo's comment, we can see that it is very efficient. Shen Kuo was only a teenager when Bi Sheng invented movable type. Bi Sheng occupies such an important position in the history of printing in the world, but his invention did not receive much attention at the time. His name is not seen in the history books. Shen Kuo was the only one to know the importance of this invention and to have it recorded.

In addition to Bi Sheng, Shen Kuo, and Shen's nephews, did anyone else in the Northern Song Dynasty know the method of book printing by using mud movable type? This has been a problem bewildering the academia. Fortunately, "*Binglv Xiansheng Wenji*" (Collected Works of Master Palm) by Deng Su (1091–1132) has been found to contain a poem, which helps prove that there were people with a certain degree of understanding of movable-type printing in late Northern Song Dynasty and early Southern Song Dynasty (no later than 1132 AD). The poem reads:

Friendship should be based on mutual understanding; common interests will make it long lasting. Lo, behold Qiuhou and Xiegong, they have a friendship seamlessly strong. In his ordinary comment on people, Qiuhou details what Xiegong likes and hates. The moment Qiuhou finishes a new poem he lends it to others; long have I heard of its praises, and now I have seen it to be true. Visitors come in an endless flow, regardless of the shabbiness of the hut. This scenario is

inevitable even though the poem is circulated the moment it is completed; only if the two iron blocks of Bi Sheng were at hand.

This poem is written in echoing the "rhyme of 铁" initiated by Xie Libu, a native of Shaowu people. It is said in the poem that "new poetry" became widely disseminated soon after its completion, and manual copying alone cannot meet the demand. So the author sighed, "only if the two iron blocks of Bi Sheng were at hand." The expression "two iron blocks" is used here to refer to the description in "*Mengxi Bitan*": "Often, two iron frames are used, so that while one is used in printing, characters can be set on the other. When the first block is printed, the second block is ready. Such an alteration occurs in virtually the split of a second." Deng Su, styled Bing Lv, was a native of Nanjiansha County, Fujian, and an official in the capital Kaifeng. From his poem, we can see that Bi Sheng's method had attained certain reputation at the time.

Books printed in the Song Dynasty with clay type also include "*Yutang Zaji*" (Notes of The Jade Hall), which was written and printed by Zhou Bida in the 4th year (1193) of Shaoxi in the reign of Emperor Guangzong. The works of Zhou were gathered in "*The Collected Works of Zhou Bida*" or "The Grand Collection of the Works of Zhou Bida." In Volume 198, there is a commission letter written to Cheng Yuancheng in the fourth year of Shaoxi, saying "I have been shallow, and become absurd in my old age. I was troubled by stomach trouble time and again, and had to put off printing my books. Recently, I followed Shen Kuo's method, using clay copperplates in alteration for printing and completing a '*Yutang Zaji*' containing 28 articles. And I am sending one of them to you for your advice. There are ten-odd articles more in waiting. Soon after their completion, I will send them to you. I thought reading them can help me remember the good old days, while sighing over the flitting time."

In the article "Shen Kuo's method" is used, because the author has learnt the method in Shen Kuo's book "*Mengxi Bitan*"—which records the clay type printing of Bi Sheng—and mistaken it for the invention of Shen Kuo. In fact, it is nothing but Bi Sheng's method. Zhou claimed "using clay copperplates in alteration for printing," probably to mean that he arranged clay types on cooper blocks or plates—hence the name clay copperplates, to be used in alteration for printing. This operation fully shows the characteristics of movable-type printing—alignment and readjustment of types is required to form a layout prior to printing. Zhou first printed his won book *Yutang Zaji* containing 28 articles. From this, we can see that people in the south in the Southern Song Dynasty were still imitating Bi Sheng in printing books. Publication of Zhou's *Yutang Zaji* marks the advent of the first movable-type print in the world, and it can fill the blank between the Northern Song Dynasty and the early Yuan Dynasty ruled by the Mongolian ethnic group.

2.2.2 Movable Type in Western Xia

In 1991, relics of Buddhist sutras "*Auspicious Tantra of All-Reaching Union Continued*" in Tangut script were found in the ruins of Baisigou Square Pagoda, in Helan Mountain, Ningxia (as shown in Fig. 25). Without frontispiece, ending or

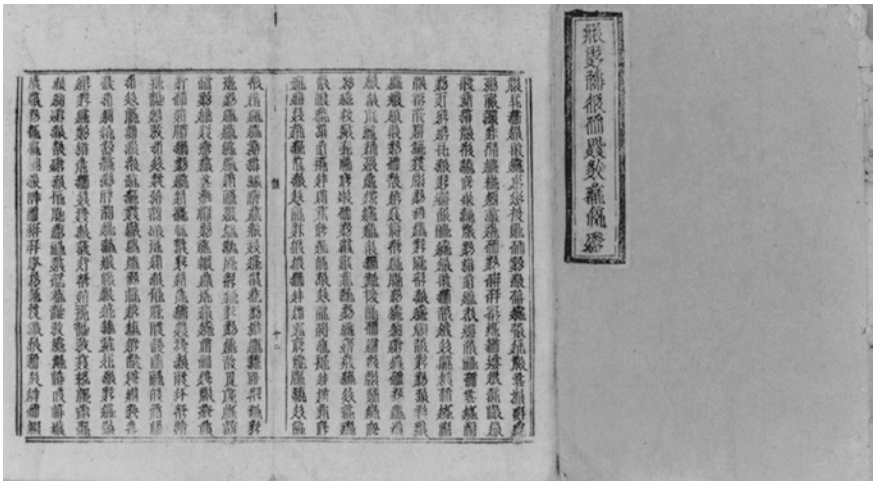

Fig. 25 Remains of *Auspicious Tantra of all-reaching union continued*

epilogue, the age of the print is untraceable. Wooden tablets inscribed with Tangut characters of ChongZong Zhen'guan, Western Xia (1102–1114) and two vows of the 11th year of Qianyou in Renzong reign (1180) were also found. "*Auspicious Tantra of All-Reaching Union Continued*" is a tantric classic of the Tibetan Buddhism, while late Western Xia is a period dissemination and development of Tibetan Buddhism in the Western Xia. It was presumed to be the result of movable-type printing in late Western Xia, because it bears the features of movable type: (1) Bar lines of the page frame do not converge in the four corners or measure the same length. (2) The shade of ink varies. (3) A few characters were printed upside down. (4) There are traces of interlaced lines. According to Volume 22 of the book *Agricultural Treatise* by Wang Zhen, "in methods for creating movable type for printing" "the character blocks are arranged in lines and each line is spaced with bamboo slips. However, Shen Kuo's "*Mengxi Bitan*" doesn't include an interlacing process. Therefore, it is concluded that this book had been the result of wooden type printing. However, interlaced lines are not a distinctive feature of wooden type; they are also found in metal type. In addition, some prints are produced through the wooden type, but are identical to woodblock prints. Some books of Wuyingdian Juzhen Ban (Treasure Editions Collected by Hall of Military Eminence) made via wooden type printing are a case in point. Therefore, there is insufficient justification to use interlaced lines for differentiation of the wooden movable type from the other types.

Japanese is in possession of ten volumes of "*Avatamsaka Sutra*" in Tangut script. In the vow, there is the sentence "vow to carve individual characters, which has been taken by Japanese scholars upon research as corroboration of the book being printed via movable wood type." And the sutra is believed to be the earliest known example of a book printed using wooden movable type. Among the Buddhist scriptures kept in the National Library of China, *Avatamsaka Sutra* is the greatest in number, accounting for 2/3 of the entire *sutra*.

In Volume 40 of *Avatamsaka Sutra* in Tangu script, there are two lines of inscriptions in Tangu scripts, whose Chinese translation are as follows: "实勾管作选字出力者盛律美能慧共复愿一切随喜者皆当共成佛道." (Those engaged in typesetting are virtuous and can expect to have all their wishes granted and attain the Buddhist Tao.)

The five characters "选字出力者" (those engaged in typesetting) means that a typesetting process is required for printing.

In addition, *Avatamsaka Sutra* contains two lines of commendations inscribed on wood in Volume 5, reading "都行愿令雕碎字勾管做印者都罗慧性 又共行愿一切助随喜者共同皆成佛道." (It is vowed that those engaged in carving characters and printing are intelligent and can expect to have their wishes fulfilled and attain the Buddhist Tao.) In the sentence, "碎字" refers to movable type. The wooden inscription means that the sutra had been printed with movable type.

In the remaining volumes of *Avatamsaka Sutra* in Tangut, the lines are uneven and askew; the ink shades in the front and back of the papers are different; there are many signs of correction by reprinting, and incorrect characters directly overlaid with the correct ones, as well as smaller characters written with writing brush. Some people believe that these are the signs of movable type. Others think that the Tangut script "*Avatamsaka Sutra*" during Renzong reign (1125–1193) had been printed with wood type carved in Hangzhou during the Yuan Dynasty.

In 1987, Buddhist classic "*Vimalakirti Nirdesa Sutra*" (as shown in Fig. 26) in Tangut script was found in Wuwei, Gansu. Initial studies have concluded that it had been a print of Renzong reign and identified it as having used clay movable type according to hollowness in the strokes, deformed or broken strokes. If the above works in Tangut script have been printed using movable type, then they should be the earliest extant examples of movable-type printing.

2.2.3 Movable Type in the Yuan Dynasty

1. Clay Type (Yang Gu)

Yao Shu, an adviser of Kublai in the early Yuan Dynasty, "was engrossed with influencing the people and forming moral customs, printed the primary school textbooks including *Analects*, *Mengzi*, *Alternative Questions*, *Family Rite*, Yang

Fig. 26 A glimpse of *Vimalakirti Nirdesa Sutra*

Zhongshu-version Four Books, Minister Tian Heqing-version "*Collection of Shengshi Poetry,*" "*The Biography of Yi Cheng,*" "*The Biography of Shucai,*" and "*The Annals of Spring and Autumn*"—all were printed in Yanjing. When he found that primary school books were not widely distributed, he instructed his disciple Yang Gu to use Shen's mobile (note: should be "movable") type to print *Thought about Nearness*, *Classics and History Books of Donglai*, and so on, for distribution across the country." (see Volume 15 "*Stele of the Left Prime Minister Yao Wenxian,*" *Mu'an collection* by Yuan Yaosui.)

Shen's movable type is Bi Sheng's movable type recorded in the work of Shen Kuo. The time of the above-mentioned activity is between the 13th year of Taizong of Mongolia and the 3rd year of Queen Regent of Ogul Gaimysh (1241–1250), exactly 200 years later than Bi Sheng's invention. The article failed to detail whether the printing occurred in Huixian or Yanjing, or what kind of movable type had been used.

As for Yao Shu, Su Tianjue (1294–1352), native of Zhending, also wrote in "*Records of Famous Courtiers in the Yuan Dynasty*": "printed the primary school textbooks including *Analects*, *Mengzi*, *Alternative Questions*, *Family Rite*, Yang Zhongshu-version Four Books, Minister Tian Heqing-version '*Collection of Shengshi Poetry*,' '*The Biography of Yi Cheng*,' '*The Biography of Shucai*' and '*The Annals of Spring and Autumn*'—all were printed in Yanjing. When he found that primary school books were not widely distributed, he instructed his disciple Yang Gu to use Shen's mobile (note: should be 'movable') type to print *Thought about Nearness*, *Classics and History Books of Donglai*, and so on, for distribution across the country." "*Records of Famous Courtiers in the Yuan Dynasty*" is based on tombstone inscriptions written by Yao Sui, but the text is slightly modified. Later, Xu Youren (1287–1364) also introduced the activities of Yaoshu in Volume VI, "R*ecords of Snowy Book House,*" "*Guitang Xiaogao*" and mentioned "teaching disciple Yang Gu to Shen's movable type in printing." "*List of Celebrities in Zhongzhou*" written by Liu Chang of the Ming Dynasty cited from "*Records of Snowy Book House,*" making Yang Gu's use of ancient movable type in printing books widely known.

In the fifteenth century, the famous North Korean scholar Kim Jong-jik remarked in the postscript to "*Pak Anthology,*" a movable-type print in Korea: "Movable type printing was invented by Shen Kuo, and reached its peak through the promotion of Yang Weizhong, who made all the books, ancient and present, printable. The benefits were enormous. However, Yang's movable types were made of fired clay, and easily broken, thus could not last long." Kim said that the movable types prevalent in Yang Weizhong's time were fired clay. However, according to the original record in "*Mu An Ji,*" books published in Yanjing by Yang Weizhong still used engraving. The reason for Kim to make the mistakes may be that he confused "Secretary Yang" (Yang Weizhong) with Yang Gu and erroneously attributed movable-type printing to Yang Weizhong. In addition, in the postscript to the Korean version of "*Chen Yuyi's Poems*" "Movable type printing was invented by Shen Kuo, and reached its peak through the promotion of Yang Chong, who made all the books, ancient and present, printable. However, Yang's

movable types were made of fired clay, and easily broken, thus could not last long." Domestically, no record has been found of Yang Weizhong or Yang Chong using movable clay types in printing books. The claims of Korean scholars might be supported by otherwise facts. Although Yang Gu printed Zhu Xi's books and Lv Zuqian's books in a time later than Zhou Bida did, those books are still earlier movable-type printed copies.

Seen from the Song and Yuan literature above, movable type invented by Bi Sheng was not only recorded by Shen Kuo, but also made in late Northern Song Dynasty. In the Southern Song Dynasty, it was used by Zhou Bida to print his own anthology, and in the Yuan Dynasty, by Yang Gu to print textbooks. In the fifteenth century, these records spread to Korea and became also familiar to the locals. Therefore, popularization and application of Bi Sheng's movable-type printing in the Song and Yuan Dynasties were quite extensive.

2. Wooden Type (Wang Zhen, Ma Chengde)

Before making clay type, Bisheng also experimented with wooden movable type, but he believed that difference in the texture and density of wood would make the characters uneven once they got wet. In addition, wood easily got stuck with the paper drug. Those drawbacks made wood an undesirable material. On the other hand, fired clay did not get smeared easily. Therefore, clay, instead of wood, was chosen. The first one to formally printing books with wood type was Wang Zhen of the Yuan Dynasty, in a time a bit later than Yang Gu using movable clay type. Wang Zhen, a native of Dongping, Shandong, was a famous agronomist and mechanical scientist with important contributions to the printing history. From the first year of Yuanzhen (1295), he had assumed the post of prefecture governor of Jingde, Anhui for 6 years. Within his tenure, he lived a simple life, donated his salaries to building schools, bridges and roads, taught farmers arboriculture, and doled out drugs to rescue people. In the fourth year of Dade (1300), Wang was made prefecture governor of Yongfeng, Xinzhou (now Guangfeng county in Jiangxi), where he advocated cotton and mulberry cultivation. Thus, people from those two prefectures were full of praise for him.

Wang Zhen's biggest contribution was undoubtedly the "*Agricultural Book.*" During his tenure in Jingde County, Wang Zhen had begun writing this book and planned to publish it. Fearing that this book would be too long and thus engraving too difficult, he hired artisans to carve out more than 30,000 characters in 2 years. The carving took the following steps: write on paper the characters, stick the paper on a woodblock, and engrave the characters, after engraving separate the characters one by one with a fine saw, and then finish with a knife the characters to the same size. Arrange the characters row by row, separated with a bamboo slip. After the box is full of wooden characters, flatten the characters with bamboo mats, and secure them with wooden wedges so that they would not move. Coat the characters with ink, spread out a paper on top, and print with a palm brush. Wang Zhen had a technical innovation in typesetting. Sensing it would be inconvenient for the typesetter to around looking for the characters, he created two large wooden

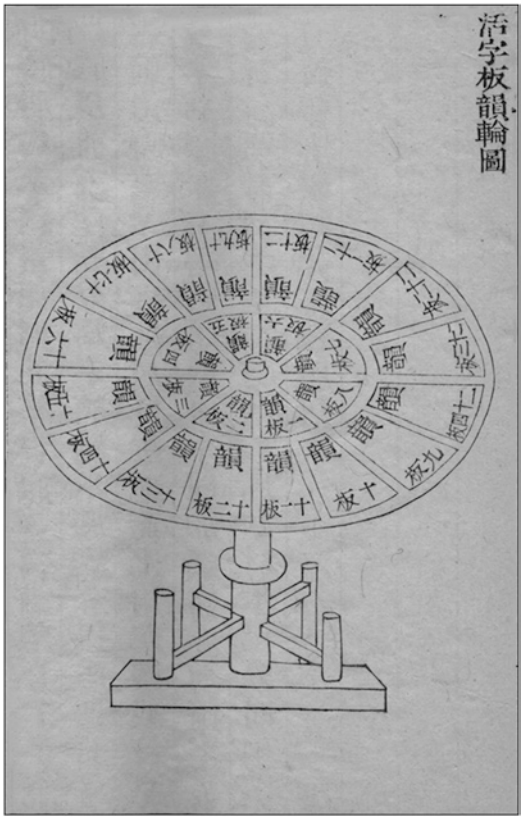

Fig. 27 The master wooden wheel made by Wang Zhen

wheels (as shown in Fig. 27) in which wooden characters were placed according to numbers. During typesetting, a person would sit in the middle and push the wheels with both hands. This method is called "bringing the characters to the people." Compared to looking for characters, it reduced labor and increased efficiency. Titled "Book Printing with Movable Type," the part of "*Agricultural Book*" after Volume 22 recorded movable-type printing, systematically documenting the entire process of writing according to rhymes, engraving, sawing, finishing, making the wheels for picking characters, securing the characters, and printing system. This made *Agricultural Book* a very precious literature in the history of printing.

Wang Zhen had originally planned to use his movable type for printing his own work "*Agricultural Book.*" So when he was transferred to Jiangxi, he took the new set of printing tool with him. However, officials in Jiangxi had already engraved the entire book on wooden blocks, and Wang's invention was laid idle. During his tenure in Jingde, he only printed "*Jingde County Annals*" compiled by himself, in about the second year of Dade (1298). The book had over 60,000 words, and it took less than a month to print one hundred copies, reflecting the high efficiency of moveable type. This book is also the earliest regional chronicles printed via movable wood type.

20 years after Wang Zhen, Ma Chengde also used movable type to print books. Ma, a native of Guangping, Hebei, was made state governor of Fenghua in the sixth year of Yanyou (1319). In the following 3 years, Ma dredged rivers and built dames, constructed irrigation facilities, reclaimed 13-Qin of land (=214.3 acre), launched large-scale afforestation, set up schools, and constructed library buildings. During his tenure, he also "carved as many as 100,000 movable characters," three times more than Wang Zhen. In the second of Zhizhi (1322), books like "Da Xue Yan Yi" were printed with movable type. *Fenghua State Annals* compiled by Ma Chengde may have also been printed with the new movable type. We have no idea whether Ma imitated Wang in printing books; however, we do know that in the Yuan Dynasty, movable wooden type was popular in southern Anhui and eastern Zhejiang regions.

The movable wooden type also spread to the Uighurs in the Yuan Dynasty. In 1908, French sinologist Paul Pelliot found in Dunhuang wooden movable type in Uighur of the Yuan Dynasty. The movable type is now kept in Musée Guimet in Paris. Later, additional findings were made in Dunhuang, and those are now in the possession of the Dunhuang Academy. Uighurs played a very important role in the process of spreading printing from China to the West.

3. Tin Type

Tin type was first mentioned by Wang Zhen in "*Book Printing with Movable Type,*" which said: "Nowadays tin is cast to make characters, which are then strung together with iron bars to form lines. The lines are then embedded in a frame and separated with boundary lines for printing books. However, because tin type does not absorb ink well, misprints are widespread. Therefore, tin type does not last long." "Nowadays" in the passage refers to early Yuan Dynasty or late Song Dynasty, almost two centuries earlier than use of metal movable type in book printing in the West. Since Wang explicitly mentioned casting tin for movable type, it is obvious that tin type had been made after modeling and casting, rather than directly carved on the tin blocks. The tin characters could be strung together with a wire, presumably because there was a small hole in each of them. After typesetting, they could be used for printing. The transition from non-metallic movable type to metal tin type is a big step forward in type-making technology. However, bad printing repeatedly occurred because there was no quality printing ink to support it. Therefore, this new invention becomes just a flash in the pan and failed to be popular for a long time. Regarding the inventor of tin type, its place of invention, and books printed using it, Wang gave no detail.

2.2.4 Movable Type in the Ming Dynasty

1. Wooden Type

With socioeconomic and cultural development wooden movable-type printing was more popular in the Ming Dynasty than the Yuan Dynasty. Prints in the

Wanli Years (1573–1620) were especially numerous. Hu Ying-lin (1551–1602) remarked: "At present, people in a rush to print can use movable type, which originated in the Song Dynasty. However, without mud drug, they have to make do with wooden movable type." Gong Xian of the Qing Dynasty once remarked: "People in the Ming Dynasty used wooden movable type in printing books, and book printing thus became popular." Seen from the actual prints handed down, wood type was indeed quite common in the Ming Dynasty. Some copies can be ascertained for movable-type prints the moment they are open, but some were indistinguishable from engraved printing. As for the differentiation between wooden movable type and copper movable type, the difficulty is even greater. Many copperplate-printed books had been marked as such, while those printed with wooden type rarely labeled the use of wooden type. Therefore, it is common for A to claim a print as the result of wooden type printing, and B to claim it a result of copperplate-plating. There are divergent views, and an agreement is impossible.

There is no record of the Ming Dynasty government using movable type in printing books, while the tetrarchs distributed across the country used movable type, in addition to carving extensively for printing books so as to show their respect for literature and scholarly pursuits or to pose lovers of culture. Mostly, they had made wooden movable type, instead of metal movable type. In the Song and Yuan Dynasties, many colleges engraved books, but application of movable type in colleges began in the Ming Dynasty. In the Ming Dynasty, there were also private use of movable type in printing books, and Hu Min, a scholar of the Imperial College, was one of them. In the Jiading years of the Qing Dynasty, Xu Zhaoji borrowed movable type from someone else to publish his father Xu Xuemo's work "*Shi Miao Shi Yu Lu*" (Records of Temples), which recorded anecdotes and historical facts in the reign of Emperor Jiajing in the Qing Dynasty. The work contained twenty-six volumes, and one hundred books. Movable type can be intended for personal use, as well as lent to others. This is where it eclipses woodblock printing.

There are about 100 kinds of books with verifiable titles printed in the Ming Dynasty using wooden movable type. Mostly, they were printed in the Wanli years, and printed copies before Hongzhi years were rare. Printing places ascertainable include Jiangsu, Zhejiang, Fujian, Jiangxi, and Yunnan, aside from Chengdu, Jianchang, and Nanjing.

A famous wooden movable-type print from the Ming Dynasty is "*Heguanzi*" (The Comb of a Fighting Bird). In the center of the type area, there are the characters "活字版" (movable-type versioni)、"弘治年(Hongzhi Years), or "碧云馆" (Green Pavilion Studio), and the host of the studio remains to be verified. On the cover, there is a large red seal reading "两淮盐政李质颖送到马裕家藏《鹖冠子》壹部计书壹本" (Salt Policy Li Zhi presents One Copy of '*Heguanzi*' to Ma Yu's Home for Private Collection) dated April the 38th year of Qianlong's reign. At the beginning, there is a poem written by Emperor Qianlong in Kuisi year (1773). Because Qianlong repeatedly mentioned the book, and because "*Complete Library in Four Branches of Literature*" had a master copy of "*Heguanzi,*" this book became quite prestigious among movable-type prints. In late Ming Dynasty, people in the south started using the wooden type for printing genealogy.

2. Copper Type

In history, the most popular metal movable type in China is not tin type or type, but copper type.

2.1 Wu Xi (the Hua's and the An's)

The earliest authentic copper movable-type printing in China should be that implemented by Huasui Huitong Studio in the Ming Dynasty. Hua Sui (1439–1513), also known as Wenhui and styled Huitong, was a native of Wuxi, Jiangsu. "In his early years, Hua read extensively in classics and history. In his middle years, he took a fancy to collation and proofreading, and recorded his findings based upon deliberation and investigation. He fashioned copperplate and tin type so that when he came across rare books that had been hard to come by, he would collate and print them, saying 'Now I have learned and mastered the art of printing.'"

Shao Bao's "*Collection of Rongchuntang Biography of Huitong*" recorded "Later, [he] followed up with copper type, saying 'Now I have learned and mastered the art of printing8.' Thus he named his printing house Huitong Studio." Hua Sui made his copper type in the third year of Hongzhi (1490), because in his own account: "I am obliged to spread civilization, and the copper type is like a godsend." His initial motivation was just to reduce the trouble of manual transcription, but later his invention became popular across the country. At that time, there was a plan to re-engrave the book "*Song Zhuchen Zouyi*" (Memorials of Courtiers in the Song Dynasty), but the vast cost had been daunting. So Huitong Studio was commissioned to typeset it in copper type and print it, so as to popularize it. Finally in the third year of Hongzhi, Huitong Studio succeeded in printing fifty copies. Back then only one set of movable type was used, so the body and the notes were of the same size. Each line had two rows of type, making the print uneven, and only one half of some words came out. The ink was fuzzy and sloppy and left the hand black. In addition, insufficient care was executed in collation, passage loss, and mistaken characters occurred in each and every volume. In some cases, even one or two entire pages were left out, making the text incoherent and severing the meaning of passages. However, despite the shoddy printing quality, those books are the first metal movable-type prints known. Later Hua successively printed "*Jizuan Yuanhai*" (Profound Ocean of Records and Compilations) written by Pan Zimu in the Song Dynasty, "*Gujin Hebi Shilei Qianji*" ("Well-prepared Digest of Categorized Matters of the Joint Jade Circles Quoted from Old And New [Literature]") written by Xie Weixin, and "*Jinxiu Wanhua Gu*" (Splendid Flower Valley) by an unknown author. "*Jinxiu Wanhua Gu*" has a big copper version and a small copper version, which refers to big fonts and small fonts, respectively. Books verifiable as being printed by Huitong Studio amount to 19, an unrivaled number in copper-type prints in the Ming Dynasty. These were also the earliest in time. The eight books, i.e., "*Song Zhuchen Zouyi*" (as shown in Fig. 28), "*Jinxiu Wanhua Gu,*" "*Rongzhai Wubi*" (The Fifth Volume of Rongzhai Collections), "*Baichuan Xuehai*" (The Sea of Learning), "*Jiujing Yunlan*" (Rhymes of the

Fig. 28 A glimpse of "*Song Zhuchen Zouyi*"

Nine Classics), "*Wenyuan Yinghua Zuanyao*" (Collected Blossoms of Literature), "*Yinshi Chunqiu*" (Transcription of Spring and Autumn Annals), and "Gujin Hebi Shilei Qianji," printed before the 13th year of Hongzhi (1500) are equivalent to Europe's incunabula and are especially precious.

Hua Cheng, uncle of Hua Sui, a scholar of the 8th year of Chenghua (1472), served as the governor of Guanglu Temple, Beijing. He warehoused vast quantity of millets, reclaimed thousands of Qin of land (1 Qin = 16.5 acre), and collected numerous calligraphy and painting antiques, which he was good at identifying. "*Wuxi County Annals*" of the Kangxi years said that Hua Cheng "Collected various books. He could make very sophisticated letterpress, and could turn the rare books to print he got in merely a few days." Zhu Yunming, a personage of Suzhou said: "Guanglu (Hua Cheng) was over seventy and still as studious as youngsters. He made movable type, chose books urgently needed for studying, and actively printed for the benefit of the learners. Movable type is also the reason for this collection to come into shape easily. After Shen Mengxi (Shen Kuo) described movable-type printing in '*Mengxi Bitan*,' it has recently become popular in Sanwu Region. However, their skills in printing also vary greatly." Although senior to Hua Sui by one generation, Hua Cheng printed Lu You's "*Weinan Wenji*" (Anthology

of Luyou) and "*Collected Poems of Luyou Volume 2*" in the 15th year of Hongzhi (1502), later than Hua Sui's Huitong Studio.

Hua Sui's nephew Hua Jian also printed book in Zhengde years. Most of the books printed by Hua Jian are marked with the label or publisher's words "锡山兰雪堂华坚允刚活字铜版印行" (Printed via copper movable type by Hua Jian (styled Yungang) in Lanxue Studio in Xishan), as well as the circular seal "锡山," and "兰雪堂华坚活字铜版印" (copper movable-type print by Hua Jian of Lanxue Studio) in seal character. Lanxue Studio printed the collected poems and essays of famous writers like Cai Yong of the Han Dynasty, Bai Juyi and Yuan Zhen of the Tang Dynasty; "Yi Lin" by Ma Zong, and "Yiwen Leiju" ("Collection of Literature Arranged by Categories"), a reference book of the Tang Dynasty. "Yiwen Leiju" included an epilog written by Hua Jing, son of Hua Jian, in Zhengde Yihai year (1515). While printing, Lanxue Studio typesets two rows of characters in one line. And the prints are known as Lanxue Studio double-line versions, and very few have been handed down. Thus, they draw much praise from bibliophiles. However, "*The Collected Works of Cai Zhonglang*" is also "abound in mistakes on almost every single page." Most of the books printed by Lanxue Studio are labeled with "刊字芦宽" (typeset by Lu Kuan), which seems to have been engraved for printing.

Apart from the above-mentioned Hua Cheng, there were three millionaires in Wuxi in mid-Ming Dynasty, who were mentioned in the balladry of the time as: "An Guo, Zou Wang and Hua Linxiang, the three millionaire whose gold and silver are measured by buckets." Among the three, An Guo (1481–1534) was especially rich. With enough wealth to match a state, he was called "millionaire An." An boasted 20,000 mu fields in Songjiang Prefecture alone. An planted over 1 km of sweet-scented osmanthus in Jiaoshan Mountain in Wuxi where he lived, and thus styled himself "Osmanthus slope." Rising from a commoner to prominence through commerce, An had built the city proper of Changzhou, and doled out relief in case of famines. Therefore, he was known as "a high-minded person." He liked to buy old books and famous paintings. Whenever he heard of a masterpiece, he would buy it at a cost, filling his house with books. After he got the book, he would "cast copper movable type and printed it to spread its distribution.

An Guo started making movable-type and printing books in about the 7th year of Zhengde (1512). Liao Jixiu, then Ministry of Personnel in Nanjing Shangshu, commissioned An Guo to print his six volumes of "*Dongguang County Annals*" when he heard An Guo had copper movable type. An completed printing in the 16th year of Zhengde and sent them to Liao. This "*Dongguang County Annals*" printed in Zhengde years can be seen as the only local annals printed with copper movable type. In books printed by An, the months and years were generally left out. And the only exception is "*Wuzhong Water Conservancy Annals,*" which has the label "嘉靖甲申 (1524年) 安国活字铜版刊行" (printed by An Guo with copper movable type in Jiashen Year (1524) of Emperor Jiajing). Yu Tai of the Ming Dynasty remarked in an epilogue to "*Record of Initial Learning*": "[An] collected and printed over 20 years the classics, history books, philosophical works and miscellaneous works to benefit students of later generations. The books printed

amounted to thousands of volumes." Currently, 10 books can be verified as prints of An Guo, putting An second to Hua Sui only in number of books handed down. Qian Qianyi of early Qing Dynasty wrote in the epilog to "*Rich Dew of Spring and Autumn*": "Jinling version had multiple misprints and mistakes, and hundreds of words were changed in the movable-type print by An's of Xishan." From this, we can see that An had taken quite seriously his book printing, and there were fewer errors. Qin Jin of the Ming Dynasty wrote in the epitaph to An "cast copper movable type." Since Qin and An were fellow townsmen from the same period, this saying should be credible. However, An Guo's offspring An Ji said that An Guo "had engraved type copperplate" for printing the "*The Collected Works of Yan Lugong,*" Xu Jian's "*Record of Initial Learning*" and other books. What had been cast with or engraved in metal should be the movable type, rather than the copperplate or copper-disk character shelf for placing the movable type. An Guo made movable type in about the Zhengde years, about 20 years after Huitong Studio. Then, he was about 30 years old, so whether casting or carving, he should have made his movable type in imitating the Hua's. An Rui of the early Qing Dynasty "while he had time, my ancestor (An Guo) would pick out the less printed ancient books and printed them through copper movable type. Therefore, he was known far and wide. Bibliophiles today have books printed by An's in Jiaoshan Mountain and those books had been printed via copper type." In fact, An Guo used woodblock, aside from copper movable type in printing books. For instance, "*Selected Poems of Shitian*" (in Zhengde Years) by Shen Zhou and "*Zuocui Leizuan*" claimed themselves to have been carved by An Guo in Hongren Studio in Xishan. Both "*Collected Works of Yanlugong*" and "*Record of Initial Learning*" had two versions, one copper movable-type edition and the other woodblock edition. Unfortunately, after the death of An Guo, his copper type was "measured and divided by his six sons." All of the copper type, together with fields and other properties, were carved up by his six sons. And the copper type obtained by each of them was incomplete and turned into useless waste.

In the biography of Hua Sui, there is a sentence "imitating copperplate and tin type." Therefore, it is suspected that Hua's Huitong Studio had cast tin type, aside from copper type. However, we find it difficult to conclude whether the type made by Hua Sui is tin type or copper type, or both, before we find the actual type used back then and more detailed and reliable historical data. So generally, Hua's movable type is still categorized as copper type. As for the movable type of An Guo, due to the record of "measured and divided the copper type," we know for certain that it is copper movable type.

2.2 Changzhou

Changzhou, a place adjacent to Wuxi, also used copperplates, known as "Changzhou copperplate." Only two kinds of Changzhou copperplate prints, i.e., "*Du's Tongdian Zuanyao*" and "*Yiwen Leiju,*" kept in Baowen Studio by Chao Li, native of Kaizhou, the bibliophile in the movable of JiaJing years of the Ming Dynasty. However, details about the printer have been unavailable.

2.3 Suzhou

In the Ming Dynasty, there were Jinlan Studio, Wuyunxi Studio, Wuchuan Jingshe, and Sun Feng from Wu Prefecture and others engaged in book printing, and they were mainly concentrated in the vicinity of Suzhou, just as Zhu Yunming remarked "recently the enthusiasts in Sanwu region have been active." Tang Jin, native of Shanghai, remarked, "Nowadays, the masters mainly engraved movable type for printing on copperplates, for it is easy to use. It originated in the movable of Qingli years invented by the commoner Bi Sheng." Xie Qiyuan of the Ming Dynasty also mentioned in "*Mr. Xie's Miscellanies*": "Nowadays, the masters mainly engraved movable type for printing on copperplates, for it is easy to use. It was invented in the Qingli years of the Song Dynasty, when the commoner Bi Sheng fashioned movable type by engraving characters in clay and harden them by firing. While printing, two iron plates are used. The movable type is arranged on the plate, and when one plate is used in printing, typesetting on the other can begin. Alternate the two plates, and copies can be completed soon. And the cost is lower than copper movable type." Thus, the convenience of copper type has been generally recognized.

In Zhengde years, "*Collected Works of Fifty Poets in the Tang Dynasty*" was printed in Changzhou. In the 5th year of Zhengde (1510), Shu Zhen engraved "*Collected Works of Cao.*" In the preface, Tian Lan remarked: "Shu said: 'One year when I passed Changzhou, I got one hundred copies of '*Collected Works of Zijian*,' and sold them as I went on. They were sold out soon. Now, there are many inquiries for them, but I have none available. This is because limited copies were produced via movable type back then and now they are no longer available" He Liangjun, native of Huating, Songjiang in the Ming Dynasty said in Volume 24 of "*Siyouzhai Series*": "the Xi's in Xuyan printed *Liduan Ji*, the movable-type version of the 'Collected Works of Fifty Poets in the Tang Dynasty.'" Therefore, we know that the book had been printed by Xu Jin.

2.4 Nanjing

In Nanjing, there was a certain Zhang engaged in printing, but his name is unknown. Only one of his prints, i.e., "*Forgotten Tales of the Kaiyuan and Tianbao Periods,*" is handed down. In the first page of Volume 1, there is a line saying "建业张氏铜版印行" (published by Zhang's via copperplate in Jianye)." However, the time of printing is nowhere to be seen. Wen Zhengming, originally an artist in the Ming Dynasty, took to book collections, and he had a book printed by Magnolia Studio. Wen died in the 38th year of Jiajing (1559) at the age of 90. Therefore, the book should have been printed in Hongzheng or Jiajing period.

2.5 Zhejiang

Among copperplate prints in Zhejiang, only "*Zhugeliang's Book of the Mind*" of the Zhengde Years is known. Inscribed with "浙江庆元学教谕琼台韩袭芳铜版

印行" (printed by Han Xifang through copperplate in Qiongtai under instructions from Qing Yuanxue in Zhejiang), the book has a preface by Han Xifang, saying "I hereby reprint the book with movable type for sharing with people wishing to dedicate themselves to military service and also to remind people of danger in times of safety". The end of the preface reads "In April of Dingchou Year (12th year of Zhengde (1517)), by Han Xifang in his bookstore in Qiongtai, eastern Zhejiang. It can be seen that Han's copperplate also used movable type, and the printing was carried out in eastern Zhejiang. In old times, Qingyuan County was the state capital of Zhejiang. Located in the junction between the two provinces of Zhejiang and Fujian, a quite remote region, Qingyuan County, actually had copperplate.

2.6 Zhicheng (Jianning)

Among extant copper-type prints of the Ming Dynasty, the fifteen volumes of *Mo Zi* of Zhicheng are most highly praised by bibliophiles. Printed with blue ink on white papers, it consists of two books. In the middle of the last page in Volume 8, there is a line saying "嘉靖三十一年(1552年)岁次壬子季夏之吉, 芝城铜版活字" (Zhicheng Copper Movable Type in June of 31st year, the year of Renzi (1552) during the reign of Jiajing). In the middle of the last page in Volume 15, there is a line saying "嘉靖壬子岁夷则月中元乙未之吉, 芝城铜版活字" (Zhicheng Copper Movable Type in July in the year of Renzi during the reign of Jiajing). The printing took only 1 month and a half between June to July. Zhicheng, a name derived from Zhishan Mountain, is the alias for Jianning prefectural city—present-day Jian'ou County, Fujian. Therefore, Zhicheng movable type is actually the copper movable type of Jianning prefectural city. On seeing *Mo Zi* printed in the Ming Dynasty, the Master of Tangcekan remarked: "After seeking far and wide, I finally got the transcribed version printed via Zhicheng movable type." Instead of calling the book a copperplate type version, he called it transcribed version via copper type, so it seemed that he believed that what he got had been a transcribed book based on a movable-type print, rather than the print itself. In addition, Zhicheng copper-type prints also include "*Tongshu Lei Jukeze Daquan.*"

2.7 Jianyang

Apart from the prefectural city, Jianning also had copperplate in its subordinate county Jianyang County. Jianyang copperplate prints verifiable include Yourong Productions. In the first year of Wanli reign (1573) in the Ming Dynasty, Mao Kun, a native of Huzhou, printed "*Differentiation of Styles*" written by Xu Shizeng and inscribed the line "建阳游榕活版印行" (printed via Yourong movable type in Jianyang) or "建阳游榕活版印行" (printed via Yourong movable type in Jianyang, Fujian). After the book was published, people scrambled for it, pushing higher the price of paper mulberry. How can we say that the movable type made by Yourong is copper instead of wooden? This can be proved by "*The Imperial*

Readings of the Taiping Era" printed in the following year (1574). Because the characters and annotation scripts in these two books are exactly the same in font, and the surrounding single lines, typographical format, and paper and ink are also mostly the same. In "*The Imperial Readings of the Taiping Era,*" below the type area there is often a line saying "宋版校正, 闽游氏仝版活字印一百余部" (collation of the version published in the Song Dynasty, over 100 copies printed by You's in Fujian with Tong plate). In the content of the fifth volume, there are two lines of characters "宋版校正, 福建游氏梓制活版, 排印一百余部" (collation of the version published in the Song Dynasty, over 100 copies typeset and printed by You's in Fujian with movable type). The so-called 仝版 above is actually simplified edition of "铜版" (copperplate). In some places, it was written as "Rao's Tong plate," like in "宋版校正, 饶氏仝版活字印行壹百余部" (collation of the version published in the Song Dynasty, over 100 copies typeset and printed by Rao's Tong plate). This copperplate was made by You Rong and later came into the hands of You's and Rao's. Therefore, within the same book, it is called You's Tong plate or Rao's p Tong late. Rao refers to Rao Shiren, a bookseller from Fujian. Zhou Tang of Changshu bought half of "*The Imperial Readings of the Taiping Era*" printed in the Song Dynasty from Fujian through the merchant Rao Shiren and borrowed the other half from Gu's and Qin's in Wuxi. Using the combined version as the master copy, Zhou printed over one hundred copies and divided them with Gu's and Qin's. This masterpiece of one thousand volumes and one hundred eighteen books repeatedly labeled itself a collation of the version published in the Song Dynasty, but turned out to be of rather sloppy proofreading, with many mistaken and lost characters. The characters were skew, and some words were typeset erroneously, reflecting a mediocre typesetting technology. The strange thing is that these two books were not printed in Jianyang, but in Jiangsu and Zhejiang, reflecting a high mobility in the job.

The copper type of the Ming Dynasty did not use pure copper, but copper alloy. The literatures only said that Hua Sui made tin type in imitation of copper type and that the movable type made by Hua Cheng was sophisticated. However, there is not enough data to show how the type was made. Tang Jin claimed: "Nowadays, the masters mainly engraved movable type for printing on copperplates." It seems that the type was engraved on copper. Some people think that probably it was made by casting according to models. Although the individual character is not very regular, the most commonly used words may have had more than one model. So the font of the same character might differ. Cast type is very coarse and needs trimming before application. Since there is no clear record, or actual samples handed down for demonstration, it is still hard to know for certain whether the type had been cast or carved.

In total, there are about 62 copper-type prints produced in the Ming Dynasty, with Hua's of Wuxi producing the most and An's the second most, followed by Jianning and Changzhou. Huang Pilie of the Qing Dynasty remarked in an epilogue to "*Copper Type Mo Zi*": "Among ancient books engraved since the Song and Yuan Dynasties, the most trusted is none other than those produced via movable type on copperplates." This is because they are based on earlier editions

produced via woodblock printing. Copper-type prints of the Ming Dynasty have been treasured by generations of bibliophiles since the Qing Dynasty.

3. Lead Movable Type

Chinese-made lead movable type was first seen in late Hongzhi and early Zhengde years (1505–1508) in the Ming Dynasty. Lu Shen remarked in "*Jin Tai Ji Wen*" (Record of Jintai): "recently people in Piling have used copper and lead for making type, making typesetting and printing convenient. However, typesetting is especially susceptible to mistakes." People from Changzhou in the Ming Dynasty not only used copperplate, but also created lead movable type, making remarkable achievements in the manufacture of metal type.

2.2.5 Movable Type in the Qing Dynasty

1. Wooden Movable Type

Wooden movable type was more extensively used in the Qing Dynasty, spreading to almost all provinces. Fang Yizhi said: "Shen Cunzhong once remarked: 'in the reign of Qingli, Bi Sheng created movable type using clay and firing.' Today wooden is used for carving, and carved characters are put together on a copperplate." The so-called put together on a copperplate might refer to typesetting the wooden characters on a copperplate character wheel. Wooden movable-type prints were popular between the early Qing Dynasty and the reign of Emperor Qianlong in regions in the north and south. In Hongzhi, Zhengde, and Jiajing years of the Ming Dynasty, metal movable type was prevalent in book printing. However, Fang Yizhi and Wang Shizhen the early Qing mentioned copperplate printing using wooden type. Thus, use of metal type in book printing had been gradually fading by the early Qing Dynasty.

During the reign of Emperor Qianlong, Zhou Yongnian of Jinan advocated printing "*Scripture of confucianism*" with movable type, in an attempt to award "*Scripture of Confucianism*" the functions of a modern library and publishing institution, and to supply poor readers with diet and salary. All domestic schools and colleges and ancient temples in famous mountains keeping "*Scripture of Confucianism*" were equipped with a set of movable press, for printing rare books for exchanges. After a few decades, circulation of books gradually got started and increased. Zhou tried to use movable type to increase production of books for better exchanges, and he is the first to advocate large-scale use of moveable type.

While compiling "*Complete Library in Four Branches of Literature,*" Emperor Qianlong wanted to include and print the books found to be missing at the time when "*Yongle Encyclopedia*" was compiled. However, the copper movable type and copperplate originally kept in the library of Wu Yingdian had been recast as coins. Therefore, he had a poem saying "destroying the copper type

and copperplate is a regret, it's a shame we have to resort to wood engraving." He appended an annotation to the poem: "if the copper type were available now, wouldn't it be far more efficient to print books now? Nothing can describe my regret." However, this time a number of books required to be printed, making engraving a challenging job. Jin Jian, the manager then of book engraving in Wu Yingdian, and a native of Korea, suggested that movable type made of date wood should make a preferable choice, in that it not only can accelerate book printing, but also save a lot of cost and materials. He made a careful comparison and gave a vivid example to illustrate that the aggregate for carving woodblocks and 150,000 wood characters and purchasing wooden shelves, and boxes require over 1,400 liang(1liang = 37.3 g) of tael. He also found that carving "*Records of the Grand Historian*" by Sima Qian required 1,189,000 characters, 2,675 pear-wood plates, and the aggregated labor cost would amount to more than 1,450 liang of tael. However, one set of date-wood movable type would solve the problem once and for all, as it can be used to typeset and print the various books if necessary. It would be very convenient, while wood block engraving could only produce one book "*Records of the Grand Historian.*" With this detailed calculation, he convinced Emperor Qianlong. Emperor Qianlong looked his memorial and wrote the commented "甚好, 照此办理" (very good, proceed as the instructions herein). In addition, Emperor Qianlong instructed him to add 100,000 characters for standby. In May, the following year (1774), a total of 253,500 date-wood characters were carved, costing 1749 liang 1 qian 5 fen of taels. Addition to alternative date-wood characters, character-holding Phoebe slot, clamp bands, pine wheel for categorizing, holding and picking characters, typesetting lattice, character cabinet, type boxes, and typeset stool put the aggregate cost at 2339 liang 7 qian 5 fen. This set of new movable-type tool was successively used to print a total of 134 kinds of books for the "*The Essential Collections from the Wuying Hall*" series. Each book had two versions: one on Liansi Paper (also known as Lianshi Paper), and the other on bamboo paper. The former, ranging from 5 to 20 copies, were specially intended for display at the palace. The latter, of about 300 copies, were priced for sale. What we see today are almost all the yellow bamboo paper versions. Each book was preceded with the verse by Emperor Qianlong "*A Ten-Rhyme on the Essential Collections from the Wuying Hall.*"

In the 42nd year of Qianlong (1777), this series of books was distributed to the five provinces in south and east China and allowed to be replicated for distribution. However, the official presses of the five provinces of Jiangsu, Zhejiang, Fujian, Jiangxi, and Guangdong still used woodblock printing in reproducing the book, instead of movable-type printing. Therefore, the cover of those reprints had the cover inscription "乾隆丁酉九月颁发, 奉敕重锓" (re-engraved under imperial decree based on the copy distributed in Sep. Dingyou Year in the Reign of Qianlong). In later period of Qianlong's Reign and during Jiaqing's Reign, eight more books were typeset and printed, including "*A Sequel to Survey of Ryukyu,*" "*Qianlong Otogenarian Festival for Longevity,*" and "*Board of Civil Rules.*" Different from "*The Essential Collections from the Wuying Hall*" in line space, they are known as offprint.

Wooden movable type for "*The Essential Collections from the Wuying Hall*" was made in Internal *Affairs* office of Qing Dynasty and is large in scale. It is a development and improvement at the method invented by Wang Zhen in the Yuan Dynasty. For instance, Wang first carved the characters in a wooden board and then separate them with a fine saw. In the case of "*The Essential Collections from the Wuying Hall,*" individual wooden cubes were made first and the written characters were stuck to them for engraving. Wang cut bamboo slices as the boundary line, and here type in the style of an authentic book was carved on pear wood first. On each block, 18 lines were carved, and this was called "Taoban." In printing, the format of 18 lattices was printed first, and then, the characters were printed within the lattice. Therefore, the four margins of each page did not have any gap, as found in other prints using movable type. Wang used small bamboo slips to support the plate, but this time folded paper bars were used. Wang used a turning wheel for choosing characters for typesetting so as to bring the characters to the typesetter, but this time character cabinets were used—characters were stored in 12 large cabinets in accordance with The 12 Earthly Branches like Zi Chou, Yin, Mao, as used in the format of *Kang Xi Dictionary*. Each cabinet consisted of 200 drawers and each draw 8 large grids and 8 small ones, which stored 4 large characters and 4 small ones. All the characters were labeled with section number, name, and stroke number and were easily located. For people familiar with the arrangement system, each character could be found instantly. The typesetter just shouted the characters needed to the keeper, who can gave them to him presently after he was heard. Back then, it was believed that "in this way, convenient checking and fast typesetting are guaranteed." Roughly two plates of large characters or one plate of small characters could be typeset per person per day. However, it was feared that simultaneous typesetting of the same book would result in insufficiency of a certain type of characters due to repetition. Thus, a daily rotation was created. That is, typesetting of other books should temporarily replace that of the present book, and when the movable type was recovered, its typesetting should resume. In the weather happened to be hot, and the wooden movable type expanded due to increased ink infiltration, the work would be stopped for a while, to let the plate become dry before printing was continued. Jin Jian wrote a summary of his experience handling the printing of the book, illustrating one by one the processes of making wooden characters, engraving, making character cabinet, making the slot, making clamp bands, making top wood, making the central piece, making the categorization disk, setting grid, typesetting and supporting, proofreading and printing, classifying, daily rotation approach, and clauses for separation, namely instructions were illustrated one by one drawing instructions. The typesetting format of the book, called "*The Imperial-endorsed Format for The Essential Collections from the Wuying Hall*" (as shown in Fig. 29), was more detailed and specific than Wang Zhen's "*Method of Book Printing with Movable Type.*" It is an important literature in history of movable-type printing. The essential collections from the Wuying Hall were once kept in Wuying Hall in the Forbidden City, accessible through Xihua Gate. The large number of precious wood type was stored in Wuying Hall for a long time, without full application. Later, it was used by the guards as firewood and was long gone.

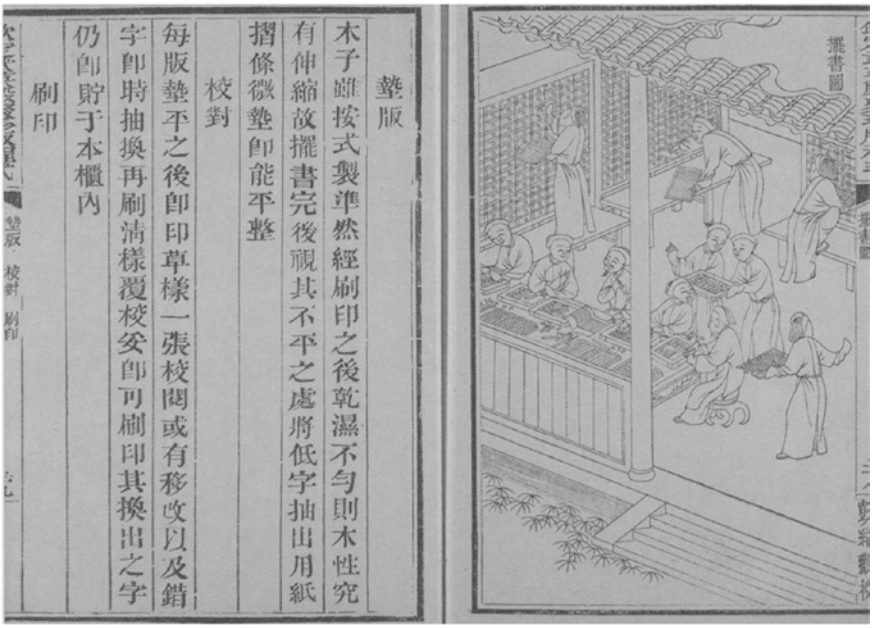

Fig. 29 A glimpse of "*The Imperial-endorsed Format for The Essential Collections from the Wuying Hall*"

The simple and easily implemented book printing method introduced in "The *Imperial-endorsed Format for The Essential Collections from the Wuying Hall*" was imitated by official and private printers from various places. All local governmental offices used movable type in book printing, but the number of copies was limited. Between Emperor Tongzhi and Emperor Guangxu, official bookstores were successively set up in all the provinces, for engraving and printing classics and history books, and those productive ones printed hundreds of books each. Some people think that all the books were result of woodblock printing, but actually there were many movable-type prints. Colleges of the Qing Dynasty were like those of the Ming Dynasty, in that some of them used movable type to print books. The privately carved wooden movable type was more prevalent in the Qing Dynasty. The literati often chose to produce movable type on their own, or borrow or purchase movable type to print the writings of their own and their ancestor's writings or local literatures, so as to expand their fames, to give prestige to their parents, and to sing praise to the preceding sages. In addition, there were many business-oriented bookshops using wooden characters in book printing.

In short, in the Qing Dynasty, fourteen provinces, i.e., Zhili (now Hebei), Shandong, Henan, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Fujian, Guangdong, Shaanxi, and Gansu had movable-type prints.

In addition to genealogy, wooden movable-type prints in the Qing Dynasty are far behind woodblock prints. In addition, the number of movable-type prints

is generally smaller than engraved prints. In some cases, only a few copies were printed, and in others, only dozens or a little over one hundred were printed. In the Qing Dynasty, wooden type was used in printing newspapers, following the precedent set in the 11th year of Chongzhen (1638) in the Ming Dynasty. Yuan Dong said, "Recently Di Bao is often printed with movable type in order to meet the needs of repeated changes. This is the last resort. Even if there are mistakes, they can be forgiven." It was the case in the early years of Qianlong reign and remained so in late Qing Dynasty. In the nineteenth century, wooden movable type was used to print "Jingbao" (literally, The Jing Newpaper). In August, 21st year of Guangxu (1895), reformers in Beijing used wooden movable type to publish a newspaper under the name of "*Multi-national Communique,*" which was renamed later to "*Records of Incidents at Home and Abroad.*" Also known as "*Chinese and Foreign Communique,*" it was issued every other day, in a form similar to "*Jingbao.*" In each issue, there was only one essay. And one to two thousand copies were printed for each issue. The paper was sent to the princes, dukes, and ministers. However, in the winter of 1895, it was banned by the Qing government.

Genealogy Printed with Wooden Movable Type

The ancient Chinese attach great importance to patriarch, so the science of genealogy was prevalent. Genealogy re-emerged in the Yuan and Ming Dynasty and prevailed in the Qing Dynasty. The most prevalent were family tree and genealogy, which were printed using wooden movable type. Family tree and chronicle are two main streams in the Chinese historiography. The former concerns family history and the latter local history.

In the Qing Dynasty, wooden type genealogies were found in Jiangsu, Zhejiang, Anhui, Jiangxi, Hunan, Hubei, Sichuan, Fujian, and other provinces. The wooden movable-type genealogy in the Qing Dynasty was most prevalent in the two provinces of Jiangsu Zhejiang, especially in Shaoxing state and Changzhou state. In those regions, people of the same clan often lived together in the same area. Thus, the clan power was developed, and almost every village had ancestral halls, and each surnames genealogy. All the eight counties under Shaoxing state had chronicles. In Shaoxing, there were workers specializing in genealogy printing, commonly known as "genealogy artisans" or "genealogy masters." Shengxian alone boasted over 100 genealogy masters in late Qing Dynasty. Every time after the autumnal harvest, they would shoulder type stalls on a pole and go to townships in Shaoxing or Ningbo to make genealogy. Wooden type in their stalls was also known as wooden seals and usually amounted to a little more than twenty thousand in number. Consisting of big and small sizes, the wooden characters in Song Ti were made of pear wood. In case of missing characters, the genealogy masters could presently carve them out. The type trays are made of fir and padded with bamboo slips.

In the long-term practice, genealogy artisans of Shengxian County divided the type trays into common type trays and rare type trays, also known as internal trays and external trays, respectively, so as to facilitate typesetting. The internal trays contained characters related to emperor reigns and the Chinese era, as well as "年" "月" "日" "时" "长" "次" "幼" "男" "女" "讳" "字" "号" "行" "娶" "配" "适"

“葬” “一” “二” “三” “四” and other Chinese numbers, as well as function words like “之” “乎” “者” “也.” To facilitate memorization, the external tray contained words classified into categories describable with a poem of 28 lines with 5 characters for each line, like “君王立殿堂” and “朝辅尽纯良.”

Wooden characters with the head, feet, or radical were grouped under each line, for example, “君(群)王(弄理圣王)立(产端)殿(殿殳)堂(尚掌).” Once the line was remembered, character-picking would become fast. This is different from the word cabinet used in Wuying Hall, and the turning wheel invented by Wang Zhen. The arrangement of characters broke through the Radical conventions in dictionaries. Such a creative spirit is praiseworthy and desirable. Usually, five to eight people were grouped into a shift, complete with posts of character carving, imaging, typesetting, brushing, and printing and odd jobs, in the charger of a contractor (manager). The time needed in making the genealogy depended on the size of the clan and the amount of data, ranging from a couple of months in the minimum to 4–6 months in the maximum. Genealogy was popular in Yinxian, Cixi, Zhenhai, and Fenghua, four subordinates to Ningbo. Its popularity in Taizhou, Jinhua, and Quzhou diminished, and that in Western Zhejiang diminished further.

In Jiangsu, genealogy was most popular in the Changzhou and Wuxi area. Typographical workers from Changzhou were the most prestigious in the Qing Dynasty. Bao Shichen remarked: “movable type in Changzhou featured great differences in size, and the tidiest craft.” In the beginning, it was used only in compiling genealogy, and poetry of the literati in between. Recently, “*Wubei Annals*” typeset in Changzhou movable type has become a spectacle. The matching between pictures and texts and the arrangement are all elaborate. In addition, on the bottom of each wooden character, the character was written, facilitating picking. The typeset characters were aligned with fine soil, making easier recovery and adjustment. Changzhou the wooden type, the character was carved on the top, and written at the bottom. Therefore, character-picking is easy. In addition, the characters were aligned with fine soil on the plate to make it even. Such a printing craft is called “clay tray printing.” Because the technology of the Changzhou clay tray printing is ingenious, the official bookstore of Anhui Province–Qushui bookstore—was set up in the temple to worthies of former times in Longcheng College in Changzhou. The bookstore collected money to hire printing workers and purchase rare books. Even people from Sichuan sent their genealogical manuscripts to Changzhou for typesetting and printing. It took printing workers in Changzhou less than fifty days to print “*The Genealogy of Gao’s Family in the South Gate of Luzhou.*” Genealogy was also popular in Suzhou and Zhenjiang Prefectures, as well as their subordinating counties, near Changzhou. In Anhui, genealogy was most popular in Jixi, She, Yi, Xiuning, Qimen, and Wuyuan Counties, as well as Tongcheng. Printing of genealogy occasionally occurred in the four states of Anqing, Ningguo, Chizhou, and Luzhou.

Generally, seven or eight to ten, or dozens or even one hundred copies of a genealogy were print and each was labeled with the style of the household that was to keep it. Often, they were print on white Liansi paper. The format was usually large: since the wooden type was large, the prints were accordingly large. Ordinary genealogy measured about 30 cm high and 20 cm wide. Prints in the

vicinity of Shaoxing and Ningbo sometimes measured 46 cm high and 37.5 cm wide. In the 53rd year of Emperor Kangxi (1714), "*The Genealogy of Xu's in Huangbu*" in Yugan Jiangxi was actually 50 cm high and 33 cm wide, much larger than the average printed copies. In genealogies printed with movable type in the Qing Dynasty, there was one printed with clay type and one with copper type, aside from those based on wooden type.

2. Copper Movable Type

The earliest movable type made by the Qing Dynasty government is copper type, about 60 years earlier than wooden type. Copper movable type already appeared in the reign of Emperor Kangxi and the astronomical book "*The Origin of Calendar,*" the mathematic book "*Collected Basic Principles of Mathematics,*" and the musical book "*Standard Interpretation of Tone-system*" were typeset with copper type and printed by the internal affairs office in late Kangxi's reign. Chen Menglei in the official residence of the Prince Ying Chi printed nine volumes of his "*Collected Poems of Chen Menglei*" and twenty volumes of his "*Anthology,*" with movable types borrowed from the internal affairs office. The poetry and anthology used Song Ti characters slightly resembling Yan Ti, and the strokes were coarse, different from the standard fonts with light horizontal stroke and heavy vertical stroke used in "*The Integration of Ancient and Modern Books.*"

Chen Menglei, a successful candidate in the highest imperial examinations in the ninth year of Kangxi, was exiled northeast China for getting involved with Geng Jingzhong the rebel. In the 37th year when Emperor Kangxi embarked a tour east, Chen offered a poem to the Emperor and was pardoned. After his returning to Beijing, he was ordered by the emperor to tutor Yin Chi, the third prince, in reading. In order to repay the gratitude for receiving help and encouragement from the emperor, he did some serious study and research. Using the books kept in the palace of the prince and in his own house, he edited an all-inclusive reference book covering more than 3,600 volumes and called it "*The Collection.*" Beginning from October the 40th year of Kangxi (1701), he hired people to transcribe all the books with sliver tael subsidy from the palace and completed the whole book in April the 45th year of Kangxi. The draft of such a masterpiece was completed in a mere 5 years. The first draft was submitted for imperial approval in the 55th year of Kangxi and was given the name "*The Integration of Ancient and Modern Books.*" In the same year, an institute was established for the 80 compilers led by Chen Menglei to expand the book. The expansion completed in around the 58th year of Kangxi. Chen's "*The Collection*" included more than 3,000 volumes; however, "*The Integration of Ancient and Modern Books*" had 10,000 volumes. There seems to have been an increase of over 6,000 volumes. This magnum opus of 16 million characters is also an important reference book used by scholars from home and abroad. "*The Integration of Ancient and Modern Books,*" typeset and printed using copper types, is the largest printing undertaking by the internal affairs office of the Qing Dynasty. It was printed in the 59th year of Kangxi under imperial decree.

Emperor Qianlong claimed that in the compilation of "*The Integration of Ancient and Modern Books*" during the reign of Emperor Kangxi, "copper characters are carved for movable-type printing." Copper character carvers working in Wuying Hall were paid 2 fen 5 li silver tael for each character carved, almost dozens of times higher than those carving Song Ti (Ming Ti) and soft words (Kai Ti) on wood. Metal is hard and more difficult to carve than woodblock, so the labor price would naturally increase fast. The saying "People carving copper characters" was adopted back then, instead of "people casting copper characters." Thus, we know that the copper characters were carved. After the typography of this masterpiece was completed, the numerous copper types were stored in the copper warehouse in Wuying Hall, without being used to print any other book—at least to our knowledge. A warehouse manager and two warehousing officials were appointed to manage it. Later on, these management personnel stole from the warehouse, and copper money happened to be precious in Beijing. Afraid of punishment, they proposed destroying the copper characters to cast money. In the 9th year of Qianlong's Reign (1744), the remnant copper characters were all destroyed, to cast copper money. Later when Emperor Qianlong wished to publish the lost books categorized during compilation of *Yongle Encyclopedia*, he was full of regret in vain and had to re-carve a large number of types using date wood.

2.1 Jiangsu

The earliest private user of copper movable type in the Qing Dynasty is none other than Chuilige, the master of which might have been from the vicinity of Changshu in south Jiangsu. Its prints include the four volumes of "*Selected Rhymes of the Cream of Literary World.*" On the title page, at the lower section of the content and the last line of Volume IV, there are five characters "吹藜阁同版" (copper movable-type print of Chuilige). "同版" was the shortening for "铜版" and was also written as "仝版" in the Ming Dynasty. The book contains selections made by Qian Lucan from Yushan. In the preface written by Qian himself in the 25th year of Kangxi (1686), he said: "So I chose some articles and printed them via movable types so as to distribute them across the country." The cover said that copperplate had been used, and here, Qian said movable types had been used. Therefore, it is without doubt that copper movable-type printing had been used. However, he did not mention whether copper movable types were his own or borrowed from someone else. "*Selected Rhymes of the Cream of Literary World*" precedes "*The Integration of Ancient and Modern Books*" by four decades. It is the earliest copper-type print of the Qing Dynasty.

2.2 Hangzhou

Verifiable use of copper-type printing in Hangzhou, Zhejiang includes the application of copperplate for "The Essential Collections from the Wuying Hall" by Wu Zhongjun in the 2nd year of Xianfeng (1852) to print the three volumes of "*Miaoxiangge Essays*" and "*Miaoxiangge Poems*" written by his maternal

grandfather Sun Yungui, from Changzhou. Wu said in the postscript: "In this summer, collation was completed. So I began to typeset [those books] with copperplate for 'The Essential Collections from the Wuying Hall' to print and disseminate them." During his tenure as an official in Hangzhou, he would typeset and print any books constituting "Wuyingdian Juzhen Ban" when he got them. Therefore, it is clear that the copper types did not belong to him, but were borrowed from someone else. Another copper-type print from Hangzhou includes the seven books of "*Secret Strategies for Offensive and Defense on Water and Land*" printed by the Manchurian Lin Gui in the following year (1853) when he was an official in Zhejiang. In the last book, there is a line "省城西湖街正文堂承刊印" (printed by Zhengwengtang in Xihu Street, the Provincial Capital). The printing was funded by Lin Gui and exercised by a bookstore in Hangzhou. While the 7th book mentioned movable-type printing, how do we know that copper type was used? Because its font is the same as that of Lin's from Futian Shuhai, this is also the reason for some people to believe that the books were Lin's copperplate prints produced in the 3rd year of Xianfeng. Among the copperplate prints, there was the book "*Essentials of Medicines in the Military,*" which is also found among the series. Comparison has found that the two books are the same in content and identical in font. However, the one in "*Secret Strategies for Offensive and Defense on Water and Land*" series has incomplete lines. Moreover, the numbers of characters are different. Therefore, we can see that they were not typeset at the same time. Because one was printed in Fuzhou and the other in Hangzhou, there are minute differences. Lin's only production is the series of "Essentials of Medicines in the Military." However, the books printed by Lin Gui were preceded with his remarks, instead of Lin's name. In addition, on the covers of the seven books, there is the line "麐月方伯集印" (Collected and printed by Linyue Fangbo). Therefore, there is no doubt for them to have been printed by Lin Gui in Hangzhou. Moreover, the font in "*Secret Strategies for Offensive and Defense on Water and Land*" is almost identical to that in "*Miaoxiangge Essays*" and "*Miaoxiangge Poems.*" While the latter two books are prints based on copper movable types for "The Essential Collections from the Wuying Hall." Therefore, all of them are copper movable-type prints. The copper types used in Hangzhou are probably that used by Lin's of Futian Shuhai in Fuzhou. As for why his copper types reached Hangzhou, we have no way to find out, due to the lack of literatures.

2.3 Fuzhou (Lin Chunqi)

The movable copper type of Futian Shuhai was created by Lin Chunqi in Fuzhou. Chunqi went to Hangzhou and Suzhou for schooling at the age of 20. Following his father's official career, he toured Luoyang and Guangdong. Since childhood, he had heard his grandfather and father talk about copperplate-printed books and often regretted that the lack of copperplates in the society had caused the valuable works of ancient and modern scholars to be lost—because they could not afford it. To realize his grandfather's ambition, he began donating to carving from the age of 18 onwards. After 20 years of hardworking and spending over 200,000 liang

liver tael, he finally completed carving 200,000 large copper types in Kai Ti and as many small ones, according to the strokes in "*Hongwu Rhymes.*" His carving covered various styles and fonts in ancient and his own time. Those types can be used to print all kinds of books, big or small. Lin engraved a total of over 400,000 copper types, and the feat is rarely rivaled in the history of metal movable-type-making in Asia. During manufacture, the difficulties in financial, material, and human resources must have been numerous. No wonder he would say: "To undertake it, is difficult, and to complete it, is even more difficult. In the process, there has been more than one occasion that I wish to discontinue. I have exhausted half my life's energy and effort to achieve the result, however mediocre it may be." He added: "Starting donation to engraving in the year of Yiyou (1825), I was only 18 years old, and I completed it in the year of Bingwu (1846)." After 21 years, Lin was only 40 years old. Lin was a native of Longtian, Fuqing, thus the name of his movable types "Futian Shuhai." Lin printed "*The Five Books of Phonetics*" by Gu Yanwu, but only "*On Phonetics*" and "*Poetry Is Song*" are now seen. In the beginning of "*On Phonetics,*" there is the essay "*About Copper Types*" (as shown in Fig. 30) illustrating that the causes and process of making copper movable types. It is the only literature on copper-type manufacture in China.

On the page reverse to the title page, there were the characters in four rows "福田书海铜活字版,福建侯官林氏珍藏" (printed via the Futian Shuhai copper

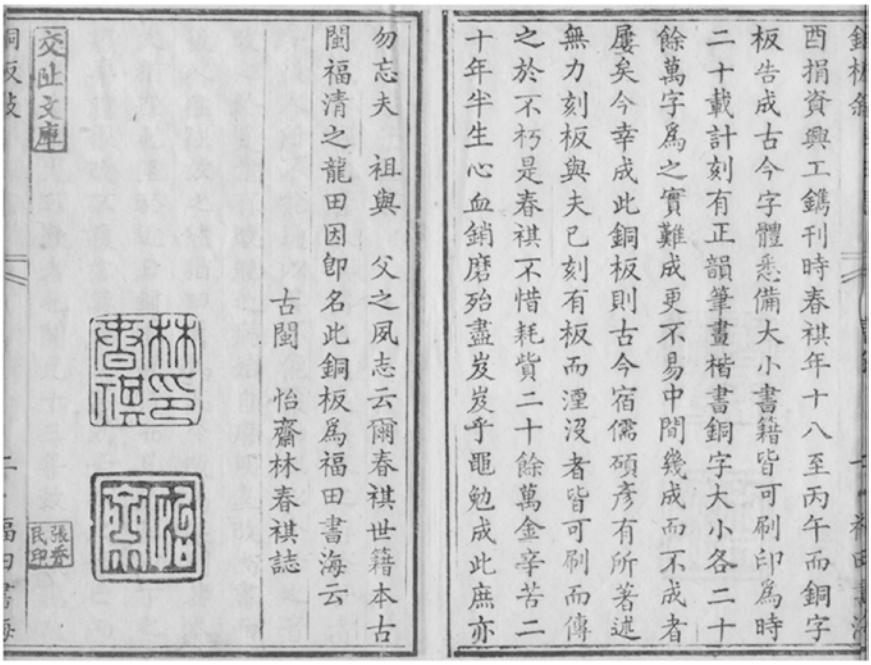

Fig. 30 Lin's *about copper types*

movable types, kept by Lin's in Houguan Fujian." At the end of "*Poetry Is Song,*" the type carver's name was inscribed: "古闽三山林春祺怡斋捐镌" (Engraved via donation from Lin Chunqi in Sanshan, Fujian). The movable type in Kai Ti was elaborate, and the paper and ink sophisticated. At the lower section of the type area on each page, there are four characters "福田书海" (Futian Shuhai). In addition, Lin also printed "*Essentials of Medicines in the Military.*" Divided into two booklets, they had the title "侯官林氏铜摆本" (typeset with Lin's Copper Movable Types) on the yellow paper cover. And each of the lines in the two books has the same number of characters as the previous two books. However, they do not contain "福田书海" in the type area, or the date of publication. Lin Chunqi had also printed 14 volumes of "*Four Books on Enlightenment,*" which had "福田书海" in the type area and "考镌铜字侯官林氏珍藏" (printed via copper movable types and kept by Lin's in Houguan) in the title page.

2.4 Taiwan (Wu Long'a)

In the 12th year of Jiaqing (1807), the copper movable-type prints appeared in Taiwan. Back then, there was a Manchuria General Wu Long'a, surnamed Guwalgiya, and a native of the Yellow Banner. He was then the military commander of Taiwan town. He made copper types and printed books, just as Gong Xianzeng remarked in Volume 1, "*Documents of Yiyuan*": "in Taiwan Town, Wu Long'a engraved copper movable types. I have once seen his prints of '*Annotation to 'Dissemination of Imperial Decrees.*'" The calligraphy and illustration were exquisite. Yao Ying, a native of Anhui, during his tenure as an official in Taiwan in Emperor Daoguang's reign in the Qing Dynasty also saw the cooper type prints of Wu's, and he said: "Here in Taiwan, General Wu also cast the cooper types as used for 'The Essential Collections from the Wuying Hall,' also in Song Ti style. However, there were eight rows in each printing and that was not satisfactory to me.

Although books printed using cooper types in Qing Dynasty were not as numerous as those in the Ming Dynasty, printing centers were found in Beijing and Taiwan, aside from Jiangsu, Zhejiang, and Fujian. Thus, copperplate printing was popular in a wider scope. The large scale and exquisite engraving were far better than copperplate printing in the Ming Dynasty.

3. Tin Type (a Printing Worker Surnamed Deng in Foshan)

According to the records of the American Samuel Wells Williams, shortly after the Opium War, the Chinese people not only cast a large number of tin types, but also produced tin type prints. The town of Foshan in Guangdong Province was one of the four major towns in the Qing Dynasty, and its commerce and industry were developed, and gambling particularly prosperous. A printing worker surnamed Deng started casting tin types in the 30th year of Daoguang (1850) in order to print lottery and completed two pairs of movable types in May of the

same year, totaling more than 150,000 characters. He spent 10,000 silver dollars and completed three sets of movable types, amounting to over 200,000 characters in total. The movable types consisted of a set of flat characters, a set of slender large characters, and a set of slender small characters for annotation to the body of the text. While casting, Den first engraved the characters in small pieces of wood, ensuring all the strokes were clear, and printed the engraved character in ultra-fine clay. Next he poured the molten tin liquid into the clay mold and waited for it to cool and solidify. After that, he broke clay molds, removed the movable types, and trimmed them, so that they were all of the same height. The broken mud could be reused to make clay mold. It is said that this method is simpler and more economical than type casting using copper mold in the West. In order to save the metal material, tin types were only four fens (1 fen = 0.33 cm) tall, shorter than the foreign counterpart. At printing, he arranged the movable types in a smooth and sturdy rosewood type tray and secured the four sides to prevent them from moving while printing. Three sides of the tray had ridges, which were of the same height as the movable types. After printing, they became the margins of each page. Pure brass was used for the boundary lines, and 10 lines were contained on half a page. The page was divided in the center by the type area, just like separation of one folio into two pages in woodblock-printed book. When the manuscript was corrected, ink would be applied and printing shall begin, using a brush broom. Later, he almost spent 2 years to complete in the 2nd year of Xianfeng (1852) printing "*Comprehensive Studies in Literary and Documentary Sources,*" by Ma Duanlin, a historian of the Yuan Dynasty. The masterpiece consisted of 348 volumes, 19,348 pages, and 120 books. The font is large and pleasing to the eyes, the papers white and ink clear. This is the first tin movable-type printed copy in the history of printing in the world. He was ingenious in making models and casting types, and successful in typesetting and ink application. He also printed several other books, but the titles have been untraceable.

Woodblock printing was born in the seventh century AD in China, and movable type first invented in the eleventh century by the Chinese. The origins and development are worthy of our pride and commemoration. And the historical suspense also awaits further exploration. Over the 1,300 years, woodblock printing has always been the mainstream in printing and movable-type printing has always been of secondary importance. Movable-type printing again is mostly wooden type-based, and primarily out of private hands. Officially engraved types are relatively rare, including the copper type engraved by the internal affairs office in Emperor Kangxi's reign and wooden type made in Emperor Qianlong's reign, but they failed to become universal. Around the Opium War of the nineteenth century, Western lithography and letterpress printing technology entered China and phased out traditional Chinese printing technology. This phenomenon is also worthy of our careful reflection. With China's rise and its improved international status in the new century, approaches to improve and develop Chinese printing technology in today's environment of information technology and digitization will be our long-sought goal.

3 Lecture 3 The Invention of Gunpowder and Its Influence on the World

Zhaochun Wang

3.1 Invention of Gunpowder

Gunpowder is one of the four great inventions of China (i.e., gunpowder, compass, papermaking, and printing). Historical development has shown that the invention of gunpowder was not achieved by one person at one place in one moment, but by ancient Chinese medical scientists, pharmaceutical scientists (i.e., Materia Medica scientists), and alchemists on the basis of production practices and the accumulation of scientific experiments over about one thousand years in the third year of Xianzong (808 years). This gunpowder was a mixture of saltpeter (potassium nitrate, KNO_3), sulfur(S), and carbon (C) powders. Because it generated a lot of black smoke in combustion, it was called black gunpowder. Saltpeter and sulfur are the key raw materials for preparation of gunpowder, and without saltpeter discovery gunpowder would not have been invented. British historian Joseph Needham arrived at the conclusion that Arab and Western countries could not have invented gunpowder on the fact that they did not know of saltpeter in the late thirteenth century.[39] Engels gave full recognition to this great invention realized in ancient China in "Artilleryman": "Now it is almost universally recognized that gunpowder was invented and used to fire heavy objects toward a certain direction by a country in the east… In China, saltpeter and other pyrophoric agents were blended to make pyrotechnics at a very early period, for use in the military and grand ceremonies."[40]

3.1.1 Scientific Practices Related to Invention of Gunpowder by the Ancient Chinese Before the Tang Dynasties

Saltpeter is a key raw material for gunpowder preparation. From the end of the Spring and Autumn Period to the Tang Dynasty, in-depth recognition and research in the producing area distribution and drug and chemical properties of saltpeter and sulfur had been made, at least 1,200 to 1,500 years earlier than other countries and regions of the world. This is the fundamental reason for gunpowder to be invented in China.

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[39] Cf. Joseph Needham, Lu Gwei-Djen. A New Perspective on Gunpowder and Firearms within the Realm of Chinese Culture [J]. Journal of Translations in The History of Science and Technology, 1982:2.

[40] Engels. Artilleryman, in Collected Works of K. Marx and F. Engels, Volume 14 [M]. [M]. Beijing: People's Publishing House, 1964:193.

1. Recognition of Producing Areas for Sulfur and Saltpeter

Before being exploited by artificial means, saltpeter follows a pattern of natural distribution and is mostly produced in places with conditions suitable for its generation. In ancient China, production in Gansu on the route of "Long Road" and Sichuan on the route of "Shu Road" was most prominent, to be followed by Qinghai, Shanxi, Hebei, Inner Mongolia, and other places. These origins were gradually learnt and documented by the ancient Chinese. "*Fan zi Ji Ran,*" a book from late Spring and Autumn Period (about the sixth century BC), once said that "消石出陇道" (niter is produced in Long Road) and "石流磺出汉中" (saltpeter and sulfur are produced in Hanzhong).[41] So far there are still different theories regarding the author and publication time of the book, for example, it is claimed that "*Fan Zi Ji Ran*" could have been the pseudo-work of someone from the Qin and Han Dynasties (BC 221–AD 220). Even if it is so, the fact that China already knew of the Long Road and Hanzhong as the origins of saltpeter (niter) and sulfur in the Qin and Han Dynasties at the latest. Long Road was a transportation network in the Qin Dynasty between Gansu and Sichuan, consisting of Yinping Road and Xixia Road in Gansu region and Jinniu Road, Sichuan Section of Yinping Road, and Chencang Road, Baoxie Road, Tangluo Road, Micang Road, etc. in Sichuan Region. Historian referred to it as Long–Shu Road. Classics touching on medicine and materia medica after the Han Dynasty eloquently proved that many places along the Long–Shu Road produced saltpeter.

Tao Hongjing (456–536), a physician of the Southern Liang Dynasty, clearly documented "Niter…is produced in Yizhou and Wudu."[42] in "*Records of Famous Doctors.*"

A team of 23 people led by Su Jing the pharmacologist of Tang Dyansty completed in the fourth year of Xianqing (659) the world's first officially compiled pharmacopoeia "*Newly Compiled Materia Medica.*" The pharmacopoeia listed Yizhou (in ancient times, Yizhou included present-today the majority of Sichuan, part of Yunnan, Guizhou, Shaanxi, Gansu, and Qinghai), Wudu (now part of Gansu), Xiqiang (now Qinghai Datong), and Wenshan County (now the Qiang Autonomous County in Beimao State) as origins of saltpeter.[43]

After the invention of gunpowder and its commission to military use, the study of this issue continued among scholars of the Song, Yuan and Ming Dynasties. "*Kai Bao Materia Medica*" written by Ma Zhi et al. in the Northern Song Dynasty, "*Miscellaneous Anecdotes in the Court and Among the Civilians since Jianyan Reign*" by Li Xinchuan in the Southern Song Dynasty, and "*Compendium of Materia Medica*" by Li Shizhen in the Ming Dynasty dealt in greater detail with

[41] Norther Song Li Fang, et al. The Imperial Readings of the Taiping Era, Volume 988. Medicine (5) Saltpeter, Volume 987, Medicine (4) Sulfur. Cited from "Dialog between Fan Zi and Ji Ran".

[42] Tao Hongjin. Records of Famous Doctors. In Li Shizhen, Compendium of Materia Medica, Volume 11, Stone saltpeter.

[43] Su Jing. New Materia Medica [M]. Shang Zhijun (collate). Hefei: Anhui Science and Technology Publishing House, 1981:94–97.

Fig. 31 Long road, Shu road, and distribution of some saltpeter origins

many origins for saltpeter. Plot on a diagram the saltpeter origins documented before the Ming Dynasty (Fig. 31), and we will have sufficient proof that the records by our ancestors of the saltpeter production are conclusive and credible.

From the Ming Dynasty to the present day, incidents of saltpeter production and application in Longxi and Wudu of the Longshu Region, Gaolanshan in Gansu, and Jiangyou City in Sichuan are seen not only in a lot of literatures, but also in the ruins of ancient saltpeter-mining sites discovered. Some of the sites also made exploration reports. The discovery of ancient saltpeter mine sites in Jiangyou has become a rare historical testimony.

Jiangyou is located in the crossroads of ancient Long and Shu Roads, and the necessary path to Chengdu from Gansu Province. Saltpeter mining in Jiangyou is documented in classics and regional annals after Qianlong years.

Volume 894 of "*Collected Statutes of the Great Qing*" in the 20th year of Qianlong (1755) reads: "There are nitrate mines in Jiangyou County, away from fields and properties, and exploitation is allowed." This record shows that the saltpeter used by the army of the Qing Dynasty in suppressing riots in Big and Small Jinchuan areas was mostly mined in Jiangyou.

"Zitong County Annals" (revised in the 45th year of Qianlong) reads: "Chaoyang Dong in Laojunshan, Jiangyou County produces saltpeter, which was exploited in the 20th year of Qianlong, carried out by Jiangyou City for its adjacency."

Long'an Fu Annals (revised in the 20th year of Daoguang) records, saltpeter were produced in Chaoyang Dong and Daxing Dong, and were annually submitted to Xiaohe Battalion (the barracks in Songpan Town, a Qing garrison town,Sichuan) for use.

The Songpan Wei and Yongning Wei (capital cities in present-day Songpan County and Xuyong County, Sichuan, respectively) set in the early Ming Dynasty

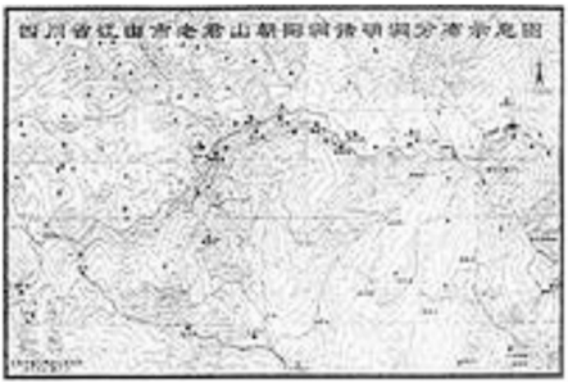

Fig. 32 Diagram of saltpeter cave distribution in Laojunshan Mountain, Jiangyou city

are not far from Jiangyou. And the gunpowder unearthed, which had been used for firearms manufactured by the military bureau of Yongning Wei in the 11th year of Hongwu (1378), is also related to saltpeter produced in saltpeter mines in Jiangyou.

Between 2003 and 2004, delegations of Cultural Heritage workers from Beijing and Mianyang City and Jiangyou City jointly launched investigations for research and found many ancient saltpeter mine sites in Laojunshan Mountain, Zhonghua Township, Jiangyou City, as well as firework crafts that had been circulated for many years. In 2005, the mountain has been approved by the State Administration of Cultural Heritage as a site of natural and cultural heritage under state protection. The above documentations and discovery of the ancient saltpeter-mining sites (as shown in Fig. 32) show that Jiangyou is probably one of the birthplaces of gunpowder in ancient China.

Compared with saltpeter, sulfur has a much broader distribution of origins. Hanzhong (now Shaanxi Nanzheng), the origin of sulfur mentioned in "*The Imperial Readings of the Taiping Era*" is located at the starting point on the northernmost section of Micang Road, a part of the ancient Shu Road. It stretched southward to bazhong (now bazhong County), Sichuan, and sat together with Jiangyou on the traffic network of Long-Shu Road. In addition to the Hanzhong region, Sulfur circulateis also found in many other places. In around the Western Han Dynasty, people found sulfur origins in Hunan, Shanxi, Henan, and other places. "*Huainanzi* • *Ben Jin Xun*" said, "sulfur appears and auspicious red grass grow." Zhang Heng, the writer and scientist of the Eastern Han Dynasty, also mentioned sulfur in the line "赭垩流黄" (red and white earth and sulfur) in "Ode to the Southern Capital." "*Record of Famous Doctors*" claimed that sulfur was produced in Taihang, Hexi, and Muniushan valleys in Donghai. "*Annotations of Materia Medica*" said that sulfur was produced in North Xuzhou (now Linyi region of Shandong), Jishan (now South Kaifeng, Henan), and Hunan and other places. "*Maps of Materia Medica*" mentioned that sulfur was produced in the remote regions in Nanhai, Guang Nan, Rongzhou (now Sichuan Rongxian and

Weiyuan), etc. "*The Book of Wei*" and Zhang Hua's "*Natural History*" said Bole, Yining, and East Urumqi in Xinjiang also produced sulfur.

2. Research in the Medical Properties of Saltpeter and Sulfur

According to the records of the "Records of the Grand Historian• Biography of Bianque and Duke of Taicang," Chunyu Yi (BC 215–BC140), Duke of Taicang in late Qin and early Han Dynasties said: King of Zichuan (now Shandong Linzi) summoned me for help because one of his concubines encountered difficult labor. I went there … and make the patient drink saltpeter decoction." As a result, the patient was instantly cured and delivered the child safely.

Among the silk book "52 prescriptions" unearthed in 1973 in a Han Tomb, Mawangdui, Changsha, there was a prescription of saltpeter: put (immerse) Xiao (saltpeter) in lukewarm water and sprinkle the water on carbuncles,"[44] indicating that saltpeter can be used to treat ulcers. According to investigation by experts, this prescription appeared during the Warring States, before the completion of "*The Yellow Emperor's Classic of Internal Medicine,*" and transcribed in late Qin and early Han Dynasty. This means that there were doctors using saltpeter as the medicine for treating carbuncle.

In November 1972, a number of medical bamboo slips dating back to the early Eastern Han Dynasty (AD 25–220) were found in Hantan, Wuwei, Gansu Province. Including a total of 92 pieces, the slips recorded more than 30 prescriptions on acupuncture, internal medicine, surgery, pediatrics, gynecology, and over 100 pharmaceuticals in the three categories of animal, plant, and mineral. And saltpeter was used as one of the 16 mineral drugs.[45]

In "*Shennong's Classic of Materia Medica*" the book completed in the Eastern Han Dynasty, 365 kinds of medicines were divided into three categories. In the book, saltpeter was listed as the sixth kinds of top-grade non-toxic drug, respected as the monarch drug responsible for supporting life. Sulfur was classified as the second one of less-toxic drugs and called the minister drug responsible for cultivation. Severely toxic drugs had the lowest ranking and called assistant and guide drugs. There are 125 of them in total, responsible for medical treatment.[46]

Physicians made inflated publicity of the treatment efficacy of prescriptions prepared with saltpeter, claiming that pills made of mercury through alchemy, "can make one young like a boy after 30 years if it were taken together with saltpeter"; and that Sodium Sulfate "dissolves 72 kinds of stones, and can make one

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[44] Collation panel for silk books unearthed from Han Tombs at Ma Wangdui. Interpretation of Medical Books unearthed from Han Tombs at Ma Wangdu i(2) [J]. Cultural Relics, 1975 (9):36.

[45] Gansu Museum, et al. Brief of Excavation in Han Tombs in Hantan, Wuwei [J]. Cultural Relics: 1973 (12).

[46] The original book is missing, but its content was preserved in materia medica classics through secondary citations. It is generally believed that this book was completed in the Eastern Han Dynasty.

light like the immortals if processed via alchemy and taken," and that "refined saltpeter is like cream and long-term intake can make one light." Such publicity fit in exactly with the wishes of emperors who had been dreaming about longevity and dominating the earth eternally. So they advocated alchemy and became deranged. However, the years of alchemy failed to produce the miracle of immortality by taking elixir. Yet the experimental activities of alchemists were not entirely in vain—it is precisely because they discovered among alchemical disasters the blasting phenomena, which occurred in refining mixtures containing saltpeter and sulfur, and carbonaceous materials, that human beings were able to invent gunpowder.

3. Research in the Chemical Properties of Saltpeter and Sulfur

Thanks to this research, alchemists concluded that saltpeter, lead, mercury, etc. were yin drugs (drugs that were dull in color, inactive in property and not inflammable, and produced in the shaded side of mountains, along the water side and in cold regions) and that sulfur, orpiment, and realgar were yang drugs (red and yellow or green drugs that evaporated when exposed to fire, i.e., were easy to burn and evaporate and that were produced in places exposed to the sun) and invented gunpowder based on the theory of combination between yin and yang (i.e., take the essence of yin and yang for the feat of generation by heaven and earth, complemented by the force of water and fire). A lot of research experiments of this type have been documented.

Wei Boyang the alchemist of Eastern Han Dynasty (active in AD 147–167), recorded in "*Zhou Yi Can Tong Qi*" (The Kinship of the Three According to the Book of Changes) combination of sulfur and mercury to generate red mercury, thus starting involvement of chemical properties of sulfur in people's research. Since then, people found in many experiments that sulfur would start bouncing after catching fire, assuming a very active nature. It was also found in experiments that niter could interact with many substances, and flame phenomena could occur when saltpeter is sprinkled on charcoal. Therefore, alchemists often used saltpeter together with other substances in refining, so as to change and adjust the properties of certain drugs.

Saltpeter generated naturally fall into two categories: "true saltpeter" (i.e., potassium nitrate, also known as fire saltpeter or smoke saltpeter) and "Sodium Sulfate." Both were bitter in taste, white in color like frost and snow, similar to needles in shape, easily soluble in water, and very much alike in appearance. So no scientific method was found to tell the two apart in a very long time. Tao Hongjing (as shown in Fig. 33) is the first person to find this method. He said in "*Annotations of Materia Medica*" that bluish purple smoke rose from saltpeter set to the flame but not from Sodium Sulfate, thus clearly telling saltpeter from Sodium Sulfate, and creating the "flame color method" for identifying potassium nitrate, laying the foundation for refining pure saltpeter for the preparation of gunpowder. This method is still used in modern chemical experiments.

Fig. 33 Tao Hongjing

In the Tang Dynasty, further development of the research in the medical and chemical properties of saltpeter and sulfur drugs, development of alchemy and the developed social economy and science created the conditions for the invention of gunpowder.

3.1.2 Tang Dynasty at Its Peak Laid the Foundation for Invention of Gunpowder

The Tang Dynasty marked the heyday of the civilized society of ancient China. During the period, China became a country with the world's solidest economic basis and most developed science and culture. This situation created directly or indirectly, the conditions for the invention of gunpowder.

1. Solid Socioeconomic Foundation

1.1 Developed Irrigation and Water Conservancy

Waterwheels, cylinder wheel, and other waterwheel irrigation technologies were created, and 219 canals, levees, and ponds were constructed, improving irrigation efficiency. Jiangdong plow and iron plowshare were used to expand the area of reclaimed land, and the country's total households rose rapidly, exceeding the number of 12 million in the Western Han Dynasty.

1.2 Large-scale Handicraft

Governmental and private handicrafts were very impressive. Shaofu Jian, the governmental agency overseeing handicraft, had 19,850 handicraft artisans, and Jiangzuo Jian had 15,000 artisans.

1.3 Fine Division of Labor

In textile and dyeing industry, there were cloth, thin tough silk, damask, soft silk, soft and thin silk, satin and large carpet and blue, yellow, white, black, purple, and

other colors. In ceramics, there was the famous Tang San Cai (tri-color pottery). In metal smelting, there were 168 smelters of silver, copper, tin and iron, and cupellation technology was invented for refining silver.

1.4 Huge Capacity in Shipbuilding Industry

In the 18th year of Zhenguan (644AD) alone, 400 vessels of various types were built and watertight bulkhead technology was invented and the development of vehicle ferry construction technology improved the equipment of warships. Papermaking and other handicraft workshops were found across the country.

1.5 Developed Water and Land Transportation and Active Commerce

Major cities and municipalities in the country were entitled facilitate transportation. On land and seas, there were "Silk Roads" leading to West Asia, Arab, Europe, Africa, Southeast Asia, and neighboring countries from Chang'an, Wuwei, Dunhuang, etc.

All those have created conditions for the development of science and culture.

2. Developed Science and Culture

2.1 Development of Papermaking Technology and Promotion of Engraving Technology

In papermaking industry, world-famous rice paper was created. Promotion of woodblock printing expanded the exchanges of scientific and cultural achievements.

2.2 Astronomy, Calendar, and Arithmetic Obtained Fruitful Results

Improving the armillary sphere, Seng Yixing successfully measured the meridian data, determined Dayan Li the most accurate astronomical calendar of the time and found that the phenomenon of relative movement of satellites (1,000 years earlier than the discovery of Harley the British). Arithmetic colleges were established, and mathematical books like "*The Ten Mathematical Classics*" were compiled.

2.3 One Hundred Schools of Thought Blossomed in Cultural and Historical Works

The greatest achievement in literature was the poetry of the Tang Dynasty. In historical monographs, there were Liu Zhiji's "*General History,*" Du You's "*Classical Records,*" and a number of others. "Huiyao" style was created to in historiography. In geographical works, there were "*Records of the Western Regions in Great Tang*"

dictated by Xuanzang, as well as "*Encyclopedia of Local Annals*" and "*County Annals of Yuanhe Prefecture.*"

2.4 Developed Medical Science

The world's first officially compiled pharmacopoeia "*Newly Compiled Materia Medica*" was completed (the pharmacopoeia collected 844 drugs, made a detailed illustration of the origins, potency, taste, and efficacy of saltpeter and sulfur, and their properties for refining pills and application. It became a symbol of highly developed medical science and provided the basis for alchemists in refining precious medicines.), and medical and pharmaceutical writings, such as *Qian Jin Fang* (Prescriptions Worth a Thousand in Gold) by the famous doctor Sun Simiao and "*The Four Pharmacopoeias*" a Tibetan medicine classic, were published.

2.5 Alchemists of the Tang Dynasty Made Many Achievements in the Ancient Chemical Research

During the ancient chemical experiments (as shown in Fig. 34), they designed and created some chemical instruments and equipment applicable at their time, observed and found a lot of chemical changes, artificially made compounds non-existent in nature, and extracted many chemicals. They explained many phenomena discovered in the alchemy process. In refining "longevity drugs" using the cinnabar, artificial mercuric sulfide, lead and its compounds, lead powder, yellow lead, lithargyrum (lead oxide, PbO), arsenic and arsenic compounds, sulfur, orpiment, realgar, white arsenic and other inorganic materials, metals, and minerals, they sought vegetable "elixir," carried drug research, found many medicines for healing difficult and serious diseases (Famous representatives include Taiyi Shenjing Dan (As_2O_3), a treatment for malaria, Baijiang Medicine, a treatment for skin diseases, and a medicine effective in removing toxicants and pus. Medicines similar to the above drugs were not invented until the mid-nineteenth century in Europe.), and invented the use of

Fig. 34 An alchemist weighing materials

tin, mercury, and silver for making filler in tooth filling. They experimented with smelting of metals, such as copper and copper minerals, iron, and aluminum alloys, as well as other compounds. They made an in-depth research of the doctrine of "transformation and generation of the yin and yang and the five elements." All of these at that time were unique in the world. Therefore, it can be said that the ancient Chinese alchemy is the predecessor of the modern chemistry.

Alchemists of the Tang Dynasty invented gunpowder. They developed "Fuhuo Method" (processing by fire) based on inheritance from their predecessors. The purposes of "Fuhuo Method" are threefold: First, detoxication, that is, reduction of the inherent toxicity of certain drugs by baking in fire. Second, subdue the property of volatility in some drugs when they are exposed to fire; third, tame the explosive nature of drugs including more than one ingredients. In accordance with the third purpose, the alchemists of the Tang Dynasty added an appropriate amount of saltpeter, a yin drug, enhanced the intensity of processing by fire, and avoided alchemy disasters in processing the "four yellow drugs" (sulfur, realgar, orpiment, arsenic trisulfide). Fuhuo Methods related to invention of gunpowder include the following: First, "sulfur processing by fire" in "*Collected Theories on Making Precious medicines*"; second, "vitriol processing by fire" in "*Jiageng Treasure Collection of Lead and Mercury*"; third, "co-refining method for saltpeter, sulfur, realgar, and honey" in *Essentials of the Mysterious Way of the True Origin.*

Among them, Qingxuzi the Taoist disciple in Jinhuadong and the alchemist recorded in "*Secrets to Golden Pills from the Sagacious Ancestor*" completed in the third year of Yuanhe in the Tang Dynasty (later the book was included in Volume II of "*Jiageng Treasure Collection of Lead and Mercury*") that in "vitriol processing by fire," a yin drug, i.e., 2 liang saltpeter, a yang material, i.e., 2 liang sulfur, a carbon-containing substance, i.e., 3.5 liang aristolochic were mixed and refined repeatedly and resulted in an accident with burnt down houses, burnt hands, and faces (as shown in Fig. 35). The earliest gunpowder was invented precisely in such a co-refining process. The reaction process in co-refining accords with the modern chemical reaction in expression of the oxidation and reduction of the above substances (other similar formulation equations will not be dealt with here):

Fig. 35 Alchemist discovered explosion phenomena in refining mixture of saltpeter, sulfur, and charcoal

$$16KNO_3\ (\text{oxidant}) + 3S\ (\text{reducer}) + 21C\ (\text{reducer}) \rightarrow 5K_2CO_3 \downarrow + 2K_2S \downarrow + K_2SO_4 \downarrow + 13CO_2 \uparrow + 3CO \uparrow + 8N_2 \uparrow \text{ reducer}$$

In 1825, the reaction equation proposed by (Xiefulieli) the British chemist was

$$2KNO_3 + S + 3C \rightarrow K_2S \downarrow + 3CO_2 \uparrow + N_2 \uparrow$$

Thus, the gunpowder invented by alchemists in the Tang Dynasty is completely consistent with the scientific truth and reflects the highest level of chemical tests back then.

Since alchemists had simple purposes in alchemy, the restricted experiments in refining immortality pills to prescription of drug materials paid close attention to the phenomena in the test process only without investigating the underlying mechanism. As a result, this important invention did not attract enough attention. Instead, alchemists earnestly warned people against experiments of co-refining saltpeter, sulfur, and charcoal since such tests might incur disasters. The invention of gunpowder was not put to use timely.

3.2 Significance of Gunpowder Invention

Gunpowder invention marked a second revolution following the recognition and use of fire by human beings.

3.2.1 Recognition and Use of Natural Fire by Human Beings Is the First Revolution

Recognition and use of natural fire by human beings ended "barbarian ages" of eating animal flesh raw and drinking its blood and ushered in the period of eating cooked food and disengaging from the animal kingdom. The fire first recognized and used by human beings was resultant from combustion in air of trees and firewood, coal grease, oil, and other carbonaceous materials abundant in nature. Gases such as CO and CO_2 generated in the combustion process slowly dispersed in the air. This slow combustion does not cause explosion, but produces heat and light (as shown in Fig. 36).

3.2.2 Recognition and Use of Fire from Gunpowder Explosion Is the Second Revolution

The oxygen required for combustion of gunpowder is released in the combustion of saltpeter. And gunpowder was thus called a combustion system with self-sufficient oxygen. Such a combustion releases in an instant a large amount of CO, CO_2, and N_2 and other high-temperature and high-pressure oxygen, and

Fig. 36 CO and CO_2 released in the slow combustion of natural fire

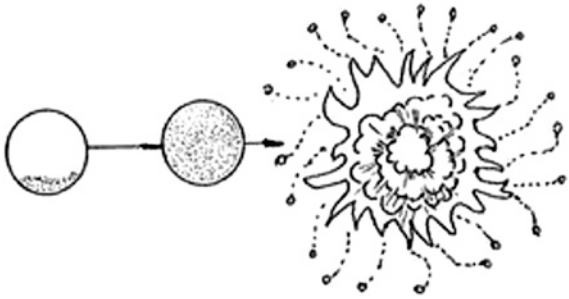

Fig. 37 Huge volumes of CO, CO_2 and N_2 released from gunpowder explosion

the volume is one thousand times larger than the substance used for combustion. It also produces a lot of light, heat, and shock wave; when the amount is large enough, powerful destructive and even lethal forces will be produced: the trees could be snapped, houses tumbled, and stone shattered. If the gunpowder is burned in a sealed container, the container will burst and violent explosion and loud sounds (as shown in Fig. 37) will occur. Utilization of chemical energy from gunpowder combustion brought about unprecedented upgrade and improvement of the human ability to conquer nature and survival conditions, marking a great fundamental contribution by the Chinese nation to the progress of human civilization.

3.2.3 Creation and Development of Firework Culture

In the early Northern Song Dynasty, firework artisans and army generals began to use gunpowder in the manufacture of fireworks and firearms.

1. Use in Manufacture of Fireworks

In late Northern Song Dynasty and early Southern Song Dynasty, Bianliang (now Kaifeng) the eastern capital set up a fireworks workshop, using improved

gunpowder to make firecrackers, pyrotechnics, Qilun, Zouxian, Liuxing, Shuibao, Dilaoshu, shelf fireworks, pyrotechnic barriers, and other products for holidays and festivals.[47] During the Lantern Festival, in the Royal Palace, the official residences and in the streets, lanterns, and festoons were put up everywhere, firecrackers and fireworks were set off, increasing the festive atmosphere. Since then, setting off firecrackers was handed down and became a custom. From the fourteenth century on, pyrotechnic technology has been widely popular in the neighboring and Southeast Asian countries. Today, the pyrotechnics are used by countries and regions all over the world for grand festivals and major events, and fireworks competitions are even held, creating a unique fireworks culture in the world today. Thus, fireworks are also a major contribution made by the Chinese nation.

2. Use in Firework Display

According to records in books such as "*The Dream of Hua in the Eastern Capital • Peking Opera Crafts,*" "*Anecdotes in the Capital • Various Stunts in Washe,*" "*Ancient Affairs of the Martial Arts Circle • Various Artists,*" "*Menglianglu • Chuye,*" there were firework theaters in Kaifeng in the Northern Song Dynasty, and pyrotechnic effects were used for staging "stories using smoke or of ghost, war, and legal cases" and similar shows. In some cases, even the recoil power of the gas generated by gunpowder was used for performing "Zhong Kui Catching Ghosts," "Eight Immortals Crossing the Sea," "Five Ghosts Mock the Judge," and other mythological programs involving images and actions. In addition, the shielding effect of fireworks was also used as objective view of the stage and shift in episodes, to increase the visual effects. Such technology is also widely used in today's movies, TV shows, and all kinds of drama.

3. Use in Military Sports Display

"*The Dream of Hua in the Eastern Capital • Enjoying Military Performance on Baojin Building*" made a more detailed description: after bayonet charge performance by soldiers in 5–7 teams, firecrackers are set off as the sign for changing the stage. After the first batch of firecrackers, huge volumes of smoke and fire rose, and players came onto the stage dressed like ghosts, with masks and unkempt hair and spitting wolf-tooth fire and smoke from their mouths (this fire results from lit rosins)… they went around the stage several times, and set fireworks on the spot. After the second batch, the music department comes into play, and performers staged a show bearing various arms, with faces painted, wearing masks with golden eyes, and decorated with leopard skin, silk, belts and the

[47] Song Zhoumi. Old Affairs of the Martial Grove. Volume 3 "New Year's Eve". Beijing: China Commercial Publishing House, 1982:51.

like. After the third batch, a player in cosplay of Zhong Kui appeared, dancing together with four others dressed as ghosts. After the fourth batch, pyrotechnics gushed out, shrouding the faces of the performers, and among the smoke and fire, seven tattooed people with disheveled hair could be seen fighting each other with real knifes. After the fifth batch, fireworks are set off, and players are dressed in masks and strange clothes, like statues of ghosts in the temple, and this is called a break from the battle. After the sixth batch, players dressed in various clothes came onto the stage, each gripping a boating knife, posing to grab the knife of others and stab. So there are dozens of paired performers, given ten-odd episodes of performance.

4. Use in Naval Drill

According to the description in "*Ancient Affairs of the Martial Arts Circle • Tide Watching,*" the navy of Zhejiang would take advantage of the moment when the tide of Qiantang Jiang River approached to carry out a parade every year. After parade is started, "Hundreds of warships arranged on both sides of the river exercise five arrays of battle, spreading out in one moment and gathering together in the other, speeding up in one instant and jumping into the air in the next. Presently, people on horseback can be seen waving banners and showing their skills with spears and knives. Suddenly yellow smoke sprang up, and people and things became invisible, with only the roar of the water burst to be heard, as if an alpine is collapsing. After a while the smoke clears and the water wave calms, no sign of the ships can be seen, except for the burnt remains of the enemy boats drifting along with the water flow. Hundreds of youngsters from Wu who are good at swimming appear with loose hair and tattoos. Holding ten banners, they struggle upstream, betraying a glimpse now and then amongst the towering waves. The tails of the banners are kept dry, to show their prowess."

3.2.4 Ushering in the Era of Combined Use of Firearms and Cold Weapons in the History of Warfare

After its foundation, the Northern Song Dynasty established a large-scale weapon-manufacturing workshop "Siege Preparation Workshop" for the purpose of unification war and the need for battles with the Western Xia, the Liao Dynasty in the north. The workshop consists of 21sub-workshops for manufacture of various weapons, and the "Gunpowder Sub-workshop" is specialized in manufacturing firearms.

In view of the combating provocations from countries in the North, Zhao Zhen, Emperor Renzong of the Song Dynasty (1010–1063) required civil officials and military ministers and officers and generals to get well versed in the military strategies of previous ages and the Song Dynasty, in order to outwit the opponent in military strategy, aside from proficiency in issues related to military technology, in

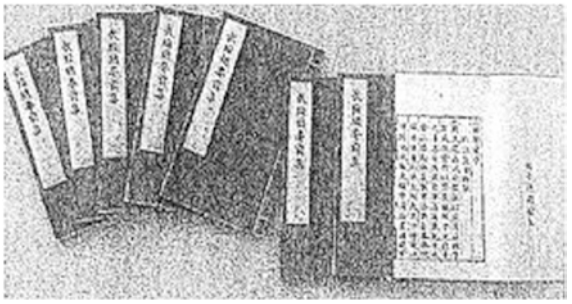

Fig. 38 "*Collection of the Most Important Military Techniques*" published in the Zhengde years of the Ming Dynasty

order to exceed their predecessors technically and tactically, for the purpose to outsmart the opponent, simultaneously "considering the situation" and "using skills." He also required that breakthroughs and innovations be achieved in weapon manufacturing, and the old situation be changed of military commanders "rarely knowing anything about history" and "ignorant of the military technology." He ordered Zeng Gongliang, the Literature Official of Tianzhangge Department, and Ding Du, the assistant minister of the Department of Construction, to compile "*Collection of the Most Important Military Techniques*" (as shown in Fig. 38). When the book was published in the 4th year of Qingli in the Northern Song Dynasty (1044), it completely recorded three formulas for preparing military gunpowder.[48]

1. Preparing the Three Earliest Gunpowder Formulas in the World

Gunpowder prescription for fireball: 14 liang Jinzhou sulfur, 7 liang wohuang (a sulfur), 2.5 catties yanxiao (a saltpeter), 1 liang maru (a carbonaceous material), 1 liang dry paint, 1 liang arsenic trisulfide, 1 liang solidifying powder, 1 liang zhuru (a carbonaceous material), 1 liang lead pills, 0.5 liang yellow wax, 1 fen vegetable oil, 0.5 liang tung oil, 14 liang turpentine, 1 fen thick oil … spin to make them well mixed, wrap the mixture up with five layers of paper, tie the wrap with a hemp string and cover it with additionally molten turpentine. Set if off as cannon.

Gunpowder prescription for caltrop fireball: 1 catty and 4 liang sulfur, 2.5 catties Yanxiao, 5 liang crude charcoal powder, 2.5 liang asphalt, 2.5 liang dry paint (mashed into powder); 1 liang 1 fen shredded zhuru and 1 liang 1 fen shredded maru; 2.5 liang tung oil and 2.5 liang xiaoyou (literally small oil), 2.5 liang wax melted for mixture with the above materials. (Materials used on the outside as wrapper) 12.5 liang paper, 10 liang hemp, 1 liang 1 fen lead pills, 0.5 catties ash,

[48] Northern Song. Zeng Gongliang, Ding Du, recorded in *Collection of the Most Important Military Techniques*, Book 1, Volume 12, *City* Defense Gunpowder, and City Defense Caltrop fire balls, and Volume 11, Fire Attack • Caltrop fire balls (2).

2.5 liang asphalt, 2.5 liang yellow wax to be molten and mixed with the rest materials before being coated on the paper.

Gunpowder prescription for Poisonous Smoke Ball weighing five catties: 15 liang sulfur, 5 liang aconitum, 1 catty 14 liang yanxiao, 5 liang patong beans, 5 liang radix euphorbiae lantu, 2.5 liang tung oil, 2.5 liang Xiaoyou, 5 liang charcoal dust, 2.5 liang asphalt, 2 liang arsenic, 1 liang yellow wax, 1 liang 1 fen zhuru, 1 liang 1 fen maru—mash the ingredients and make a ball, put a hemp rope of 1 zhang 2 chi through the ball, and use it for firing the ball. Materials used on the outside as wrapper include 12.5 liang paper, 10 liang bark, 2.5 liang asphalt, 2.5 liang yellow wax, 1 liang 1 fen lead pills, half a catty of charcoal dust—mix and mash the materials (for coating on the shell of the ball).

The above three military gunpowder formulas were prototypes determined by the military of the Song Dynasty trials and improvement and were distributed across the country as samples for preparation of military gunpowder. Compared with previous embryonic gunpowder used in experiments, the ratio between the saltpeter, sulfur, and charcoal was becoming reasonable and the proportion of saltpeter reached about 50 %. After being lighted, they were thrown to the enemy position with a bow (as shown in Fig. 39), a crossbow (as shown in Fig. 40), and

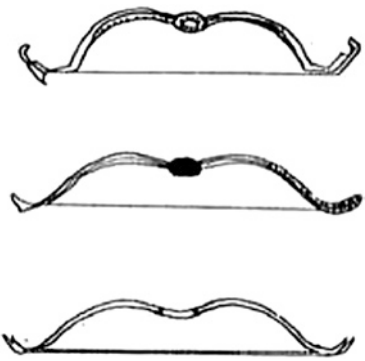

Fig. 39 Bow

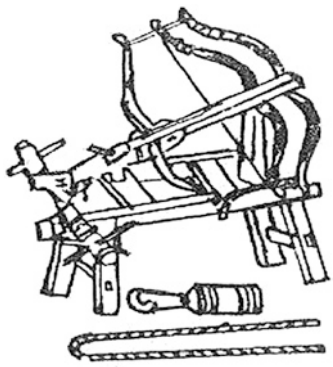

Fig. 40 Cross bow with three bows

Fig. 41 Single-barrel Cannon

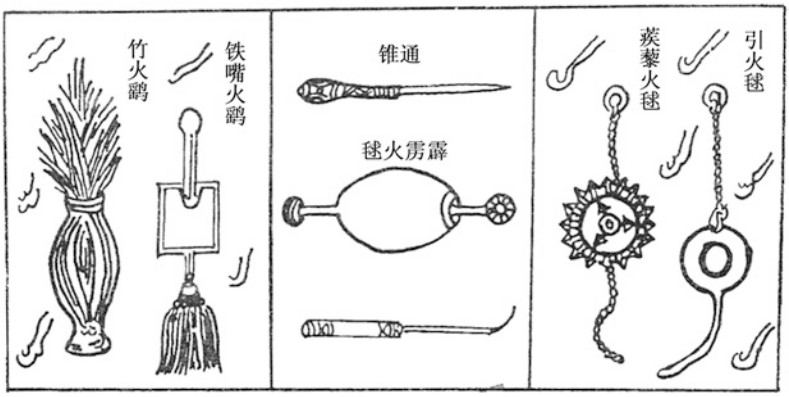

Fig. 42 Fireball made in the early Song Dynasty

trebuchets (as shown in Fig. 41), to produce lethal effects of combustion, explosion, blocking, confusion, poisoning, making military applications of gunpowder a reality. In the preparation process, there had been the transformation from rough processing to fine processing. In product quantity, there was the transformation from scattered production in small amounts to bulk manufacturing, thus creating the conditions for expanded manufacture of firearms and its military use, and opening new areas for improving the destructive and killing powers of weapons. Therefore, Needham said that, so far, "*Collection of the Most Important Military Techniques*" the world's most valuable data recording the first three gunpowder formulas for military purposes.

Based on the three gunpowder formulas, the Northern Song court made the world's first fireball (as shown in Fig. 42) and gunpowder arrows (as shown in Fig. 43) for use in war, ushering the era of concurrent firearms and cold weapons in the history of human warfare. Since then, display of human skills in war was

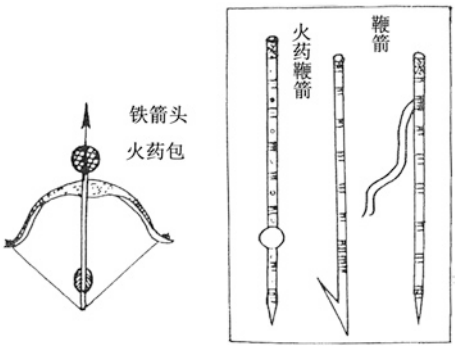

Fig. 43 Gunpowder *arrow* and gunpowder scourge *arrow* made in the early Song Dynasty

elevated to a new level. In the battle field of the glint and flash of cold steel, heavy smoke and loud explosions were added. It was not until the late fourteenth century when gunpowder as a Chinese invention had dominated the world for more than 400 years that Europeans began to realize this magic thing capable of explosion.

Soon after their creation, fireball and gunpowder arrows were used in Kaifeng Battle, Chenjia Island Water Battle between Song and Jin, creating the conditions for transformation in warfare mode.

3.2.5 Creating the Conditions for Subsequent Engineering Blasting

After the gunpowder invented by the Chinese was introduced to Europe, it witnessed improvements over three centuries and was used in engineering. In the beginning of the seventeenth century, the Europeans (another theory says it's the Hungarians) began use gunpowder for the exploitation of mines, replacing manual excavation with the drilling and blasting method, leading to the birth of blasting technology and marking a milestone in the development of mining technology. From the late nineteenth century to the twentieth century, mining explosives were invented, specifically for mining. Roughly in the same period, gunpowder was used in road construction, tunnel excavations, and blasting in other engineering projects.

3.2.6 It is an Irrefutable Fact that Gunpowder Has Been Invented by China

Some Western firearms history researchers proposed in their writings some "theories on gunpowder invention" that could not withstand scrutiny, for the purpose of shaking and denying the history of China inventing gunpowder. These theories have been negated by historical facts and overthrown by the research findings of firearms historians from many countries, but they still need further clarification, so as not to mislead the people.

1. Neither Greek Fire nor Sea Fire Is the Early Gunpowder

Some people say that the "Greek fire" is the predecessor of gunpowder, or it is the early gunpowder. These theories are unfounded.

"Greek fire," also known as "wildfire" and "burning agent," was initially trial manufactured by the Arabs and improved by the Greeks. Between the fifth century and the fourth century BC, it was used in battles, such as the Battle of Delium in 434 BC, the Battle of Rhode in 304 BC, etc. And subsequently, it was used in some countries for more than a thousand years and introduced to the East. Therefore, before invention of gunpowder, "Greek fire" is a major material for fire attack used on the battlefields of Europe. The "Greek fire" has various formulas but all are little known. In 350 BC, the Greece tactician Aeneas once wrote down a formula, including such ingredients as sulfur, pitch, turpentine, and other firelighters, and hemp shavings, and other combustible materials. Burning agent prepared according to this formula was once introduced to Arabian, India, and other countries. It is said that in 326 BC, the Indians had used such an incendiary agent to fight against the invasion of Alexander the Great (356 BC to 323 BC). From the eleventh to the twelfth century when European Crusades invaded Arab in the East, both sides in combat used fire attack appliances made of "Greek fire." However, the major ingredients of the early "Greek fire" are asphalt, honey, sulfur, mignonette, tallow, rosin, naphtha, powdered metal, etc., but not saltpeter.

The first person to call "Greek fire" gunpowder is Robert Valturiuss (1413–1482), who mentioned in his book "*12 Volumes on the Art of War*" in 1450, and the Byzantine emperor Leo VI (866–912) had in his reign ordered his soldiers to use a "fire-projecting equipment" to counterattack the enemy and called it gunpowder arrows. But at that point, Europeans still did not know what saltpeter was. So Valturiuss' theory is nothing but misinformation.

From the nineteenth to the twentieth century, there were still some Western scholars holding the view that Greek Fire was the early gunpowder, including French Oriental scholar Lanoux and artillery colonel Faver in 1845, the French chemical historian Erifee in 1866, the French Maciunas in 1952, the British Ellis in 1932. In the "*Soviet Military Encyclopedia*" completely published in 1980, there is an entry of "Greek Firing Agent" also said that the ingredients for "Greek Firing Agent" probably included saltpeter, sulfur, oil, resin, adding that the Greeks successfully used this firing agent in 673. However, they have forgotten that Fred Gorz, Soviet scholars and their predecessor had rejected this theory, and said: "Greek fire is not a mixture similar to gunpowder, because its ingredients do not include saltpeter, which was discovered by the Chinese."[49]

In addition, Joinville's book "*The History of St. Louis*" said that, it was not until the Seventh Eastward invasion of the European Crusaders (1248–1254) did the Arabs began to use "smoke and fire agent" containing saltpeter, by projecting

[49] [Soviet Union] H.A.Schillinger (ed.), Zheng Ting, et al. (tr.) Course on Gunpowder [M]. Institute of Military Engineering of PLA, 1956.

toward enemy position with long-tail feathered arrows, and that the power of this agent was much greater than the "Greek fire" without saltpeter. The arrows were like fire dragons crossing the air, lightning flitting across the sky, illuminating the night and changing into day, and the crusaders were finally repulsed. Since then, the European Crusaders also used "smoke and fire agent" containing saltpeter in its eighth eastward invasion of Arab (in 1270).

The Arabs and the Europeans did not use saltpeter until the mid-thirteenth century when they prepared the "smoke and fire agent." However, at that time, China had not only long used firearms in wars, but also developed the primary firearms to the stage of tubular shooting firearms. From this, we can see that "smoke and fire agent" containing saltpeter is not the first gunpowder.

Another foundation for Western scholars to take "Greek fire" as the early gunpowder is the "*Book for Fire Attack*" written by someone under the Greek name of Marco between the eighth and ninth century. The book listed some gunpowder formulas. However, research by scholars rejected this view. First, the so-called Greek Marco does not exist as a person, but a pseudonym name; second, the book is not written by one person at a specific time, but by some Arabs through successive additions; third, the book was written in the late thirteenth early fourteenth century, instead of between the eighth and ninth century. Therefore, we can see that the theory of "Greek fire" being the early gunpowder has lost its foothold.

Another burning agent similar to and often confused with "Greek fire" is sea fire, which first appeared between AD 670–AD 680. Thenophanes' "*Chronicle*" (811–815) records that in AD 673, the Syrian technician Kallinikos fled from Heliopolis, Silesia to Constantinople, the capital of the Byzantine empire, and provided the formula and preparation methods of the "sea fire." In AD 674, the Byzantine used "sea fire" in combat, and in 717 used it to attack the Arab fleet, saving Constantinople from the danger of fall. Due to the enormous power sea fire, its formula and preparation method were extremely confidential and known only to the leading figures of the Eastern Roman Empire that used it. It was a strictly guarded secret from other nations, especially the Arabs. Therefore, after the demise of the Eastern Roman Empire, the "sea fire" disappeared along with it.

"Sea fire" is different from "Greek fire." Fire attack devices made of sea fire are mainly used in naval battles to destroying enemy ships, hence the name. "Sea fire" in a battle emits flames from rainbow a fire-breathing pipe and produces a lot of smoke and a loud sound. The Europeans have tried to unlock the mystery of the "sea fire" formula. After several trials, they believe that its main ingredients including sulfur, asphalt and turpentine, but not saltpeter. So it is not the predecessor of gunpowder, or the early gunpowder.

2. India is not the Country that Invented Gunpowder

Someone once took "*Life of Apollononios of Tyana*" written by Flovius Philostratus (170–245) as the evidence to back the theory that India had in the fourth century BC used of gunpowder weapons. It is said in the biography that

in 326 BC, when the Macedonian king Alexander the Great invaded India in the East, he was met with the stubborn resistance of the local Indians between the Hyphasis River and the Ganges basin. It was reported that these Indians fired thunder-like monsters from the city wall to repel intruder's offensive. In addition there is another piece of record: When the Egyptians Hercules and Bacchus led forces to invade India, they also encountered resistance by the Indians in the same place. Legends have it that these Indians also projected a monster over the intruder's head, and the monster created flash of thunder and overwhelming storms, so the intruder was forced to retreat. Later, some people say that the stuff issuing lightning-like light and thunder-like roar was firearms and gunpowder. A lot of historical data have proven that this theory is untenable.

"*Indian History*" written by India historians Sinha and Banerjee documented Indians's resistance against the invasion from the Macedonian army: 326 BC, Alexander's army advanced toward Hyphasis, and annexed on the way some small principalities. Alexander had originally wanted to move on to the Ganges River, but the troops do not want to go eastward anymore, because the Ganges River was being ruled by Nanda King. The Nanda King had a fully prepared army, including 80,000 cavalries, 200,000 infantries, 8,000 chariots, and 6,000 war elephants, waiting to get engaged in war. None of the Macedonians dared to fight him in a battle. Be seen from the above description, the Indian army was mainly reliant on horses, war elephants, chariots, and spears, bows and arrows in combat and did not use firearms. "*World History*" published in the Soviet Union said in the narrative of the war that the assault forces used by the Indian armed forces in combat war elephants, not firearms.

In addition, the "*Manu Code*" also provides more convincing historical data. "*Manu Code,*" written between third century BC and the second century BC, is a compilation of the literature on ancient Indian religion, philosophy, and law. In it there is a provisions saying: "In fighting the enemy, do not use weapons that are not trustworthy or justifiable, use (or) toothed arrows, poisoned arrows, or arrows with red-hot tips to kill your enemies."[50] The provision shows that the arrows used by Indian army in combat were ones with serrated tips, which were coated with poison, fired red-hot and then shot, and there were no firearms based on gunpowder. Engels said in "*Artilleryman*": Greek writers Ellianus, Curtis, Filostrat, and Tamil Christie gave evidence, saying that the Indians seem to at the time of Alexander the Great have used some pyrotechnics in the military, which was by no means gunpowder.[51]

In 1441, the Indian ambassador Saluk said the Indian Army used war elephant-mounted soldiers to fire naphtha throwers toward Muslim soldiers between 1290 and 1300 in besieging Ranthambhore Fort, creating a large volume of

[50] Zhou Yiliang, Wu Yujin (ed.) Selected Historical Data The First Half [M]. Commercial Press, 1964:225.

[51] Engels. *Artilleryman*, in Collected Military Writings of Marx and Engels, Volume 1 [M]. Fighters' Publishing House, 1981:417-419.

sparks. After that, in 1398–1399 in the Batmil war the Indian Army used naphtha throwers to fight the enemy, raining arrows, stones and gunpowder among the invading enemy. Saluk thus believe that the Indian Army in the two combats had used firearms. Japan firearms history researcher Seiho Arima pointed out that naphtha throwers mentioned by Saluk were called Naghribiha in Hindi, meaning "Greek fire" from the west, rather than gunpowder. Seiho Arima concluded that before the invasion of the Portuguese in 1498, the Indians did not know the formula for gunpowder.[52]

The Indian firearms historian Godet also said that gunpowder and rocket were invented in China and spread to India after the fourteenth century, because Sanskrit or Persian manuscripts on firearms found in India were dated later than 1400. It is also said that the earliest firearms found in India were left in North India in 1222 by the Mongolian Army chasing Djelaled-Din, the king of Khwarezmia, instead of being manufactured by India.[53]

3. Roger Bacan is not the Inventor of Gunpowder

There is no exact record of the life of Roger Bacan in British history books, except for the data saying that he was active between 1214 and 1292, and was the inventor of the gunpowder. In 1914, the United Kingdom published his collection of essays. This book is divided into three parts, and the first part includes the letters that Bacan wrote in 1249 to the Bishop of Paris. In the part, Chapter 6, 9, 10, and 11 mentioned gunpowder, and Chapter 10 and 11 listed the gunpowder formula, which states the quantity ratio of saltpeter, sulfur and charcoal as 7:5:5, and the matching ratio as 41.2, 29.4, and 29.4 %. However, textual research by firearms historians has found the chapter harboring the formula flawed, including hypothesis, conjectures, additions, deletion, and revisions by subsequent generations, for example, at the beginning of Chapter 10 and 11, there were, respectively, the two sentences "Transactis annis Arabum Sexcentis et duobus" and "Annis Arabum 630 Transactis." Translated into English, the two sentences are "in 602 of the Arabia year" and "in 630 of the Arabia year." Here, the Arabian year means Muslim year. 602 in the Muslim Calendar is AD 1205 and 630 AD 1233. At this point, the Europeans had no idea of what saltpeter was. How could they say Bacan invented gunpowder? To say the least, even if the gunpowder formula in Bacan's papers was not a patchwork added by people after him. It was over 200 years later than the gunpowder formula published in "Collection of the Most Important Military Techniques." Therefore, the theory of Roger Bacon inventing gunpowder is sheer nonsense.

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[52] [Japan] Seiho Arima. The Origin of Artillery and Its Dissemination [M]. Tokyo: Yoshikawa Kobunkan. 1962:4–5.

[53] [India] P.K. Gode: The history of firework in India between 1440 and 1900, p. 20.

4. Berthold Schwarz is the Fictional Gunpowder Inventor

Some European, especially German researchers of firearms history, believed that a German monk, Berthold Schwarz, is the inventor of gunpowder. However, there are different theories regarding various data concerning Berthold inventing gunpowder, including his last name, his nationality, his religion, the year, and location of the invention. The earliest German document mentioning him says that he was a Greek engaged in alchemy, rather than a monk. Later, there were theories saying that he was from Denmark, Prague, Cologne, Freiburg, Braunschweig, and Metz. In religious denomination, he was said by some to be a member of Franciscan faction of Christianity, and by others to be of the Dominique faction. No one can say for sure. When it comes to the year of his inventing gunpowder, there are a variety of claims, including 1,250, 1,313, 1,348, 1,354, 1,372, 1,380, and 1,393, with a difference as great as 143 years. German firearms history researcher G Kohler listed a lot of data in his book "*The Development of Military and Strategy in the Era of Knights*" published in 1886 to show that the so-called Schwarz was actually fictional and couldn't have been be considered the inventor of gunpowder. In 1909, the British scholar Clephen pointed out that Schwarz had been an imaginary character fabricated by the Germans, and the objective was to make their nation entitled to priority of invention of gunpowder and artillery. British gunpowder history researcher Partington said after comprehensive research of literatures that Schwarz was a purely legendary figure, fabricated to make people believe that gunpowder and artillery originated in Germany, and that the monument built in 1353 to commemorate his birth had no historical basis.[54] Later, memorial facilities for Schwarz built in the city of Ghent, Belgium, and Metz City, France, were eventually dismantled, due to the fact that he was purely fictional. Therefore, the so-called theory of Schwarz inventing gunpowder was also proved unfounded. In addition, there are some other theories on the invention of gunpowder and firearms, but none is worth refuting.

By recounting the process of China inventing gunpowder and spread of firearms beyond its borders in the Yuan Dynasty, as well as clarifying a variety of gunpowder invention theories, we have proven from both the positive and negative aspect that China is the world's first country to invent gunpowder and use firearms in battles and that it has made outstanding contributions to the widespread use of gunpowder and firearms in all countries around the world.

3.3 Westward Spread of Gunpowder and Its Influence on the Development of European Society

3.3.1 Westward Spread of Gunpowder

From the thirteenth century AD, the invented gunpowder and firearms in China began to spread westward to Arabia, and thereafter to European countries.

[54] J.R. Partington: A history of Greek fire and Gunpowder. p. 96.

1. Learning of Alchemical Technology and Saltpeter-Refining Technology by the Arabs

The Arab Empire was a multi-ethnic country sometimes called Black Tajik in Chinese history books. It created in the eighth to eleventh century extremely prosperous and diverse Arab culture, which includes inherent Arab culture, the culture of the conquered nations, India and Chinese culture, Greek and Roman culture. Medicine and alchemy were particularly well developed, as witnessed by "*Encyclopedia of Single-agent Medicines*" and other medical books. The Arabs used the four elements of air, earth, water, and fire to explain the evolution of all things, similar to the Chinese theory of the Five Elements generating everything. Many Arabs went to China for business and learning, including the Persian alchemist Li Xuan (another theory says it's a Persian chemist also known as Li Silang), who learned alchemy in Sichuan, China, in the middle of eighth century, and obtained remarkable results in refining medicine and herbs, becoming especially learned in the method for refining Prepared Salt created by Liu An, King of Huainan. Later, these alchemists introduced through trade channels, the herbs, the refined immortality pills, and alchemy into Arabia and called alchemy gold refining technology.

The Arab word for alchemy is similar to the Chinese term of 炼丹术. Arabic assigned al-kimiya for alchemy, in which kim was transliteration of the character "金" in the phrase "金液" mentioned in the Chinese alchemy book, "*Bao Pu Zi • Jin Dan Pian*," while the English term is alchemy. In English, the word chemy is derived from the word alchemy by abbreviating the article al. Therefore, we can say that there is a source-development relationship between alchemy in China and modern chemical science.

In the 1340s, China's saltpeter refining technology spread to Arabia, whose saltpeter refining process is similar to that of China. Arabs called the saltpeter and gunpowder coming from China "Barude," "Asian stone," and "Chinese snow."

2. Mongolians Spread Firearms to Arab and Europe in Their Thee Westward Expeditions

Between the 12th year of Jiading and the 1st year of Jingding in the Southern Song Dynasty (1219–1260), the Mongolians spread fireballs, gunpowder arrows, and other firearms to Arab and Europe in their three westward expeditions. The Europeans since learned this magical thing—Firearms. However, at that time, Europe was still in the dark period of the Middle Ages, and the science and technology was extremely backward, so it failed to conduct imitation. While the Arabs had had a considerably solid foundation after learning alchemy and saltpeter, refining technology introduced from China, soon learned the technology for manufacture of gunpowder and firearms, and started to imitate firearms to suit their own needs.

Fig. 44 Madfa

Fig. 45 Arabs using madfa in combat

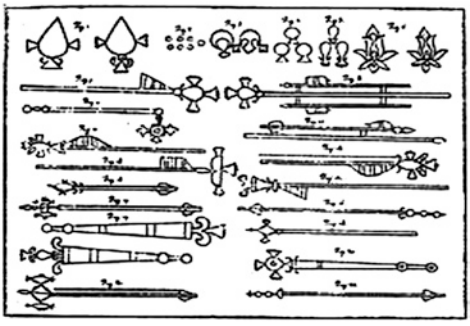

Fig. 46 Gunpowder *arrows* and muskets made by the Arabs

3. The Early Firearm Imitated by the Arabs in Late Thirteenth Century

Arabs did not use the firing agent containing saltpeter until the seventh eastward crusade by the European Crusaders between 1248 and 1254. Neither did them imitate madfa (as shown in Fig. 44), a wooden tubular shooting firearm until the end of the thirteenth century and use it in battles (as shown in Fig. 45). In addition, Arabs also manufactured rocket (as shown in Fig. 46), fireball (as shown in Fig. 47), and other firearms.

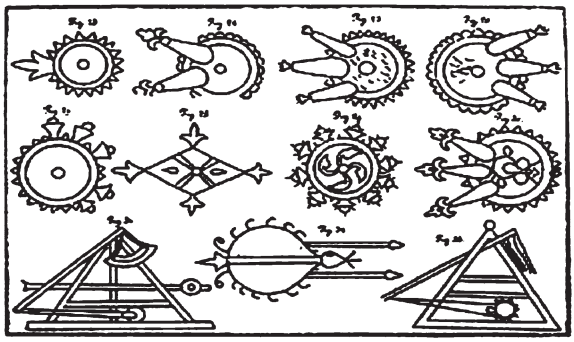

Fig. 47 Fireball and stone-projecting machine made by the Arabs

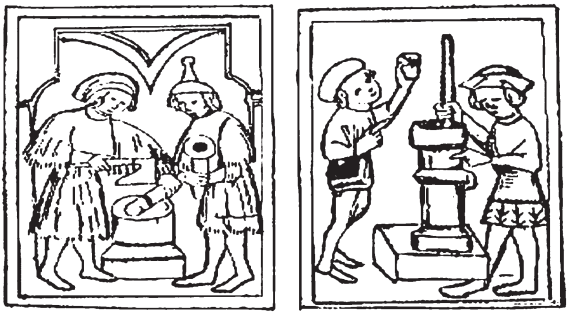

Fig. 48 Manual preparation of gunpowder by Germans in late fourteenth century

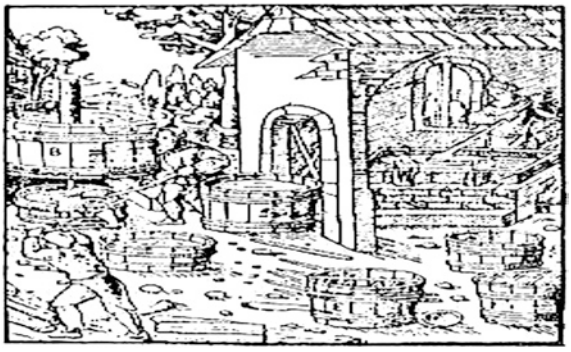

Fig. 49 Workshop for refining saltpeter and sulfur by Europeans in fifteenth century

4. The Arabs Spread Firearms to Spain in the Early Fourteenth Century

Arabs invaded Spain in 711 AD, established a caliphate in 929, and introduced from the eleventh-to-thirteenth-century Chinese silk, porcelain, paper, and printing to Spain. The Spaniards fought many wars to free themselves from the rule of the Arabs. They gradually learnt the firearms manufacturing technology from the Arabs during the wars, opened firearms manufacturing workshops, used manpower to pulverize saltpeter and sulfur for preparation of gunpowder (as shown in Fig. 48) and

Fig. 50 Handguns used by the British troops

Fig. 51 Use of Handguns in attacking a castle painted in Murals of Nili Church, Italy

to select and extract saltpeter and sulfur (as shown in Fig. 49), and successfully imitated the first firearms in the early fourteenth century. Subsequently firearms spread to France, Britain, Italy, Germany, Russia, and other countries.

Europeans imitated the first handguns (also known as fire valve guns), a metal tubular shooting firearm, in the late fourteenth century. According to records of documents in the British royal family, the British army in the mid-fourteenth century began use hand gun (as shown in Fig. 50). In murals in Nili church in Italy, scenes of soldiers holding handguns in combat during siege of a castle were painted (as shown in Fig. 51).

5. The Route of Chinese Gunpowder and Firearms Spreading West

Regarding the route of the gunpowder and firearms spreading from China to the west, the Europeans have many famous assertions.

J. von Romocki the German firearms history researcher said: “between 1225 and 1250, saltpeter first spread from China to Arabia, and then through Arab to

Europe. That is why the British scholar Roger • Bacan was aware of this salt in 1248." [55]

Engels said in "*Troops*": "France and other European countries learned the manufacture and use of gunpowder from Arabs in Spain, while the Arabs learnt it from the people of countries to the east of their country, and those people from the first inventor—Chinese people."

Engels said in "*Artilleryman*": "In the names of saltpeter given by Arabs, two of them mean 'Chinese salt' and 'Chinese Snow' … It seems that Arabs soon enriched the knowledge that got from the Chinese … and knowledge of artillery was passed by the Arabs to the Spaniard in the fourteenth century. The knowledge of artillery use spread from the Spaniards to other European countries."[56]

When the Chinese inventions of gunpowder and firearms were introduced to Europe in the fourteenth century, the Chinese inventions of printing, papermaking, and the compass were also successively brought to Europe through Arab. After their introduction to Europe, these inventions had a huge impact on the development of European society.

3.3.2 The Huge Impact of Gunpowder Introduction to the West on the Social Development in Europe

Over the past few centuries, many great men and celebrities in the world have made a variety of comments on this, and the following ones are the most representative:

Marx said: "Gunpowder, the compass, printing—are the three inventions marking the arrival of the bourgeois society (the original did not mention papermaking). Gunpowder blew the Knight class to atoms, the compass (introduced to Europe in the thirteenth century, making possible ocean voyage) opened the world market and established colonies, while the printing became a tool of the Protestant, and the general means for a scientific renaissance and the most powerful lever to create the necessary preconditions for spiritual development."[57] Engels claimed in "Anti-Dühring • violent Theory (continued)": "Firearms on the outset have been a weapon for emerging monarchy in or relying on cities to fight against the feudal aristocracy. What once have been unassailable stone walls of the castles for the nobility could not withstand the cannon of the public. The public's bullets pierced the armor of the knight, and aristocratic rule died together with aristocratic cavalry donned with armors."[58]

Called by Marx "the true ancestor of modern experimental science," the British materialist philosopher Francis Bacon (1560–1626) said in his famous "*Novum Organum*": "These three (printing, gunpowder and compass) have changed the whole

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[55] S.J. Lomocki: Geschichte der Explosivestoffe, Bd.I, pp. 37–38 (Berlin, 1895).

[56] Collected Military Writings of Marx and Engels: Volume 1, 365–366.

[57] Collected Military Writings of Marx and Engels: Volume 1, 418–419.

[58] Karl Marx. Machine. Nature Force and the Application of Science (1861–1863). Economic and Philosophical Manuscripts [M]. Beijing: People's Publishing House.

aspect and state of things throughout the world—the first in literature, the second in warfare, the third in navigation - bringing about countless changes; so that there seems to have been no empire, no philosophical system, no star that has exerted greater power and influence in human affairs than these mechanical discoveries."[59]

In May 1982, Yabuuchi Kiyoshi, Honorary Professor of the University of Tokyo, Japan, spoke highly of the historical role of the four great inventions of China after they spread to the West: "The four great inventions of China, i.e., gunpowder, etc., spread to the West before the Renaissance in Europe. Without the introduction to the West of the four great inventions, the Renaissance in Europe would have been impossible. Without renaissance, modernization in Europe would have been impossible. The Europeans themselves admit this."

John Frederick Charles Fuller (1878–1966), the founder of the theory of mechanized warfare believed that the Chinese invention of gunpowder not only brought the Renaissance to life, but also bombarded and toppled the order of the European Middle Ages.

The above comments reflected the following connotations in a concentrated manner.

1. Announcing the Arrival of Capitalism and Starting the Renaissance

The budding capitalism became faintly visible from the fourteenth to fifteenth century in the famous cities of the Mediterranean coast, including Florence, Venice, and Genoa, and the early public culture began to emerge. The emerging urban bourgeoisie called for a campaign against the church and feudal culture in the ideological field to maintain its political and economic interests. It joined hands with farmers, used a new view of the world to overthrow theology, scholasticism, as well as fideism worldview and ushered in a cultural renaissance with "*The Divine Comedy*" published in 1307 by Dante Alighieri (1265–1321) as the prelude. Renaissance is the ideological reflection of transition in Western Europe from feudalism to capitalist society, creating public opinion for capitalism to establish its dominance. Embodied as humanism in scientific and cultural ideology, it nurtured the culture of the Western European bourgeois. At that time, the emerging bourgeoisie seized the opportunity and made use of the favorable situations, pushed the European society toward capitalism, by promoting the socioeconomic, scientific and technological and industrial changes with the assistance of the four great inventions, i.e., gunpowder, the compass, papermaking and printing, introduced from China. Therefore, Marx said that gunpowder, the compass, and printing were the three inventions foretelling the arrival of capitalism.

2. Bombarding and Toppling the Order of Middle Ages in Europe

In political and social revolutions, Italy as the origin of Renaissance did not become the vanguard. Until the sixteenth century, Italy was still a divided country with

[59] F. Bacon. Novum Organum. Tr. Guan Qitong [M]. Shanghai: Commercial Press, 1936:114.

multiple states. To make matters worse, it underwent invasions from France, Spain, and the Holy Roman Empire in 1494–1559. Therefore, the seeds of capitalism only germinated in a few cities, the south, west, and the vast rural areas were still closed in feudalism barriers. However, Portugal and Spain were different from Italy. In the late fifteenth century, the two countries have completed the process of political unification and centralization. They were also two early colonial countries that were supported by the cities and that were becoming increasingly powerful. So they established large fleets for oceanic voyage since the end of the fifteenth century. Guided by compass in navigation, the two countries became maritime hegemonies with matchlocks and cannons, launching overseas expansion and plundering some countries in Africa, Asia, and Latin America, for primitive accumulation of capital. On August 8, 1588, the British fleet defeated the Spanish Armada in the Battle of Gravelines with advanced naval guns and artillery tactics. Afterward, the British fleet controlled the Atlantic sea, consolidating Britain Europe's supremacy at sea. In 1600, the British began to equip all its troops with matchlock guns and sent the longbows which had been in use for a long time to the museum, making it the first country in Europe to enter the firearms era. In 1640, the revolution to establish the rule of the bourgeoisie broke out in Britain. On May 19, 1649 Britain declared it a Republic, tolling for the first time the encoffining of the feudal system and completing the transition from the feudal system to a capitalist society. The world takes this as the sign of the modern society. The success of the bourgeoisie revolution in Britain cleared the road for the development of capitalism and the earliest fruit harvested of social changes in the post-Renaissance era. On July 14, 1789, the people of Paris rose in rebellion, marking the beginning of the French Revolution. In July 1794, the French Revolution overthrew the feudal autocracy and established a capitalist system. Development of large-scale machine industry in the late eighteenth century consolidated the dominance of capitalism in Europe. Since the nineteenth century, the feudal king's crowns of the remainder European countries successively fell to the ground, noble knights wearing armor and aristocracy died together, and the bourgeoisie of the countries showed up singing tunes of victory, establishing within their territory the bourgeois state, and eventually completing the transition from feudal system to capitalism in European society. This is also what the founder of mechanized warfare theory Fuller had said: after its introduction to the West, the gunpowder invented by China bombarded and toppled the European medieval order.

3. Opening of New Routes and Early Colonial Expansion

In the late fifteenth and early sixteenth century, the early European colonial expanders modified the gunpowder and compass introduced from China and equipped them to large ships, making possible the ocean voyages, looting of colonial wealth and primitive accumulation of capital. After the completion of political unification and centralization in Portugal and Spain, the warlike aristocracy attempted to benefit from the voyage adventures and the authoritarian monarchy again took opening up of new routes as an important source of income. All this prompted the two countries'

businessmen and feudal kings to become the first colonists. Thus, Portugal and Spain became two of the earliest foreign countries to engage overseas plundering.

In 1487, King Joao II of Portugal sent the Portuguese Bartolomeu Dias (1450–1500) on a southward voyage along the west coast of Africa in 1487 with an expedition team, who finally reached the southernmost tip of Africa, "Storm Corner" (later renamed to Cape of Good Hope).

In July 1497, King Manuel I of Portugal sent the Portuguese Vasco Da Gama (1460–1524) on a voyage with 170 people. Setting off from Lisbon on November 22, the fleet passed the Cape of Good Hope, reached Mozambique, kilwa, Sofala, and other cities on the Eastern coast of Africa, and established commercial sites.

After the approval of the Spanish State Isabella I, in August 1492, the Italian Cristoforo Colombo (ca. 1451–1506, moved to Portugal and Spain successively) set off from Palos on the southwest coast of Spain, leading three ships spearheaded by the "Santa Maria" and 90 people and discovered Guanahani Island of the Bahamas on October 12 after over 30 days (another theory say over 70 days) of hard sailing, and Columbus renamed the island San Salvador. Then, the fleet discovered northeast coast of the island of Cuba, and later the Haitian Island. After that, it reached the Americas twice, but Columbus insisted that the place he reached was the edge of Asia. It was not until 1499–1504 when the Italian navigator Amerigo Vespucci (1454–1512) made several field trips to South America that people confirmed that what Columbus discovered was not Asia, but the New World–the Americas. And later America was used to name the new continent.

On September 20, 1519, the Portuguese navigator Fernao de Magalhaes (ca. 1480–1521), with support of Spanish King Carlos I (1500–1558, reigned 1516–1556), set off from San Luca (another theory say Sevilla), spain with 5 ships and 265 crew, traversed the Atlantic, entered the Pacific Ocean, and arrived in the Philippines in March 1521. On April 27, Magellan was killed by the local indigenous people. The remaining 18 people embarked the ship "Victoria" and returned to Spain on September 6, 1522.

The new routes opened up by the Portuguese and Spaniards changed the state of the world's continents and oceans being separated and isolated from one another, strengthened worldwide communication, and prepared the conditions for the formation of the world market. However, along with the opening up of new routes, there came the overseas colonial expansion of the Western European countries. This expansion is full of evil and soaked with blood. The matchlocks of Spain and Franks of Portugal were used to shoot and kill innocent people in many Latin American, Asian, and African countries. Matchlocks and Frank also spread to Asian and African countries among this bloody killing.

4. Trumpeting the Horns of Scientific Revolution and Promoting Industrial Revolution

In the field of natural science, the Copernicus' heliocentric theory of the Earth revolving around the sun blew the horn of scientific revolution, freeing natural science from the shackles of theology, and dealt a fatal blow to the banal preaching

of God creating the world. The great geographical discoveries made by Columbus and Magellan are an irrefutable proof of the correctness of round earth theory. The achievements of Galileo in astronomy and physics enabled a new understanding by human beings of the universe. In 1687, Newton's "*Mathematical Principles of Natural Philosophy*" forged the keys for industrial revolution. In the 1760s, the most developed capitalist country Britain ushered in Industrial Revolution. The invention and use of the steam engine in the 1880s made possible further development in the industrial sector. In the late 1830s, the industrial revolution in Britain was basically completed. In the end of the nineteenth century, the USA, France, Germany, Japan, and other countries also completed the Industrial Revolution successively.

The four great inventions of China was timely promoted and used in Europe. The ideological emancipation brought about by the Renaissance, the scientific and technological revolutions and the rapid development of the machinery industry made possible unprecedented improvement in the European military technology. Black powder evolved into smokeless powder. In the invention and manufacture of matchlock guns, flintlock guns, firing guns, Breech-loading rifled guns with firing pins, magazine guns, machine guns, layered guns, built-up guns, and other special guns, many scientific methods were created and used, again under the guidance of the accurate ballistic theory. Sailing ships were replaced by steam ships of large tonnage and high-speed navigation. Universal construction of modern fortresses made ancient castles merely historical monuments for travel and sightseeing. All these shows that modern military technology in Europe and the USA has been walking in the forefront of the world in the sixteenth to nineteenth century after learning the technologies from China for making and using gunpowder and firearms.

Just as Bacon had said, China's three (actually four) inventions have changed the face of the world and the state of things in the world. Nothing has brought about greater impact.

4 Lecture 4 The South-Pointing Needle and Compass

Nianzu Dai

The south-pointing needle, papermaking, printing, and gunpowder are collectively referred to as the four great inventions of ancient China. They had been highly praised by Francis Bacon (1561–1626) and Karl Marx (1818–1883). Marx called those technological inventions as the "necessary preconditions of bourgeois development."[60] The four great inventions have been universally recognized as the creation of the ancient Chinese people. Even though there are some different opinions in the international academic community, there is no conclusive evidence or historical fact to show that other ethnic groups or regions had made earlier inventions or discoveries.

Speaking of the south-pointing needle, the electrostatic and magneto-static knowledge mastered by ancient people will be involved. Due to space limitations,

[60] The Complete Works of Marx and Engels. Volume 30 [M]. Beijing: People's Publishing House, 1975:318.

we can only mention the part relevant to the compass. To learn more about the ancient Chinese people, you may refer to my book "*The History of Physics in China*" or "*A History of Static Electricity and Static Magnetism.*"

Correspondence between the South-Pointing Needle as a technical invention and magnetism knowledge

Level	Knowledge	Technological invention and its era
1	Magnetic polarity	Brawl chess game, the late warring states to the Han Dynasty
2	Magnetic polarity of pointing needle	Sinan (south-indicating ladle), the late warring states to the Han Dynasty
3	Declination	The south-pointing needle, compass, Tang Dynasty
4	The earth is a giant magnetic body	Terrella, 1600, W. Gilbert

4.1 Sinan (South-Indicating Ladle)

"Sinan is a magnetic direction pointer polished from natural magnets (Fe_3O_4). The compass cart in history is a mechanical pointer created by Ma Jun (dates of birth and death unknown) in the Three Kingdoms Period. In historical literature, especially the classics since the Wei and Jin Dynasties, mixed use of "司南" and "指南" results in today's objections and doubts in academia about related scientific knowledge and technological processes. Half a century ago, Museology scientist Wang Zhenduo (1913–1992) launched a comprehensive research of Sinan and the compass and laid the foundation of today's cognition of Sinan as a magnetic pointer (as shown in Fig. 52).

The earliest record of Sinan in writing is seen in *Hanfeizi Youdu*, a philosophical classic of the late Warring States Period

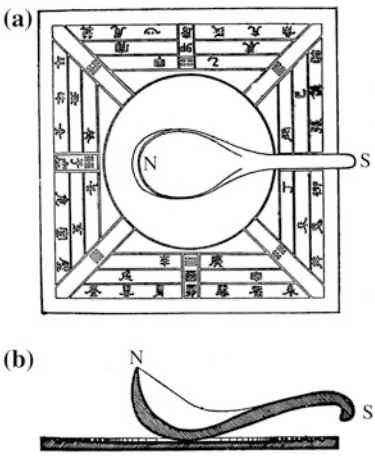


Fig. 52 Sinan restored by Wang Zhenduo **a***top view*; **b***side view*

> In infringing upon his king, a courtier has to get close from far off, much in the same way as one walks, so as to make the king lose his bearings. It would be dangerous for the king to remain ignorant of the change in directions. Therefore, the late older king set up a south-indicating instrument to make them right.

Here, the character "端" has two meanings: first, the "starting" and "front" of things, implying directions. The first "端" in the citations should be interpreted this way; second, "端" as a verb, meaning "to make right," as is the case in the second instance of the character. "朝夕" here was borrowed to mean the directions of "east and west." "端朝夕" means making right the directions of east and west. The citation says to the effect that: Traitors attempting to harm his king by change his governing ideas or guidelines always take actions step by step and bit by bit. In this way, they hope to make the monarch lose his directions and transform his route without knowing it. Therefore, the late older king created "Sinan" in order to help telling the east-west direction.

Is "Sinan" a political principle or utensil? It is not until the Eastern Han Dyansty that Wang Chong (27-ca. 97) described its shape and physical characteristics. He wrote "*Lun Heng* • *Shiyingpian*":

The grass Quyi may have been fabricated or actually in existence but with fabricated capability of pointing at people. If it can point at people, the reason might be that it can move at the sight of human beings. The ancients were simple in thought, and when they saw it moving, they believed that it could pointing at people, specifically, at the sycophants. When put on the ground, the ladle of Sinan points south. Worms feeding on rotten fish gather and crawl northward when they fell to the ground. That is the nature of such worms. When the grass can point at people, it is also the nature of such grass.

The whole text describes three "objects": grass named Quyi, ladle of Sinan, and worms feeding on rotten fish. The first is a plant, the last a small animal, and the intervening an ordinary object. They have the same nature of indicating directions. According to Wang Zhenduo's research: in the citation, "地" refers to the lower half of the Han Dynasty divination tool "Shi Pan," known as the "Earth Disc" (literally earth plate); "柢" originally referred to the root of the tree, and is used here to refer to the handle of the ladle. The Sinan is similar to the household object "ladle." When it is placed on the divination utensil "Earth Disc," its handle (柢) points to the south. Based on the records in "*Han Feizi*" and "*Lun Heng,*" Wang concludes that the utensil for indicating directions must have been a ladle-type pointing device made of lodestone and restores it as shown in Fig. 52. The original Sinan must have been created in the late Warring States period.

Inner beauty of the curved Sinan in Fig. 52 has been accepted and appreciated by the academia and has become a symbol of scientific and technological artifact of China in the media today.

However, there are individual different opinions: one believes that Sinan is the constellation of the Big Dipper; another believes that Sinan was an official position in the Western Zhou Dynasty. In fact, the former was subconsciously influenced by the similarity between the curved form of the restored Sinan and the shape of the Big Dipper constellation; as for the latter, no evidence has been found, and the Western Zhou Dynasty did not have the official post of "Sinan."

The crux of the matter still consists in science. The curved bar magnet, especially the inward bend of the dipper handle end, greatly weakened the polarity of Sinan as a magnet bar and weakened its induction intensity with the weak magnetic field.

Therefore, even magnetic dipper made of tungsten steel in a strong magnetic field would shortly become completely demagnetized and stop rotating. It is very simple to solve this problem. Wang Zhenduo painted in his masterpiece "*Sinan, the South-Pointing Needle, and Compass*" 14 species of dippers in the Han Dynasty. Among them, only one or two shaped like that shown in Fig. 52, while up to 11 have straight shanks (as shown in Fig. 53). In restoration of Sinan, a dipper with straight shank is used: the dipper has a handle with a sharp tip and the dipper body is not hollowed out (as shown in Fig. 54), such as a magnetic dipper is actually a bar magnet, in full compliance with the physical law "a bar magnet hanging free point to the north–south direction" (as shown in Fig. 55). A Sinan dipper placed on a smooth flat surface with minimal frictional resistance enjoys the same physical conditions as a bar magnet hanging free. To reduce the frictional resistance, the restored Sinan should not be too big (as shown in Fig. 56). The impression of Sinan dipper being rather like the big dipper of the kitchen should be changed.

Others question, why has not archeology found any such object? As for this question, firstly we have to ask our ancestors whether they had buried such objects together with their masters; and secondly, we have to ask modern archaeologists whether they had the awareness for Sinan in their excavations. As we all know, a lodestone scoop in the ground for over a thousand years is more easily prone to rust and peeling. Without the awareness of "Sinan," even if the handed touched it ten times, one could still not recognize it.

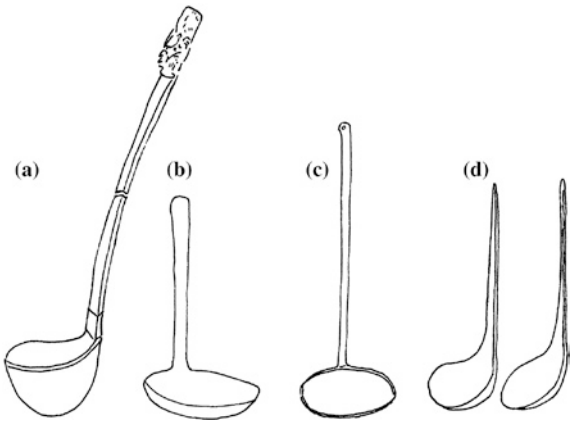


Fig. 53 Four straight shank ladles used in the Han Dynasty. **a** Jianyuan Dragon ladle; **b** Luoyang copper ladle; **c** Shibei ladle; **d** Gourd-bowled ladle

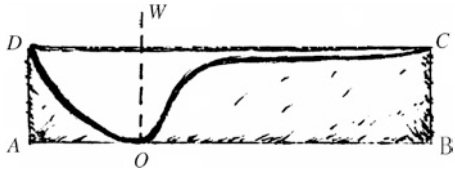


Fig. 54 Sketch of the restored Sinan ladle ABCD is a bar of natural magnet, WO is the center of gravity perpendicular to DOC

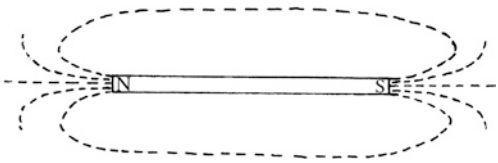


Fig. 55 Polarity and magnetic lineation of a bar magnet

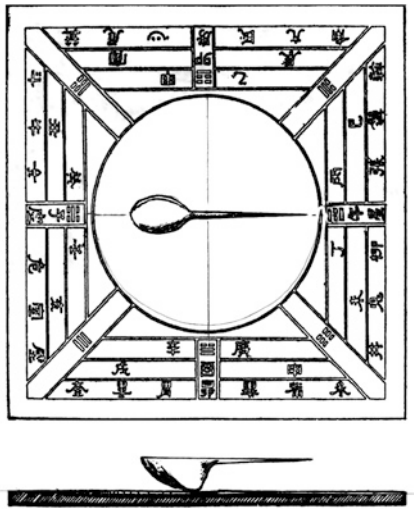


Fig. 56 Picture of the newly restored Sinan and "Earth Disc". **a***Top view*; **b***side view*

The present author believes that Sinan existed in history, and before the invention of the south-pointing needle in the Tang Dynasty, there must had been people "fiddling with" Sinan. In "*Ode to Mysterious Views,*" Xiao Yi, Emperor Yuandi of Liang (508–554) described his glory ancestors, expressed his reflections on affairs ancient and present, spoke of his own power and prestige and his enjoyment, and occasionally even thought about the Yuezhi Tribe rushed by the Huns to the remote areas in the northwest. This time he pinned his hopes on divination, saying "See the divination on Xun by the spiritual bird and observe the turning of Sinan to Li." In the verse, both "Xun" and "Li" are directions in the Eight Diagrams. In the Tang Dynasty, Weizhao (766–779 as Court Secretary) in its "*Ode to Gourd Ladle*" praised the elegance and simplicity of gourd ladles and compared them with the "Big Dipper" and "Sinan," writing "The gourd ladle is different from the Big Dipper Constellation in that it can be used to scoop wine, and from Sinan in applicability."

People also feared that the ancients might cause demagnetization due to beating in carving lodestones into Sinan and worried about whether they had had the appropriate processing tools. Just think about the jade articles (jade bird, jade turtle, jade fish, jade cong, jade hat, and ornaments) of 2500 BC unearthed in Liangzhu, Fanshan, Yuhang County, Zhejiang, as shown in Fig. 57), and these concerns can be dispelled. See the following Moh's hardness scale (as shown in Table 1).

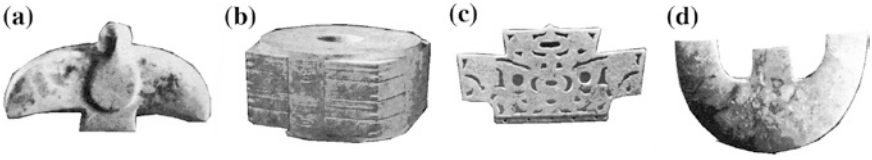


Fig. 57 Jade articles of Liangzhu, Fanshan jade bird, jade cong, jade ornaments, jade token

Table 1 Moh's hardness scale (relative value)

Material	Moh's hardness
Iron, natural lodestone	5–6
Steel	6–7
Jade (nephrite)	6.5
Corundum (emerald)	9
Diamond	10

Now that several thousand years before the Han Dynasty, people could process jade ornaments with complex patterns by using line cutting and other methods, why couldn't the people of Han Dynasty process lodestones which are much softer than jade? Slow and steady wins the race. Among the ancients, the must have been some who know that battering with hammer should be avoided in processing.

It is worth noting that a bar magnet dating back to about BC 1400–BC 1000 was unearthed in the Mexican city of San Lorenzo a few years before 1975. The American physicist Carlson (John B. Carlson) published an article in "*Science,*" saying that it had been over 1,000 years older than the Sinan discovered by the Chinese" (Science, Vol. 189, 1975, p. 753). So far, however, this discovery

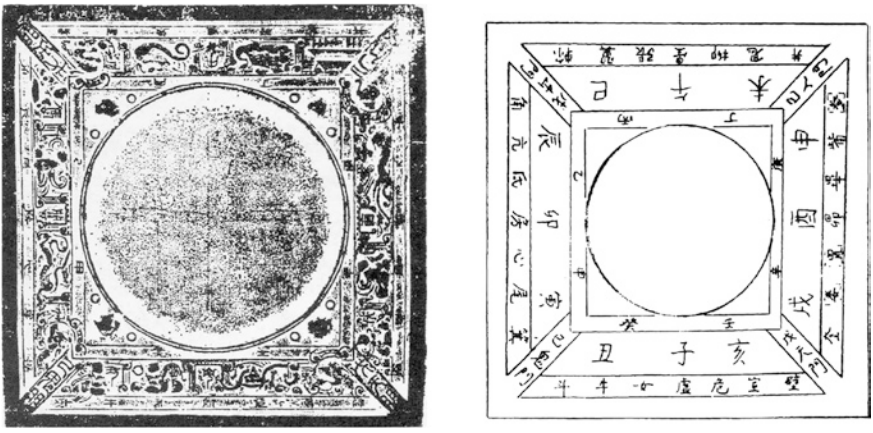


Fig. 58 Han Dynasty copper diviner's board found in the Qing Dynasty. **a** Overall effect diagram, **b** orientation sketch

remains uncorroborated evidence. Moreover, there is no textual or relevant legend in the Olmec Culture to prove it. Sinan from China is still the earliest magnetic pointer with written record by the human race.

Earth Disc (present-day azimuth card), on which the Sinan is placed, is part of "Shi Pan," a divination tool of the Han Dynasty. At the end of the Qing Dynasty, the Han Dynasty copper Shi Pan (as shown in Fig. 58) was also found. In the 1970s, Han Dynasty lacquered wooden diviner's board (as Fig. 59 shows) was unearthed in Mojuzi, Wuwei County, Gansu Province, and Ruyinhou's Tomb in Fuyang City, Anhui Province. The upper half of "Shi Pan" is called "the heavenly disc" in which the names of the 28 stars are inscribed; lower half is called "earth

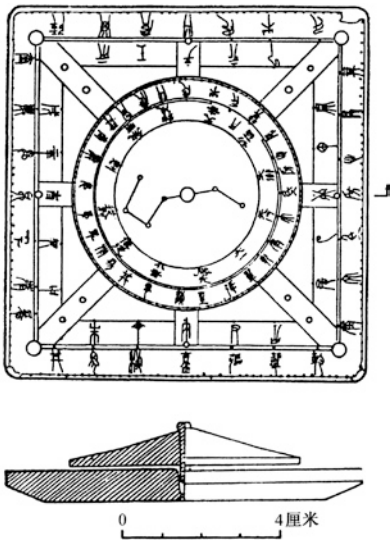


Fig. 59 Han Dynasty lacquered wooden diviner's board unearthed in Mojuzi, Wuwei

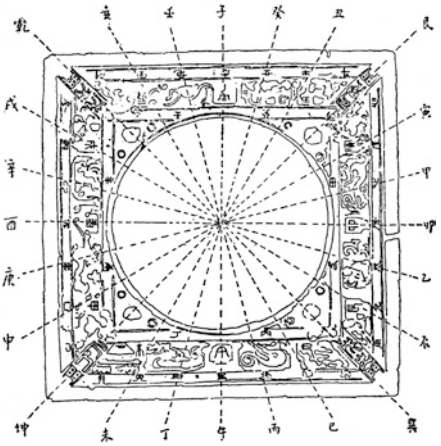


Fig. 60 The 24 directions on a Shi Pan

disc," including 24 directions. The heavenly disc is round; and the earth disc is square, denoting directions of east, south, west, north, etc., with some characters of the heavenly stems and earthly branches and eight diagrams. Among them, "子" (Zi) and "午" (Wu) denote due north and due south, respectively (as shown in Fig. 60). Interestingly, from the Ming and Qing Dynasties to the beginning of the twentieth century, Anhui was a rich land of compasses, which were referred to as the "Anhui Compasses." It is truly amazing for a local tradition to last so long!

4.2 The Sociocultural and Scientific Backgrounds for Appearance of Sinan

Appearance of Sinan in Qin and Han Dynasties is related to the social culture of that time: states merged and geographical concept expanded; a unified China and the germination of large geographic concepts; diversification of divination forms and divination tools; and academic contention of the philosophers.

Those schemas are known to the reader, but we are going to focus the scientific and knowledge background prompting the creation of Sinan.

From a technical point of view, mining and iron metallurgy technology witnessed considerable development between the Warring States Period and the Han Dynasty, leading to the emergence of a large number of magnetite ore. Some places were even named for its production of magnetite ore, for example Cizhou, Cixian, and Cishan. Magnetic stone was widely used in medical treatment (magnetic stone is one Materia Medica drug), construction (Qin Shi Huang built Epang Palace using magnetic stones as the material), alchemy (alchemists' belief in magnetic stones exceeds that of any other school of thought), and ceramic manufacturing (magnetic stone was used to remove iron impurities from the glaze compound). Some physical characteristics of the magnetic stones are documented in a variety of classics.

Initially, "磁铁石" (the Chinese for magnet stone) was written as " 慈石" ("*Guanzi* • *Dishu*"), as seen in "慈石召铁, 或引之地" (a magnetic stone attracts iron and can pull it up from the ground) (*Lü's Spring and Autumn Annals* • *JI Qiu Ji* • *Articles on Proficiency*), and "慈石为铁之母" (the magnetic stone is the mother of iron), thus it attracts iron. The three expressions of 慈, 石慈, and 磁 were used in accordance with change of the times. In the early Han Dynasty, the School of Liu An (BC 179–BC 122), King of Huainan, made much contribution to the magnetic studies and laid the foundation for ancient knowledge on magnetism.

Liu supported almost one thousand spongers in his mansion. Under the auspices of Liu An, they co-edited "*Huai Nanzi,*" "*Complete Craftsmanship of Huainan,*" and other books. In the books, various magnet experiments they did were recorded. They not only knew that the magnet attracts iron by nature, for example, they said "the magnetic stone attracts iron ("*Huainanzi Lan Min Xun*"), "the magnet stone flies upward" (*Huainanzi* • *Di Xing Xun*"). The latter refers to

the phenomenon of iron chunks pulling magnet fragments up from the ground, showing that magnetic interaction can occur at a spatial distance. They used rectangular magnets to make pawns and also clearly knew that bar magnets having different polarities, as seen from their remarks "magnetic stone pulls the pawns" and "magnetic stone repels the pawns." "Pull" suggests attraction, and "repel" "rejection." Although they did not describe the physical property "Magnets of the same polarity will repel each other, while those of different polarity will attract each other," they used "pull" and "repel" to vividly portray this property. Beyond that, they also made experiments of using a magnet to attract copper and pottery, clay, tiles, and stones, and concluded: "A magnetic stone can attract iron, but not copper" ("*Huainanzi* • *Shuo Shan Xun*"), and "using a magnetic stone to attract iron is easy, but using it to attract pottery is difficult indeed" ("*Huainanzi* • *Lan Min Xun*"). These words appear ordinary, but they are invaluable! They show the curiosity of King Huainan School in natural knowledge. Interpretation of those experimental results is possible only after the birth of the modern magnetism. This is the concept of magnetic permeability μ depicting the magnetism of substances in modern magnetism:

略大	Slightly larger
负值	Negative value
铁磁性物质	Ferromagnetic substances
顺磁性物质	Paramagnetic substances
弱磁性物质	Weakly magnetic substances
抗磁性物质	Diamagnetic substances
μ	Magnetic permeability

Copper is diamagnetic substance, and it is not attracted by magnets; tile, stone, and soil are weak magnetic substances, and it is hard for them to be attracted to magnets.

A fact not to be overlooked is that Liu An and his spongers found the pole-pointing property of bar magnets. "Pole-pointing property" refers to the phenomenon of magnet in free rotation pointing to the earth's north and south poles when it comes to a rest, because the Earth is a huge magnet. Liu An's findings not only provided or explained the scientific knowledge foundation for manufacturing Sinan, but also made complete the correspondence table between knowledge and technologies in the beginning of this chapter. "*Complete Craftsmanship in Huainan*" wrote: "hang a magnetic stone in the well (or "room"), and spirit of the missing will find his way home."

In the Han Dynasty, Gao You annotated: "Take clothing of the missing person, wrap a magnetic stone in it, and hang it in the house (or "well" or "room"), and the missing person shall return of his own accord.

The individual words within the brackets are different due to different versions of the saying. Both "亡人" and "亡者" refer to the missing person. When a person

is missing from home, a magnet is hung in the house so as to guide the missing person home safely. This is perhaps the belief of the Taoist art practitioners among Liu An's spongers. The key here is that only a bar magnet suspended-free can point the right direction, not a polygonal magnet of irregular shape as usually imagined. Wrap a long magnet in clothes and then suspended it in the air—this is a typical example of the ancient science donned in the coat of witchcraft. After the Han Dynasty, a large number of magnetic illusions (or magnetic games) were developed, and probably, they were of the same nature.

What is most surprising is that Liu An School discovered the earliest method for making a magnet in the history: "Take some chicken blood and iron filings. Mix them, and coat the mixture on the pawns. Put the pawns on the chess board, insert the iron stick in between and the paws repel or attract each other." ("*Complete Craftsmanship in Huainan*"). Gao You annotated: "take some chicken blood and iron needle filings, mix them to form a magnetic stone, coat the pawns with the mixture, and exposure the pawns to dry. Put the pawns on a chess set, and they repel or attract each other incessantly."

In these two citations, the "杂磨针铁杵" or "针磨" refers the filings resultant from honing steel needles. As the saying goes, "As long as one sets his mind to it, he can hone an iron stick into an iron needle." "Chicken blood" serves as the coagulant. The character "和" in "和磁石" should be pronounced as "huò," meaning "mix," as in "和灰浆" (preparing mortar) and "和药" (mixing medicines). When on keeps filing the needle tip in one direction, the filings will become magnetic naturally, due to the influence of geomagnetic field. Mix this powder with chicken blood to make a magnet, coating the mixture on both ends of the pawns, and the pawns becomes magnetic. So they would repel or attract each other on the chessboard. In the original text, "抵" means "attract mutually" and "击" means "repel mutually."

Making pawns of magnet or making artificially magnetic pawns was once popular in the early days of the Han Dynasty. Compositions set with such pawns are called "Brawling Chess Games." The outcomes of "Brawling Chess Games" are dependent on the magnetic strength of pawns. Those with stronger magnetic strength can pull the pawns of the other side over or push them away and thus lead to victory. Emperor Wudi of the Han Dynasty had on several occasions called the alchemist Luan Da to the palace, to perform "Brawling Chess Games." Liu An, King of Huainan, was the grandson of Emperor Gaozu in the Han Dynasty and uncle of Emperor Wudi of Han. Since he was "good at debate and diction," Emperor Wu "held him in high respect" and "would discuss with him the gains and losses in chess games and make odes on them until dusk." ("*Biography of King of Han Huainan*"). He probably had told Emperor Wudi the artificial magnetic pawns, and "Brawling Chess Games." From Han Feizi to Liu An and Wang Chong, the Chinese created Sinan and were aware of the polarity in long bar magnets, building the complete knowledge of magnetism of a whole era. Since then, another major development of magnetism was to be obtained in the Tang and Song Dynasties, with the advent of a large number of geomancers.

4.3 The South-Pointing Needle

Magnetization of ordinary needles is a contribution of herbalists. Further, the use of magnetized needles as direction indicators and naming them the south-pointing needle is the joint masterpiece of Taoists and geomancer. In turn, the geomancers improved and developed orientation disk, making the compass sophisticated.

Magnet is a Chinese medicine for soothing the nerves and refreshing the mind, and its property has been recognized early by the Materia Medica specialists. The method for telling their quality is by observing the amount of needles that it can attract. Tao Hongjing (456–536) of Xiao's Liang Dynasty said in "*Record of Famous Doctors*": "good magnets can attract needles when hung up, and those capable of attracting three or four (needles) to form a line are better." In the Liang Dynasty or early Sui Dynasty, the Taoist Su Yuan Lang also said in "*Records from the Stone Wall of Great Clarity*": "magnets capable of attracting five or six needles in one continuous line are good; the more needles attracted, the better their quality." In the Tang Dynasty, Su Gong pointed out in "*Annotation to Materia Medica of Tang Dynasty,*" "When first carved, good magnets can link ten needles."

This method of appraising magnet leads to the discovery of ordinary needle magnetization through magnetic induction. And the subsequent discovery of the needle pointing directions is a matter of course in the history of science. According to present-day discovery, the earliest person to describe the south-pointing needle is Duan Chengshi in the late Tang Dynasty (803–863). Duan Chengshi once assumed the official posts of Collator of the Secretary Department and Vice Minister of the Ancestral Temple. In the 3rd year of Huichang (843), Duan invited several colleagues and Taoist "Sheng Shang Ren" (the exalted) to tour the temples in Changan. At the height of fun, they started a game of composing a poem together with each one contributing one line alternatively, and Sheng Shang Ren wrote "勇带磁针石, 危防丘井藤" (I have brought a needle and magnet stone, in case we get lost somehow), while Duan Chengshi submitted "有松堪系马, 遇钵更投针" (there are pines for tying horses, and iron bowls for casting needles.) ("*Miscellaneous Morsels of Youyang*" Volume 5 "*Record of Temples and Pagodas*"). Obviously, they have brought with them a magnet, a needle, and tried to put the needle in the bowl used by monks to hold water so as to observe the direction. This is the earliest record of water-floating compass.

About 200 years after Duan Chengshi, i.e., in the 1040s, like the explosion of knowledge, the south-pointing needle, more precisely, the compass, was almost simultaneously recorded in the following three books:

1. Annotation of "*Guan's Introduction to Geography*" by Wang Ji. The book was a collection of geomancy writings in the Tang and Song Dynasties. Wang Ji (ca. 988–1058) the annotator was styled Zhaoqing. He annotated the book from about 1030–1040, leaving a poem "*Interpretation of Needle Directions*":

Clearly, the needle points at somewhere between Xu and Wei, and its direction to the south is slightly tilted;

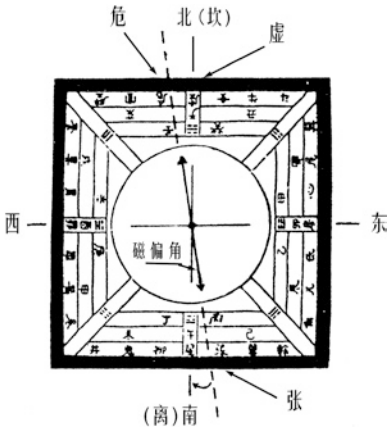


Fig. 61 Graphic expression of a compass and declination (the board is a Shi Pan of Han Dynasty)

If one cannot recognize the deviation from Kan and Li, the minute difference might make the needle useless.

In the poem, "虚," "危," "坎," "离," and "张" are directions on the compass referring to the due north, north by west, due north, due south, south by east (as shown in Fig. 61), respectively. In the poem, there is another direction "南" (south). The poem clearly point out that the two ends of the south-pointing needle, one indicates a direction between "虚" and "危," i.e., north by west, and the other "南方张度," i.e., south by east. The angle between the needle direction and the geographic north–south direction is called magnetic declination. The magnetic declination varies with the location and the specific year. From Fig. 60 we can see that the declination described in "*Interpretation of Needle Directions*" is about 7.5° (where Bianjing, the capital of Northern Song States was located). The box and needle and the magnetic declination are expressed in the same poem.

Wang Ji was a geomancer with widespread fame in Fujian and Jiangxi. His father Wang Xiyuan (961–1081) and grandfather Wang Chune (915–982) were both recorded in "*The History of Song*" as proficient with ephemeris and astrology. Wang Ji's geomancy skills have been a family tradition.

2. "*Total Record of Graves,*" a book on appraisal of tombs, completed by Yang Weide in the Northern Song Dynasty. The book was completed in the 1st year of Qingli (1041) during reign of Emperor Renzong. The book wrote in Volume I "Mountains":

In choosing the site, it is best to follow the four directions without deviation. The method: Take the Bingwu direction according to the compass needle. And then take the other directions by drawing a vertical line through it. The direction between Bingwu and Renzi is along the central line of the earth, and ensure the directions of due south and due north. However, the direction between Bingwu and Renzi is only approximate. If you need more precise data, you might as well use a compass and dangle a rope…

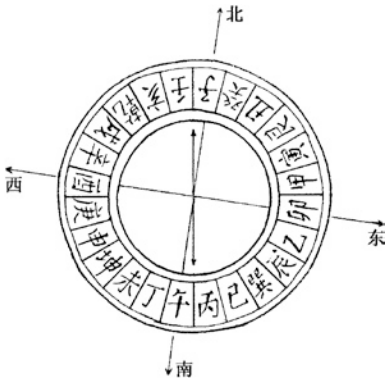


Fig. 62 Bingwu direction on the compass

The character "的" cited in the first sentence refers to the target, and "四正" to the four directions, i.e., east, west, south and north. "当取丙午针" refers the direction indicated by the compass needle (as shown in Fig. 62). Yang Weide knew that the north and south (magnetic north and south poles) are not completely consistent with the geographic north and south. So "约而大概"—only approximate bearings are taken. To obtain the geographic due north and due south, Gui, Gao and other instruments should be used to judge the direction by exposing to sunlight and make calculations based on the shadows. The whole text shows that Yang Weide was familiar with the compass and magnetic declination. The so-called "Bingwu" and "Direction between Bingwu and Renzi" also shows that the magnetic declination of Jingdu in the Northern Song Dynasty was about 7.5°.

Yang Weide, an important astronomer in the Song Dynasty, was the assistant to Han Xianfu (940–1013) in making copper armillary sphere. He was first made "Almanac Secretary" and then "Astronomical Secretary." He became known in the first year of Jingyou (1034) for formulating the table of stars and joined Yan Su (961–1040), an astronomical mechanic in inspecting the Lotus Glass. He was also one of the discoverers and faithful observer and recorder of the 1054 supernova which is world-famous today. He is a naturalist who wrote books on "fate prediction and symbols." In his old age, he used yin and yang theory in geomancy and wrote the book "Total Record of Graves." "茔" is the graveyard.

3. Zeng Gongliang, the Military strategist of the Northern Song Dynasty (999–1078), wrote "*Collection of the Most Important Military Techniques*" (completed between 1040 and 1044). The aforementioned Taoists and geomancers used the magnetic induction method to manufacture the south-pointing needles, while Zeng Gongliang discovered another method, which can be expressed in modern scientific language as: via transformation of magnetic domain from disorder to order in the process of cooling red-hot steel. He wrote:

Method for making the Guide Fish: cut a thin iron leaf into a fish shape, two Cun's in length and two fen's in width, and with a sharp head and tail. Fire it with charcoal, wait until it is red throughout. Pincer it out of the fire, adjust the tail to face

north, dip it in water basin, until several fen's of the tail is submerged. Store the Fish in an airtight container. In use, set a water bowl in a windless place, lay the fish flat so that it floats on the water. And the head of the fish constantly points south. ("*Collection of the Most Important Military Techniques*: Part I" Volume 15).

This approach needs some interpretation from the perspective of modern magnetism: carve out a fish-shaped steel piece, i.e., a common strip of sheet iron with sharp tips at both ends. Expose it to a high temperature of about 700 °C (this temperature is called the Curie point where the magnetic domain of the magnet reaches a state of confusion), so that the magnetic order is completely disrupted. Then adjust the steel piece so that it follows the geomagnetic field direction (tail facing the Zi position, i.e., north and south) and dip it in water, waiting it to cooling. After that, the magnetic domain of the steel gets reordered, thus generating magnetism. The Fishtail facing the North becomes the southern pole and the head facing south becomes the north pole. Therefore, the fish-shaped south-pointing needle "always points to the south with its head." The description of "Points to the south," instead of "due south," shows the presence of the magnetic declination.

Seen from the above, we can know that people had discovered two methods for magnetizing steel. Compass and magnetic declination were also recognized by them.

Later, Shen Kuo summarized in "*Brush Talks From Dream Brook*" and "*Supplement toBrush Talks From Dream Brook*" prior knowledge about the south-pointing needle and magnetic declination. He said: "After polishing a needle with a magnetic stone, specialists can make the needle point to the south. However, the needle often deviates slightly to the east, instead of point due south." "Among needles in my collection, there are some pointing to the south as well as some pointing to the north." "Polish a needle with a magnetic stone, the tip often points to the south, and sometimes to the north." Shen Kuo also proposed various methods for installing the compass. In addition to water floating, he especially dealt with thread suspension method (as shown in Fig. 63), that is, hanging the magnetic needle up with silk thread. In 1777, the French scientist C.A. de Coulomb (1736–1806) used this method to design a marine compass and was awarded first prize by the French Academy of Science. Coulomb balance invented by him also used Shen Kuo's method.

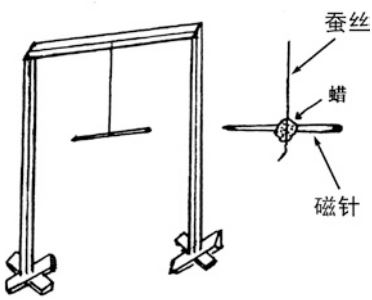


Fig. 63 Thread suspension method of Shen Kuo

As for water-floating south-pointing needle, so long as there is no wind and the needle is carefully put onto water, a copper needle or iron plate could stay afloat on the water for some time, due to surface tension of water. However, the ancients "pierced the needle through a wick (grass) to make it float on water" (Kou Zongshi "*Augmented Materia Medica,*" Volume 5 "*Magnet*"). Water compass is often used this way.

The compass and the south-pointing needle are repeatedly seen in literatures since the Song Dynasty. So is the use of the compass and needle in nautical navigation. Since the third year of Huichang (843), when Duan Chengshi documented the compass, to the time when Shen Kuo completed his book "*Brush Talks From Dream Brook*" (in about 1090), the compass and the box and needle had witnessed great development.

4.4 Compass and Geomancy

The board of the compass is undoubtedly from the earth plate of the earliest Shi Pan. The Fig. 64 shows an earth plate in "*The Residential Classic of the Yellow Emperor,*" a book completed in the Sui and Tang Dynasties. Previously cited Fig. 61 is based on an imitation of Han Dynasty Shi Pan. In the middle, there is a square or circular smooth plane, and the needle placed on this surface will rotate freely due to the influence of the geomagnetic field and become stationary in the north–south direction. This is the onset of drought compass. If a pool (geomancers call it "Heavenly Pool") is mounted to accept the needle, the device becomes a water compass. The square compass makes inconvenient observation, so they are reshaped round. In the early Song Dynasty, Xu Dong (980–1011) started writing the book "*The Classic of the Tiger Seal,*" completed it in the first year of Jingde (Jiachen year, 1004) during the reign of Emperor Zhenzong, and presented it as tribute to the court in the second year of Jingde (1005). In Chapter "*Bird Divination,*" two kinds of direction-guiding plates are painted (as shown in Fig. 65), of which the twelve-direction azimuth circular board is used in transition from square compass to round compass. Transition from square to round also marked a revolution in the history of instrument. Xu Dong pointed out in "*Preface to the Classic of the Tiger Seal*" that the book, "either reflects my own opinions or describes those of the ancients," "Six Ren, Dun Jia, stars the sun and the moon, winds and clouds and the climate, wind angle and birds, although they are not close to world affairs, I dared not leaving any one out." Those two forms of compass must have been made by people before Xu Dong.

Once a geomancer holds a compass, his belief must be included in it. In "*Green Satchel and Cape Classic by Xuan Nü of the Ninth Heaven,*" a book written in the Song Dynasty by pooling writings on geomancy, there is a water compass (as shown in Fig. 66) called "floating needle Indicating Directions": in the center, there is Tianchi for placing the needle; the second and third tiers are the twelve azimuth circles (also called twelve directions); the fourth and fifth tiers are the twenty-four directions. Yang Yunsong (also known as Yang Jiupin), a geomancer of the Tang

Fig. 64 The earth plate drawn in "*The residential classic of the yellow emperor*"

Fig. 65 The classic of the tiger seal. **a** Painted square board of eight diagrams, **b** round board of twelve earthly branches

Dynasty heralded as immortal in the Ming and Qing Dynasties, "cut his hair and entered Mountain Kunlun after Huang Chao captured the Capital," that is, began to devote himself to geomancy 40 years after Duan Chengshi documented magnetic needles, i.e., the first year of Zhonghe (881 AD) in the reign of Emperor Tang Xizong. Yang said in "*Esoteric Pronouncements of the Green Satchel*": "The natural conditions should be measured with the twelve directions on the compass and the artificial complementation should be made with the heavenly stems and earthly branches." Figure 66 gave the historical relics of compass directions gradually becoming more and more specific. Wu Wanggang of the Ming Dynasty painted a compass in "*Interpretation of Compass Classics*" and called it "The General Figure of the Three Needles" of a compass (as shown in Fig. 67). It expanded the five tiers

Fig. 66 Floating needle indicating directions

Fig. 67 The general figure of the three needles

of Fig. 66 to seven tiers, with each layer having a name. Obviously, the directions in the second and fourth tiers are the same as those of Fig. 65; the 24 directions of tier 3 are called "original needles," and as the same as those in tier 5 of Fig. 66; the 24 directions of tier 5 are called "Master Yang's Needles" (Master Yang is Yang Yunsong), and they are the same as those in the fourth layer of Fig. 66; the sixth tier, added by geomancers between the Song and Ming Dynasties, uses stars to indicate directions; the seventh layer is called "Master Lai's Needles." "Master Lai," named Lai Taisu or Lai Wenjun, was from the early years of the Southern Song Dynasty and active in the twelfth century. The indication of three needles (original needles, Master Yang's Needles and Master Lai's Needles) in a compass painting indicates that the purposes and means for geomancy are becoming more complicated and changed. Deviation in meridian of Master Yang's Needles and Master Lai's Needles from the original needle may have been associated with related changes in the geomagnetic pole and magnetic declination.

Since the Song Dynasty, geomancy compass became mystified and complicated by masters of feng shui and geography. Eight trigrams, heavenly stems and earthly branches, heavenly stars, and divinations of good and bad fortunes, and terminology were painted on the board (as shown in Figs. 68, 69, and 70).

Fig. 68 Copper geomancy compass used in the Yuan Dynasty

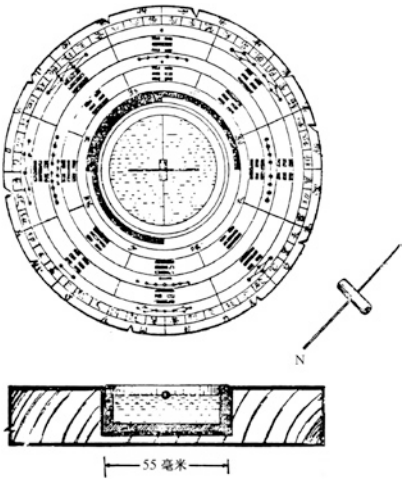


Fig. 69 Geomancy compass of the Qing Dynasty

Fig. 70 Modern geomancy compass

Fig. 71 Porcelain figurine of immortal Zhang unearthed in a Song Tomb in Lin Chuan, Jiangxi Province

The above are water compasses for geomancy purposes. It is worth noting that the dry compass is also first invented and put to use in geomancy by the Chinese. In the 1980s, a "Porcelain Figurine of Immortal Zhang" was unearthed in a Song Dynasty Tomb in Linchuan County, Jiangxi Province (as shown in Fig. 71). The figurines held vertically a compass in the right hand which is placed before the left chest, and the pivot jack can be seen in the middle of the needle. The one buried in the tomb is Zhu Jinan, governor of Shaowu Military Prefecture (in present-day Fujian) in the Southern Song Dynasty. Zhu died in the 3rd year of Qingyuan (1197) and buried in the fourth year of Qingyuan (1198). Therefore, it is irrefutable that the dry compass was popular in the latter half of the twelfth century in Fujian and Jiangxi.

4.5 Compass and Navigation

In the turn of the eleventh or twelfth century, there were texts describing sailing-oriented compasses. In the Song Dynasty, Zhu Yu described boatmen "observing the stars at night and the sun during day time, and used the compass when it is cloudy" in "*Pingzhou Table Talks*." The book was finalized in the first year of Xuanhe (1119). However, Zhu Fu, the father of Zhu Yu served as Marshal of Guangzhou between the second year of Yuanfu (1099) and the first year of Chongning (1102); thus, the book mainly recorded Zhu Fu's experience. Therefore, we can say that use

of compass in navigation should have begun in the latter half of the eleventh century. Four years after Zhu Yu completed his book, Xu Jing was dispatched as an envoy to Korea in the fifth year of Xuanhe (1123), and he mentioned that on the day of crossing the Ocean "if it is obscure south-pointing floating needle is used to tell north and south" ("Record of Envoys to Korea in Xuanhe Years" Volume 34). The so-called south-pointing needle for tell directions has to be no other but a compass.

The reason for south-pointing floating needles or water compass to be used on obscure days is that on sunny days "Astronomy Technology" can still be used to distinguish the directions. "Astronomy Technology" is the observation of the height of Polaris with some simple tools. In maritime navigation over many dynasties, steersmen have accumulated much knowledge. Relevant experience and knowledge of the compass, as a new instrument for navigation, naturally need accumulation. In the beginning of the thirteenth century, compass navigation finally came into all-weather use. Zhao Rushi (1170–1231) mentioned "*Annals of Foreign States*" complete in the first year of Baoqing (1225), "On the boundless sea, the water and sky merges in the distance. Incoming and outgoing boats have to rely on the south-pointing needle, and observe it day and night, since even the slightest deviation would make the difference between life and death." Zhao Rushi, member of the Song imperial clan, ascended through official ranks to Grand Master for Closing Court. Starting from 17th year of Jiading (1224), he was made chief of Quanzhou Customs, Fujian Route. "*Annals of Foreign States*" results from his collection of navigation incidents during his tenure there. Half a century after Zhao Rushi, Wu Zimu documented in "*Record of the Splendors of the Capital City*" (completed in the 10th year of Xianchun, i.e., 1274) sea merchants from Lin'an (now Hangzhou) in the Song Dynasty. In the book, there were similar records of south-pointing needles similar to *"Annals of Foreign States.*" The pointer "had to be watched day and night," and even the slightest difference should be avoided. This documentation undoubtedly refers to a compass. The compass set a direction with the 24 orientations on its board; if the partition between two adjacent orientations (also known as the "Master Yang's Needles") were included, there should be actually 48 orientations (as shown in Fig. 72). Therefore, it could tell the difference of heading within 7.5°.

Fig. 72 Correspondence between compass directions and degrees

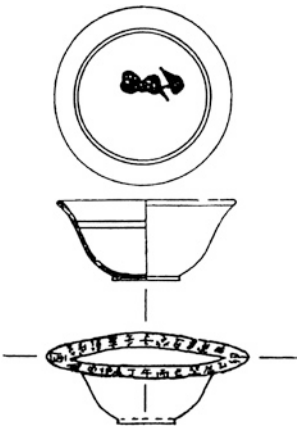


Fig. 73 Needle bowl—nautical water compass

The above geomancy compasses can naturally be used for sailing, but the nautical compass orientation needs only one layer (or circle). A nautical compass needs to be simple, straightforward, easy to identify, and easy to distinguish. In initial stages, the nautical compass may have been a porcelain bowl or plate, with an azimuth circle fitted to the rime or orientations painted in the inner bottom glaze. If one bowl (or plate) was broken, fetch another. Such a bowl was also known as the "needle bowl." In the recent decades, numerous needle bowls of Jin and Yuan Dynasties were unearthed in Lushun, Dalian, Jiangsu, Dantu County, and other coastal areas, even in a Yuan Dynasty wooden boat in Kaihe Village Cixian County, Hebei. In the inner bottoms of those bowls, there is a pattern of a float needle pierced through the lamp wick. In some cases, on the outer bottom there is the glaze character "针" (as shown in Fig. 73). In the Ming Dynasty, Huanan Yao (south China kiln) fired specifically porcelain plates to be used as marine compasses (as shown in Fig. 74). These are the water compass used in the early days of navigation.

Figures 75 and 76 show the nautical compasses of the Ming and Qing Dynasties. Numerous pictures of them can be found in literatures, and material objects of the Ming and Qing Dynasties are kept in museums

Accumulation of sailing experience prompted people to know the compass directions of various points on the navigation route (such as islands, reefs, or other signs on the sea). Ancients call this "needle path," "guide," or "needle through," "needle spectrum" or "needle book." To reach the destination, one has to use the needle path simultaneously with the sailing time (or distance). The unit for calculating the length of the voyage is "geng"; roughly one day and one night can be divided into ten geng's, and one geng equals about 60 li. In describing the route from Wenzhou to Japan, the "*Handbook of South-pointing Needle*" of Ming Dynasty wrote "start from Wenzhou, go 5 geng's along Danjia direction, 6 geng's along Jiayin direction, 20 geng's along Danyin direction, 15 geng's along Genyin direction, and you will reach the Mountain of Japanese. So fabulous." See Fig. 72.

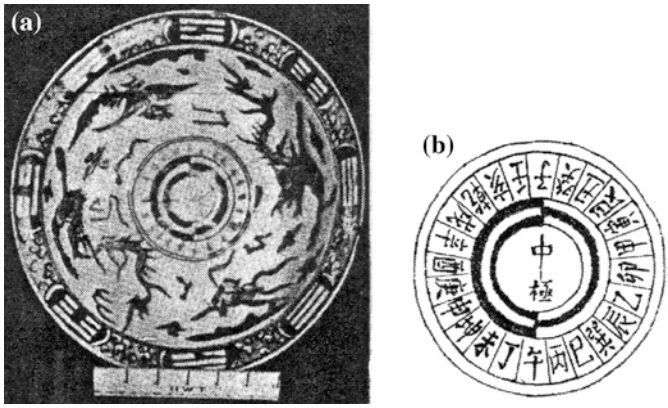


Fig. 74 Eight Trigram Porcelain compass. **a** The overall effect figure, **b** sketch of the magnified central dial board

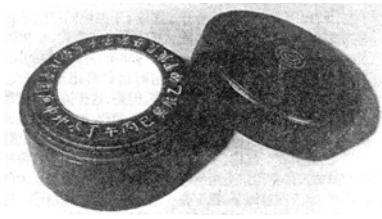


Fig. 75 Water nautical compass of the Ming Dynasty

Fig. 76 Dry nautical compass made in the early Qing Dynasty

Set sail from Wenzhou and take the "Danjia" direction, i.e., the direction of "甲" in the center of the compass, equivalent to 15° east by north; after sailing for "five geng's," change the direction of the ship to "Jiayin," i.e., the direction between "Jia" and "Yin" on the compass, equivalent to 22.5° east by north; sail for six geng's, and switch to "Danyin" direction, i.e., the direction indicated by the center

of the character "寅" on the compass, equivalent to 30° east by north; after going 20 geng's, switch to "Genyin" direction, i.e., the direction between "Gen" and "Yin" on the compass, equivalent to 37.5° east by north. Stick to this direction for 15 geng's and the boat reaches Japan. Calculation based on this direction, the destination is Nagasaki, Japan.

The "*Handbook of South-pointing Needle*" also documented "the needle direction for returning from Japan to Ningbo": "starting from Goto, and follow the direction of Kunshen and go seven geng's, then switch to Gengshen direction and go 15 geng's; switch to Dangeng and Gengyou, and go 25 geng's. You will find yourself in Ningbo." Compare the description with Fig. 72, it is not difficult to see that the compass orientation for returning to Ningbo is basically Japan reverse to that going to Japan.

The above are the so-called needle path of ancient mariners. Textual descriptions of needle paths in many classics and books so far can still be restored into route maps, consistent with present-day routes or route maps. In the Yuan Dynasty, Zhou Daguan (ca. 1275–1346), who was dispatched as envoy to Siem Reap (present-day Cambodia) in the first year of Yuanzhen (1295), wrote "*The Customs of Siem Reap*" and mentioned in its "General Preface" the needle path: "start from Wenzhou, follow the Dingwei direction, pass the ports of Fujian and Guangdong, Seven Islands Sea, and the Cochin Sea to Champa. The favorable wind of Champa can take you to Zhenpu in half a month, that is, the territory of Siem Reap. Start from Zhenpu along the Kunshen direction, pass the Kunlun Sea, and enter the port."

Based on this description, archaeologist Xia Nai plotted the restored chart of the needle path (as shown in Fig. 77). The ancients also painted nautical needle path maps. For example, in the Qing Dynasty, Zhou Huang took imperial orders and visited Ryukyu in the 21st year of Qianlong (1756), and wrote "*A Brief*

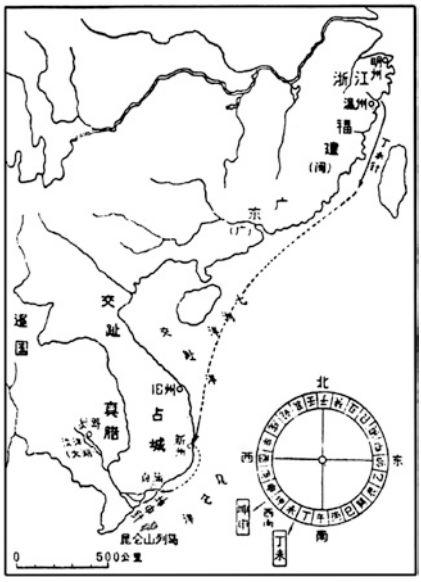


Fig. 77 The needle path from Fuzhou to Cambodia sketched by Xia Nai on the basis of "*The customs of Cambodia*"

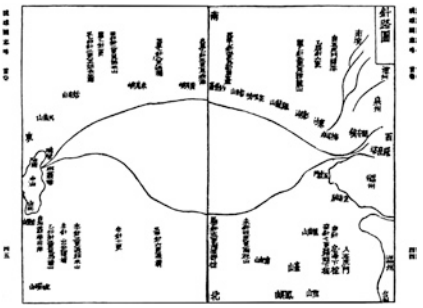


Fig. 78 The needle paths from Fuzhou to Ryukyu (*upper line*) and back (*lower line*)

Fig. 79 Zheng He's nautical chart (part) (The route from the State of Liushan (Maldive Islands) to State of Kezhi (now Kochi) and State of Guli (now Calicut) along the southwest coast of the Indian Peninsula. On the route, the islands, mountains, country names, temples, and pagodas are indicated, and "Astronomy Technology" degrees, as well as the geng's and needle paths to and fro. The latter from right to left reads: 50 geng's along the direction of the Yin is the State of Guli, and 25 geng's along the same direction is the State of Kezhi; 25 geng's along the Yimao direction is the State of Kezhi; 28 geng's along the direction of Jiamao is the State of Li, and 15 geng's along the Mao direction is the State of Guli; and 16 geng's along the direction of Mao is the State of Jiajialiu.) in "*Account of Military Arts and Science*" by Mao Yuanyi

History of Ryukyu." In the book, he painted the needle paths for the route from Fuzhou to Ryukyu and the return trip (as shown in Fig. 78). Next to the routes, mountains and islands, needle position, number of geng's were indicated. In the Yuan Dynasty, Mao Yuanyi (ca. 1570–1637) left an extremely valuable chart of needle path used by Zheng He during his voyages in the book "*Account of Military Arts and Science*" (as shown in Fig. 79).

Combination of compass and needle path made China one of the earliest countries to conduct ocean voyages. After serving in the Yuan Dynasty for 17 years, the Italian Marco Polo (1254–1324) returned home in 1292 on the ship escorting the Mongolian princess Cocachin to Persia. The fleet, including fourteen four-mast ships, and taking more than 600 people, set sail from the port of Quanzhou, Fujian, passed Sumatra, Java, Indian coasts and arrived in Persia. In the Yuan Dynasty, the folk navigator Wang Dayuan set off twice from Quanzhou between 1,330 and 1,339 and reached Southeast Asia, the Indian Ocean, the Arabian Peninsula, and even East Africa. In the early Ming Dynasty, Eunuch Grand Director Sanbao Zheng He made seven expeditions to the Western Ocean between 1,405 and 1,433, reaching as far as Kenya in Africa. The size of his ships, the scale of his fleet, the number of his crew, the vastness of waters sailed, the level of maritime technology, and commanding and management were all unrivaled in ocean voyages around the world back them.

4.6 Spread of the Compass to the West and Its Influences

In Europe or the Arab countries, when was the south-pointing needle or compass documented in literatures? Where were they from? This issue has been of concern to historians of science. Belgian-born American historian G. Sarton (1884–1956), in his famous book "*An Introduction to the History of Science,*" United Kingdom Dr. Joseph Needham in his monumental work "*History of Civilisation in China,*" and even American historian of science F. Cajori in "*History of Physics*" have all involved a large number of related documents and historical materials. Those documents and materials have proven that the Chinese were the earliest people to invent the south-pointing needle, compass, and to discover the magnetic declination.

According to verifiable documentation, the earliest people in Europe to address compass is the English Alexander Neckam (1157–1217). He said in the book "The Nature of Things" completed between 1190 and 1200 that the seafaring sailor "touches the needle with a magnet; the needle starts spinning, and when it stops, its tip points north." In 1205, the French Guyot de Provins said that the sailors "touches a needle with a magnet, fixes the needle to a straw, and floats the straw on the water, and the needle points north." Although there are similar descriptions between the two theories, the earliest account by Neckam is 100 years later than that by Shen Kuo in "Brush Talks From Dream Brook," which is not the earliest Chinese literature on the south-pointing needing and compass.

A significant progress in magnetism knowledge and compass in Europe was written in a letter by the French Petrus Peregrinus (or Perre de Maricourt) on August 12, 1269. Petrus Peregrinus knew the magnet polarity and that a strong magnetic body could inverse the polarity of a weaker one, and invented a compass with scale and a pivot needle. He was an engineer in the army of Louis IX, as well as one of the

few scholars engaged in experiments in the Middle Ages, but he was not yet aware of the magnetic declination. His compass was over 200 years later than that of the geomancer Wang Ji and Yang Weide, 170 years later than that of the nautical south-pointing needle or compass seen by Zhu Fu and his son Zhu Yu in Guangzhou, and even 70 years later than the dry compass (pivot compass) model resultant from the archaeological excavations of "Porcelain Figurine of Immortal Zhang."

Arab literatures on south-pointing needle or compass appeared later than their European counterparts. It is not until the thirteenth century that was south-pointing needle or compass mentioned in several documents. One literature is "*Collection of Anecdotes*" written by Muhammad al-Awfi in about 1,232 in Persian; it mentioned sailors rubbing fish-shaped iron sheet against a magnet. The other literature is "*Complete Gems*" written by Bailak al-Qabajagi in 1,282; the book dealt with the scene of a sailor using a water compass that he had seen with his own eyes, and the south-pointing needle was also a floating fish-shaped iron piece.

In view of above, some historians pointed out that the south-pointing needle or compass may have been introduced by land to Europe via Russia, and the earliest disseminators may have been interested in astronomy, geography, or magic. In the beginning of the thirteenth century, it spread by sea to Arabia. In the fifteenth century, the compass was used as a navigation instrument, to make it possible for the European adventurers, pirates and navigators to cross the oceans and reach Asia.

It should be noted in transportation history that Zheng He crossed the Indian Ocean and arrived in East Africa, and Bartolomeu Dias passed the Cape of Good Hope. Therefore, it can be said that half of traffic route between East and West has been opened up by the Chinese and half by the Europeans.

It should still be pointed out in the history of science that after the compass was introduced to Europe, the Europeans carried out improvements to make it better. A particularly important innovation is putting the compass into the gyro ring (also known as gimbals, i.e., "the censer to be used in bed" invented by the ancient Chinese). Such a compass is known as the "Cardan Ring." The Italian mathematician Jerome Cardan (or Jerome Cardano, or Hieronymus Cardanus, 1501–1576) did not claim the rights of this invention. The gimbals were not originally intended for the compass, but for the carriage seats, to ease the discomfort resultant from bumpy roads when he saw a Tibetan "lamp" (the lamp fitted within the incense burner to be used in bed). Both the compass and the censer to be used in bed (as shown in Figs. 80 and 81, respectively) were invented by the Chinese. Unfortunately, the Chinese people seemed never to have thought of putting those two inventions together.

The compass mounted in the gyro ring (as shown in Fig. 82) is free from impacts of wind and waves in navigation, and this is the biggest advantage of the modern compass. In the early stages of space exploration, in 1910s, the liquid compass was mounted on the gyro ring, as an important instrument of aerospace. Aside from use in determining the direction of flight, the compass was also used to determine the flight altitude by using the magnetic inclination of its needle.

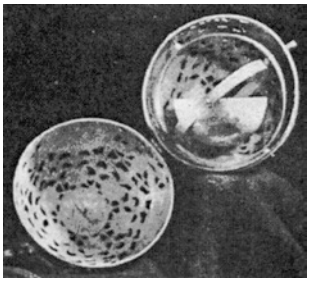


Fig. 80 Tang Dynasty silver censing balls unearthed in Shapo village, Southern Suburbs of Xi'an

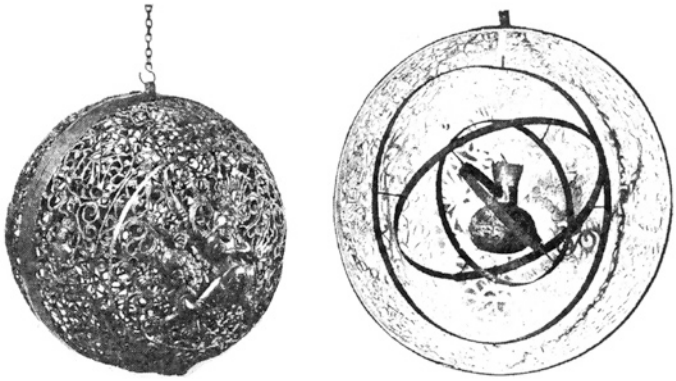
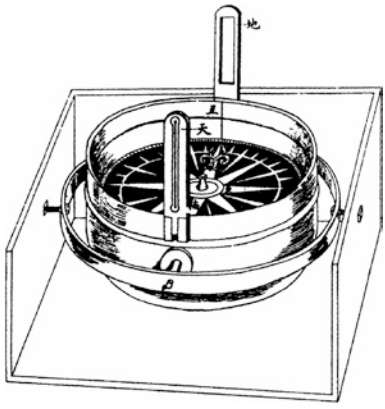


Fig. 81 The shell and internal structure of copper lamp ball in Tibet in the Qing Dynasty

Fig. 82 Nautical compass in Europe in the nineteenth century



The application of compass in horizons, mappers, and other instruments makes it an important instrument of modern science. The initial orientation board and needle has become the ancestors of instruments and meters designed for modern industrial technology and scientific tests.

Author Biography

Jialu Fan was born in February 1964, a native of Jinzhai, Anhui Province; he awarded PhD in history of science and technology; he is vice-president of Huangshan University; part-time professor of University of Science and Technology of China; guest researcher of the Institute for the History of Natural Sciences, Chinese Academy of Science; and member of the National expert panel for protection of intangible cultural heritages under the Ministry of Culture. Fan Jialu's research fields are field investigation of traditional workmanships, and theories for protecting intangible cultural heritages; and his monographs include *Complete Traditional Workmanships in China—Paper Making* and *Chinese Handicraft—The Scholar's Four Jewels*.

Qi Han born in 1963, graduated in 1988 from University of Science and Technology of China, and awarded PhD of Science in 1991 from the Institute for the History of Natural Sciences, Chinese Academy of Science; he was named as research fellow in 1999; he was a former director of Research Office for Modern and Contemporary Chinese and World History of Science, currently as member of the academic committee of the Institute for the History of Natural Sciences, Chinese Academy of Science; he was a PhD candidate supervisor, professor of archaeology in Department for the History of Science and Scientific Archaeology and also a part-time professor of the History Department of Zhejiang University, member of the Academic Committee of the Christian Research Center of the Chinese Academy of Social Sciences; member of Academic Committee of Religion and Chinese Society Research Center of Chung Chi College of the Chinese University of Hong Kong; member of the Academic Committee of the Ricci Institute for the History of Chinese and Western Cultures, University of San Francisco. Qi Han was a Vice Chairman of International Society for the History of East Asian Science, Technology, and Medicine (1999–2002), vice chairman of the Chinese Society for the History of Mathematics (2002–2006), editorial board member of the History of Natural Science, the editorial board member of the History of Science and Technology of China, the editorial board member of the French Sinology, specially invited editorial board member of "Jinan Historians," and invited to visit the USA, Japan, France, Britain, Germany, Portugal, Italy, and other countries. From 1999 to 2000, he was a member of Institute for Advanced Study in Princeton; USA published over 60 papers (in Chinese, English, French, Japanese); he won the Outstanding Paper Prize of Liqing Award for Young

Scholars of History of Science in China, in 1998; in 1999, the first prize in Elephant Award for Outstanding Papers in "Scientific and Technological History" from 1999 to 2001, he awarded project support by the National Natural Science Foundation of "Chinese Astronomy in Europe." He was the winner of the 12th Session of Academic Research Scholarship from the Cultural Affairs Bureau of the Macao Special Administrative Region Government (2004–2005). He was the host of Science and Technology Records in the Institution Panel of National "History of the Qing Dynasty" Compilation Project (2005–2009).

Zhaochun Wang Researcher at the Academy of Military Sciences. With native of Gaoyou, Jiangsu Province, he was born in Shanghai in 1937. In July 1963, he graduated as a major of Nuclear Physics from Department of Physics, Nanjing University. From 1963 to 1973, he engaged in defense-related research, and participated in the projects of "the two bombs and one satellite." Since 1974, he engaged in research into Chinese firearms history, Chinese military technology history, Ming Dynasty military history at the Academy of Military Sciences; he published 13 monographs including "*Chinese Firearms History,*" "*World Firearms History,*" "*History of Chinese Science • Military Technology Volume*" "*History of Ancient Chinese Military Engineering* (*Song, Yuan, Ming and Qing*)," "*General History of Chinese Military Technology,*" "*Introduction of Gunpowder and Firearms to the West and Its Historical Influence,*" "*Ancient Weapons in China,*" "*A Glimpse of Ancient Chinese Books on the Art of War*" and "*Ancient Chinese Books on the Art of War*" (an updated version), "*Generations of Famous Generals in China.*" Being as a Co-author of "*The History of Modern Warfare,*" "*General History of Chinese Military • Military History of the Ming Dynasty* (*Book 1*)," and five in all. In addition, he also participated in the preparation of more than 10 of "*biographies*" such as books and over 10 dictionaries. He submitted over 60 entries for "*Encyclopedia of China • the Military Volume*" and "*Chinese Military Encyclopedia,*" including "ancient weapons." Published more than 40 papers, he granted special allowance certificate in 1992 by the State Council. He was hired in 2007 by the Chinese Academy of Sciences as the consultant of Terminology Committee for Ancient Chinese History of Science and Technology. He was selected to the roster of the Academy of Military Sciences (military history expert) in April 2008 and earned twice Merit Citation Class III.

Nianzu Dai a native of Changting, Fujian Province he graduated from Department of Physics, Xiamen University, in 1964. He has since been engaged in the study of the history of science at the Institute for the History of Natural Science, Chinese Academy of Sciences and he is one of the founders of the discipline of the history of physics. He was named the advanced worker of the Chinese Academy of Sciences in 1978, made researcher in 1990, entitled to special government allowances since 1992. He was awarded the title of Young and Middle-aged Expert with Outstanding Contributions in 1996. He is an incumbent chair Professor of Capital Normal University. He published more than 100 papers on the history of physics. The major works include the "*History of Mechanics in China,*" "*History of Acoustics in China*", "*History of Optical Study in China,*" "*History of Electricity and Magnetic Studies in China,*" "*History of Physics in China*", "*Zhu Zaiyu–the Star of Science and Art in the Ming Dynasty,*" "Zhu Zaiyu the Immortal Royal Descendant," "*Cultural Relics and Physics,*" and "*Records of Physics and Mechanics*"; editor of the "*Collected Papers in Physics in China During the First Half of the 20th Century,*" co-author of Essentials of Physics (via cooperation with Professor Lin Qingliang of National Taiwan University), proceedings of "*Physics under Close Scrutiny*" (edited by Wang Shiping, LI Yanping, etc.).

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