On the origin of movable metal-type technique

PAN Jixing

Institute for History of Science, Chinese Academy of Sciences, Beijing 100010, China

Abstract China is the birthplace of woodblock, copperplate and non-metal-type printing, movable metal-type technique, as the product of combination of copperplate and non-metal-type technique, also originated in China. However, the problem on the origin of metal-type has not well been solved for a long time. This paper proved that metal-type was cast and used for paper money printing in China since the early 12th century, copper-type and tin-type technique was further developed during the 13th to 14th centuries, on the basis of investigation of excavated findings, textual research and scientific judgment. Finally a comparative research of the early metal-type technique in China, Korea and Europe was briefly discussed. A lot of unearthed material evidence were provided here.

Keywords: China, origin, copperplate, copper-type, tin-type, Song-Jin, Yuan-Ming.

1 Early copperplate printing and the origin of metal-type printing

Traditional printing mainly includes woodblock printing and movable type printing, according to the historical records and archaeological discoveries, woodblock printing was in the practical stage in China between the 6th and the 7th centuries[1]. Copperplate printing began in China from the 9th century. Movable type printing was invented by Bi Sheng (fl. 990—1051) during 1041—1048. His experiment began with wooden-type, but was successful with earthenware type.

The invention of movable type printing was an important milestone in the history of printing. After Bi Sheng's technique spread up in the society, it arouse countrymen to make type with different materials, as a result, earthenware type, wooden-type and metal-type appeared in China. The appearance of metal-type was an inevitable tendency of the development of copperplate and non-metal-type printing. Metal-type can be regarded as a copperplate which has only one character. So long as copperplate containing many characters or images could be cast, it was very easy to cast an indivitual metal-type used for printing.

Copperplate printing in China can trace its origin back to the Tang Dynasty (618—907). The extant earliest specimen is 108 Buddha image plate (14.8 cm × 11.5 cm) which was cast in the year 834[2]. From the 10th century copperplate printing was widely used in the economical field with the development of commodity economy. A copperplate for advertisment of the needle shop of

family Liu in Ji'nan in the Northern Song (960—1126), is kept in the Historical Museum of China. Apart from the trade mark of a white rabbit, 44 characters were cast on the plate.

China is the country which first issued paper money in the world, and copperplate printing was used for large-scale paper money printing since the Song. According to the record of chap. 181 of the *Song shi* 《宋史》("History of the Song Dynasty", 1345), in 1023 the local authorities established a special office to issue the earliest paper money called *jiaozi* (交子). In 1107, the Song government issued a new kind of paper currency called *qian-yin* (錢引). The Southern Song (1127—1279) issued the *guanzi* (關子) and *huizi* (會子) as its legal currency. The Jin (金) (1115—1234) coexisting with the Northern Song modelled the financial system of the Northern Song to issue paper money called *jiaochao* (交鈔) from 1154.

Paper currency was printed with copperplate which usually contained the name of money, nominal value, areas of circulation, organizations of issuance, date of printing, notice of prohibition of counterfeit and decorative patterns, all of these were cast on the plate beforehand. But in order to prevent from the appearance of counterfeit other measures were also taken. Apart from affixing official seals, some secret numbers were printed on every sheet of paper money, and the signatures of officials from issuance organizations were also included. Such parts were not cast simultaneously with other parts mentioned above, but some hollow blanks were retained on the plate, which were then filled in with movable copper-type to form a complete plate for final printing. Therefore, paper money was a special product of combination of copperplate printing and movable metal-type printing, and copper-type was applied on a large-scale with the issuance of paper money in China for more than 600 years.

Xu Ziyin (徐子隱) (fl. 1792—1857) collected a copperplate for 5 *guan* (貫) (5 strings of 1 000 cash or 5 000 cash) of the *Zhenyou baoquan* (貞祐寶券) (paper currency circulated during the reign of Zhenyou, 1215—1216, in the Jin Dynasty). On the plate there are two sets of special numbers called *ziliao* (字料) and *zihao* (字號). Over the *ziliao* a copper-type with a smaller character *you* (囿) was placed (fig. 1). Such *liaohao* were taken from characters in the *Qian-zi-wen* 《千字文》("Thousand Characters Classic") written by Zhou Xingsi (周興嗣) (c. 470—521) in about 515. On the same plate there are nine signatures, and at least six among them were placed with metal-types. This currency was issued during 1215—1216[3].

Figures 1 and 2 are the same plate for 5 *guan* of the Jin currency cast and circulated during 1215—1216, but kept in different places. Fig. 2 reflects the original situation, namely, over the *ziliao* and *zihao* two square hollow blanks were reserved on the plate in order to put in with two pieces of metal-types before printing. Only one signature was cast out with other content. But on fig. 1 at least eight signatures were put in with types. From another plate for ten *guan* of the *jiaochao* currency circulated in the Jin six dark hollow blanks can be found, into which six types should be placed for expressing the *ziliao*, *zihao* and signatures. This plate is kept in the Museum of the Inner Mongolia Autonomous Region. The paper currency of the Jin was first issued from 1154, this means that in the year 1154 movable copper-type had already been used for paper money printing in the Jin Dynasty.



Fig. 1. Copparplate for 5 *guan* (5 000 cash) of the *Zhenyou baoquan* (paper currency circulated during the reign of Zhenyou, 1215—1216, in the Jin Dynasty). A copper-type with a character *you* (貐) was placed on it (from Wei Yuewang).



Fig. 2. Copperplate for 5 *guan* (5 000 cash) of the *Zhenyou baoquan* (paper currency circulated during the reign of Zhenyou (1215—1216, in the Jin Dynasty). There are 2 hollow blanks for filling in with movable copper type on the plate (Shanghai City Museum).

The use of movable copper-type for paper money printing in the Northern Song should be earlier than the Jin. But such kind of plate was not kept to the present time, only few plates cast in the Southern Song are available. For example, on the plate kept by the Historical Museum of China three types with the characters *yi* (壹), *bai* (佰) and *shi* (拾) were placed, which means one of the given numbers. This plate for 1 *guan wensheng* (壹貫文省) (1 000 cash) of the *huizi* was cast during 1161—1168 in Hangzhou. Of course, before this on all currency issued by the Song government should be printed with some movable copper-types to express the numbers. This means that movable metal-type technique originated in China in the early 12th century, and during the 12th to 13th centuries it was widely applied to paper currency printing. Early metal-type in China was copper-type, which should be cast with copper alloy.

2 Copper-type and copperplate printing during the 13th to the 14th centuries

Copper-type and copperplate printing in the Yuan Dynasty (1260—1368) was further devel-

oped. When the Mongol ruler Kublai (r. 1260—1294) ascended the throne in 1260, he decided to issue the *Zhongtong yuanbao jiaochao* (中統元寶交鈔) (paper currency issued during the reign of Zhongtong, 1260—1263) in the same year, which was then used until the end of the Yuan. From 1287 Kublai issued again the *Zhiyuan tongxin baochao* (至元通行寶鈔) (paper currency issued during the reign of Zhiyuan, 1264—1294).

In 1907—1908, a sheet of the *Zhongtong yuanbao jiaochao* of 1 *guan* was excavated in Kharahoto (now Ejin Banner, Inner Mongolia), and now it is kept in the Ermitazh Museum in Sankt Petersburg, Russia. From its surface (33.2 cm × 25.5 cm) two smaller characters *tao* (陶) and *tang* (唐) were printed with copper-types for expressing the *ziliao* and *zihao* of the paper currency (fig. 3). It was printed during the reign of Zhizheng (至正) (1341—1367) of the Emperor Huizong (惠宗).

In the early 20th century some seals cast of copper were excavated in Xinjiang. Cai Meibiao, an expert in the history of Mongolia, told us that such seals were used by the Mongols and Uygurs as their signatures in the 13th to 14th centuries. Each seal usually contains one Basiba (八思巴) Mongolic word or one Chinese character to express the related family name, or sometimes the Mongolic word and the Chinese character were put together on one seal[4]. In fact, such kind of copper seal is a piece of movable copper-type, only it was edged around. Mr. Cai thinks that the unearthed copper "seals" could be used for printing if enough amounts would be available.

There was also textual record concerning copper-type printing in the Yuan. For example, Huang Jin (黃溍) (1277—1357) wrote that the Emperor Renzong (仁宗) (r. 1311—1320) usually visited the temple Yanshousi (延壽寺) in Peking and met its abbot the monk Zhiyan (智延), sent him some Buddhist sutras and images. The Emperor Yingzong (英宗) (r. 1321—1323) also respected Zhiyan and discussed with him about the problems of the Buddhist affaires, then "the emperor ordered him to collate the *Tripitaka* with other eminent monks in the temple Yongfusi (永福寺) in order to print it with copper-type to hand it down to later generations. Later (1323), during copying the collated *Tripitaka* with golden powder, many mistakes were found, so the emperor ordered them to collate it once again"[5]. This means that during 1320—1323 the Mongol emperor even wanted to publish a new edition of the *Tripitaka* with copper-type.

As to the original of Huang Jin, "*jiang lou tong wei ban yi chuan*" (將鏤銅為板以傳) means "engrave characters on copper material for making printing plates in order to hand it down to later generations." However, it was impossible to print such large-scale Buddhist series with copperplates, and there was only possibility that the *Tripitaka* would be printed with copper-type. In fact, the Emperor Yingzong had granted the temple Yongfu-si a lot of money for printing the *Tripitaka* with copper-type, and ordered the prime minister Baizhu (拜住) (1298—1323) to take charge of this matter in 1323. Everything was ready, but in fall of this year the Emperor Yingzong and the prime minister Baizhu both were killed in a coup d'état launched by the censor Tieshi (鐵失). So the work was suddenly stopped.

The Ming (1368—1644) government issued the *Daming tongxing baochao* (大明通行寶鈔) (paper currency circulated in the Great Ming Empire) from 1375. A printing plate for 1



Fig. 3. 1 *Guan wensheng* (1 000 cash) of *Zhongtong yuanbao jiaochao* (paper currency issued during the reign of Zhongtong, 1260—1263, in the Yuan Dynasty). Copper-types on the currency can be found. Ermitazh Museum in St. Petersburg.

guan of the Ming currency was unearthed in Nanking. The copperplate (32 cm × 20.8 cm, thickness 1.0 cm) is similar to the *baochao* of the Yuan in its design. On its back five copper-types with five characters *quan-zi* (泉字), *san-shi-hao* (參拾號) were placed, which represent the special numbers called so-and-so *zi* (字) (character) and so-and-so *hao* (號) (number), like those on the Song-Jin paper money, but were removed from the front to the back (figure 4).

The Historical Museum of China collects a clay mould plate for 50 *wen* (文) (50 cash) of the *baochao* currency in the Ming. The mould with characters in intaglio was made of pottery clay, should be used for casting copperplate. This must have embodied the traditional method of Chinese metalplate and metal-type casting. Pottery clay was first made into two pieces of casting

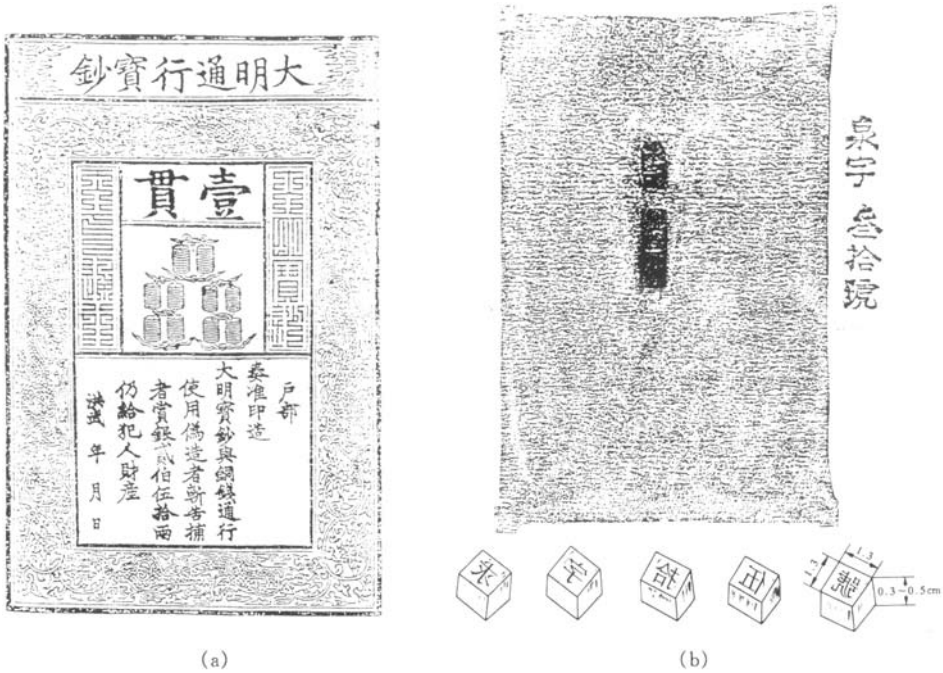


Fig. 4. (a) Copperplate for 1 *guan* of the *Daming tongxing baochao* (paper currency circulated in the Great Ming Empire), cast in Nanking during 1376—1395 (Guizhou City Museum). (b) The back of the plate, 5 copper-types were placed.

blanks, on one of which characters were stamped in intaglio, after burning in a kiln they became a set of casting moulds. Two pieces of casting moulds were put together and fastened on, through the joint molten metal was poured to make metalplate or metal-type. There must have been a master model made of metal or wood, on which characters were cut in relief, then stamped it into pottery clay to make casting blank in intaglio. This method was just similar to that of coin casting in ancient China.

3 Tinplate and tin-type printing during the 12th to 13th centuries

Tinplate and tin-type techniques were also used for printing during the 12th to 13th centuries. Jin Bodong reported that a piece of tinplate (27.5 cm × 16.5 cm, thickness 0.65 cm) was unearthed in Hangzhou in 1957[6]. It was made of tin alloy, rectangular in shape, there are characters on its both sides. On its one side the text is a kind of *dharani*, the so-called *Satisfactory Dharani* consisting of 49 characters. On the plate there are two characters Hu Yan 胡彦 in intaglio, this is the name of a craftsman who made the plate and worked during the reign of Emperor Xiaozong (孝宗) (r. 1163—1189) in the Southern Song. An inscription for making a vow by Wu Zhang (武章) and Tang Shiwuniang (唐十五娘) (a woman) says that this plate was cast in the year of *bingwu* (丙午), the 13th year (1186) of the reign of Chunxi (淳熙) (figure 5).

Copper alloy is hard and durable, but more expensive; tin alloy is cheap and easy to be smolten, but cannot compare with copper alloy in quality. Copper or tin alloy, each having its

strong points, was used for printing by the Song people from the 12th century. All metallic materials are not easy to absorb prepared Chinese ink used for woodblock printing, so improved ink must have been made by adding more animal glue content. It might be better that carbon black from pine-soot and animal glue would be mixed in the medium of vegetable oil.

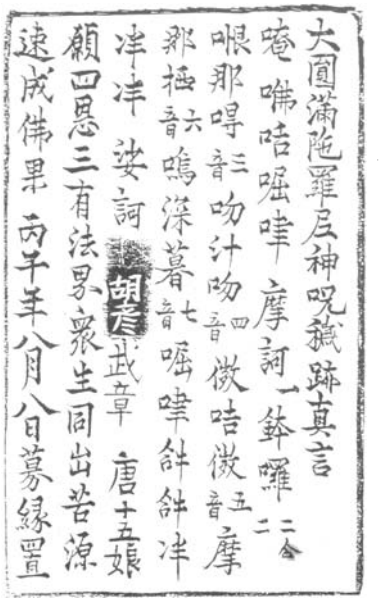


Fig. 5. Tinplate for printing the dharani charm, cast by Hu Yan in 1186, unearthed in Hangzhou in 1957 (Zhejiang Provincial Museum).

Now that the Song people could print Buddhist sutras with tinplate, they could, of course, print other works with tin-type, as the scientist of the early Yuan Wang Zhen (王禎) (fl. 1260—1330) wrote in his paper *Zao huozi yinshu fa* 《造活字印書法》 ("Method of Printing Books with Movable Type"). This paper was written in 1298, and then collected as an appendix in his *Nong shu* 《農書》 ("Treatise on Agriculture") published in 1313. Wang summerized his experiment on wooden-type printing in his paper, but before talking about his test, he first described the short history of printing in China from the 10th century up to his time, the late 13th century, from woodblock printing, earthenware type printing to metal-type printing. He wrote: books were published in the Five Dynasties (the 10th century) with wood-block, but this took more time and labour. "Somebodies utilized their technical skills to plant earthenware type made of clay by burning into the columns on the plate and finally made the printing plate with movable type." Here, "somebodies" refer to Bi Sheng and others who developed earthenware type to replace woodblock.

After this, Wang Zhen said: "In the modern time, movable type had been made of tin by casting. They were strung together with an iron wire and thus made fast in every column on the plate, in order to print books with them. Both sides of every column of types were separated and fastened by two pieces of thin splints. But the above-mentioned type could not take ink readily, and paper was often broken by hard press. So they could not have been popular long. In the present time, there is also an ingenious method … a block is engraved with characters, it is then cut into squares with a small fine saw till each character forms a separate piece …. Then types are placed in the columns and bamboo strips which have been prepared are pressed in between them"[7].

When Wang described the history of printing in China, he enumerated four stages of development. Here the "modern time" cannot be understood as the early Yuan, because Wang called it *jin* (今) or the present time. The "modern time" referred to the former dynasty of the Yuan, namely, the Southern Song. Therefore, tin-type was used for book printing in China during the 12th to 13th centuries, its raw material should be tin alloy.

Tin-type and copper-type for book printing were cast in the shape of long cube. In its body a small hole was left in order to string it together with an iron wire on the plate to fasten it. Other

spaces on the plate were filled in with wooden wedges. It is obvious that metal-type for book printing was a little different from that for paper money printing. The height of the latter was about 0.3—0.5 cm, and there was no small hole in its body. As mentioned above, copperplate and metal-type were successfully used for paper money and book printing in the Song and Jin. This shows that the problem of ink absorption had long been solved. So Wang Zhen was incorrect to say that metal-type printing "could not have been popular long".

4 Comparison of early metal-type in China, Korea and Europe

China developed woodblock printing and non-metal-type printing earlier than Korea by several centuries. It is obvious that Korea cast metal-type later than China. The extant earliest typographical edition in Korea is the *Puljo chikchi simch'ye yojŏl* 《佛祖直指心體要節》("Traités édifiantes des patriaches bouddhiques") printed by the temple Hungdŏk-sa (興德寺), Ch'ongju (清州), in 1377. This means that metal-type appeared in Korea at the end of the Koryo Dynasty (936—1392), from the 14th century. In fact, the large-scale typography started from the Yi Dynasty (1392—1910) since the early 15th century. The comparative study proved that the early Korean typography used the experience of China for reference in the following aspects: (ⅰ) the thought of Chinese type printing; (ⅱ) the coin and type casting technique introduced from China; (ⅲ) the method of type setting used in China[8].

This was the consequence of Sino-Korean close contacts and the technical exchange. During the 13th to 14th centuries Koryo was controlled by Mongol rulers of the Yuan, and the paper currency issued in China was also circulated throughout the Korean Peninsula from 1287. Metal-type technique could be introduced to Koryo through the circulation of the Chinese paper currency. At the same time, exchange visits of the peoples from both sides were very frequent, visitors could also be the medium of transmission of the technical information.

However, some Korean scholars put forward that metal-type was invented in Korea before China. One of their arguments is a piece of bronze, on which a character *fu* or *pok* (複) was cast. It was purchased from a Japanese curio-dealer Akahoshi Sashichi (赤星佐七) in 1913. It was said to be excavated from a tomb of a certain king of Koryo, thus was thought to be "the extant earliest metal-type in the world"[9]. To the saying from the curio-dealer one must give a discount and cannot totally believe what he said is true. Although its chemical composition is identical with that of coins cast from 1102 in Koryo, but this cannot prove that they were cast at the same date. Because some bronze mirrors made in the Han and Tang or coins cast in the Tang and Song have the same chemical composition, but their dates differ from each other by more than 900 or 300 years[10, 11].

The calligraphy of the character *fu* or *pok* is regular script. But if one compares such an isolative character with those appeared in early or later editions, he can obtain different conclusions on its date. The fact that Korean scholars date it from 1102 to 1232, and the upper limit and lower limit differ by 130 years, also explained this point. So it is difficult to date it only according to its chemical composition and the style of calligraphy. The most important is that the

size of its length and width is not uniform, its shape is not regular, the side angles are not of 90°, its backside was gouged out[12] (fig. 6). In short, it does not have any shape characteristics of a real metal-type, and is quite different from other extant ancient Korean metal-types. It cannot be regarded as an argument of early metal-type. The dates of the origin of metal-type in Korea suggested in other historical documents were all later than China by more than 100 years.

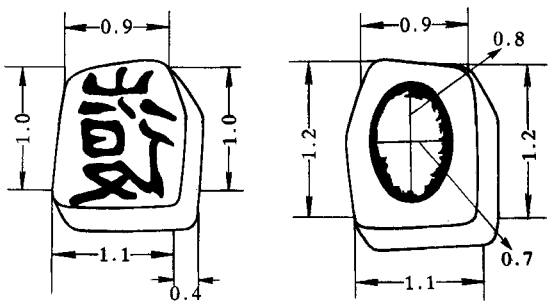


Fig. 6. An irregular cube cast of bronze and the size (in cm) of its different parts. There is a character *fu* or *pok* (福) on its front side, no date. National Central Museum. Seoul. From Chon Hye-Bong's book.

During the 13th to the 14th centuries the western expedition by the Mongol army opened up once blocked the Sino-European communication, and made some Chinese inventions to be transmitted westward in clusters. Woodblock printing was introduced to Europe from China in the Yuan Dynasty. However, Europeans soon found that block printing was not suitable to their alphabetic writing, thus Chinese movable type printing found favour in their eyes. The use of wooden-type for ancient Uygur language provided a model for transition from type with Chinese character into type with alphabetic writing. Xinjiang was just the place through which Europeans usually went to and fro between China and Europe along the silk road, which was more safe and busy than any other time before.

During this time many Europeans visited China and they could transmit the knowledge of movable type to Bohemia, Italy and Germany. The movable type technique started in Europe with wooden-type, and the method of its making and printing was identical with that of China. During 1420—1440, the Italian Pamfilo Castaldi (1398—1490) and the Dutch Laurens Janszoon called Coster (fl. 1395—1465), printed some books with wooden-type. But they met difficulty when they tried to make wooden-type of small size for printing, so someones modelled the Chinese way to cast metal-type using the technical information they got from travelers who visited China. According to Professor Wolfgang von Strömer's research[13], a German goldsmith Prokop Waldfoghel grasped a special technique called "an art for writing artificially" (*ars scribendi artificialiter*) by casting metal into Latin letters during 1430—1440s.

Waldfoghel originally settled in Prague, the capital of Bohemia under the dominion of the German emperor Charles Ⅳ von Luxemberg (r. 1347—1378) who was fond of Eastern trade. He then migrated to Avignon, the seat of the Pope and an important center of book copying and book selling. Here he taught his secret art to others. As to Johann Gutenberg (1400—1468), he was engaging in mirror making in cooperation with Andreas Dritzehn, Hans Riffe and Andreas Heilmann during 1434—1444 in Strasbourg. But he suddenly changed his profession and turned to do secret experiment concerning "something to do with printing" (*das zu den Drucken gehoret*). This must have been kindled by some kind of external factor. Gutenberg perhaps heard of something done by Prokop Waldfoghel, but his experiment in Strasbourg was not successful. During

1444—1448 Gutenberg left Strasbourg and went on a journey in the Netherlands, Basel or Venice[14]. In 1448 he returned to Mainz. The journey widened the field of his vision, and he got the suitable method to solve the problem of printing.

From 1450 Gutenberg printed the *Ars Grammatica* and other works with metal-type. The famous 42 *Line Bible* was published in Mainz in 1455, this marked the greatest achievement in his life. Since then typography was soon spread throughout Europe and became the main way of printing in the West. As the contemporary German and French experts said, during the 13th to 14th centuries some travelers who made their ways along the silk road spread the information to Europe by mouth, and at last through many hands or places to Strasbourg or Mainz. So it is difficult to imagine that Gutenberg had never heard about this way of printing texts[15, 16].

The comparative research also proved that European metal-type was identical with the Chinese one in its shape, and the method of type casting was the same in principle[8]. But Gutenberg, as the founder of metal-type technique in Europe, had also improved existing metal-type technique in the East in the aspects of type material selection, mode of impression and the use of oil-based ink. Among them, the creation of the Gutenberg press should be considered as an invention. The Korean people made their invention too, such as iron-type casting. The history of printing told us that although the metal-type technique originated in China, the peoples of all other countries and areas also made their own contributions to its further development (table 1, figure 7).

Table 1 Comparison of starting date of metal-type in China, Korea and Europe

Place	Time	Item				
		papermaking	woodblock	copperplate	wooden-type	metal-type
China	starting date (century)	−2	6	9	11	12
Korea	starting date (century)	4—5	11		14	14
	time difference with China (century)	6—7	5		3	2
Europe	starting date (century)	12	14—15	15	15	15
	time difference with China (century)	10	7—9	6	4	3

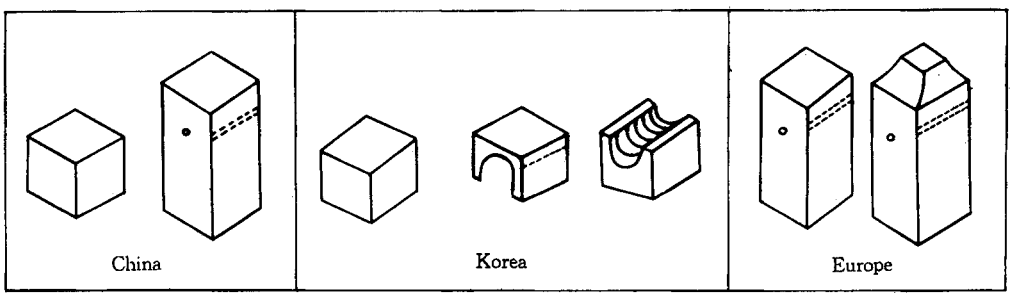


Fig. 7. Comparison of the shape of early metal-type in China, Korea and Europe.

5 Conclusions

1) Copper-type appeared in China in the early 12th century, it was widely used for paper money printing after combining with copperplate. Besides paper money printing, copper-type was also used for book printing during the 12th to 14th centuries.

2) Tinplate printing has been used since the 12th century in China. Tin-type and copper-type used for book printing during the 12th to 13th centuries were cast in the shape of long cube. In its body there was a small hole through which an iron wire was pierced to keep set types in line on the plate for printing, therefore, it was different from that for paper money printing.

3) The casting method of metalplate and metal-type in China was similar to that of coin casting. A master model was first made of wood or metal, on which the related characters or one character was cut in relief. Then the master model was stamped into pottery clay to make casting mould in intaglio. After burning in a kiln, two pieces of casting moulds were put together and fastened on, through the joint molten metal was poured to make metalplate or metal-type.

4) Special ink for metal-type was made of carbon black by adding more animal glue content, or carbon black from pine-soot and animal glue were mixed in the medium of vegetable oil. Such kind of improved ink was suitable to copperplate and metal-type printing.

5) Chinese metal-type technique was first transmitted to Korea in the 14th century, and it was introduced to Europe by travelers who went to and fro between China and Europe along the silk road in the late 14th century. This special topic should be dicussed in detail in another case[17].

Acknowledgement This work was supported by the President Foundation of the Chinese Academy of Sciences. The author would like to express his cordial thanks to Profs. Lu Yongxiang and Xu Zhihong for their powerful support.

References

1 Pan Jixing, On the origin of printing in the light of new archaeological discoveries, *Chinese Science Bulletin*, Beijing, 1997, 42(12): 976.

2 Gao Ciruo, Introduction on some Buddhist images cast of bronze collected in Baoji City Museum, *Kaogu yu wenwu or Archaeology and Cultural Relics* (in Chinese), Xi'an, 1986(5): 71.

3 Wei Yuewang, Qiao Xiaojin, Yao Suoming *et al.*, *A Compilation of Pictures of Chinese Ancient Paper Money*, Beijing: China Finance Publishing House, 1992, 26—27.

4 Cai Meibiao, On the origin of copper-type printing, *Guangming Daily* (in Chinese), Beijing, 9 Jan., 1954.

5 Huang Jin, *Jinhua Huang xiansheng wenji* or *Collected Essays of Mr. Huang of Jinhua*, ch. 41, Shanghai: Commerial Press, 1929.

6 Jin Bodong, The extant earliest tinplate, *Tongfang bowu* or Oriental Antiquities (in Chinese), Hangzhou, 1996(1): 157.

7 Wang Zhen, *Nong shu* (*Treatise on Agriculture*), Shanghai: Shanghai Chinese Classics Publishing House, 1994, 760.

8 Pan Jixing, A comparative research of early movable metal-type printing technique in China, Korea and Europe, Speech at the International Symposium on Printing History in the East and West (Seoul, Korea, 30 Sept., 1997).

9 Sohn Pow-key, *Early Korean Typography*, Seoul: Po-chin-cai Co. Ltd., 1982, 129—133.

10 Zhou Shimin, A study in the composition of the *liuji* 六齊 ("6 kinds of alloys") in the *Kaogong Ji* 《考工記》 or the Artificers' Records, *Huaxue tongbao* or *Chemistry Monthly* (in Chinese), 1978(3): 54.

11 Wang Jin, Zhang Hongzhao, Liang Jin *et al.*, *Metallic Chemistry and Alchemy in Ancient China* (in Chinese), Shanghai: Science and Technology Press, 1957, 88—89.

12 Chon Hye-bong, *Hangŭk sejihak* (in Korean) or *Bibliographical Research on Korean Literatures*, Seoul: Min-eoun-sa (People's Voice Press), 1997, 264—267.

13 von Strömer, Wolfgang, Hans Friedel von Seckingen, der Bankier der Strassburger Gutenberg Geselschaften, *Gutenberg Jahrbuch*, Mainz, 1983, 45—48.

14 Martin, Henri-Jean, *The History and Power of Writing* (tr. Lydia Cochrane), Chicago: University of Chicago Press, 1994, 217—219.

15 Martin, Henri-Jean, The development, spread and impact of printing from movable type in the 15th and 16th century Europe, Speech at the Internatinonal Symposium on the Printing History in the East and West (Seoul, Korea, 29 Sept., 1997).

16 Hanebutt-Benz, Eva, Features of Gutenberg printing process, Speech at the International Forum on the Printing Culture (Ch'ongju, Korea, 2 Oct., 1997).

17 Pan Jixing, From Khanbaliq to Mainz, *China Historical Materials of Science and Technology* (in Chinese), 1998, 19(3): 62.

(*Received May* 29, 1998)