

Study of Great Chinese Inventions Based on the Concept of Cultural Consciousness

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Abstract: Based on the concept of cultural consciousness, this paper clarifies the misunderstanding of the “Four Great Inventions”, then defines the concept of inventions and corresponding grading and rating systems. Numerous senior historians of science and technology were invited to review the great Chinese inventions before the book *The Thirty Great Chinese Inventions* was finally compiled and published. This paper also points out that the Chinese themselves must clearly understand things concerning China and China must have a say over the issue of inventions. The scientific spirit of deriving truth from facts must be rigorously upheld during the study and rating of great inventions.

Keywords: great Chinese invention; cultural consciousness; scientific spirit

How inventions, especially the great ones, have shaped human history has always been a wide concern that sparks clarification. The Four Great Chinese Inventions—papermaking, gunpowder, printing and the compass—have been fairly well known throughout China since the 1920s and are presumed to be the most important and top-ranking of all Chinese inventions. Backed by long-standing recognition, the concept of the Four Great Chinese Inventions seems to stand firm on its post as a self-evident axiom. Some scholars even pose the concept of the “Fifth Greatest Chinese Invention”, which falls among iron smelting, tiller fermentation and hybrid rice. This paper is to clarify the misunderstanding of inventions by following such steps as: first defining the grading and rating system of inventions;

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then reviewing and sequencing the great Chinese inventions; last introducing the invention incentives and further stating their positive influence on human civilizations.

1. The exact great inventions in ancient China

The Four Great Chinese Inventions are papermaking, gunpowder, printing and the compass. Although commonly known, popularity doesn't mean quality of understanding. It was in 1550 that Jerome Candan, an Italian mathematician first proposed that the compass, printing and gunpowder were the three great Chinese inventions. Later, Jean Bobin echoed the idea, holding that "They were incomparable throughout the whole of ancient

history" (Cang, 1998, p.267). In 1620, Francis Bacon, in his book *Novum Organum*, further posed that the three Chinese inventions radically altered the look and the course of the world and caused countless changes so significant that no empire, church or assembly of powerful individuals could equal them in shaping the course of human progress. In one volume of his reading notes known as the *Application of Machines, Natural Forces and Science* in Chinese, Karl Marx (1979) again pointed out that "Gunpowder, compass and printing heralded the upcoming of the bourgeois society. Gunpowder first smashed chivalry. It was then followed by the compass, opening the world markets and leading to colonization, and printing, as a Protestant tool, which in general turned out to be a method of scientific rejuvenation and a most significant lever



in creating prerequisites for spiritual development” (p. 427). During this time the origin of papermaking was yet to be decided, hence the mentioning of the three great Chinese inventions. The three were later became four when papermaking was finally proved to be of Chinese origin. By the 1940s and 1950s, the idea of the “Four Great Chinese Inventions” had become well known in China. The quartet was announced to the world in October 1946 by Joseph Needham. While making a speech at a UNESCO conference in Paris he added papermaking. In his opinion, “But for the gunpowder, papermaking, printing and compass, the end of European feudalism might never have been imagined” (Joseph, 1986, pp. 118-123).

We can conclude that the concept of the three great Chinese inventions originated in the West, when scholars tried to remark upon the influence of the three on human civilizations, especially modern Western civilizations, then later enlarged to a list of four. This origin is classically meaningful, yet also has its unique background and connotation. If it results in the delusion that the four must be the most important and top-ranking in Chinese ancient history, that will not be good, nor in accordance with what the scholars meant. It is rightly from this delusion that the concept of the “fifth greatest Chinese invention” has been frequently mentioned in recent years. The truth is, there has never been any serious study on the number of ancient Chinese inventions or their ratings by historians of science and technology whether in China or abroad, let alone any accepted conclusions. So, the question remains: What are the greatest inventions of ancient China?

2. Definition of inventions and their corresponding grading and rating

Academia has several versions of the definition for inventions. For example, *Cihai* defines an

“invention” as a new item that is created, or a first-time new way to make a thing. But the meaning of the word “new” might be ambiguous, for example, let there be a plane, which is surely an invention, and when another plane is built, should we call it a “new thing”? Maybe or maybe not. As for the idea of “a first-time new way to make a thing”, the computer might protest, for though a new computer-making method is a kind of invention, a computer as a real invention is much more than that. Therefore, the definition for “inventions” given by *Cihai* is not precise enough and could not be applied to all inventions. I propose a new definition for inventions: an invention is an original technical means or method that helps humanity learn about, adapt to, or change nature, society and humanity. Here is a more specific interpretation: an invention must be original. Whether they are created by luck or by need, they share one thing in common: helping humanity learn about, adapt to, and change nature, society or humanity itself. As a means or a method, an invention may be an object, such as a plane, or a non-object, such as a language. The addition of the determiner “technical” means to separate inventions from those strategy-type or institutional means or methods such as using operational research in horse racing or the imperial examinations in ancient China. Some inventions still lack solid evidence for their originality, but are totally unique and hugely influential, like the bronze smelting technological system in the Shang and Zhou Dynasties of China. These can also be listed as great inventions.

Inventions, according to their contribution to nature, society and mankind, are divided into four grades: great inventions, important inventions, ordinary inventions and minor inventions. Take the automobile for example. It was undoubtedly a great invention, while its air bag to protect the driver is an important invention, its windshield wipers an ordinary invention and its power-rising-

lowering window a minor invention. As for the inventions during times without written records or during medieval times, their value could be assessed according to their importance in history and influence on neighboring areas. For example, the ancient Chinese iron and steel smelting technology based on pig iron, featuring excellent skills like cast iron heating and softening, appliqué casting, iron forging and steel smelting by mixing pig iron and wrought iron, has created a long-standing, top-ranking glorious steel civilization in the world and has exerted a strong influence on China's neighbors such as Japan, Korea and Vietnam. Iron and steel smelting being listed as a great invention is reasonable and fully backed. Other such inventions include millet planting, rice planting and woodcraft. The rating of an invention should not solely be based on its span of history, for great inventions can appear if circumstances are right, regardless of time or location.

There are four clarifications to make if a scientific definition of "invention" is to be given. First, inventions are completely different from scientific discoveries or sheer academic research, which naturally must not be listed as inventions. Second, engineering construction may invent things out of need, but engineering construction itself should not be included in inventions. Third, some great inventions shared by early mankind, such as drilling wood for fire and pottery, had better not be included in a specific regional or national list of inventions. Fourth, largely controversial inventions must go through further research before a conclusion is made. As important as it is to define inventions, it can be more challenging to further rate them, and only through careful weighing and consideration can things be appropriately defined.

In a former paper I listed traditional Chinese medicine as one of the twenty-four great Chinese inventions, which was challenged by some scholars,

whose skepticism is not without reason. However, if it is the diagnosis and treatment of traditional Chinese medicine that is being talked about, then there is the very invention. Acupuncture, pulse feeling, bone setting, prescription and herb preparation that make up the unique diagnosis and treatment of traditional Chinese medicine has for thousands of years been influencing the health of the Chinese people. That is objectively true and worthy of full recognition. Another example is Chinese cuisine, which is ruled out by some scholars from the list of great inventions, or is even regarded as merely tiny skills far from an invention. However, in my opinion, among all Chinese cultural heritage, the Chinese characters, the diagnosis and treatment of traditional Chinese medicine and the Chinese cuisine have the most potential with the greatest prospects. There is already a boom in Chinese learning across the globe, a wider acceptance of acupuncture (with the pinnacle of Tu Youyou winning the Nobel Prize for her discovery of artemisinin) and a rising number of Chinese restaurants everywhere in the world. As China becomes stronger and has more say in international affairs, the headway is expected to grow. Considering these conditions, Chinese characters, the diagnosis and treatment of traditional Chinese medicine and the Chinese cuisine must be valued.

To be sure, the rating of inventions must be based on scientific judgment. Whether it is to be listed as a great invention, the details about the invention must be logically and explicitly displayed. This is something that can never be slighted. For nearly a century the "Four Great Chinese Inventions" have been mentioned, yet in such an unclear way that some scholars, including myself, proposed the concept of "the five great Chinese inventions", which did not pan out. Study of the Chinese history of science and technology in a modern sense has been carried out for nearly a century, branching out

into several disciplines that boast in-depth research based on the concept of cultural consciousness and a number of authoritative scholars. As for the question of exactly what great inventions ancient China had, a satisfying answer must be provided for all the Chinese people, and the international academia. The answer may not be so spotless or satisfying, yet it is better than nothing. Besides, chances for discussion and improvement remain. The Chinese themselves must clearly understand things concerning China, and China must have a say over the issue of inventions.

3. The origin of the thirty great Chinese inventions

Joseph Needham once listed, from A to Z, the 26 ancient Chinese inventions, with a British sense of humor. Robert K. G. Temple also held that ancient China completed one hundred sci-tech achievements. Jin Qiupeng, in his paper “The One Hundred Chinese Inventions”, however, included some scientific discoveries and engineering achievements in his list. None of the three authors graded or rated the inventions. In my paper “A Review of the Four Great Chinese Inventions and the Twenty-four Great Chinese Inventions” published in *Science News* in 2008, I tried to clarify the misunderstanding of the “Four Great Chinese Inventions” and comb through all the great ancient Chinese inventions. The idea of the “twenty-four great Chinese inventions” was retained in my paper “What Are the Great Inventions in Ancient China?” published in *Studies in the History of Natural Sciences*, the 4th issue of 2013.

In March 2014, the China Association for the Promotion of Chinese Culture held and chaired an academic consultative conference themed on “What the Chinese Invented,” attended by senior scholars of the history of science and technology, including Xi

Longfei, Guo Shuchun, Yang Yongshan, Luo Jianjin, Zhou Jiahua, Wan Fubin, Wang Yusheng, Jiang Zhenhuan, Li Ling, Liu Changhua, Hu Huakai, Guan Zengjian, Su Rongyu, Zhong Shaoyi, Qian Wei and Hua Jueming. After rounds of discussion, millet planting and rice planting were listed as separate inventions; jade carving was ruled out due to uncertain techniques; variolization was added to the diagnosis and treatment of traditional Chinese medicine; bean curd making and application was added to Chinese cuisine; and several new inventions were posed: weights and measures, stern rudders, horse harness and stirrups, armillary sphere and abridged armilla, blunderbuss and hybrid rice. After the conference, further opinions were proposed by some scholars: weights and measures should not be included since they are institutional inventions; and the stern rudders should be considered only after they are more deeply studied. Upon careful consideration these insightful opinions were adopted. Later, artemisinin was removed from the diagnosis and treatment of traditional Chinese medicine as an independent item. Finally, there came the list of the thirty greatest Chinese inventions; millet planting, rice planting, sericulture and silk weaving, Chinese characters, decimal notation and rod-arithmetic, bronze smelting, iron and steel smelting based on pig iron, canals and navigation locks, ploughs and drill barrows, water wheels, lacquer decorations, papermaking, the diagnosis and treatment of traditional Chinese medicine, chinaware, Chinese woodcraft, Chinese cuisine, horse harness and stirrups, printing, tea planting and processing, armillary sphere and abridged armilla, watertight bulkhead, gunpowder, compass, deep well drilling technology, the ecological agriculture featuring intensive and meticulous farming, abacus, tiller fermentation, fire arrow and blunderbuss, artemisinin, and hybrid rice.

Thirty is not a small figure, and that requires



Armillary Sphere

order. The sequence above is based on the time the inventions were first created or first took form. The work of defining inventions cannot be done overnight, and the concept of the “thirty greatest Chinese inventions” only serves as one possibility. To boost further discussion and research, the following choices are also given here for reference; jade carving, bow and crossbow, clepsydra, wheelbarrow, square-pallet chain-pump, seismograph, writing brush making, ink making, map drawing, geodetic measurement, Yellow River harness engineering, species variation, low-temperature glazed pottery, money prototype, astronomical clock tower, flowers cultivated in warm indoor conditions, gong brass

forging, double actuated blower, steel cable bridge, biologically based bridge building, plangi and batik in silk printing and dyeing, Ming Dynasty furniture, twelve-tone equal temperament, Zheng He’s treasure ship, foil forging, gardening, violet sand earthenware, cupronickel, crucible zinc smelting and vertical shaft windmill.

4. Inventions and civilization

The entire history of human civilization has demonstrated that sci-tech discoveries and inventions were closely linked with daily living, folk customs, economy, politics, culture, art, and military

affairs. Drilling wood for fire is doubtless the first major invention. It was not achieved until countless generations had survived an unimaginably arduous path, from accidentally using fire two to three million years ago, to learning to preserve fire around half a million years ago, to finally succeeding in making fire and passing it down. Drilling wood for fire is in fact making heat and fire through friction, marking the first attempt of mankind to dominate the natural power by using the principles of Physics. Fire, which brought warmth and light to early humans, better armed them against savage animals and natural disasters, and ushered in the primitive agriculture marked by slash-and-burn cultivation. Fire used for cooking allowed people to eat food that made them stronger and smarter. Fire also led to a broader living space by helping people conquer climatic and geographic limitations. The extensive use of fire inspired a surge of inventions, such as pottery made by Shennong (God Farmer), salt made by Susha, stone refined by Nüwa and arrows invented by the Yellow Emperor, leading humans from ignorance into civilization.

After that, the invention of the steam engine ushered in the industrial society, electricity the age of electric power, nuclear power the atomic age, and computers plus the internet of things the age of information. From farming to industrialization and informatization, from theocracy to monarchy and democracy, the historical inclination for changes in daily life, customs and society proved irresistible for people throughout the world. The reason for these changes can be traced to the innermost incentive: inventions, especially the great inventions. Then why is it that scientific inventions can drive civilizations? Because humans, the so-called “masters of all things”, must appropriately handle their relationships with nature, and their relationships with each other. These two relationships support and contradict each other. Through scientific inventions, relationships

with nature can be improved, which then influences the relationships with each other, and vice versa. Appropriately handled, the two can become a single driving force for civilizations, or they can generate disasters. The crucial role of inventions should be further valued, and at the same time their risky potential for destruction must be guarded against.

We can conclude here that the creativity of the Chinese fluctuated throughout history. Generally speaking, for the middle and late Neolithic Age, every one thousand years or so witnessed a great invention; for the Xia, Shang and Zhou dynasties the emergence of a great invention required about 450 years; the pinnacle came during the Western and Eastern Han dynasties, when the cycle of making a great invention fell to 45 years; and then plunged during the Wei, Jin, Northern and Southern dynasties, when only one great invention emerged in the span of 370 years; the Sui, Tang dynasties and Five Dynasties witnessed a great invention every 75 years; for the Song and Yuan dynasties, the peak of science and technologies of ancient China, producing a great invention required 65 years, a figure only second to that of the Western and Eastern Han dynasties; the Ming Dynasty, restrained by its outdated, creaky political and economic systems, declined and had only one great invention for each 140 years; the Qing Dynasty, on the brink of ending the imperial autocracy, was infertile in terms of great inventions for all of its 268 ruling years. Since the overthrow of the monarchy in 1911 and the start of building a republic, China experienced a national and cultural rejuvenation, which created two great inventions during one hundred years. That is a vertical comparison. Horizontally compared, during the five centuries after 1609 AD (the 37th year of the Wanli era of the Ming Dynasty), when Galileo invented the telescope with 20-times magnification, the world produced hundreds of great inventions, among which only two or three belonged to China.

This is a truth all Chinese must accept.

Great inventions throughout the history of China and even the world indicate innovation stems from illuminating the people, liberating the soul, following one's inclinations and using pragmatic incentives, all of which, however, require specific social conditions. With wise and clean politics, a prosperous economy, thriving sciences, freedom of thought and academic independence, innovation would be encouraged and supported, interests of inventors would be safeguarded and then inventions would come one after another. Legendary great inventors include Shennong, Cang Jie, the Yellow Emperor and Lei Zu, while names recorded by real history are Lu Ban, Bian Que, Ou Ye, Cai Lun and Bi Sheng. During the Vernacular Movement of China, when Liu Bannong invented the Chinese character “她” (“she or her” in English), which made sense to the Chinese and was soon adopted, he was in fact continuing Cang Jie's work. Moreover, Yuan Longping and Tu Youyou were inheritors to Shennong, Wang Xuan to Bi Sheng, while Lu Ban, Bian Que, Ou Ye and Cai Lun could all find their heirs in the history that followed. Innovation has been leading civilization and inventions have always been an important part of the lives of generations of Chinese people.

5. Study of the great Chinese inventions based on the concept of cultural consciousness

First the doubt about the misunderstanding about the “Four Great Chinese Inventions”, then the proposal of the “twenty-four great Chinese inventions” and the shaping of the “thirty great Chinese inventions”, all the work I have undertaken is based on the concept of cultural consciousness, for culture defines the genes that help a nation survive, develop and maintain its own characteristics. The

cultural consciousness decides whether a nation can go on living, developing and reviving in a spiritual sense. It must also be referred to when inventions are reviewed and its application, as shown in the following passages, comes down to two aspects: cultural independence and cultural self-discipline.

First, “the Chinese themselves must clearly understand things concerning China,” and “China must have a say over the issue of inventions.” Be they created in ancient China or modern China, the Chinese are and should be the ones that know their own inventions best. Earlier Chinese scholars used to suffer the lack of conditions or time for studying Chinese history of science and technologies, but in modern times, local study of Chinese history of science and technologies has been carried on for nearly a century, has accumulated a profound academic foundation and a most authoritative group of scholars, and also has easy access to foreign research for reference. To place the study and sifting of the great Chinese inventions on the agenda and make that a liability is what the historians of science and technology must and can do. It is true that foreign scholars are supported by better conditions in research and have produced more excellent outcomes not only in scientific history but also many other academic areas concerning China, but Chinese scholars also have their own strengths, since only the Chinese know best about or could know best about things concerning China. The scholars' sense of mission and responsibility would be a most fundamental factor here. Meanwhile, in terms of inventions, the Chinese must strive for cultural independence, which has already been well demonstrated by the study, sifting and compiling pertaining to the thirty great Chinese inventions. The list is yet to be perfected though, requiring further discussion and improvement.

Second, the study and evaluation of inventions must be taken seriously. The scientific spirit of

seeking truth from facts must be rigorously upheld during the study and rating of great inventions. Any disregard or disrespect of inventions in a nation, or of the people's wisdom and pursuit of innovation, is a symptom of nihilism, while exaggerating or forging one's own inventions and disregarding others' creativity and wisdom is a symptom of chauvinism. Neither of the two should be accepted. Instead, the core principle of the research on the great Chinese inventions based on the concept of cultural consciousness should be respecting the objective facts, adhering to the academic standards, and adopting a most rigorous and precise approach

whether it is for discussion, evaluation, sifting, or narrative. Cultural self-discipline is what makes Chinese research and narratives hold water. Only by combining cultural independence and cultural self-discipline can China have a real say over the issue of inventions. From 2004 to 2017, 14 years on, after joint efforts by a large number of scholars, the discussion of great Chinese inventions finally came to a temporary end, producing the book *The Thirty Great Chinese Inventions*.^① As a first-time try, the book may not be perfect and it is sincerely hoped that more scholars will come forward and offer their opinions.

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REFERENCES

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- Cang Xiaohu. (1988). *Shorter natural science: The role of science in history and the influence of history on science*. Beijing: Beijing Publishing Group.
- Compilation and Translation Bureau of the CPC Central Committee. (1979). *The complete works of Marx and Engels (Vol. 47)*. Beijing: People's Publishing House.
- Joseph Needham. (1986). Science and civilization in China. In Pan Jixing (Eds.). *The works of Joseph Needham*. Shenyang: Liaoning Science and Technology Press.

① *The Thirty Great Chinese Inventions* is chiefly edited by Hua Jueming and Feng Lisheng and its compiling team includes 32 scholars. Totalling over half a million words, close to 600 pictures, it was published in May 2017 by Elephant Press. This paper is based on its preface: "Talking about the Thirty Great Chinese Inventions" and the article used as a postscript: *Inventions and Civilization*.