Wang Zheng (1571–1644)

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Abstract Wang Zheng was a Chinese official interested in machine design from a young age. In the 1620s, he became familiar with European missionaries and the knowledge they brought to China. Together with Johannes Schreck Terrenz (1576–1630), a German Jesuit missionary, he compiled *Yuanxi Qiqi Tushuo Luzui* (*A Record of the Best Illustrations and Descriptions of Extraordinary Devices of the Far West*) to introduce European mechanics and machines to China. This remained the most authoritative book on mechanics and machine design in China until the 1860s. Wang Zheng published two further books on machine design and constructed several devices himself. In 1644, he committed suicide because of the fall of the Ming Dynasty.

Biographical Notes

Wang Zheng (Fig. 1), who styled himself Liangpu, was born on May 12, 1571, in Jingyang County, Shanxi Province, China. His father, Wang Yingxuan, was an erudite village teacher with an interest in ancient books, skilled in calculation, methods for preserving health, geography, and astrology. His mother came from a family of scholar-officials (Wang Zheng 1987a, pp. 252–258).

Wang learned from his father from a very young age. In 1577, he went to live with his maternal grandfather and began to study with his uncle, Zhang Jian, a brother of his mother. Zhang, who held various official positions during his lifetime, was proficient in the Confucian classics and history, well acquainted with military knowledge, and had extensively studied arcane knowledge such as the arts

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Fig. 1 Wang Zheng Portrait (anonymous painter, modern imitation, preserved in Wang Kejü's home)

of astrology and divination. He was also good at making devices. Zhang exerted great influence on Wang, who later highly praised his morality and profound learning, claiming that his skill in crossbow and chariot-making was remarkable (Wang 1987a, p. 208).

In 1587, Wang became a student in the county school. In 1594, he successfully passed the imperial examinations at the provincial level. Over the following years, he took the highest imperial examination ten times, finally succeeding in 1622. Soon after, he was appointed an official in charge of juridical affairs in Guangping Prefecture. At the end of the autumn of 1622, he reached Guangping to take up the post. He was an able and dutiful official. According to his own account, during 1 year he inspected the army and its armaments and led the reform of the military, compiling the *Bing Yue* (Soldiers' Rules); he quelled local unrest and released innocent persons falsely accused of belonging to a rebellious sect, the White Lotus Society; and he ordered the construction of canals and embankments and designed water-gates for the Qinghe river. With the death of his step-mother in March, 1624, he left Guangping for his hometown to observe the prescribed 3-year period of mourning.[1]

[1]After the death of a parent, a son should observe a 27-month period of mourning at home, eschewing all social intercourse. If an official, he must leave his job.

At the beginning of 1627, he was appointed an official in charge of juridical affairs in Yangzhou Prefecture. He arrived at his post in July of 1627. During his tenure of office, besides his juridical duties, he reconstructed floodgates, improved irrigation systems, introduced military methods, built Confucian temples and painted.

In 1628, he again had to leave his post and return to his hometown to observe the prescribed period of mourning after the death of his father. In 1629, he organized local militia to fight against insurgents in his hometown and neighboring areas. In 1631, he was promoted to supervisor of military affairs. However, he was soon removed from his post due to a rebellion by low-ranking military officers and returned to his hometown. From then on, he invested his efforts in serving his hometown and writing. In 1643, the town was overrun by one of the rebelling armies. Refusing to serve them, he committed suicide.

As a result of this act, he was highly regarded as a loyalist and martyr by his contemporaries. However, subsequently he became famous as a member of the first generation of Chinese converts to Catholicism, and for his achievements in the history of the transmission of knowledge between Europe and China, especially machine design and mechanics.

There is no solid evidence to tell us exactly when Wang converted to Catholicism. He was attracted to it when he met the Spanish Jesuit missionary, Diego de Pantoja (1571–1618), in 1616. During 1625 and 1626, Wang helped the Jesuit missionary Nicolas Trigault (1577–1628) to compile and publish the first Chinese phonetic dictionary using transcriptions in the Latin alphabet. Interestingly, in his preface to this book, he stressed that, through the study of Western writing, he had come to understand why the ancient Chinese classic, the *Yi Jing* (*Book of Changes*), was the origin of all written characters. In 1634, he established a Catholic society, "Ren Hui" (Benevolence Society), framing its "Rules" and building a church.

Influenced by his uncle Zhang Jian, from his youth he took an interest in ingenious mechanisms and devices, especially those for military use. In 1622, he presented a memorial to the throne to introduce several military devices, and became known as an expert in machine design and military affairs. Between 1623 and 1626, he used his devices for various purposes such as dredging rivers, flood defense, and military defense. All the machines constructed by him were concerned directly with farming, daily life, or military affairs.

Thus it was that he was able to appreciate the machines that he saw brought by missionaries to China and recorded in their books. Inspired by the mechanisms of European clocks, he invented a weight-driven quadricycle in imitation of an ancient device he had sought to reconstruct for many years (Zhang Baichun 1996). In 1626, he wrote *Xinzhi Zhuqi Tushuo* (*Illustrations and Descriptions of Several Newly-built Devices*), which included eight kinds of machines. In 1627, together with the German Jesuit misssionary Johann Terrenz (1576–1630), he composed *Yuanxi Qiqi Tushuo Luzui* (*A Record of the Best Illustrations and Descriptions of Extraordinary Devices of the Far West*), which systemically introduced European mechanics and machines to China. Terrenz interpreted the Western texts in spoken Chinese while he illustrated Terrenz' interpretations and formulated them in written Chinese. After that, he used European technology to make more devices, playing a central role in the transmission of knowledge about Western machines to China.

In his old age, he was still interested in constructing devices based on Western knowledge and Chinese technology. At the end of 1640 or the beginning of 1641, he integrated his old writings and new ideas into a new book entitled "*E La Ji Ya You Zao Zhuqi Tushuo* (*Illustrations and Descriptions of the Devices Created by Gratia*)". This book described 24 kinds of devices, all of which he thought practical. Unfortunately, as the book was lost during the twentieth century, little is known of the specific content.

Wang lived the ordinary life of a low ranking scholar-official. His interest in machine design and the transmission of European mechanics was not widely shared by his contemporaries, though his endeavors were in accordance with the Confucian doctrine of serving society (Jami 1999, Huang Yi-Lung 2005). However, converting to Catholicism was definitely unusual in the seventeenth century. Nevertheless, an open attitude toward non-Confucian knowledge was not so unusual among Chinese scholars at that time. In fact, both his father and uncle, Zhang Jian, were interested in non-orthodox Confucian thought and knowledge, and he was open to knowledge from different traditions from early on in his life (Zhang Baichun and Tian Miao 2006). In his preface to *Yuanxi Qiqi Tushuo Luzui*, he claimed: "[As for] learning, [I] originally do not ask whether [it is] fine or coarse, [but] always expect [it] to be of benefit to the world; [as for] a person, I also do not ask whether [he is] a Chinese or a Westerner, [but] always expect him not to disobey Heaven" (Terrenz and Wang Zheng 1830). In his various works, he tried to incorporate Catholic ideas into Confucianism. We believe that this was an effort to legitimize Western knowledge and Catholicism in China. His satisfaction with the fact that Western knowledge and religion did not violate Confucian tradition was the basis for his adoption of Western knowledge and for his conversion to Catholicism. In fact, he believed that both European knowledge and thought were in accordance with Confucianism. Even though he was interested in Daoism, and converted to Catholicism, he remained a Confucian scholar (Tian Miao and Zhang Baichun 2007). In his *Liang Li Lüe* (*An Outline of Two Administrations*), he mentions that whenever "I arrived at a county, I would first pay homage at the temple of Confucius. I would examine the sacrificial utensils and books. Obeying the Sage, esteeming (his) *Dao* and respecting (his) learning are the main acts of righteousness of a country" (Wang Zheng 1987b, p. 27). His suicide in 1644, displaying such loyalty to the Ming emperor, is proof of his life-long commitment to Confucianism (Zhang Pengfen 1830). Loyalty toward the emperor was one of the prime principles of Confucianism, while suicide was strictly forbidden by Catholicism.

List of Wang Zheng's (Main) Works

Xinzhi Zhuqi Tushuo (新制诸器图说, *Illustrations and Descriptions of Several Newly-built Devices*), written in 1626, first published in 1628.
Yuanxi Qiqi Tushuo Luzui (远西奇器图说录最, *A Record of the Best Illustrations and Descriptions of Extraordinary Devices of the Far West*, written in 1627, first published in 1628.

Liang Li Lüe (两理略, *An Outline of Two Administrations*), written in 1637.
E La Ji Ya You Zao Zhuqi Tushuo (额辣济亚牖造诸器图说, *Illustrations and Descriptiions of the Devices Created by Gratia*), written in the 1640s.

Review of Wang Zheng's Main Works on Mechanism Design

In his *Xinzhi Zhuqi Tushuo* (*Illustrations and Descriptions of Newly-built Devices*, hereafter *Zhuqi Tushuo*), Wang Zhang illustrated and described nine devices, including a single-cylinder siphon-pump, a flume-beamed swape, a crank-operated man-powered mill, a wind-driven mill, a weight-driven geared mill, a weight-driven quadricycle, a combined clock, a mechanical cable plough, and a multiple crossbow (Wang Zheng 1830a, b, pp. 1–21). The single-cylinder siphon-pump (Fig. 2), which consists of a pipe and a single-cylinder pump, may be used to lift water.

The flume-beamed swape (Fig. 3) is a long water-lifting flume. The crank-operated man-powered, mill is not a particularly special mill, but he emphasized its two gear wheels. The wind-driven mill was drawn by him on the basis of a mill described by Nicolas Trigault. He also imitated the transmission and power mechanisms of European clocks, namely combined gear wheels and driving weights, with millstones or quadricycles in order to design a weight-driven geared mill and a weight-driven quadricycle (Fig. 4). For his combined clock, he made a copy of the transmission and power mechanisms of a European clock and combined them with a drum, a bell, and puppets (Fig. 5). The mechanical cable plough (Fig. 6) is driven by a windlass with handspikes. The multiple crossbow is a traditional Chinese device, which he tried to assemble on the basis of an unearthed trigger.[2]

Yuanxi Qiqi Tushuo Luzui (远西奇器图说录最, *A Record of the Best Illustrations and Descriptions of Extraordinary Devices of the Far West*, hereafter *Qiqi Tushuo*, see Fig. 7) is the first monograph on Western mechanics and machines in Chinese (Terrenz and Wang Zheng 1830), most of which was new for the Chinese of the seventeenth century. Following the introduction to the art of force or science of weights, there are three chapters that selectively expound Western mechanics and machines from Archimedean times to the early seventeenth century. The first chapter, which consists of 61 sections, is called *Explanations of Weight*. It discusses such topics as weight, center of gravity, geometrical center, specific gravity, buoyancy, etc. The second chapter of 92 sections, *Explanations of Devices*, discusses principles and calculations concerning simple machines such as the balance, steelyard, lever, pulley, wheel, screw, etc. The third chapter consists of illustrations and explanations of 54 Western machines, including devices to hoist and move heavy objects, water-lifting devices, wind-mills, water-mills, wood-sawing machines, and so on. This chapter also describes such mechanisms as the worm wheel and the ratchet wheel.

[2] The trigger unearthed from the ground tells us that there was no cross-bow trigger available for Wang Zheng.

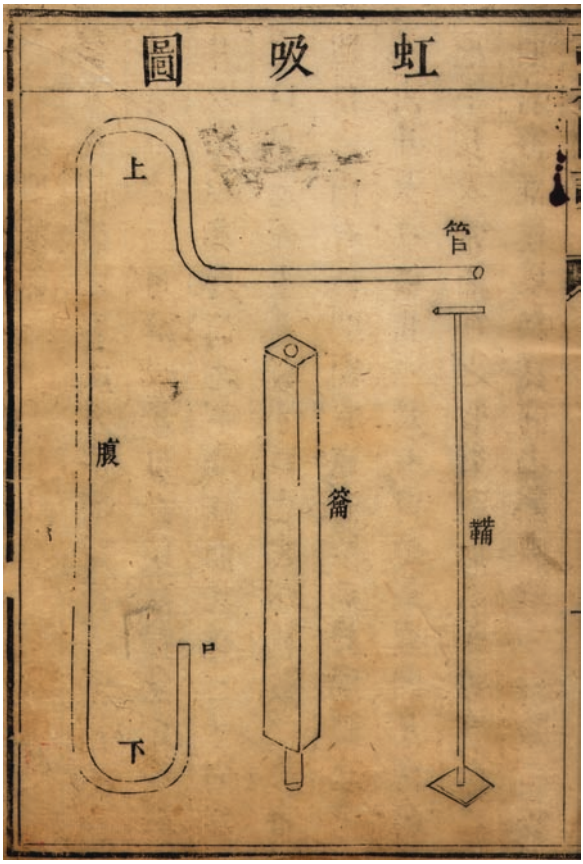

Fig. 2 Single-cylinder siphon-pump (*Xinzhi Zhuqi Tushuo*, Lailutang edition)

The first and second chapters of *Qiqi Tushuo* are probably derived mainly from Simon Steven's *Hypomnemata Mathematica... Mauritius, Princeps Auraicus, Comes Nassoviac...* (1608), Guidobaldo del Monte's *Mechanicorum liber* (1577) (Damerow and Schoepflin 2006). All the mathematical proofs in the Western sources were left out by Terrrenz and Wang. The third chapter is obviously derived from Agostino Ramelli's *Le Diverse et Artificiose Machine del Capitano* (1588), Faustus Verantius' *Machinae Novae Fausti Verantii Siceni, cum Declaratione Latina, Italica, Hispanica, Gallica et Germanica* (written *c*. 1595), Jacques Besson's *Théatre de Instruments Mathématiques et Mécaniques* (1578) and Vittorio Zonca's *Novo Teatro di Machini e Edificii* (1607). Terrenz and Wang integrated knowledge from these books into a new system of mechanical knowledge and machines (Tian Miao and Zhang Baichun 2007).

The most outstanding invention Wang made is the design of a weight-driven quadricycle (Fig. 4), which he called a Self-motion Vehicle. He made a great effort to reconstruct the famous transporting device known as the Wooden Ox and Gliding Horse, created by Zhuge Liang (181–234). He was unsuccessful until he learned

Fig. 3 Flume-beamed swape (*Xinzhi Zhuqi Tushuo*, Lailutang edition)

about the mechanism of mechanical clocks transmitted from Europe (Wang Zheng 1987b, pp. 81–82). The weight-driven quadricycle is the result of his application of such a mechanism.

According to Zhang Pengfen, it was believed in Wang's hometown that he made wooden models for farming and other purposes, such as making fire and operating bellows. It was also believed that he used his weight-driven quadricycle to help with binding and transporting stalks (Zhang Pengfen 1830). However, modern historians no longer believe such accounts.

On the Circulation of Wang Zheng's Works

Qiqi Tushuo is the most important publication that Wang Zheng was involved with. *Zhuqi Tushuo* was published attached to it. *E La Ji Ya You Zao Zhuqi Tushuo* was never published, remaining in manuscript form, and is now lost.

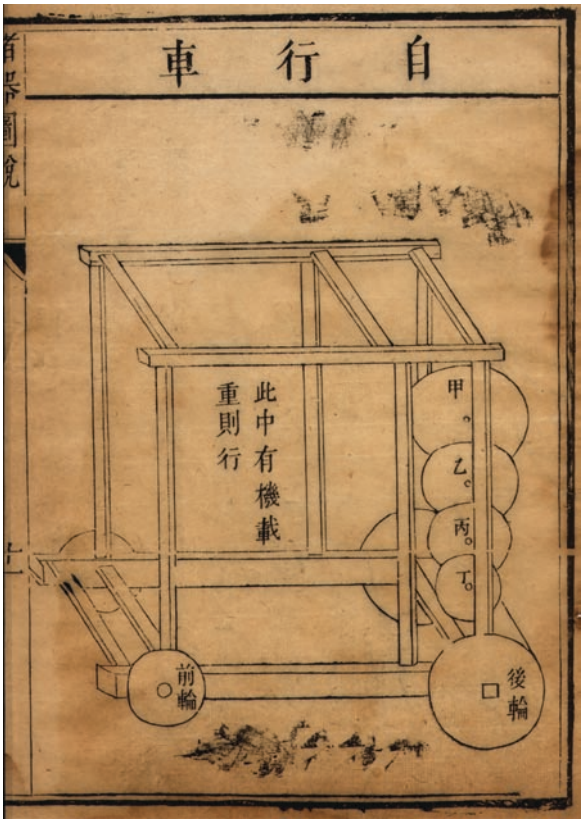

Fig. 4 Weight-driven quadricycle (*Xinzhi Zhuqi Tushuo*, Lailutang edition)

In 1628, Wu Weizhong, one of Wang's friends, printed a woodblock edition of *Qiqi Tushuo* with *Zhuqi Tushuo* in Yangzhou. Subsequently, Wang Yingkui copied the blocks and reprinted the two works in order to make them more widely available. Wang Yingkui's edition introduced some new errors and simplified a few of the illustrations. On the basis of this edition, Wu Huaigu reprinted them again in 1631. The content of this edition is the same as Wang Yingkui's, except that all the Western characters used as markers are replaced by Chinese ones.

Later, new editions of the two books based on these were reprinted in such collections as *Gujin Tushu Jicheng* (*GJTSJC, Collection of Ancient Chinese Books*, 1728), *Siku Quanshu* (*SKQS, Complete Collection in Four Treasuries*, 1781–1782), *Shoushange Congshu* (*Shoushange Book Series*, 1844) and by the Lailutang printing house (Zhang Baichun et al. 2006). *GJTSJC* and *SKQS* were compiled on imperial order. The editors of *GJTSJC* left out the first and second chapters, while the editors of *SKQS* added a short introduction to *Qiqi Tushuo*, remarking that Johann Terrenz and Wang's explanations of the art of force (science of weight) "exaggerated the marvellousness of these methods. Most of them are preposterous and

Fig. 5 European-styled clock (*Xinzhi Zhuqi Tushuo*, Lailutang edition)

excessive, not worthy of investigation. However, the skill of the manufacture of the machines is, in fact, the finest of any age" (Ji et al. 1983). This paragraph demonstrates the attitude of some Chinese scholars towards theoretical mechanics.

Shoushange Congshu and *GJTSJC* were repeatedly copied by other publishers so that *Qiqi Tushuo* and *Zhuqi Tushuo* were widely transmitted in the nineteenth and twentieth centuries not only throughout China, but also to Japan and Korea. The publishers and editors of new editions selected and changed their content based on their interests in Western knowledge about mechanics and machines. The majority of the errors in the first edition were repeated in subsequent ones. Though some revisers improved the content or added new misunderstanding, all the editions played a role in the acceptance and transmission of western scientific knowledge in China before the twentieth century.

Prior to the 1860s, *Qiqi Tushuo* was the most authoritative book on mechanics and machine design in China. Its content was repeatedly cited and discussed by later Jesuit missionaries and Chinese Scholars (Tian Miao and Zhang Baichun 2006a, Tian Miao and Zhang Baichun 2006b). Xue Fengzuo (1600–1680),

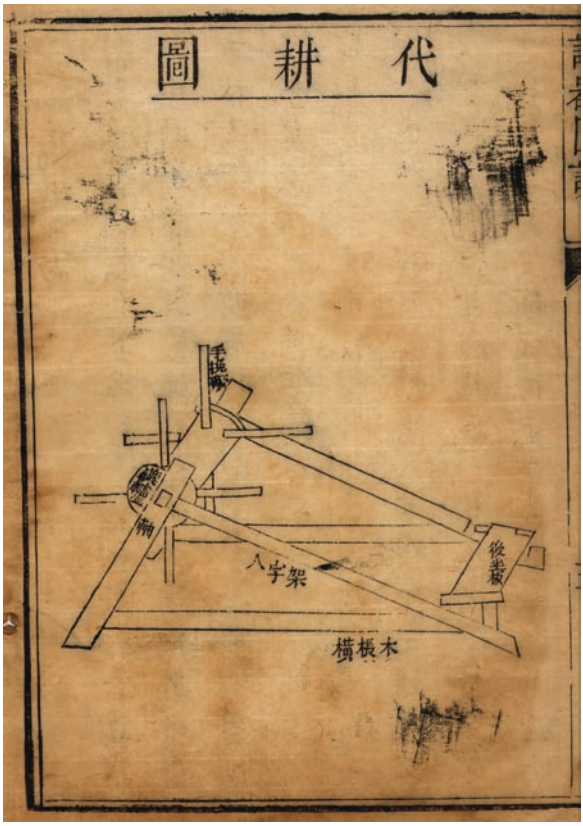

Fig. 6 Mechanical cable plough (*Xinzhi Zhuqi Tushuo*, Lailutang edition)

an astronomer and mathematician, completed a book entitled *Zhongxue* (*The science of weights*) in 1664 based on the two works (Tian Miao and Zhang Baichun 2006a). Xue had a good understanding of Western mechanical knowledge and abridged and summarized their original texts and illustrations, though he completely left out the second chapter of *Qiqi Tushuo.* He thought that the science of weights and mathematics would help people to understand the purpose and principles of machine construction, though some of the illustrations he redrew were of poor quality and he deleted some important mechanisms.

In the 1680s, another mathematician, Mei Wending (1633–1721), made a study of *Qiqi Tushuo*, contributing a commentary to its first chapter and supplementing its third chapter with some illustrations and explanations of traditional Chinese machines (Tian Miao and Zhang Baichun 2006b). He also tried to provide mathematical proofs for the mechanical knowledge in the first chapter of *Qiqi Tushuo*. A Jesuit missionary, Ferdinand Verbiest (1623–1688), compiled a book in Chinese entitled *Qiong Li Xue* in 1683, which includes mechanical theory from *Qiqi Tushuo* rather than knowledge about machines.

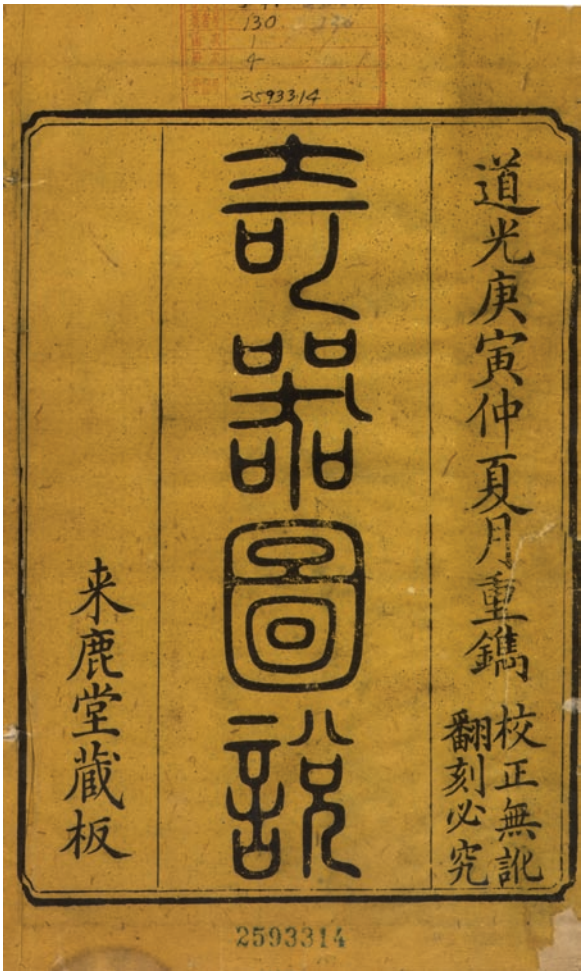

Fig. 7 The Cover of *Yuanxi Qiqi Tushuo Luzui* (Lailutang edition)

Although *Qiqi Tushuo* and *Zhuqi Tushuo* were circulated among Chinese scholars and other readers, we have not found any Chinese scholar from the eighteenth to mid-nineteenth century who made a further study of mechanics and mechanism design on their basis.

Modern Interpretation of Wang Zheng's Main Contributions

The weight-driven quadricycle was Wang Zheng's most important design (Fig. 4). A model of this kind of quadricycle could run for more than 10 m. Its mechanism was based on a system of gear wheels. Such gear wheels enable a crank-operated

man-powered mill to be turned quickly and the design was used in water-powered, gear-driven mills in ancient China. Using it to make a transportation device was Wang's own invention. He surmised that a big weight-driven quadricycle could run for three *li* (one li is approximately equal to 0.5 km). However, in order to make a quadricycle or a mill run over and over again, the operator has to intermittently lift a weight that provides the power. In fact, his designs are feasible in principle, but they cannot be used to construct a large functioning quadricycle or mill (Liu Xianzhou 1958).

His main contribution to mechanism design is his role in the earliest transmission of Western knowledge about mechanics and machines into China. He also used his skill in Chinese painting to create a traditional Chinese pictorial representation of Western machines, for instance changing all the machine operators in the illustrations from European figures to Chinese ones.

His work laid the foundation for the further introduction of modern mechanics and knowledge about Western devices into China prior to the twentieth century. From the 1840s, the door to China was pushed open and Western military and other related technology was introduced, including mechanical knowledge. Mechanical terms used in *Qiqi Tushuo* had an influence on such books as *Zhong Xue* (Science of Weights, 1859) by Li Shanlan and Joseph Edkins (1823–1905), which was a Chinese translation of *An Elementary Treatise on Mechanics* by W. Whewell (1794–1866), as well as some textbooks on machines. When the Republic of China's Ministry of Education standardized technical terms, Liu Xianzhou adopted terms from *Qiqi Tushuo* when compiling a dictionary on mechanical engineering.

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