# The Astronomical Instrument: Jesuit's Walking Stick in the 17th Century China

**Baichun Zhang**

**Abstract:** In order to discuss relation between development of technology and culture, this paper narrates Jesuit's activities and their interaction with astronomical instrument-making in China during the 17th century.

**Keywords**: Astronomical instrument, Jesuit, China

## 1 Introduction

The European Catholicism started to open up its religious career in China since 16th century. When Jesuits spread European science and technology into China, European astronomy and astronomical instruments became both calendar-making tool in China and missionaries' walking stick for missionary work.

## 2 The Successful Tactics by Matteo Ricci

With the influence of European navigation and trade coming to the east in 16th century the European missionaries rode business ships and came to Asia one after another. Portugal enjoyed protection rights over missionary work in China at the end of 16th century.

Pompilius Michele Ruggieri (1543-1607) arrived at Macao in 1579 and started to learn Chinese according to the plan of Alexandre Valighano (1538-1606). The Italian Jesuit Matteo Ricci (1552-1610) went to Macao in 1582 to study Chinese. In the coming years they bribed officials with gifts such as mechanical clocks and watches[1]. They claimed to admire Chinese culture and politics and got the permission to build the first church in Zhaoqing of Guangdong province. In order to attract Chinese and to avoid conflicts they didn't talk about religion publicly, instead they studied the Chinese language, calligraphy and customs. They displayed new stuff such as clock, watch, prism and world map and made a show of their intelligence in mathematics in order to arouse the interest of Chinese in European culture. At the same time, Matteo Ricci realized that Confucianism was the most general religion in China[2]. He continued to study Confucian works at Shaozhou[3].

Jesuits thought that China was a country with centralization of state power and only with the permission from the emperor in Beijing could the door of missionary work be opened up. Matteo Ricci believed that missionaries' "results of labour depended upon building good relations with people in power, because these people had the authority to permit a career that would arouse suspicion."[4] Matteo Ricci arrived in Nanchang and Nanjing successively with the help of Shi Xing, a vice minister of the Ministry of War, in 1595. After he came back to Nanchang from Nanjing, he did his utmost to win over the sympathy and support of the royal members. He associated with famous scholar-officials and tried to mix Catholic sermon with the Confucian theory by Confucius and Mencius so as to cater to the likes of ranking officials, aristocrats, literati and officialdom[5]. Matteo Rucci met the emperor of Ming dynasty in Beijing in 1601 after many setbacks. He presented with clocks, watches and musical instruments as gifts and got the permission to reside in Beijing. This laid the basis for the formation of the net of missionary work with Beijing being its center.

The missionaries with Matteo Ricci as their head decided to make the sermon of Catholicism

become Confucianized after trial and error. All Chinese customs not in big conflicts with religious doctrine were not prohibited, thus the relations between Catholicism and Chinese traditional psychology and customs were comprised. The effort by Matteo Ricci won approval from scholar-officials and favor from the royal government. The influence of church was growing increasingly and Chinese Catholicism believers increased every day. Most of the first to enter into Catholicism were those who were proficient at Confucian scriptures and entered into official career such as Xu Guangqi (1562-1633) and Li Zhizao (1565-1630). There were 19 Jesuits in China from 1610 to 1629. In 1627 there were 13,000 followers all together in provinces[6]. In 1650 the number of believers reached 150,000[7].

Matteo Ricci adhered to using science and technology to assist missionary work. He said, "anyone that thinks ethics, physics and mathematics are not important in church work doesn't know the taste of Chinese. They take slowly useful spiritual medicine only if it has the seasoning of knowledge to add flavor."[8]

## 3 European Astronomical Instruments and Knowledge: Jesuits' Walking Stick

### 3.1 The First Church Case and the Succour by Astronomical knowledge

Although Matteo Ricci took flexible tactics, missionary work activities could face pounding at any time. A series of conflicts and arguments already took place in Ming dynasty before 1616 and many of which were in Guangdong. Matteo Ricci passed away in 1610. His inheritor changed policies of Matteo Ricci and strictly forbade the ceremonies of offering sacrifices to the Heaven and ancestors and worshiping Confucius and the burning of pictures of God. This caused a direct conflict with Chinese ethics and the three cardinal guides and the five constant virtues, and stirred up the aversion of social figures, including the Buddhist circles. In particular the anti-church trend of thought among officials, literati and officialdom was brought into the open day by day. The Nanjing church case finally took place in 1616. Although Xu Guangqi presented a memorial doing his utmost to argue for Catholicism, the emperor couldn't stand repeated accusations by anti Catholicism people[9]. A few missionaries were expelled to Macao in the end and missionaries in other places dared not engage in public activities.

Chinese astronomy took a special place in ancient social life. Astronomical institutions, instruments and the issuance of calendar often were symbols of political power. Natural "Heaven" was deified as force with a will that controlled and governed the destiny of all things on earth. The actions and moral conducts of human beings should be in accordance with the will of Heaven. Emperor in man's world was regarded as son of Heaven. Emperor took orders from Heaven and had the authority to rule the world. Rulers of all dynasties worked out calendar to prove that they themselves were "entrusted by Heaven" and to satisfy actual needs. They used instruments to observe stars and made use of astrology to understand or to explain "Heaven's will." On the one hand they supported the work of some astronomers, on the other hand they were afraid that people would make use of astronomy to conspire against the state. In early Ming dynasty it was so autocratic that private studying of calendar among the people was forbidden. In Wanli times of Ming dynasty (1573-1619), Chinese astronomy declined so much that it was difficult to compile calendar that was in line with astronomical phenomena. The difficult situation provided an opportunity for the introduction of European astronomy and instruments. Matteo Ricci noticed the problems and needs of China in astronomy with his sharp eyes. He made celestial globe, terrestrial globe and sundial in Nanchang and Nanjing and displayed or presented them as gifts to Chinese.

Calendar lacked revision and many mistakes occurred while calculating. This was discussed in

the royal government to change the situation. On the first day of lunar month May 1629, solar eclipse occurred. The calculation of the observatory didn't tally with the reality. Xu Guangqi calculated with Western calendar and it tallied with the reality. The Ministry of Rites changed its position from opposing setting up a calendrical bureau to presenting a memorial to set up one to revise old calendar. Xu Guangqi assumed deputy Minister of Rites in the same year. He was promoted to Minister of Rites one year later. He advocated "the material from the west should be melted to be put in the model of Chinese Datong Calendar." He thought "in order to surpass and win, one must understand thoroughly. One must translate before understanding thoroughly."[10] Xu Guangqi recommended Longobardo and Johann Terrenz (1576-1630) to participate in calendar-making in the Calendrical Bureau. After Terrenz passed away, Giacomo Rho (1593-1638) and Johann Adam Schall von Bell (1591-1666) took posts in the Astronomical Bureau. They translated books and made instruments. Missionaries' contributions were praised by the emperor. Catholicism became active under the shelter of the emperor. There was a big increase in Catholicism believers in China[11].

3.2 The Second Church Case and the Efficacy of Astronomy and Instruments

Ming dynasty was replaced by Qing dynasty in 1644. Adam Schall von Bell presented their instruments and got the permission from the new government to compile a calendar according to Western means. A new calendar was used in 1645. Adam Schall von Bell received an imperial order to be in charge of the Astronomical Bureau[12]. He took advantage of all opportunities to be close to Emperor Shunzhi to win the support of the supreme rulers. The emperor had high evaluation on Adam Schall von Bell's work and promoted his ranks repeatedly. Catholicism developed rapidly in Qing China. There were 114,200 believers all together in 1664[13].

In the summer of 1660 and on March 1st, 1661 Yang Guangxian (1597-1669) presented a memorial to impeach Adam Schall von Bell and wrote the essay accusing missionaries of three crimes, which were: the calendar was ridiculous; the heresy misled the general public; the missionaries secretly plotted a rebellion[14]. After Emperor Shunzhi died in 1662, Yang Guangxian's accusation played a great inciting role in society and it aroused doubts and worry of some officials. At that time, Emperor Kangxi was at an early age and four assisting ministers including Aobai were in power. Aobai advocated that the ancestral system should be confirmed to and old rules should be restored. The incitement by Yang Guangxian took effect at this time. Adam Schall von Bell and his assistants such as Ferdinand Verbiest (1623-1688) were sent to prison and even would be beheaded.

Because of his success in correct calculation and observation of astronomical phenomena from 1668 to 1669, on 1st April 1669 Emperor Kangxi decided that Ferdinand Verbiest would be "responsible for calendar-administering". Afterward, all missionaries were permitted to go back to churches in provinces. Verbiest made great contribution in calendar-making, instrument-making and cannon producing. Emperor Kangxi commended and awarded Verbiest very much and repeatedly conferred him government posts. The emperor's interest in Western knowledge, the service of Verbiest in Beijing and his status in the royal government provided umbrella for the missionaries coming from afar and European science, which caused the recovery and development of Catholicism in China. In 1700 the number of Catholicism believers reached 300,000[15]. After Verbiest passed away, other missionaries took over to "administer calendar."

4 European Astronomical Instruments: Chinese Calendar-making Tool

The Jesuit Matteo Ricci introduced small European instruments such as celestial globe,

astrolabe and sundial to Chinese. Terrenz, Adam Schall von Bell, Rho took posts in the royal astronomical institution since 1629 at the invitation of Xu Guangqi. From 1631 to 1635 they translated successively many Western astronomical works and compiled into a 135-volumed Chongzhen Calendar (Chongzhen reign-period manual of mathematical astronomy), and made some Western instruments. The books depicted main instruments at Ptolemy's times, Tycho Brache's instruments such as Ptolemaic organon parallaktikon, astrolabe, Ecliptic-equatorial armillary sphere, torquetum, Jacob's staff, quadrants, azimuthal-quadrant, sextant, ecliptic armillary, equatorial armillary sphere, demonstrational armillary sphere and celestial globe and accounted in detail the structure and principle, the means of manufacture, installment and use, analyzing the features of the instruments of all kinds. These instruments adopted graduation of 360°and used regulative spiral, screw and plumb line. Movable sights or alidades were used in European instruments while the sighting tube was used as alidade in Chinese instruments. Because of the opposition of the conservative and turbulent situation, Chonzhen Calendar wasn't issued in the Ming dynasty. It was adapted to New Western Calendar by Adam Schall von Bell after the end of Ming dynasty and served Qing dynasty.

From 1669 to 1674 the Jesuit Verbiest was in charge of constructing ecliptic armillary sphere, equatorial armillary sphere, azimuthal instrument, quadrant, sextant and stellar globe and they replaced traditional instruments such as armillary sphere and the simplified instrument. The new instruments were installed at the Peking Observatory (figure 1)[16]. In 1674, Verbiest published his Xinzhi Lingtai Yixiang Zhi (A Record of the Newly-made Instruments at the Peking Observatory), a treatise in 16-chapters devoted to the explanation, design, manufacturing, installment and usage of his newly constructed instruments. Owing to Verbiest's labour, the precision of astronomical instruments available in China reached an unprecedented level. Obviously, in the construction of his instruments, Verbiest both followed Tycho Brahe's instrumental techniques as described in his Astronomiae Instauratae Mechanica [17].

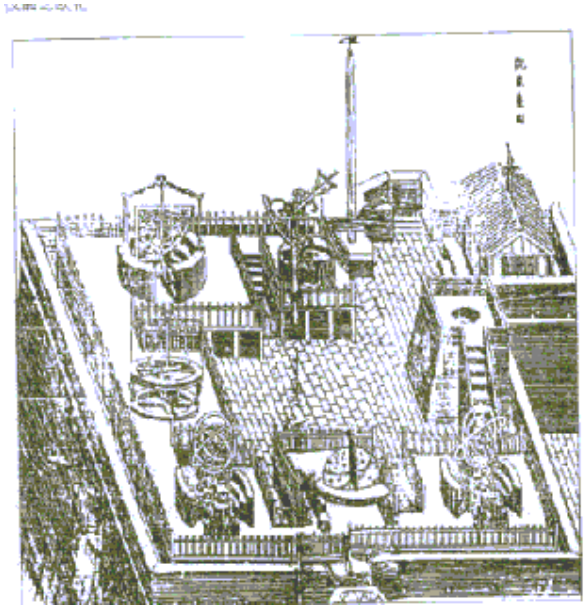

Figure.1 Instruments at Peking Observatory

From 1713 to 1715 Bernard-Kilian Stumpf (1655-1720) built an European-styled altazimuth for the observatory. From 1745 to 1754 Ignatius Koegler (1680-1746), Augustin de Hallerstein

(1703-1774) and their Chinese cooperators built an elaborate equatorial armillary sphere in line with the will of Emperor Qianlong. While the technique of the traditional armillary sphere was followed, the division of circles into 360°was adopted and the precise graduation system and techniques introduced by Verbiest were enhanced.

Missionaries introduced astronomical knowledge and instruments one after another. The instruments they built fell behind compared with the European products at the same period, but they were advanced in Chinese history. Verbiest didn't make a telescope. Telescope at that time was not competent at precise positional astronomical observation[18].

**5 The Jesuit's Constructing and Manufacturing Technology**

The missionaries' instruments were in European classical style except telescope. The function of Verbiest's instruments was concentrated with few rings. They reduced obstruction of the view and were convenient for observation. The important thing was that their graduations were far more precise and finer than that of the old Chinese instruments. For example, the graduations of the equatorial armillary sphere and its vernier were divided fine till 15″. In fact, the instruments of the missionaries were more advanced than Chinese armillary sphere.

We have not found any evidences that there was the technology such as set-screw and connection of screws in ancient China. They brought geometric method that could divide graduation and transversal line graduation. It might be said that Verbiest used the most advanced naked-eye sights before the invention of telescope.

Of course, the missionaries used their familiar European machining technology[19]. Tycho once used a horse-driven or wind-driven lathe to make his instruments.

Verbiest used a donkey milling machine to scrape and to grind the flat edges of the cast rings of his instruments (figure 2 and figure 3), and used a rotary grindstone to sharpen the cutters of the milling machine (figure 4). He also used a lathe in the cutting of the surface of celestial globe (figure 6). In addition, he once used a boring machine while making artillery. Briefly speaking, other mechanical techniques introduced by Verbiest include worm and worm wheel (figure 7), assembly pulley, man-powered forge-hammer (figure 8), hacksaw, screw and spanner (figure 9), bolt and nut (figure 10), European perspective as well as knowledge about mechanical analysis of material.

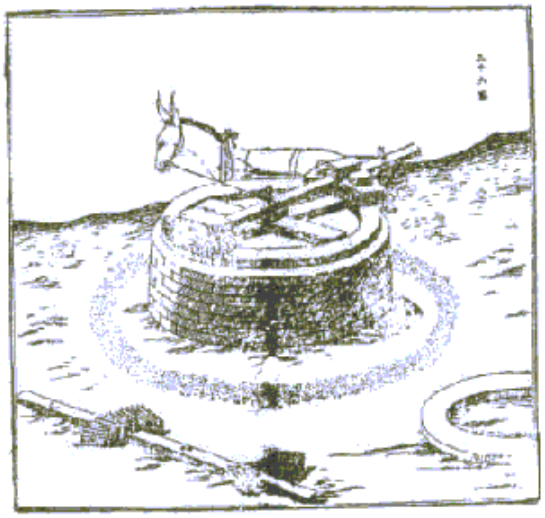

Figure.2 Scraping device

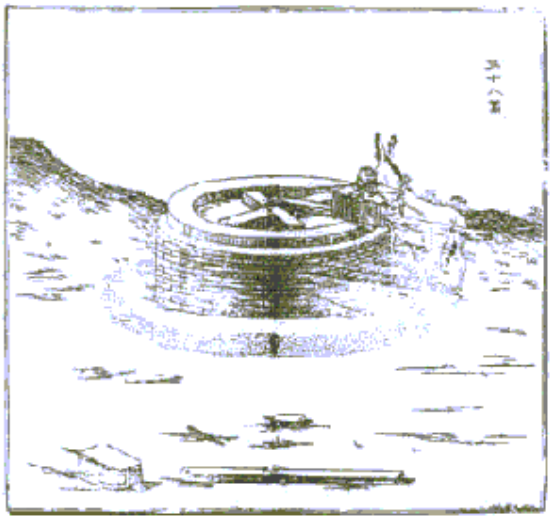

Figure.3 Grinding device

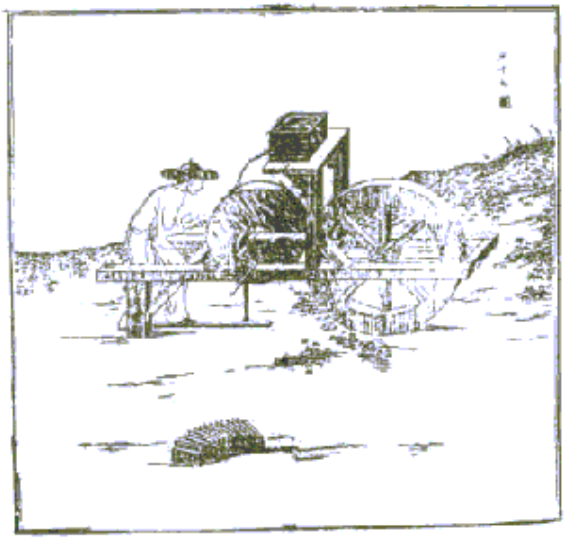

Figure.5 Sharpening the cutters

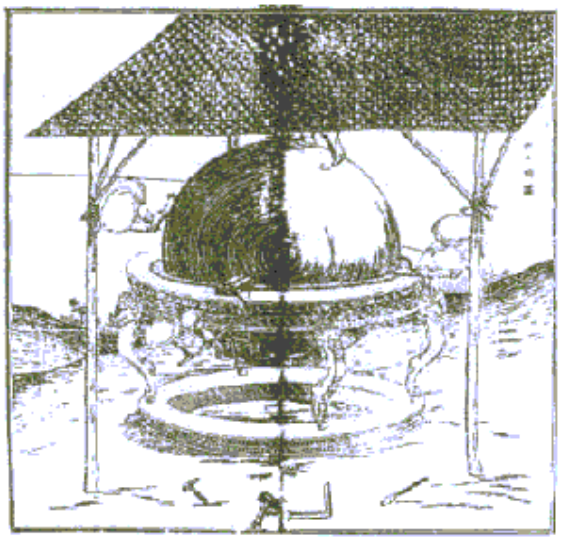

Figure.6 Cutting the surface of celestial globe

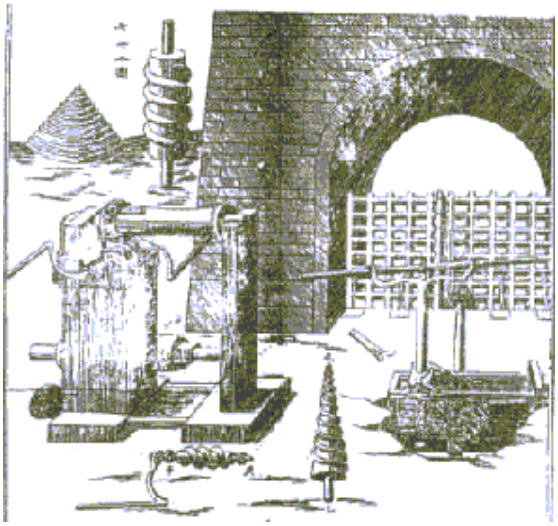

Figure 7 Worm and worm wheel

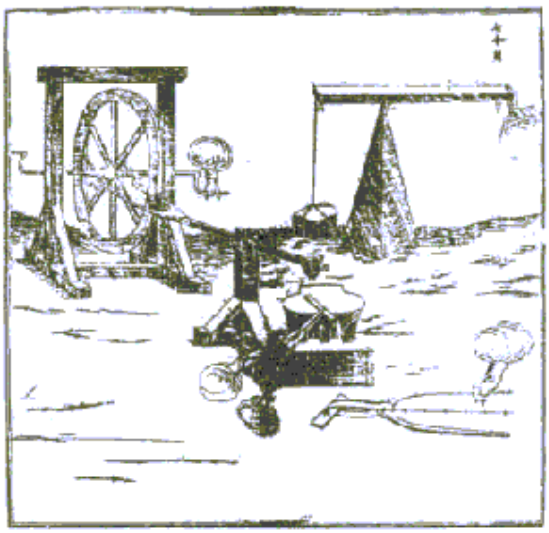

Figure 8 Man-powered forge-hammer

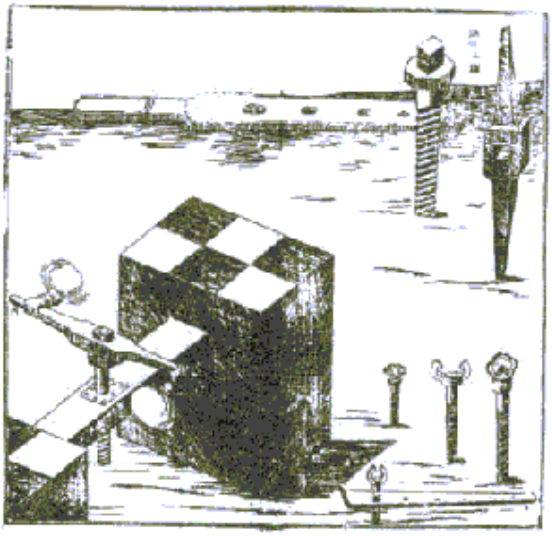

Figure 9 Screws

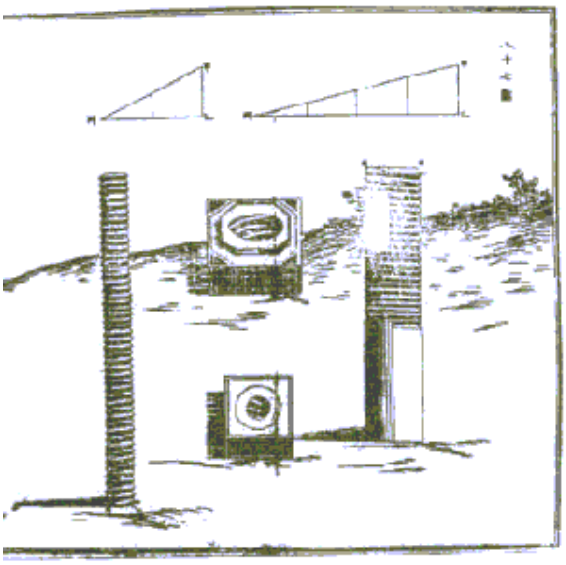

Figure 10 Bolt and nut

The missionaries paid attention to assimilating Chinese means of manufacture and cultural characteristics. Verbiest used Chinese technology of bronze casting to realize his European design. Dragons and other art modeling were used to decorate and support the instruments. He digested European technology and combined it with the traditional Chinese technology of casting and arts. It itself was a process of creation. Obviously, the cooperation of Chinese craftsmen was needed for this.

The instruments of the missionaries were out-dated compared to the new European instruments. They worked at the Astronomical Bureau for the purpose of missionary work and did not yearn for invention. The Chinese emperors only requested the missionaries to compile precise a calendar and to calculate eclipses. The instruments they made provided convenient and reliable tools for the calendar work then.

The European Johann Hevelius, who was at the same times as Verbiest, was the last outstanding typical representative in classical observation technology. He described his instruments in Machina Coelestis (1673). They imitated Tychonian design in substance. But there were obvious improvements in technology, for instance, the manufacturing technology was fine and regulation screw served as micrometer.

6 Conclusions: Limited Influence of European Astronomical Instruments and Knowledge

The introduction of European knowledge and instrumets didn't bring out the astronomical revolution like that in Europe[20]. European astronomical instrument-making technology was not widely spread in the society. The factors for the situation were very complicated[21].

Missionaries played an important role in the spread of European knowledge and technology, but their objective and means of activities affected the effect of the introduction of European science and technology. They were not special envoys of science and technology. They left Europe and were far from the mainstream of scientific and technological development of modern times. They were mainly interested in how to make Chinese accept their religious belief. When emperor was satisfied with calendar it was not necessary for the missionaries to seek newer scientific knowledge and more advanced technology, let alone it was not easy for them to know the

breakthrough of European science and technology.

The exchanges and spread of science and technology were realized with joint efforts of giver and receiver. In fact, missionaries brought more scientific knowledge and technology than what Chinese actually received. The limited need of Chinese society towards European astronomy and instruments restricted the spread and development of European science and manufacturing technology in this country. The Chinese government valued too much the actual objective and relied on missionaries' administering astronomical work after it was decided to use Western calendar.

Perhaps the royal government regarded Western scientific and technological experts as subjects of a feudal ruler that came as soon as called. The main task of the Astronomical Bureau was still limited to calculation of calendar, forecast of an eclipse of the sun and the moon and observing abnormal astronomical phenomena till the end of Qing dynasty. Chinese people were satisfied with the calendar made by missionaries and the instruments at the observatory. The scholars that had contacts with missionaries lacked a fairly correct and thorough understanding and grasp of Western learning and society. They lacked further opportunities to have contacts with Western learning and enough motives for new things and incentives.

With this background Chinese astronomers lacked the consciousness to deeply explore the universe and observe celestial bodies from the angle of material structure. They didn't have a high level demand towards and the precision of azimuth numerical value[22]. So it asn't strange at all that missionaries and Chinese scholars did not make telescopes.

The above-mentioned situation showed that Chinese society in 17th century lacked incentive to explore new knowledge and to innovate technology. It was difficult in the society to form an atmosphere of thorough digesting and absorbing foreign science and technology and pursuing world's trends. The new things introduced by missionaries and their cooperators promoted the revivification of Chinese science and technology, but it was not sufficient to fundamentally activate senile traditional Chinese scientific and technological system and couldn't start the modernization of Chinese science and technology.

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