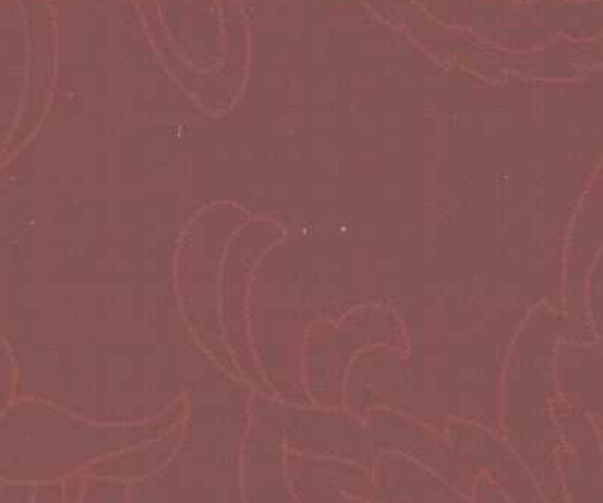
CHINA STUDIES

ANCIENT CHINA'S TECHNOLOGY AND SCIENCE

Institute of the History of Natural Sciences
Chinese Academy of Sciences

FOREIGN LANGUAGES PRESS

ISBN 978-7-119-05754-5



11-E-1567S

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Compiled by the Institute of
the History of Natural Sciences,
Chinese Academy of Sciences

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First Edition 2009

ISBN 978-7-119-05754-5

Published by
Foreign Languages Press
24 Baiwanzhuang Road, Beijing 100037, China
http://www.flp.com.cn

Distributed by
China International Book Trading Corporation
35 Chegongzhuang Xilu, Beijing 100044, China
P.O. Box 399, Beijing, China

Printed in the People's Republic of China

图书在版编目（CIP）数据

中国古代科技史：英文／中国科学院自然科学史研究所编著；
外文出版社英文部译．－北京：外文出版社，2009（学术中国）
ISBN 978-7-119-05754-5
Ⅰ．中…　Ⅱ．①中…②外…　Ⅲ．科学技术－成就－中国－古代
－英文　Ⅳ．N092

中国版本图书馆CIP数据核字（2009）第087293号

项目策划：胡开敏
责任编辑：杨春燕　李建安
装帧制作：北京维诺传媒文化有限公司
印刷监制：韩少乙

中国古代科技史

中国科学院自然科学史研究所　编著

出 版 人：呼宝民
总 编 辑：李振国
出版发行：
外文出版社（中国北京百万庄大街24号）
邮政编码：100037
网址：http://www.flp.com.cn
电话：008610-68320579（总编室）
008610-68995852（发行部）
008610-68327750（版权部）
制　　版：北京杰瑞腾达科技发展有限公司
印　　制：北京外文印刷厂
开　　本：787mm×1092mm　1/16　**印　　张**：40
2009年8月第1版第1次印刷
（英）
ISBN 978-7-119-05754-5
10800（精）
11-E-1567S

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Preface

For 2,000 years the Chinese people had a most remarkable record in science and technology. Then from two to three centuries ago a decline set in. Commenting on ancient Chinese technological discoveries and inventions, Dr. Joseph Needham writes in the preface to his great work *Science and Civilisation in China* that they were "often far in advance (as we shall have little difficulty in showing) of contemporary Europe, especially up to the 15th century".[1]

Scientific and technological achievements are without exception most vividly reflected in various activities of mankind. An original idea in science or a technological invention is no achievement unless it is verified in human practice and becomes a motive force of history. We are pleased to be able to say that all the achievements dealt with in this book qualify according to the above definition, that they are achievements in the true sense of the word.

Except for a few short periods, China has been a political entity from ancient times. The Chinese nation has stood firm on earth for the past 4,000 years and has been steadily prospering. A major reason for this is that China has achieved brilliantly in science and technology as outlined in part in this book.

The impact of China's science and technology on the rest of the world has been great. Early in the Han Dynasty, from 138 B.C., Zhang Qian in the capacity of a diplomatic envoy blazed the trail which was the "Silk Road" leading to Middle and West Asian countries. And there were other early Chinese explorers who carried China's advanced culture and science abroad, and returned with cultural achievements from other lands. There was the Buddhist priest Jian Zhen of the Tang Dynasty, who in the early years of the 8th

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1 J. Needham, *Science and Civilisation in China*, Vol. 1, p. 4.

century braved the hazardous voyage to Japan several times and finally succeeded in landing there. There was also Zheng He of the Ming Dynasty, who between 1405 and 1433 headed an impressive fleet on seven voyages to Southeast Asia and Africa.

In the 17th century, Western science and technology began flowing into China via the Jesuit missionaries. Some 200 years later, towards the end of the Qing Dynasty, the feudal rulers who had panicked before imperialist gun-boats suddenly turned from xenophobia to blind worship of anything foreign. This latter type of delusion infected certain influential people, who advocated "wholesale Westernization" even after the patriotic May 4th Movement of 1919. China was submerged in Western science and technology at the cost of almost total obliteration of her own fine traditions.

The Chinese Communist Party and the People's Government rehabilitated China's national traditions in science and technology after liberation in 1949. Today, in a new drive for socialist modernization, these traditions are carried forward alongside a quest for world-wide advanced theories and practices.

Investigation and excavation of cultural relics are meticulously done since these are of national concern. The many objects unearthed in the past 30 years are publicly exhibited and studied throughout the country, broadening and deepening people's knowledge of their cultural past. Ancient palaces, temples, pagodas and bridges — architectural wonders that have survived historical vicissitudes — and other sites are now kept in a good state of preservation. These and the unearthed articles are most eloquent witnesses to ancient Chinese scientific and technological achievement in the formation of one of the oldest civilizations of mankind.

Remarkable among them is a pair of jade burial suits sewn with gold thread which were found at Mancheng of Hebei Province in the tombs constructed in 113 B.C. for the princely house of Liu Sheng. Also the body of man buried 2,100 years ago at Jiangling of Hubei Province under the reign of the Emperor Wen Di of the Western Han Dynasty, the body and internal organs being better preserved than those of his contemporary the Marchioness of Dai at Mawangdui near Changsha in Hunan Province. Other ancient won-

ders are the large-scale construction site dating back to the Western Zhou Dynasty 3,000 years ago in Shaanxi Province, the remains of Epang Palace of the First Emperor of Qin (Qin Shi Huang) at Xianyang which was burned by Xiang Yü the Conqueror near the end of the 3rd century B.C., and the Qin and Han ship-building site recently unearthed at Guangzhou.

These cultural relics inspire utmost admiration for the ancient artisans' superb skill, which matches or even excels the best of today. Handicraft production is necessarily conditioned by the materials used, whether bronze, iron, jade, gold, silver or hardwood. The procuring and refining of these materials demanded skills in metallurgy, mining, mechanical engineering and even chemical engineering which warrant great pride today.

Science and technology thrived in the cultural upsurge after the Qin and Han dynasties. In astronomy, mathematics, physics, chemistry, meteorology, seismology and related sciences, China was once centuries in advance of the West. Zu Chongzhi's calculated ratio between the circumference of a circle and its diameter was not far off *pi*. In technology China has contributed to the world the compass, gunpowder, paper-making and printing. Originality is shown in many engineering works too. The Chinese people have through the ages shown resourcefulness and intelligence in science and technology as well as in politics, economics, military affairs, literature and art.

The creativeness and ability of the Chinese people were long handicapped by feudal obscurantism, however, especially in science and technology. The talents of many outstanding scientists, master technicians and artisans were buried in oblivion. Though nameless, these labouring people deserve their place in history. The fruits of their labour have come down to us.

Time cannot detract from their contributions. A look at modern achievements in science and technology often reveals footprints of predecessors who closely approached modern aims. The new is in fact brought into existence by sorting through the old. The facade of the new mansions may be different, but the materials used are invariably from familiar sources. Even science and tech-

nology from the West sometimes reveal certain Chinese traditional vestiges. A fitting example of ancient technology derived from long practice, forming a fine tradition and made to serve the present is the Zhaozhou Bridge built 1,300 years ago in Hebei Province. Its open-spandrel arch construction has been improved by the use of reinforced concrete in a cross-curved arch, and the bridge is still used today.

Turning past achievement into a new motive force, Chinese scientists and technologists believe that China now can and will reach or even surpass certain advanced world levels in the not too distant future.

Mao Yisheng

Records of Astronomical Events

Chen Xiaozhong

As one of the first countries to have started astronomical researches, China has in possession a store of written records of celestial events dating back to 40 centuries ago. Some of the records, systematically covering a wide range, remain valuable to modern astronomy. The present article, however, will be restricted to the documents with respect to sunspots, comets, meteors and novae.

"Dark Gaseous Masses" in the Sun

The ancient Chinese were earnest experimenters and industrious observers. They persisted in giving detailed descriptions of events on the sun, the source of light and heat. Chinese historical writings provide a rich source of such accurate records. A report of sunspots, the earliest known in the world, appeared in *Han Shu* (*History of the Han Dynasty*). It states that in the third month of the year 28 B.C., "the sun bore a yellowish colour when it rose and a mass of dark gas was observed at its centre". This account carries all the necessary information with respect to the time of occurrence as well as the precise location of the spots.

Actually, Chinese sunspot reporting started at a still earlier time. The book *Huai Nan Zi* (*The Book of the Prince of Huai Nan*) which was compiled around 140 B.C. told about the appearance of "a perching crow in the centre of the sun", which was nothing but a sunspot in the shape of a black bird. Later in the fourth month of 43 B.C., according to *History of the Han Dynasty*, "a black object the size of a pellet lay aslant over the sun near its edge".

Sunspots, or dark regions on the solar surface, are subject to constant changes arising as a result of the powerful movements involving enormous masses of matter there. Ancient Chinese astronomers made keen observations of the sunspots' durations, which ranged from no more than a day to half a year in a few particular cases, and such observations were recorded. A paragraph in *History of the Han Dynasty* states that in the first month of A.D. 188 "the sun wore the colour of orange and there was seen in its centre a dark gaseous mass in the shape of a flying magpie, which remained until several months later". And, "black spots as big as a plum", according to *Song Shi* (*History of the Song Dynasty*), appeared on March 12, 1131 and "did not vanish until three days later".

Sunspots remain for a time and change in shape during their course. A small black point near the edge of the sun at first, a sunspot grows and splits into two separate groups with a great number of tiny dots between them. Such processes did not go unobserved by the ancient Chinese. The source cited above gave a vivid description of the phenomenon involving huge masses of sunspots when it stated that on May 2, 1112 "in the centre of the sun there were dark spots the size of chestnuts, sometimes two and then three".

Relying solely on the naked eye, the ancient Chinese were able to watch the sun only when it was dimmed by clouds or haze, or when it was close to the horizon and enshrouded in mist. Otherwise they could only look at its image reflected by oil in a basin. But for all these restrictions documentary accounts of sunspots amounted to more than 100 within a period of some 1,600 years up to the 17th century. Chinese historical writings used such terms as "coins", "chestnuts", "flying magpies", etc. to depict the form of sunspots, and such expressions as "remained for several months" and "did not vanish until three days later" to show their respective durations.

As sunspots vary in size, time of occurrence and duration, only the large and conspicuous ones could be detected in the absence of the telescope. Thus the ancient records gave the number of the spots as no more than two or three and their durations as no less than several days or months. Modern observations provide convincing ex-

planations for this trend. And a description like "the sun became crimson and dim" was nothing but a truthful and scientific representation of the environments in which the particular observation was made.

Chinese astronomical observations have won the praise of scientists abroad. George Ellery Hale, an American astronomer, pointed out that the ancient Chinese made industrious and accurate astronomical observations. He said that the Chinese were roughly 20 centuries ahead of the Westerners in sunspot observation. Hale also noted the consecutiveness of the reports, which he called reliable sources.

The 11-year cycle of sunspots was discovered in 1843 by the German scientist H.S. Schwabe. Analysis of the ancient Chinese records leads to the same conclusion. The Yunnan Observatory in 1975 compiled a complete catalogue of Chinese sunspot records covering the period from 43 B.C. to A.D. 1638. A cycle of 10.6 $\pm$0.43 years was found through an analysis of the total 106 occurrences, together with two longer cycles of 62 and 250 years respectively. This is an important discovery in the study of ancient Chinese records and in the researches into the laws of sunspots.

The concurrence of the climaxes of auroras with those of sunspots was also mentioned in ancient Chinese writings. The abovementioned observatory in an analysis made in July 1977 with the help of ancient Chinese data found that the same 11-year cycle applies to both sunspots and auroras and that the cycle is not a phenomenon confined to the last three centuries. This discovery, instrumental to the solution of a series of geophysical and astronomical problems, gives another evidence to the value of Chinese sunspot accounts.

Comets

Descriptions of the comets appeared very early in China. *Chun Qiu* (*Spring and Autumn Annals*), a historical record, noted that in the seventh month in the autumn of 613 B.C. a comet was

seen travelling into the Great Dipper. This was the world's earliest report of Halley's Comet. Later, an entry in *Shi Ji* (*Records of the Historian*) gave the year though not the precise date of its reappearance in 467 B.C. This comet with an average cycle of 76 years is the largest and brightest one to be seen. Within a period of more than 2,500 years from the 7th century B.C. to the beginning of the present century, Chinese astronomers have kept written accounts of the appearance of Halley's Comet on 31 occasions. The description of 12 B.C. given in *History of the Han Dynasty* provided the best detail. It stated:

> On the 12th of the seventh month in the first year of the reign of Yanyuan of the Yuan Dynasty a star first appeared in the Dongjing[1] constellation, then travelled past Wuzhuhou[2] and the region north of Heshu[3]. It was seen successively in Xuanyuan[4] and the enclosure Taiwei[5] and was six degrees behind the sun when it appeared in the east in the morning. On the 13th it was seen in the west after sunset. Its tail was again in the enclosure Ziwei.[6] It headed south at the same longitudes as Tajiao [Arcturus] and Nieti [Muphrid]. It slowed down when it reached the enclosure Tianshi[7] with its tail in the centre of that group of stars. Ten days later it flew westward and after 56 days it disappeared along with Canglong[8] of the ecliptic.

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1 Dongjing, a lunar mansion, with μ Geminorum as its determinative star.

2 Wuzhuhou, five stars which are θ, λ, ι, γ, and φ Geminorum.

3 Heshu, a group of six stars which are λ, β and ϵ Canis Majoris and β, α and δ Geminorum.

4 Xuanyuan, a group of stars in Leo and Leo Minor.

5 Taiwei, an "enclosure" of stars in Leo, Virgo, Coma Berenices, Canes Venatici and Ursa Major.

6 Ziwei, an "enclosure" of stars most of which are the circumpolar stars.

7 Tianshi, an "enclosure" of stars in Hercules, Ophiuchus, Serpens, Bootes and Coronas Borealis.

8 Canglong, the Blue Dragon. This region includes seven mansions: Jiao, Kang, Di, Fang, Xin, Wei, Qi. It covers the Virgo, Libre, Scorpius and part of Sagittarius.

The passage, in concise and vivid language, gave lively descriptions of the route, apparent velocity and time of appearance and disappearance of this gigantic comet. Other Chinese historical writings also contain fairly detailed accounts of its appearance.

By 1910 Chinese comet reports amounted to no fewer than 500 and they were by no means confined to Halley's. The comet, providing a splendid sight, was by far not the only one that showed such glory. A Chinese historical article gave the information that in the year 676 a comet appeared in Gemini, heading for the region near Castor and was "as long as three *chi*".[1] It travelled to the north-east and "became three *zhang*[2] in length". It swept over the region near λ and μ Ursae Majoris, and headed for the region around θ Ursae Majoris. This passage, characteristic of all Chinese reports, gave not only a vivid picture of the comet itself, but also its exact locations and the name of every big star along its route.

Furthermore, the ancient Chinese tried to explain the origin of the comet's tail. *Jin Shu* (*History of the Jin Dynasty*) was evidently correct when it stated:

> When a comet appears in the morning, its tail points towards the west, and when it appears in the evening, its tail points to the east. Whether south or north of the sun, a comet always throws its tail away from the sun, and the tail varies in brightness and length. That is because the comet itself does not shine but merely reflects the sunlight.

The ancient Chinese also reported the splitting of comets. In the 10th month of A.D. 896, according to *Xin Tang Shu* (*New History of the Tang Dynasty*), three "travelling stars, one bigger than the other two, were seen" between Equuleus and Pegasus. "They travelled together eastwards, now close to each other and then

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1 According to researches by Yin Shitong of the Beijing Planetarium, a *chi* used in astrometry during the Tang Dynasty (608-907) was equivalent to 24.525 centimetres.

2 1 *zhang* = 10 *chi*.