SCIENCE AND CIVILISATION IN CHINA

The Chymists are a strange Class of Mortals, impelled by an incomprehensible Impulse to take their Pleasure amid Smoke and Vapour, Fume and Flame, Poisons and Poverty—yet among all these Evils, I seem to live so sweetly that may I die if I would change places with the Persian King!

Johann Beccher
Physica Subterranea, 1703

Quasi nimirum in Fatis esset, Sal hoc admirabile non minus in philosophia quam bello strepitus aderet, omniaque sonitu suo implere. (As if ordained by Fate, Nitre, that admirable salt, hath made as much noise in Philosophy as in War, all the world being filled with its thunder).

John Mayow
Tractatus Quinque Medico-Physici, 1674

For it is now certainly known that the great Kings of the uttermost East, have had the use of the canon many hundreds of years since, and even since their first civilitie and greatnesse, which was long before Alexander's time. But Alexander pierc'd not so far into the East.

Sir Walter Raleigh
History of the World, 1614

Dr John Bell of Antermony asked the Khang-Hsi Emperor's Tartar General of Artillery: 'How long the Chinese had known the use of gunpowder? He replied, above 2000 years, in fire-works, according to their records; but that it's application to the purposes of war, was only a late introduction. As the veracity and candour of this gentleman were well known, there was no room to question the truth of what he advanced on the subject.'

John Bell's 1 Jan. 1721
Travels from St. Petersburg in Russia to Diverse Parts of Asia, 1763

And though it be very true that man is but the Minister of Nature, and can but duely apply Agents to Patients (the rest of the Work being done by the applyed Bodies themselves), yet by his skill in making these Applications, he is able to perform such things as do not only give him a Power to master Creatures otherwise much stronger than himselfe; but may enable one man to do such wonders, as another man shall think he cannot sufficiently admire. As the poor Indians lookt upon the Spaniards as more than Men, because the Knowledg they had of the Properties of Nitre, Suplphur and Charcoal duely mixt, enabled them to Thunder and Lighten so fatally, when they pleas'd.

Robert Boyle
Some Considerations touching the Usefulnesse of Experimental Philosophy, propos'd in a Familiar Discourse to a Friend, by way of Invitation to the Study of it, 1663

中國科學技術史

李約瑟著

冀朝鼎

SCIENCE AND CIVILISATION IN CHINA

BY

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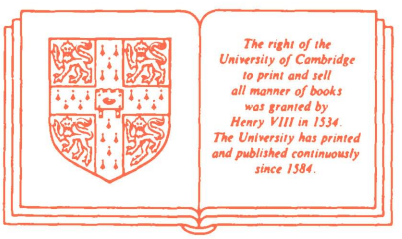
Part 7: MILITARY TECHNOLOGY; THE GUNPOWDER EPIC



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AO

To
the memory of
FU SSU-NIEN

eminent scholar of history and philology,
then at Lichuang in Szechuan, and most friendly
welcomer to war-time China,
who led a discussion one evening while we were
there on the history of gunpowder in China;

and to
YÜ TA-WEI

physicist, then
Ping-kung-shu Shu-chang (Intendant-General of Arsenals)
1942–1946
whose 'field coffee' I used to drink with him in his
office, and with whom we had a happy reunion in 1984,

this volume is dedicated.

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LIST OF ABBREVIATIONS

The following abbreviations are used in the text and footnotes. For abbreviations used for journals and similar publications in the bibliographies, see pp. 584 ff.

BN	Bibliothèque Nationale, Paris.
CC	Chia Tsu-Chang & Chia Tsu-Shan (*1*), *Chung-Kuo Chih Wu Thu Chien* (Illustrated Dictionary of Chinese Flora), 1958.
CCL	*Chê Chiang Lu* (Biographies of [Chinese] Engineers, Architects, Technologists and Master-Craftsmen). 1 to 6 See Chu Chhi-Chhien & Liang Chhi-Hsuing (*1* to *6*); 7 See Chu Chhi-Chhien, Liang Chhi-Hsuing & Liu Ju-Lin (*1*); 8, 9 See Chu Chhi-Chhien & Liu Tun-Chên (*1*, *2*).
CCT	Chao Shih-Chên, *Chhê Chhung Tau* (Illustrated Account of Muskets, Field Artillery and Mobile Shields, etc.), Ming, *c.* +1585.
CHHS	Chhi Chi-Kuang, *Chi Hsiao Hsin Shu* (New Treatise on Military and Naval Efficiency), Ming, +1560, pr. +1562, often repr.
CHS	Pan Ku, (and Pan Chao) *Chhien Han Shu* (History of the Former Han Dynasty), H/Han, *c.* +100.
CHSK	Ting Fu-Pao (ed.), *Chhüan Han San-Kuo Chin Nan-Pei-Chhao Shih* (Complete Collection of Poetry from the Han, Three Kingdom, Chin and Northern and Southern Kingdoms), Peking, *c.* 1935. Index by Tshai Chin-Chung, Harvard–Yenching Institute, Paping, 1941 repr. Taipei, 1966.
CHTP	Chêng Jo-Tsêng, *Chhou Hai Thu Pien* (Illustrated Seaboard Strategy and Tactics), Ming, +1562, repr. +1572, +1594, +1624, etc.
CKKCSL	*Chung-Kuo Kho Chi Shih Liao* (Materials on the History of Science and Technology in China), a journal.
CSHK	Yen Kho-Chün (ed.), *Chhüan Shang-Ku San-Tai Chhin Han San-Kuo Liu Chhao Wên* (Complete Collection of prose literature (including fragments) from remote antiquity through the Chhin and Han Dynasties, the Three Kingdoms, and the Six Dynasties), 1836.
CLPT	Thang Shen-Wei *et al.* (ed.), *Chêng Lei Pên Jahao* (Reorganised Pharmacopoeia), Sung, ed. of +1249.

CTS Liu Hsü, *Chiu Thang Shu* (Old History of the Than Dynasty), Wu Tai, +945.

CYMTYL Attrib. Chêng Ssu-Yuan, *Chen Yuan Miao Tao Yao Lüeh* (Classified Essentials of the Mysterious Tao of the True Origin of Things), Ascr. Chin (+3rd) but probably mostly Thang (+8th and +9th).

DSB *Dictionary of Scientific Biography* (16 vols.), ed. C.G. Gillespie et al., (Scribner, New York, 1970).

HCC Hsü Tung, *Hu Chhien Ching* (Tiger Seal Manual, a Military Encyclopaedia), Sung, begun +962, finished +1004.

HCT *Huo Chhi Thu* (Illustrated Account of Gunpowder Weapons and Firearms), running-head title of the Hsiang-yeng edition of the *Huo Lung Ching*, q.v.

HHPT Su Ching *et al.* (ed.), *Hsin Hsiu Pên Tshao* (Newly Improved Pharmacopoeia), Thang, +659.

HHS Fan Yeh & Ssuma Piao, *Hou Han Shu* (History of the Later Han Dynasty), +450.

HKPY *Huo Kung Pei Yao* (Essential Knowledge for the Making of Gunpowder Weapons), alternative title of Pt. 1 of the *Huo Lung Ching*, q.v.

HKTC Wei Yuen & Lai Tsê-Hsü, *Hai Kuo Thu Chih* (Illustrated Record of the Maritime [Occidental] Nations), Chhing, 1844, enlarged 1847, further enlarged, 1852, abridged edition, 1855.

HLC Chiao Yü, *Huo Lung Ching* (The Fire-Drake (Artillery) Manual). Ming, +1412, but probably continuing information dating from the previous half-century, perhaps back to +1300. In three parts. The first part of the back is fancifully attributed to Chuko Wu-Hou (Chuko Liang, +3d cent.) & Liu Chi (+1311 to +1375). The latter appears as editor but was perhaps co-author. The second part of the book is attributed to Liu Chi, but Mao Hsi-Ping (+1632) was probably the writer. The third part is by Mao Yuan-I (fl. +1628) and has a preface by Chuko Kuang-Lung dated +1644.

HSCH/TCTC Liu Shih-Chi: *Hsü Sung Chung-Hsing Pien Nien Tzu Chih Thung Chien* (Continuation of the 'Mirror of History for Aid in Government' for the Sung dynasty from its Restoration Onwards), i.e. The Southern Sung from +1126. Sing, *c.* +1250.

HTCTC/CP Li Tao *Hsü Tzu Chih Thung Chien Chhang Phien* (Continuation of the 'Comprehensive Mirror (of History) for Aid in Government), dealing with events from +960 to +1126, i.e. the Northern Sung dynasty, Sung, +1183.

HTS Ouyang Hsiu & Sung Chhi, *Hsin Thang Shu* (New History of the Thang Dynasty), Sung, +1061.

HWHTK Wang Chhi (ed.) *Hsü Wên Hsien Thung Khao* (Continuation of the 'Comprehensive Study of (the History of) Civilisation'), Ming, +1586, pr. +1603.

LPSC (TC) Chhi Chi-Kuang, *Lien Ping Shih Chi Tsa Chi* (Miscellaneous Records concerning Military Training and Equipment), an appendix to *Lien Ping Shih Chi*, Ming, +1568, pr. +1571.

MCPT Shen Kua, *Mêng Chhi Pi Than* (Dream Pool Essays), Sung, +1089.

NKKZ *Nihon Kagaku Koten Zenshi* (Collection of Works concerning the History of Science and Technology in Japan), 12 vols., 1944; 10 vols. 1978.

PL Ho Ju-Piu, *Ping Lu* (Records of Military Art). Ming, +1606, pr. +1628, later eds. +1630, +1632.

PPT/NP Ko Hung, *Pao Phu Tzu (Nei Phien)*, (Book of the Preservation-of-Solidarity Master; Inner Chapters), Chin, *c.* +320.

PTKM Li Shih-Chen. *Pên Tshao Kang Mu* (The Great Pharmacopoeia), Ming, +1569.

PTKMSI Chao Hsüeh-Min, *Pên Tshao Kang Mu Shih I* (Supplementary Amplifications for the 'Great Pharmacopoeia' of Li Shih-Chen), Chhing, begun *c.* +1760, first prepared +1765, prolegomena added +1780, last date in text 1803. First pr. 1871.

R Read, Bernard E. *et al.*, Indexes, translations and précis of certain chapters of the *Pên Tshao Kang Mu* of Li Shih-Chen. If the reference is to a plant see Read (1); if to a mammal, see Read (2); if to a bird see Read (3); if to a reptile see Read (4 or 5); if to a mollusc see Read (5); if to a fish see Read (6); if to an insect see Read (7).

RARDE Royal Armament Research and Development Establishment, Fort Halstead, Kent.

SCP Chao Shih-Chên, *Shen Chhi Phu* (Treatise on Extraordinary (lit. Magical) Weapons, i.e. Muskets), Ming, +1598.

SF Thao Tsung-I (ed.), *Shuo Fu* (Florilegium of (Unofficial) Literature), Yuan, *c.* +1368.

SKCS *Ssu Khu Chhüan Shu* (Complete Library of the Four Categories), Chhing, +1782; here the reference is to the *tshung-shu* collection printed as a selection from one of the seven imperially commissioned MSS.

SKCS/TMTY Chi Yün (ed.), *Ssu Khu Chhüan Shu Tsung Mu Thi Yao* (Analytical Catalogue of the *Complete Library of the Four Categories*), +1782; the great bibliography of the imperial MS collection

ordered by the Chhien-Lung emperor of Chhing in +1772.

STTH Wang Chhi, *San Tshai Thu Hui* (Universal Encyclopaedia), Ming, +1609.

TCKM Chu Hsi *et al.* (ed.), *Thung Chien Kang Mu* ((Short View of the) *Comprehensive Mirror* (*of History*), *for Aid in Government*), classified into Headings and Subheadings); the *Tzu Chih Thung Chien* condensed, a general history of China, Sung, +1189; with later continuations.

TKKW Sung Ying-Hsing, *Thien Kung Khai Wu* (The Exploitation of the Works of Nature), Ming, +1637.

TPKC Li Fang (ed.) *Thai-Phing Kuang Chi* (Copious Records collected in the Thai-Phing reign-period), Sung, +978.

TPYC Li Chhüan, *Thai Pai Yin Ching* (Manual of the White and Gloomy Planet (of War, Venus)), treatise on military and naval affairs, Thang, +759.

TPYL Li Fang (ed.), *Thai-Phing Yü Lan* (the Thai-Phing reign-period Imperial Encyclopaedia), Sung, +983.

TSCC Chhen Mêng-Lei et al. (ed.), *Thu Shu Chi Chhêng*; the Imperial Encyclopaedia of +1726). Index by Giles, L. (2). References to 1884 ed. given by chapter (chüan) and page. References to 1934 photolitho reproduction given by tshê (vol.) and page.

TT Wieger, L. (6), *Taoïsme*, vol. 1, Bibliographie Générale of the works continued in the Taoist-Patrology, *Tao Tsang*).

TTSLT *Thai Tsu Shih Lu Thu* (Veritable Records of the Great Ancestor (Nurhachi, d. +1626, retrospectively emperor of the Chhing), with illustrations). Ming, +1635, revised in Chhing, +1781.

WCTY Tsêng Kung-Liang (ed.), *Wu Ching Tsung Yao* (The Most Important Affairs to the Military Classics—a military encyclopaedia). Sung, +1044.

WCTY/cc Tsêng Kung-Liang (ed.), *Wu Ching Tsung Tao (Chhien Chi)*, military encyclopaedia, first section, Sung, +1044.

WHTK Ma Tuan-Lin, *Wên Hsien Thung Khao* (Comprehensive Study of (the History of) Civilisation), Yuan, +1319.

WPC Mao Yuan-I, *Wu Pei Chih* (Treatise on Armament Technology), Ming, +1628.

WPHLC Attrib. Chiao Yü, *Wu Pei Huo Lung Ching* (The Fire-Drake Manual and Armament Technology), Ming, after +1628, but containing much material from earlier versions of the *Huo Lung Ching*.

YCLH Chang Ying (ed.), *Yuan Chien Lei Han* (encyclopaedia), Chhing, +1710.

YH Wang Ying-Lin, *Yü Hai* (Ocean of Jade, an encyclopaedia of quotations). Sung, +1267 but not pr. till Yuan, +1337/+1340, or perhaps +1351.

YHSF Ma Kuo-Han (ed.), *Yü Han Shan Fang Chi I Shu* (Jade-Box Mountain Studio Collection of (reconstituted and sometimes fragmentary) Lost Books), 1853.

AUTHOR'S NOTE

This volume has been forty-three years in the gestating. On 4th June 1943 Huang Hsing-Tsung[1a] and I landed at Lichuang[2] in Szechuan after a rather adventurous journey down the Min-chiang and the Yangtse River from Wu-thung-chhiao[3].[b] There, near the delightful little town, were the Chinese–German Thung-Chi[4] University, and also the evacuated National Institutes of History and Sociology of Academia Sinica. These were then headed by two very famous scholars, Fu Ssu-Nien[5] and Thao Mêng-Ho[6] respectively, whom I was honoured to meet. Also in the neighbourhood were the evacuated National Archaeological Museum directed by Li Chi[7], and the Institute for the History of Chinese Architecture under Liang Ssu-Chhêng[8]. One evening the talk turned to the history of gunpowder in China, and Fu Ssu-Nien himself copied out for us the earliest printed passages on its composition from the *Wu Ching Tsung Yao* of +1044, a book which we did not then possess.[c] It was at Lichuang also that I first met Wang Ling[9] (Wang Ching-Ning[10]), who was destined to be my initial collaborator in the writing of *Science and Civilisation in China*, from 1948 to 1957, in Cambridge. At that time, he was a young research worker in the History Institute of Academia Sinica, and made the history of gunpowder, in all its ramifications, a lifelong study. Later on, he pursued a distinguished career as research professor of the Institute of Advanced Studies at the Australian National University at Canberra.

Of the other two collaborators whose names are on the title-page of this volume, Ho Ping-Yü[11], now Professor of Chinese at Hongkong University, has the great merit of having written the first draft of it. Having grown up in Singapore, he became an eminent historian of science, and later professor at Kuala Lumpur and Brisbane successively, since when he has produced many excellent books of his own. Finally, Lu Gwei Djen[12] was one of the first who converted me to Chinese studies from 1937 onwards, at which time we planned the present series of volumes; and when, twenty years later, she returned from UNESCO in Paris to Cambridge, she succeeded Wang Ling as my chief collaborator. This she still is. For the present book we have together checked all the battle accounts and the entries in the military encyclopaedias.

With the production of this volume, it will be been that all three of the fun-

[a] My first colleague in the Sino-British Science Cooperation Office, and in recent years our collaborator in Botany and Nutritional Science.

[b] There are fuller accounts in Needham & Needham (1), pp. 4off., 119, and Huang Hsing-Tsung (1), pp. 45 ff.

[c] See pp. 117–26 below.

[1] 黃興宗 [2] 李庄 [3] 五通橋 [4] 同濟 [5] 傅斯年
[6] 陶孟和 [7] 李濟 [8] 梁思成 [9] 王鈴 [10] 王靜寧
[11] 何丙郁 [12] 魯桂珍

damental inventions enumerated by Francis Bacon in +1620 have now been dealt with in detail. We quoted the *Novum Organon* fully in Vol. 1[a], but the passage is well worth reproducing in shortened form here.[b]

> Discoveries are to be seen nowhere more conspicuously than in those three which were unknown to the ancients, and of which the origin, though recent, is obscure and inglorious; namely printing, gunpowder, and the magnet. For these three have changed the whole face and state of things throughout the world, the first in literature, the second in warfare, the third in navigation; whence have followed innumerable changes; insomuch that no empire, no sect, no star, seems to have exerted greater power and influence in human affairs, than these three mechanical discoveries.

So, looking back, we dealt with the magnetic compass first, in Vol. 4, pt. 1, then with paper and printing, by the care of our valued collaborator, Professor Chhien Tshun-Hsün[1], in Vol. 5, pt. 1, and now finally with gunpowder in Vol. 5, pt. 7. Francis Bacon died without knowing that every one of the discoveries which he singled out had been Chinese. And although we have not been able to identify the personal name of any individual as the *fons et origo* of the three discoveries, no doubt whatever can remain about the people in the midst of whom they first came into being.

The present volume is the middle one of three on military technology. It is appearing ahead of the others simply because it is now ready. The first (Vol. 5, pt. 6), after an introduction, will deal with (b) Chinese literature on the art of war, (c) basic concepts of the classical Chinese theory of war, (d) distinctive features of Chinese military thought, (e) projectile weapons, the bow and crossbow, (f) ballistic machinery—pre-gunpowder artillery, and (g) early poliorcetics—the siege and defence of cities. I owe a great deal of gratitude to my collaborators in these subjects, Wang Ching-Ning, Robin Yates, Krzysztof Gawlikowski and Edward McEwen.

The third part (Vol. 5, pt. 8) wil deal with (i) close-combat weapons, (j) chariot warfare, (k) cavalry techniques, including the invention of the stirrup and its spread, (l) armour and caparison, (m) camps and formations, (n) signalling and other forms of communication; and the whole will end with some comparisons and conclusions. Here my principal collaborators have been Wang Ching-Ning, Robin Yates, the late Lo Jung-Pang[2] and Albert Dien. Professor Robin Yates of Harvard is taking charge of the general editing of both these.

It is natural enough that the present volume should take its place among the military three because the finding of the gunpowder mixture in the middle of the +9th century was no doubt the greatest of all Chinese military inventions. The gunpowder rocket might indeed turn out, as we venture to say in this volume, to be the greatest single invention ever made by man, for if the sun cools or over-

[a] P. 19.

[b] Montagu ed. (Latin), vol. 9, pp. 381–2; Ellis & Spedding ed. (English), p. 300. It is in Bk. 1 of the original work, Aphorism 129.

[1] 錢存訓 [2] 羅榮邦

heats, and we have to go somewhere else, the rocket will be our only means of doing so, since it is the sole vehicle known to man capable of navigating in outer space. Not of course the gunpowder rocket, as the Chinese military engineers knew it in the middle of the +12th century, but the rocket vehicles of today and tomorrow, powered by liquid fuels, or more probably by sub-atomic nuclear reactions.

In the same way, the story we tell here is far more exciting than it could have been if warlike applications alone had been in question. Quite apart from the application of explosions in mining, quarrying, and the building of human lines of communication—all civil engineering tasks—gunpowder, the first chemical explosive known to man, had a vital role in the development of all heat engines. Mechanical engineers were therefore also involved. Not everyone realises that before the steam-engine came into its heyday, Christiaan Huygens and Denis Papin in the late +17th century tried to make successful gunpowder-engines; and although they could never get them to work, it put them in mind of simple water and condensible steam. Hence Thomas Newcomen's success in +1712.

We have also tried to tell the story of the internal-combustion engine, which followed upon his triumph, though long afterwards; and how by 1830 Luigi de Cristoforis suggested fuelling it with petrol. The oldest internal-combustion engine was of course the cannon, but from the engineering point of view its piston was not tethered, and the work it did was not useful work. With petrol and similar fuels the internal-combustion engine came into its own, permitting, among other things, the successful aviation of today. But petrol was nothing else than the old Greek Fire, first distilled from petroleum by Callinicus in +7th-century Byzantium. This was the greatest incendiary predecessor of gunpowder; and in fact the first use of the latter in warfare was as a slow-match in the ignition-chamber of a Chinese Greek-Fire projector. This event we date at +919. So the wheel had at last come full circle, and the only tragic aspect of the affair was the centuries of time it had taken for men to see the beneficent uses of a discovery, and the celerity with which its evil uses were found out and put into practice.

We end this volume with an excursus on the travel of the knowledge of gunpowder from east to west. Perhaps the most extraordinary fact is that all the stages, from the incendiary uses of the mixture right through to the metal-barrel hand-gun or bombard, with the projectile fully occluding the bore, were passed through in China, before Europeans knew of the mixture itself. Probably there were three comings. Roger Bacon by +1260 or so was able to study fire-crackers, doubtless brought west by some of his brother friars; and the Arabian military engineers in the Chinese service must have let Ḥasan al-Rammāḥ know about bombs and rockets by +1280. Then, within the following twenty years, came the cannon, quite possibly directly overland through Russia.

The preparation of this volume has been accompanied by many changes in our group. First I must refer to the much-lamented death of Peter Burbidge in

May 1985. He had been not only Executive Vice-Chairman of the East Asian History of Science Trust, but also from 1984 onwards the presiding genius, and benign protector, of all our volumes, the publication of which he guided as Production Director of the Cambridge University Press. At our weekly meetings we have missed him tremendously. But we are fortunate that Colin Ronan, our collaborator in the *Shorter Science and Civilisation in China* series, has taken over as Project Co-ordinator.

Next, this volume has been passing through the press alongside the erection of a new and permanent building for the East Asian History of Science Library, on the basis of funds most generously subscribed both in Hongkong and Singapore. We owe particular gratitude to Dr Mao Wên-Chi[1], Chairman of the East Asian History of Science Foundation Ltd. in Hongkong, with its members and benefactors; and to the outstandingly liberal beneficence of Tan Sri Tan Chin Tuan[2] of the Overseas Chinese Banking Corporation in Singapore.

Similarly, our East Asian history of Science Board, Inc. of New York, headed by Mr John Diebold, has concentrated rather on raising funds for the endowment and research necessitated by the *Science and Civilisation in China* project, and it is due to them that the National Science Foundation, the Luce Foundation and the Mellon Foundation, have contributed generously to this end. And here Japan has also joined in, for the National institute for Research Advancement (NIRA) of Tokyo has given a noble benefaction directed mainly for Vol. 7. Our deepest thanks are due to this organisation, directed by Dr Shimokobe Atsushi[3]. One cannot be too grateful for such help in the payment of necessary emoluments and research expenses for our far-flung collaborators.

As usual, we would like also to thank those who have been of special help to us in the preparation of this volume. Thus we are glad to number among our friends Mr Howard Blackmore, formerly Deputy Keeper of the Armouries at H.M. Tower of London, who gave us valuable criticism throughout; Dr Nigel Davies, who arranged for experimental trials of gunpowders containing different nitrate percentages, at the Royal Armament Research and Development Establishment at Fort Halstead in Kent; and Dr Graham Hollister-Short, who greatly helped us in our work on the old gunpowder triers or testers, precursors of the gunpowder-engines, as also with the history of blasting in mines and quarries. Similarly, Dr Nakaoka Tetsurō[4] gave us much help with the Japanese context of the *Mōko Shūrai Ekotoba* (p. 177), the only surviving picture of a +13th-century bursting bomb-shell. A special debt is owing to De Clayton Bredt of Brisbane, the discoverer of the +10th-century painting of a fire-lance, who read through the whole volume and offered numerous amendments.

Next we wish to record our indebtedness to all the staff of the East Asian History of Science Library. In particular we want to thank Mrs Liang Chung Lien-Chu[5] who has attended to all the cross-references, as well as checking the

[1] 毛文奇 [21] 陳振傳 [3] 下河邊淳 [4] 中岡哲郎 [5] 梁鍾連杼

proofs of Bibliographies A and B. When we have had occasion to seek linguistic help, we have turned, as before, to Prof. D.M. Dunlop for Arabic, the late Dr Charles Sheldon and Dr Ushiyama Teruyo[1] for Japanese, and Prof. Shackleton Bailey for Sanskrit.

So now let us pull the lanyard and fire off this unpowder volume (to use an appropriate analogy) upon the Republic of Learning, not indeed with the intention of doing any damage, but rather hoping that it may help those still looking for enlightenment about the history of gunpowder-weapons and heat-engines. War may or may not have been a decisive factor in human evolution and social progress, but what cannot be denied is that the steam-engine and the internal-combustion engine have been this, and all were children of the cannon. And that in turn was one development of the fire-lance, while the other was the rocket, on which all space travel depends. Gunpowder-engines and the steam-engine no less than the rocket vehicle were thoughts springing from the European Scientific Revolution—but all the previous developments, through eight preceding centuries, had been Chinese.

[1] 牛山耀代

them.'[a] Knowing but refraining, this is the lesson that humanity must at all costs learn, for the price is survival, continued existence, itself, no less.[b]

(19) Gunpowder as Propellant (II); the Development of the Rocket

Now at long last we come to the problem of the rocket. It is a peculiarly difficult one for many reasons, not least because a device changed fundamentally while a name did not. 'Fire-arrow' (*huo chien*[2]), as we have seen (pp. 11 ff.), was a term applied in Thang times and much earlier to the incendiary arrow; but in the days of the Mongolian dynasty, the Yuan, it had come to mean the rocket. Nobody noticed the change, and no-one gave a thought to the difficulties which in the course of centuries it would cause for historians of technology. Thus rockets were certainly in use in warfare by about +1280, but that is just the time when Ḥasan al-Rammāḥ[c] was calling them 'arrows of China' (*sahm al-Khiṭāi*), which implies that they had already been known and used there for some time previously (p. 41 above). Their presence in Marcus Graecus, at a roughly similar date, is rather less certain; his 'ignis volantis in aere' may have been rockets, but were much more probably fire-lances.[d] At another point earlier on (pp. 153, 226) we were driven to the conclusion that the rocket is almost certainly not described in the *Wu Ching Tsung Yao* of +1044; the 'gunpowder whip-arrow' (*huo yao pien chien*[3]) was rather an incendiary javelin projected by two men. Yet the rockets are present in full force by +1340, so it is somewhere in those three centuries that we have to look to find their origin. We believe that it is to be sought essentially in the 'ground-rat' or 'earth-rat' (*ti lao shu*[4]), a firework first used for scaring troops and upsetting cavalry, then applied, with stick (the arrow shaft) and balance-weight, to long-distance trajectories.[e] But exactly when?

[a] *Wei yu Tao chih shih nêng wei chih; i nêng nêng chih erh pu wei chih*![1] (*Kuan Yin Tzu*, p. 20*a*; *Wên Shih Chen Ching*, ch. 7, p. 1*b*).

[b] To decide what to refrain from will of course necessitate great judgment. The Tokugawa Japanese knew, but refrained, in our view for the wrong reasons, and under conditions unrepeatable today. But Perrin's admiration for them was not wholly unjustified. Nor are we maintaining that pacifist reason and feeling have always been justified; later we may say something on war as an instrument of human progress. Meanwhile it may be noted that the history of pacifist philosophy in China has been told by Tomkinson (1).

Today, when many find it hard to distinguish 'terrorists' from 'freedom-fighters', we are witnessing an unprecedented 'democratisation', or better, universalisation, of sophisticated explosives and highly developed firearms. One can only hope that it is a phase which will give way to the just, equitable and healthy society of the future.

[c] Cf. Reinaud & Favé (2), pp. 314 ff.; Partington (5), p. 203.

[d] We shall remember the case of the *fei huo chhiang*[5] (p. 225 above) which must mean 'flying-fire spears' and not 'flying fire-spears'. It does not therefore attest the presence of rockets in +1232, as has so often been thought (e.g. von Romocki (1), vol. 1, pp. 46 ff.; Feldhaus (1), col. 853), though by that time they may well have existed (cf. p. 512 below). Davis (10) got it right.

[e] See pp. 477 ff. below. Of course, it may have originated as a recreational firework.

[1] 惟有道之士能爲之, 亦能能之而不爲之 [2] 火箭 [3] 火藥鞭箭
[4] 地老鼠 [5] 飛火鎗

Many things make this search difficult. For example, there was the secrecy generally surrounding arsenal and military supplies (cf. pp. 24, 93);[a] and there happens to be a dearth of battle accounts between +1100 and +1300 which mention rockets or anything similar. They do not seem to have been used in the wars between the Sung and the Chin Tartars which culminated in the fall of Khaifêng (+1126). Yet the fire-lance, as we have noted (p. 223) was already in use by +950, and over the centuries the strong backward pressure on the arms of the wielder, the recoil, must have become well known. Moreover, during fights a chance sword-cut which hacked off the haft of a fire-lance would have released its flame-throwing tube to fly swishing backwards, perhaps up into the air.[b] And there is another close connection here, in that fire-lances were occasionally rocket-propelled (cf. p. 484 below). We shall suggest that the rocket originated, as it were, from the tube of the fire-lance filled with gunpowder, but detached from its handle, and therefore free to travel in whatever direction chance dictated.

In these circumstances the best plan will be to describe first the several types of rocket weapon at the time when they first come fully into the limelight, and then to look again at their history with a view to sketching out as far as we can their probable origin and development. Here it will be desirable to follow the most logical order of arrangement possible, and this we try to do in the following sub-sections. Such order cannot be found in the military compendia of the Yuan and Ming themselves, where the weapons are all jumbled up with juxtapositions which are sometimes quite confusing; each text and each illustration have to be carefully studied before one can decide to what genus and species the weapon in question belongs.[c]

(i) *The* ti lao shu[4] *(ground-rat or earth-rat) in military use*

This contraption we met with at a much earlier point when speaking of civilian firework displays (p. 134), concluding that it was a tube of bamboo filled with low-nitrate gunpowder and having a hole in the septum at one end, then lit and allowed to rush violently about all over the floor or the ground, in a rudimentary form of rocket-propulsion. The thing could just as easily be made by floats to skate over the surface of water, when it was called *shui shu*[5]; and it took other

[a] To take a concrete case, gunpowder weapons are completely excluded from Wang Ying-Lin's *Yü Hai* encyclopaedia, though compiled as late as +1267.

[b] We owe this point to Dr Nigel Davies of RARDE.

[c] There is quite a literature on the origin and development of rockets in China, but most of it is misleading when not positively wrong, as for instance the paper of Strubell (1).

At an earlier point (p. 108) we drew attention to the possible significance of the fact that in the Germanic languages gunpowder is called *kraut*, normally a vegetable drug, like *yao*[1] in *huo yao*[2]. Now we find that the Dutch word for rocket is *vuurpijlen*, as if it was a direct translation from *huo chien*[3], i.e. fire-arrow. It was Winter (5), p. 10, who drew attention to this. Such strange similarities are at least worth meditating.

[1] 藥 [2] 火藥 [3] 火箭 [4] 地老鼠 [5] 水鼠

forms also, as we shall see (p. 514 below). Within the military realm we find it mostly enclosed in weak-casing bombs which released a dozen or more of these mini-rockets to annoy the enemy's horsemen—and foot soldiers too. This was perhaps the most primitive form and first appearance of jet-propulsion in warfare.

Perhaps the type-specimen is the 'water-melon bomb' (*hsi kua phao*[1]),[a] and significantly it appears in the oldest stratum of the *Huo Lung Ching* (Fig. 190), which would date it to the first half of the +14th century at least. Here we translate the relevant passage:[b]

The 'water-melon bomb' is the most efficacious weapon for defending city-walls, best used from a high position when (the enemy) is below. Inside the bomb there are one or two hundred small (iron) calthrops, and fifty to sixty 'fire-rats' (*huo lao shu*[2]). [On the surface of each fire-rat tube three little hooks are fastened, and each such tube has a fuse going to it. All these are put into the bomb first before it is filled with gunpowder, and this should be packed in it loosely, not pressed down. The bomb is now sealed, two layers of hempen cloth with twenty layers of strong paper being glued over it, after which it is dried in the sun. The circumference of the bomb is divided into three parts, and three small holes are bored to take in three fuses. Another hole is bored directly at the top, and a small two-inch long bamboo tube is put in. A fuse goes right into the bomb through this, to make the bomb explode evenly, and the four fuses are connected together (at the top).]

When the enemy appears below the city wall the main fuse is lit, then when the burning reaches the point of junction with the four subsidiary fuses, one throws it down into the midst of the enemy. The four fuses are necessary to prevent the flame going out as the bomb is dropped. [At the moment of explosion, even the coating can cause some damage, but in a trice the calthrops are scattered all over the ground, while the fire-rats rush about in confusion, burning the soldiers. Thus the attackers can only run away, and as they do so the calthrops hurt their feet and injure them when they fall over. They never dare to come back beneath those city walls again.][c]

Thus it would seem that each fire-rat had its own fuse and was not just ignited by the flames of the main explosion. The illustration is instructive, first because it shows inside each mini-rocket a rectangle which we think indicates the bored cavity that gives equal burning; and secondly because the three hooks on each fire-rat are clearly shown. These evidently were designed to attach themselves to the clothing and accoutrements of men and horses, causing lesions and other damage as they burnt themselves out.

Another projectile of similar type was the 'rumbling-thunder bomb' (*hung lei phao*[3]), also in the oldest stratum of the *Huo Lung Ching*.[d] It was more like a grenade in size,[e] and contained poisons as well as gunpowder, but it had its

[a] *HLC*, pt. 1, ch. 2, p. 8*a*, *b*; *HKPY*, *ibid.*; Hsiangyang ed., *HCT*, p. 13*a*.

[b] Passages in square brackets belong to the enlarged version in *WPC*, ch. 122, pp. 24*b*, 25*a*, *b*, and *PL*, ch. 12, pp. 16*a*, *b*, 17*a*.

[c] Tr. auct.

[d] *HLC*, pt. 1, ch. 2, p. 13*a*, *b*; *HKPY*, *ibid.*; Hsiangyang ed., *HCT*, p. 15*b*.

[e] Because it used sun-dried mule droppings as the spherical moulds or matrices round which to wrap the cloth and paper, after which they were broken up and taken out through the fuse hole.

[1] 西瓜砲 [2] 火老鼠 [3] 轟雷砲

Fig. 190. The origin of rockets; the 'water-melon bomb' (*hsi kua phao*), containing a number of hooked 'earth-rats or ground-rats' (*ti lao shu*) or 'fire-rats' (*huo lao shu*), i.e. mini-rockets. From *HLC*, pt. 1, ch. 2, p. 8*a*.

ground-rats (*ti shu*[1]) made of carton tubes, and its iron calthrops, so it was quite similar in conception (Fig. 191). If carefully made, it 'caused the enemy to become dizzy and disheartened', and could be used either on land or afloat. In the beginning these weapons could have had an element of real surprise, since an enemy would expect attack from above or horizontally rather than at ground level from objects originally thought of as toys.

[1] 地鼠

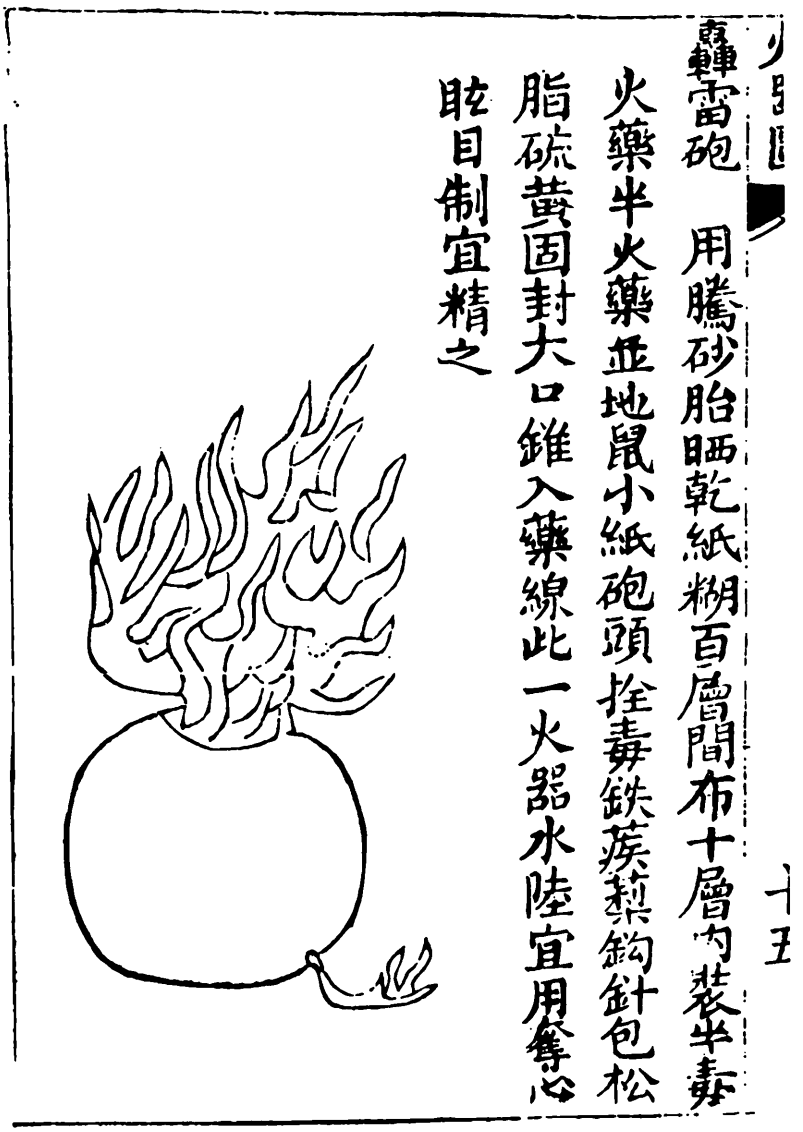

Fig. 191. Another bomb containing mini-rockets along with calthrops and poisons (*HLC*, pt. 1, ch. 2, p. 13*a*, here from *HCT*, p. 15*b*). It also belongs to the oldest stratum of the *Huo Lung Ching*.

Rather larger was the 'bandit-burning vision-confusing magic fireball' (*shao tsei mi mu shen huo chhiu*[1]), but again on the same principle, yet not described till the +17th century.[a] It has a clay matrix, over which were pasted many layers of paper with persimmon glue to make a casing, then filled with gunpowder, calthrops, ground-rats and fire-crackers, with the addition of 'flying sand' and 'magic smoke' composition. The *Huo Lung Ching* says:

[a] *HLC*, pt. 2, ch. 3, pp. 3*a* ff.; *WPC*, ch. 130, pp. 8*a*, *b*, 9*a*.

[1] 燒賊迷目神火毬

Troops carry these bombs in bags made of oiled string. In combat the soldiers light them, and throw them into the enemy's position or camp; as they explode, the (iron) calthrops are thrown about underfoot, causing wounds, while the ground-rats rush in all directions and get into the enemy's armour, hopping and bouncing up and down, so as to bring about alarm and confusion. Opportunity should be taken of this to press the attack by fire, using guns and bombards. In this way the troops of the enemy never fail to be defeated.[a]

Finally the ground-rats occur again, this time fitted with sharp little spikes, in a device called the 'fire-brick' (*huo chuan*[1]), though very different from our meaning of the term.[b] It was just a bomb (Fig. 192) made in elongated rectangular shape and filled with individually fused mini-rockets amidst the gunpowder. On ignition the brick was hurled into the enemy's camp to set it alight and sow confusion.[c]

(ii) *Rocket arrows*

The classical 'fire-arrow' (*huo chien*[2]) is shown in the *Wu Ching Tsung Yao* (+1044)[d] with the explanation that it is sent on its way from bow or crossbow, the amount of gunpowder attached to it depending on the strength of the bow.[e] Therefore it is clearly an incendiary arrow using a low-nitrate composition. But the *huo chien*[2] in the *Huo Lung Ching* is entirely different, for it is a perforating shock-weapon rocket-propelled. The name might remain the same, but the device was something entirely different.

Some time between +1150 and +1350 it occurred to someone who had seen ground-rats leave the ground and fly a short distance through the air, that if such a tube were attached to a feathered stick, i.e. the arrow-shaft, it would propel it with sufficient force to enable one to dispense with bow and crossbow altogether. This was a fundamental discovery. The oldest stratum of the *Huo Lung Ching* says:[f]

One uses a bamboo stick 4 ft 2 in. long, with an iron (or steel) arrow-head 4·5 in. long [smeared with poison; and some smear that on the rocket-tube too.] Behind the feathering there is an iron weight (*thieh chui*[3]) 0·4 in. long. At the front end there is a carton tube bound on to the stick, where the 'rising gunpowder' (*chhi huo*[4]) is lit [and it is oiled to prevent its getting wet.] When you want to fire it off, you use a frame shaped like a dragon, or else conveniently a tube of wood or bamboo to contain it [or launcher boxes of different kinds].

[a] Tr. auct.

[b] *HLC*, pt. 2, ch. 3, pp. 6*b*, 7*a*; *WPC*, ch. 130, pp. 18*a*, *b*, 19*a*, *b*.

[c] One of the two specifications stipulates also poisonous smoke-producing material. Two centuries later (*c.* +1565) the fire-brick is mentioned again by Chhi Chi-Kuang (*Chi Hsiao Hsin Shu*, ch. 18, p. 26*a*; *Lien Ping Shih Chi, Tsa Chi*, ch. 5, p. 29*b*), but now classed with obsolete weapons no longer made in the arsenals. Wang Ming-Hao still talks about it too at the end of the century (*Huo Kung Wên Ta*, p. 1296).

[d] Ch. 13, p. 3*a*, *b*.

[e] Even the nock on the end of the arrow is depicted.

[f] *HLC*, pt. 1, ch. 2, p. 22*a*, *b*; *HKPY*, *ibid.*; Hsiangyang ed., *HCT*, p. 20*a*. Sentences in square brackets come from *WPC*, ch. 126, pp. 4*b*, 5*a*. Tr. auct.

[1] 火磚 [2] 火箭 [3] 鐵墜 [4] 起火

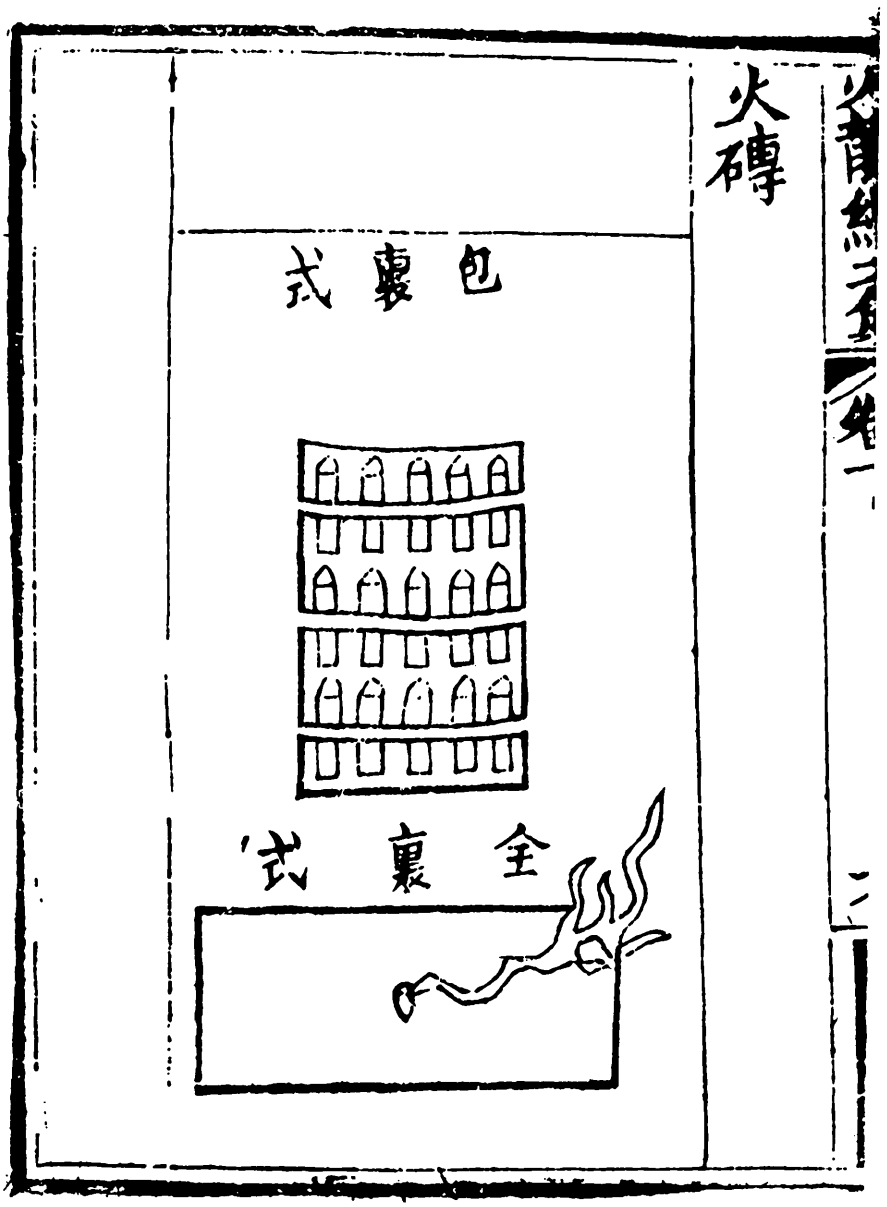

Fig. 192. The 'fire-brick' (*huo chuan*) bomb, filled with the mini-rockets bearing sharp little spikes. From *HLC*, pt. 2, ch. 3, p. 6*b*.

The illustration (Fig. 193) shows two launching cylinders, one with a dragon head. Very significant is the mention of the balance-weight at the tail; it must soon have been obviously necessary to make up for the weight of the rocket-tube, and as the gunpowder burnt away it would have added force to the rocket's velocity. This was a second aspect of the invention. A passage from the *Wu Pei*

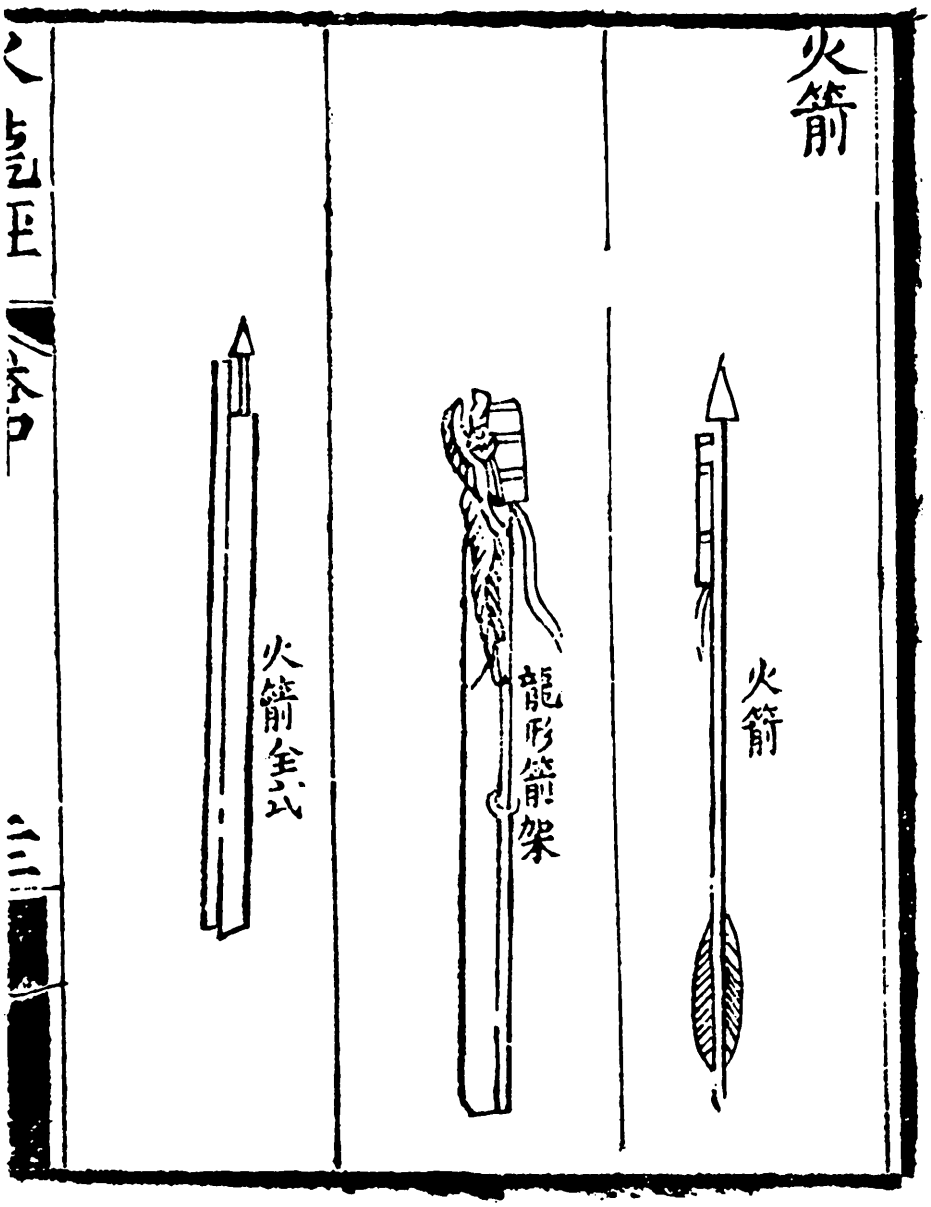

Fig. 193. The oldest illustration of rocket-arrows, from *HLC*, pt. 1, ch. 2, p. 22*a*. Although this must date from the neighbourhood of +1350, there is good reason to think that the rocket-arrow had been known and used at least a century and a half earlier. Here we see also two launching cylinders, the middle one with a carved dragon head.

Chih spells it out more clearly.[a] It says: 'An iron weight (*thieh chui*[1]) is fixed at the rear end (of the rocket-arrow), behind the feathering, of such a mass that the fulcrum of the balance is situated just four finger-breadths (*ssu chih*[2]) away from the mouth of the rocket-tube.' Davis and Ware called this the centre of gravity;[b] unfortunately the text did not specify whether the point was to be forward of the rocket-tube's orifice or aft of it.

The *Wu Pei Chih*, besides reproducing the early picture, gives further information. First, it describes several different kinds of rocket war-heads.[c] But secondly, and much more important, it illustrates the drill necessary for boring out a cavity in the gunpowder within the rocket-tube so that it would burn equally as it flew.[d] This was another great discovery, the third, and it must have been made early on in the rocket's development. In one illustration (Fig. 194)[e] the cavity is shown within the rocket-tube; in another (Fig. 195)[f] the drill is diagrammatically drawn.[g] The accompanying text says that the rocket-arrow is most valuable in land engagements, and not at all inferior to the bird-beak musket (cf. p. 432). It can be very deadly. But the centre of the charge must be bored out, for the 'fuse-eye' (*hsien yen*[3]),[h] either with an awl or a bow-drill; the artisans prefer the latter, but the result is not so good. It goes on:

If the hole is straight-sided (i.e. parallel with the walls of the tube) the arrow will fly straight; if it is slanting the arrow will go off at a tangent. If the hole is too deep the rocket will lose too much flame at the rear, if it is too shallow it won't have enough strength, so the arrow will fall to the ground too soon. If the rocket-tube is 5 in. long, the cavity must extend into it some 4 in. The shaft has to be absolutely straight, and the (rocket-tube and end-weight of the) arrow must balance perfectly when suspended 2 in. from the neck, or throat (*ching*[8] i.e. the nozzle), of the rocket-tube, while the feathering should be almost as long as the rocket-tube itself.[i]

[a] *WPC*, ch. 127, p. 12*a*, tr. auct.

[b] (1), p. 532. Chinese engineers from Thang times onwards had had plenty of experience with counterweighting, as in the hydro-mechanical link-work escapement of clocks (Vol. 4, pt. 2, pp. 459–60; Needham, Wang & Price (1), pp. 50–1). The steelyard, or balance of unequal arms, was both ancient and prevalent in China (Vol. 4, pt. 1, pp. 24 ff.).

[c] Ch. 126, pp. 5*b*, 6*a*, *b*, 7*a*. Thus there was the 'flying knife rocket-arrow' (*fei tao chien*[4]), the 'flying spear' (*fei chhiang chien*[5]), the 'flying sword' (*fei chien chien*[6]) and the 'swallow-tail' (*yen wei chien*[7]). We refrain from reproducing them.

[d] This is the principle of 'concentric burning', used in order to keep the area of combustion surface as near as possible constant. Cf. Anon. (161), Vol. 1, pp. 580–1, Vol. 2, pp. 363–4.

[e] From *Ping Lu* (+1606), ch. 12, p. 44*a*, equivalent exactly to *WPC*, ch. 126, p. 2*b*.

[f] *WPC*, ch. 126, p. 3*a*; *PL*, ch. 12, p. 46*b*.

[g] This was the 'thorn' of early European rocket-makers. Kyeser was perhaps the first to mention it (+1405), and of course it is in Schmidlap (+1591) and many others. Cf. Ley (2), pp. 60 ff., 63.

[h] The technical term at that time for the cavity.

[i] *WPC*, ch. 126, p. 3*b*, 4*a*, tr. auct. adjuv. Davis & Ware (1), p. 532. The passage is a good deal older than might be supposed, for it is verbally identical with what the great general Chhi Chi-Kuang said in his *Chi Hsiao Hsin Shu* of +1560 (ch. 15, p. 14*a*, *b*).

[1] 鐵錘 [2] 四指 [3] 線眼 [4] 飛刀箭 [5] 飛槍箭
[6] 飛劍箭 [7] 燕尾箭 [8] 頸

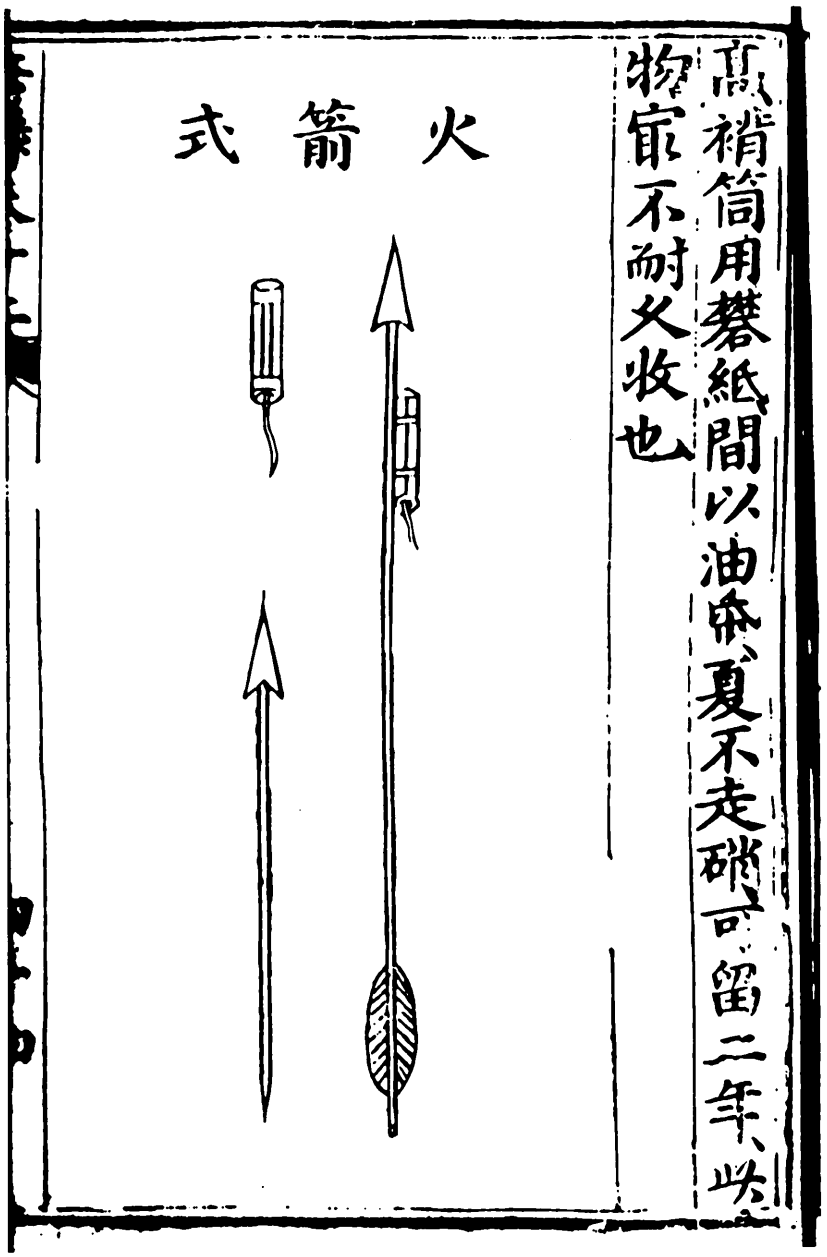

Fig. 194. A picture of the rocket-arrow from *PL*, ch. 12, p. 44*a*, important because it shows the cylindrical cavity within the rocket tube which was needed for even and equal combustion during flight.

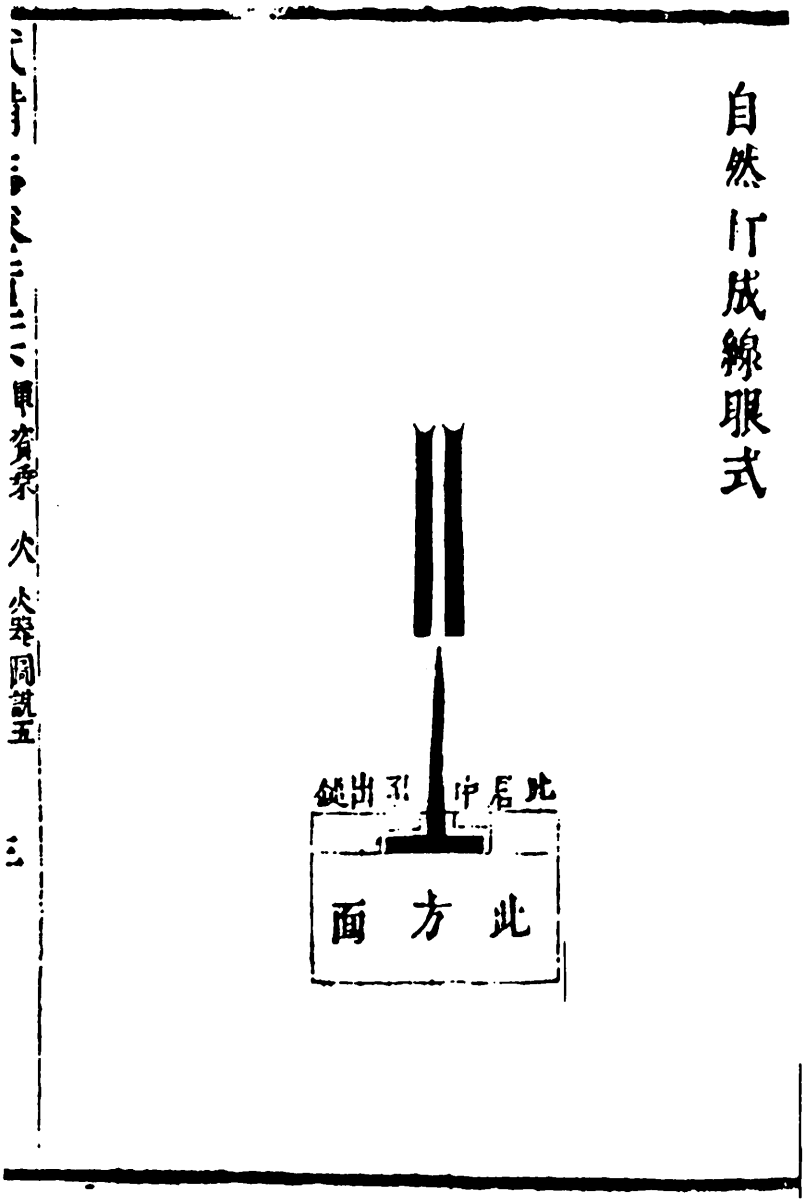

Fig. 195. Diagrammatic drawing of the drill or 'thorn' for making the cavity in the rocket tube. From *WPC*, ch. 126, p. 3*a*.

Here comes the fourth part of the invention. By +1300 at least the rocket-makers must have known that it was desirable to constrict the orifice of the rocket-tube in such a way as to increase the flow-velocity of the issuing gases, and therefore the retro-active force of the combustion. This was the principle of the 'choke',[a] later called in Europe the Venturi[b] 'waist' or nozzle.[c] Finally, a description is given of large-diameter rocket-arrows (*ta thung huo chien*[1], weighing as much as two catties, with a range of some 300 paces (500 yards), and again a drilling apparatus is illustrated.[d]

In Chhi Chi-Kuang's[2] time (+1550 to 80) the rocket-arrow was much prized as a war weapon.[e] It would fly into the enemy's rear as well as his front line, to left or to right, keeping everyone in alarm, not knowing where it was going to strike—and the launching side would of course not know either, since accurate aiming was distinctly difficult if not impossible. Hence the tendency to release flocks of rocket-arrows at the same time, from the launching-frames which we shall described in due course (pp. 486ff.); as also the practice of poisoning the arrow-tips to make a direct hit much worse. It was said to be as potent as the hand-gun, penetrating wooden planks an inch thick and piercing metal breast-plates. As for the drilling of the rocket cavity,[f] it was recommended that the boring tool be frequently wetted with water to reduce the friction which was capable of igniting the composition, and that a drill should be discarded for re-sharpening after half-a-dozen borings. Apparently rockets deflagrated or exploded quite often in the making, so directions were given for dispersing the work and the stores of powder among separate buildings. Great care was taken in making and rolling the strong carton case of the rocket-tube, but sometimes iron tubes were employed, especially for the constricted end (the choke) whence the gases escaped.

Exactly what kind of gunpowder was used for the rockets of the Yuan and Ming is not very clear, but the *Huo Lung Ching* lists several compositions the names of which would have been appropriate.[g] For example, there was 'flying gunpowder' (*fei huo yao*[3]), 'wind-opposing gunpowder' (*ni fêng huo yao*[4]), 'flying-in-the-air gunpowder' (*fei khung huo yao*[5]), 'day-rising gunpowder' (*jih chhi huo yao*[6]) and 'night-rising gunpowder' (*yeh chhi huo yao*[7]). But while the text gives

[a] Cf. Brock (1), p. 183.

[b] See Rouse & Ince (1), pp. 134ff., 189; Biswas (3), pp. 272ff., 305.

[c] Giovanni-Battista Venturi (+1746 to 1822) was a hydrodynamician very little noticed by historians of science, in spite of his important book (Venturi, 1) Cf. Anon. (161), vol. 1, pp. 206–7, 248–9. Hence the Venturi flow-meter, and a device embodied in most of our gas 'geyser' water-heaters.

[d] *WPC*, ch. 126, pp. 8*b*, 9*a*.

[e] Cf. *Chi Hsiao Hsin Shu*, ch. 15, pp. 14*a*, *b*, 15*a*; ch. 18, p. 28*a*; *Lien Ping Shih Chi, Tsa Chi*, ch. 5, pp. 27*b*, 28*a*, *b*, 29*a*, *b*, 30*a*.

[f] Today a conical 'spindle' is used, on top of which the packing of the gunpowder is done; cf. Brock (1), p. 183.

[g] *HLC*, pt. 1, ch. 1, pp. 6*a*–11*b*; parallel texts in *HKPY* and *HCT*.

[1] 大筒火箭 [2] 戚繼光 [3] 飛火藥 [4] 逆風火藥 [5] 飛空火藥
[6] 日起火藥 [7] 夜起火藥

many constituents of each of these, including saltpetre, actual quantities are listed only for two of them (the last-named)[a], and then the sulphur is so low as to cast doubt on the validity of the percentages. Perhaps the original quantities were all removed as a security measure before the book was printed. But we know (p. 351 above) that the nitrate must have been in the neighbourhood of sixty per cent to work a successful rocket.[b]

The technical affinities between the fire-lance and the rocket have already been pointed out (p. 472), and one might therefore well expect to find some attempt at combining the two. This indeed occurs, under the name of the 'tiger-catching-up-with-the-sheep rocket-arrow' (*i hu chui yang chien*[1]).[c] The explanation says that this is a five-foot-long shaft (Fig. 196)[d] with a trident at the business end and two rocket-tubes just behind it. At the rear end there are two more gunpowder tubes secured to the shaft, but these are fire-lances, not rockets, and are ignited automatically as the rocket is nearing the end of its course, said to attain 500 paces (830 or so yards).[e] It can set light to the enemy's wooden defences and ships; one man can use it yet a hundred men will be terrified of it, especially if poison is applied to the trident.[f] Verily, recondite is the craft of this weapon,[g] says the text—but on the principle of the survival of the fittest it can hardly have been all that effective. Still, a flock of them could have been rather a nuisance. Such was what could really be called the 'flying fire-lance'.[h]

Thus it would appear, looking back, that in spite of its seeming simplicity four distinct inventions had to be combined in the development of effective rocket flight. First, there was the basic idea of applying a ground-rat tube to a projectile, and secondly the balancing of the whole to give the arrow an adequate range. Thirdly there was the drilling of an internal cavity to promote equal areas of combustion surface, and fourthly the addition of a waist, throat or choke, in fact a Venturi constriction,[i] to accelerate the flow-velocity of the discharged gases, thus increasing the propulsive reaction.[j]

At some time during the +14th or +15th centuries it occurred to some ingenious Chinese artificer that if a rocket could be made to go, it could also be made

[a] *Chhi huo yao* often appears in the accounts of rocket-arrows in the military books.

[b] The standard rocket composition is 63·6 : 22·7 : 13·6 (Brock (1), p. 188).

[c] *HLC*, pt. 2, ch. 2, p. 22*a*, *b* (not the oldest stratum); *WPC*, ch. 127, pp. 3*b*, 4*a*. Nevertheless, on intrinsic grounds, this weapon could be considered rather old, quite probably developed soon after the rocket itself.

[d] From *WPC*; that in *HLC* is identical, save that the former has (more logically) 'two tigers' (*erh hu*[3]).

[e] Standard rocket ranges at the end of the +16th century are usually given as 600–700 paces, or about 1000 yards (*Huo Kung Wên Ta*, p. 1293).

[f] The second part of this sentence is only in the longer *WPC* version.

[g] *Ta yu hsüan miao*[2]. Could one not suspect a Taoist echo here? Cf. p. 117 above.

[h] Cf. pp. 171, 225 above.

[i] Among rocket engineers this is often called a Laval convergent-divergent nozzle, after the Swede Carl de Laval who introduced it for gas turbines in 1889. Cf. Baker (1), p. 18.

[j] The arrow-shaft itself can hardly be counted as an invention, but presumably the stick of later rockets must derive from it, and therefore indirectly from the shaft of the even more ancient fire-lance. Modern pyrotechnists say simply that the stick 'balances and directs the flight' (Brock (1), p. 183). Spinning, fins and wings, ultimately, it seems, took over this function.

[1] 一虎追羊箭 [2] 大有玄妙 [3] 二虎

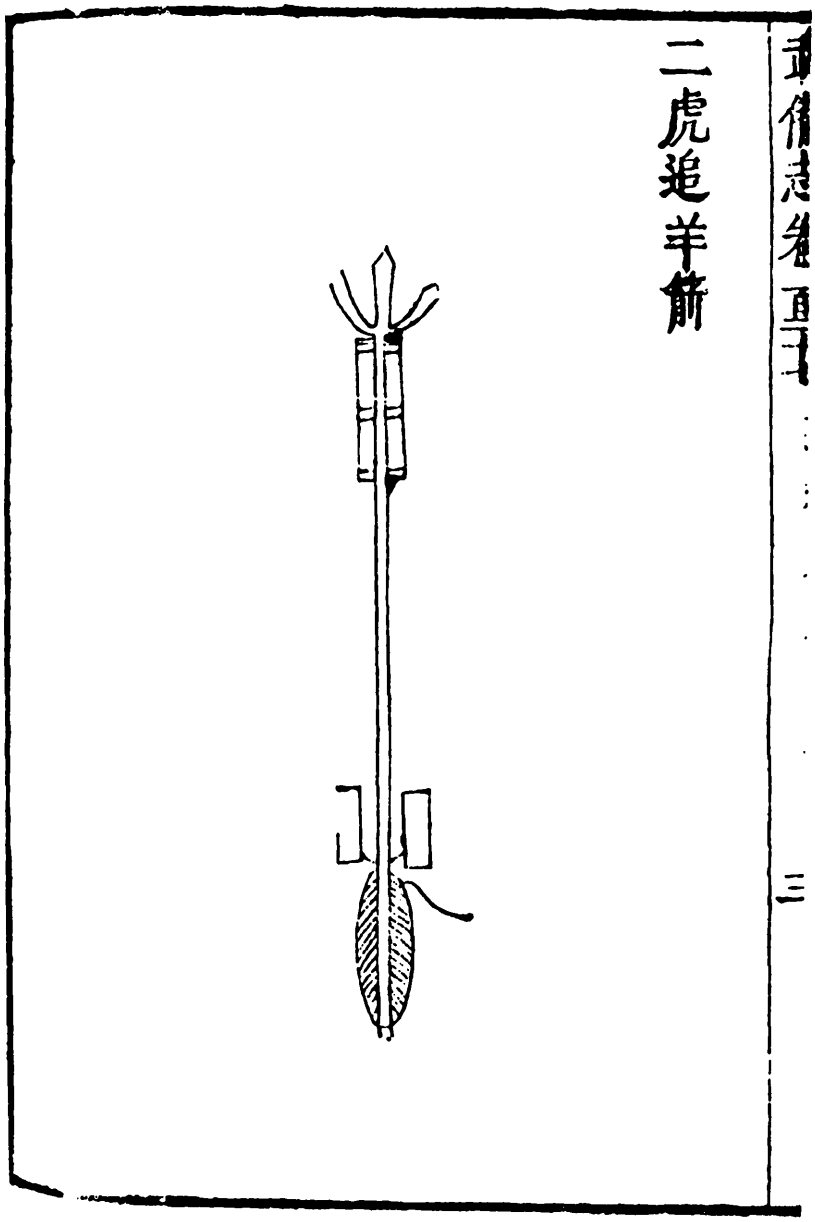

Fig. 196. A manifestation of the technical affinity between the fire-lance and the rocket, the two combined in one device. The 'tigers-catching-up-with-the-sheep rocket-arrow' (*erh hu chui yang chien*), from *WPC*, ch. 127, p. 3*b*. Two rocket-tubes are placed behind the trident, but that is not the only warhead, for two fire-lances are carried just ahead of the feathering.

to come, at least theoretically. Hence the 'flying powder tube' (*fei khung sha thung*[1]).[a] This was in fact three tubes attached to the same staff. A first rocket-tube sent it forward towards the enemy, then as it burnt out it ignited a charge in the leading tube which expelled a blinding lachrymatory powder over the enemy, before igniting a return rocket-tube and so sending the contraption back to its point of origin. Thus the enemy would not know from what direction the attack actually came. The idea was a striking one, but it would have involved great skill to get it to work even approximately in practice.[b]

(iii) *Multiple launchers and wheelbarrow batteries*

It must have become obvious very early that if one was to attempt any kind of aim at all with elongated rocket-propelled projectiles it was no use flourishing them about at random, one should rather launch them from some kind of frame, preferably movable on an axis so as to allow of some choice of trajectory (Fig. 197). Rocketry followed in fact just this course, and we can easily describe the different forms which the frames took.[c] But first it is necessary to eliminate a confusing intrusion, namely co-viative or projected arrows fired from fire-lances approximating to guns, and therefore nothing to do with rocket flight at all. This is all the more confusing because the drawings and descriptions are completely mixed together in the military compendia, and unless one studies the pictures and reads the texts with great care one will certainly come to grief, as has happened to not a few scholars already. The soldiers of Sung, Yuan and Ming did not bother about classificatory distinctions, as we do; all they were interested in were the practical effects.

The reason why we say 'approximating to guns' is that so much depended on whether or not the arrows had a plug or wad behind them which completely blocked the bore of the firearm's barrel. If not, they were simply shot out as co-viative projectiles along with the flames of the fire-lance at comparatively short range (cf. pp. 236 ff. above); if they did then they partook of the nature of cannon-balls, as presumably was the case with the arrows protruding from the muzzles of the early European bombards of Walter de Milamete (+1327, cf. pp. 10, 287–8 above). In the sub-section on fire-lances (13) we saw how difficult it can be to distinguish these two types of weapon.[d] If the barrel was of wood or bamboo it was probably a fire-lance, if of bronze or iron it was perhaps a proto-

[a] *WPC*, ch. 129, pp. 7*b*, 8*a*. Hsü Hui-Lin (1) deserves credit for having taken notice of it. There was a model of it in the National Military Museum in Peking in 1964.

[b] A closely similar 'come-and-go' rocket occurs in the Sibiu MS. of Konrad Haas, dating from about +1560 (von Braun & Ordway (1), p. 11). The question of how derivative from the Chinese sources this could have been might admit of a wide solution.

[c] It is surely needless to emphasise the great role played at the present day by all forms of launchers, whether for military uses or for space-flight. Cf. Humphries (1), p. 140 and opp. p. 150.

[d] Davis & Ware (1), p. 533, called them all guns or bombards, but they were not very sensitive to the distinction we have to make here.

[1] 飛空砂筒

Fig. 197. Oblong-section rectangular rocket-launcher, with all the rockets ignited and sent on their way by one fuse, the *shen huo chien phai* (*HLC*, pt. 2, ch. 3, p. 2*a*).

gun. If there was no vase-shaped bulge, indicating a thicker wall for the explosion-chamber, then it was a fire-lance; if one is mentioned or illustrated, then it was probably a kind of early gun. If the range is said to be short, it was a fire-lance; if it was some 500 yards or more, as often stated, then it was more likely to be a gun. This is why long ranges are so confusing, because they do not necessarily imply rocket-propulsion, as some have thought.[a]

Among the fire-lances or proto-guns we have already described, the two simplest cases involved only one arrow,[b] but there was another which shot three at a time,[c] and yet another which discharged many.[d] To these we can now add several more, the 'triple tiger-halberd' (*san chih hu yüeh*[5]) delivering three arrows,[e] the 'sevenfold tube arrow' (*chhi thung chien*[6]) sending out seven,[f] the 'nine-dragon arrows' (*chiu lung chien*[7]) shooting nine at a time,[g] and the 'hundred-aimed bow-like arrow-shooter' (*pai shih hu chien*[8]), letting off ninety-six from six tubes at one ignition.[h] All these are relevant to the present discussion only because they are scattered disorderly in the books among the true rocket-launchers, to which we must now turn. It is significant that none of the projectile arrows in these quasi-guns ever show rocket-tubes.

The most succinct means of surveying the launchers is tabulation, and this is done in Table 6, passing from the simplest to the most complicated. We must remember that all the data come from books written just before and after +1600, but it may be assumed that the simpler forms would go back one or two centuries before that time.[i] Broadly speaking, three materials were used for the launchers, basketry (cf. Fig. 198), bamboo tubing, and woodwork. All were provided with internal grids or frames to hold the individual rocket-arrows apart (Fig. 199),[j] and there was a marked tendency to make the launchers more or less

[a] Bows and crossbows are of course not at issue here at all.

[b] The 'single-flight magic-fire arrow' (*tan fei shen huo chien*[1]), and the 'magical (fire-)lance arrow' (*shen chhiang chien*[2]). See p. 240 above and Figs. 51, 52. The former was of cast bronze, and does have something that might have been a wad, while a long range and great impact force are noted. The latter was of ironwood, yet it also has something that could have been a wad, and again a long range is mentioned. This last was the weapon associated with the expeditions of +1406 and +1410 against Annam. See also p. 240 above. One can only call these weapons quasi-guns, leaving open the exact shade of difference between fire-lances and true guns. Much would depend on the tightness of the wad—and the long ranges may have been exaggerations.

[c] The 'awe-inspiring fierce-fire yaksha gun' (*shen wei lieh huo yeh-chha chhung*[3]); see p. 240 and Fig. 53 above.

[d] The 'lotus bunch' (*i pa lien*[4]); see p. 243 and Fig. 54 above.

[e] *HLC*, pt. 1, ch. 2, p. 26*a*, *b*; *WPC*, ch. 127, pp. 4*b*, 5*a*. Here a bulge over the explosion-chamber is mentioned, but not shown in either drawing. It is called an 'iron gun' (*thieh chhung*[9]) with three barrels, but there is no indication of any plugs or wads. Since this is the oldest part of the *Huo Lung Ching*, this quasi-gun may well go back to the beginning of the +14th century.

[f] *WPC*, ch. 127, p. 7*a*, *b*. The arrows were to be tipped with poison.

[g] *WPC*, ch. 127, p. 8*a*. This has no text.

[h] *WPC*, ch. 127, pp. 10*b*, 11*a*. The tubes were of carton, and it is significantly said that fire should be reserved until the enemy is quite near. We refrain from reproducing any of these.

[i] It will be seen that two items are in the *Huo Lung Ching*, but neither in the oldest stratum.

[j] From time to time there is mention of arrow-lengths (nos. 4, 8), poison applied to the tips (nos. 4, 12), and tail-end balance-weights (nos. 7, 9), etc. but we need not go into further detail. Also the usual romantic names are in the Table, so we omit them here.

[1] 單飛神火箭 [2] 神鎗箭 [3] 神威烈火夜叉銃 [4] 一把蓮
[5] 三隻虎銃 [6] 七箇箭 [7] 九龍箭 [8] 百矢弧箭 [9] 鐵銃

Table 6. *Types of rocket-launchers*

	Nature	Name	Chinese name	HLC	WPC	PL
1	Basket-work rocket-launcher (conical)	Rocket-arrow firing basket	*huo lung chien*[1] (Fig. 198)		126/16*b*, 17*a*	
2	Basket-work rocket-launcher (cylindrical)	Mr Facing-both-ways rocket-arrow firing basket	*shuang fei huo lung chien*[2]	2/2/21*a*, *b*	127/2*b*, 3*a*	
3	Basket-work rocket-launcher (cylindrical)	Forty-nine simultaneously fired rocket-arrows	*ssu-shih-chiu shih fei lien chien*[3]		127/9*b*, 10*a*	
4	Portable bamboo rocket-arrow carrier or quiver with sling	Small bamboo rocket-arrow tube	*hsiao chu thung chien*[4] (Fig. 202)		126/14*b*, 15*a*	12/49*b*, 50*a*
5	Bamboo 3-arrow rocket-launcher	Magical mechanism rocket-arrows	*shen chi chien*[5]		126/7*b*, 8*a*	12/45*b*
6	Bamboo 5-arrow rocket-launcher	Five-tigers-springing-from-a-cave rocket-arrows	*wu hu chhu hsüeh chien*[6] (Fig. 199)		127/5*b*, 6*b*	
7	Smaller bamboo 5-arrow rocket-launcher	Lesser five-tigers, etc., rocket-arrows	*hsiao wu hu chien*[7]		127/6*a*, *b*	
8	Shield with racks for rocket-arrows	Tiger-head fire shield	*hu thou huo phai*[8]		129/12*a*, *b*, 14*b*, 15*a*, *b*	
9	Square-section rectangular rocket-launcher	Pack of 100 tigers running together	*pai hu chhi pên chien*[9] (Fig. 206)		127/11*b*, 12*a*	
10	Oblong-section rectangular rocket-launcher	Magical rocket-arrow block (or screen)	*shen huo chien phai* (or *phing*)[10] (Fig. 197)	2/3/2*a*, *b*	129/16*a*, *b*	
11	Elongated rectangular double-ended rocket-launcher (cf. 2)	Covey of hawks catching rabbits	*chhün ying cho thu chien*[11]		127/14*b*, 15*a*	
12	Elongated slightly flared rectangular rocket-launcher	Long-serpent enemy-destroying rocket-arrows	*chhang shê pho ti chien*[12] (Fig. 203)[a]		127/13*b*, 14*a*	
13	Flared octagonal rocket-launcher	Leopard pack unexpectedly scattering	*chhün pao hêng pên chien*[13] (Figs. 200, 201)		127/12*b*, 13*a*	
14	Flared octagonal rocket-launcher	Wasp's nest	*i wo fêng*[14b]		127/15*b*, 16*a*	12/55*b*
15	Wheelbarrow rocket-launcher	Fire-frame combat-vehicle	*chia huo chan chhê*[15] (Figs. 204, 205)		132/9*a*, *b*	
16	Wheelbarrow launcher battery	Battery of fire-frame combat-vehicles	*lien lo chan chhê*[16] (Fig. 207)		132/10*a*, *b*	

[a] This, and the 'wasp's nest', are much spoken of in the *Huo Kung Wên Ta* towards the end of the +16th century (pp. 1294, 1303).

[b] This we shall come across again in our historical quest (p. 514 below).

To illustrate the danger of relying on terminology alone, a 'smaller wasp's nest' (*hsiao i wo fêng*) is illustrated and described in *WPC*, ch. 128, pp. 17*b*, 18*a*, *b*. It has obviously nothing to do with rocket-launching frames, but one might take it for a double-tube rocket-arrow itself if it were not far too long (12 ft), and shaped like a spear or lance with a ferrule. Showers of sparks looking like wasps are said to come out of the 1 ft 3 in. wooden or bamboo canisters, causing blindness among the enemy, and the flames reach forward 30–40 ft (which is said to be the range). The weapon is thus a lachrymatory fire-lance, though several kinds of co-viative projectiles are described also. There follows a gunpowder composition corresponding to 67·8 : 19·1 : 13·1; but with additions of mercury and mercuric sulphide (cf. p. 344 above), and doubtless plant drugs also.

[1] 火籠箭 [2] 雙飛火籠箭 [3] 四十九矢飛廉箭 [4] 小竹筒箭 [5] 神機箭 [6] 五虎出穴箭 [7] 小五虎箭
[8] 虎頭火牌 [9] 百虎齊奔箭 [10] 神火箭牌(屏) [11] 鞏鷹逐兔箭 [12] 長蛇破敵箭 [13] 鞏豹橫奔箭 [14] 一窩蜂
[15] 架火戰車 [16] 聯絡戰車

Fig. 198. Conical rocket-arrow launchers made of basketwork (*WPC*, ch. 126, p. 16*b*).

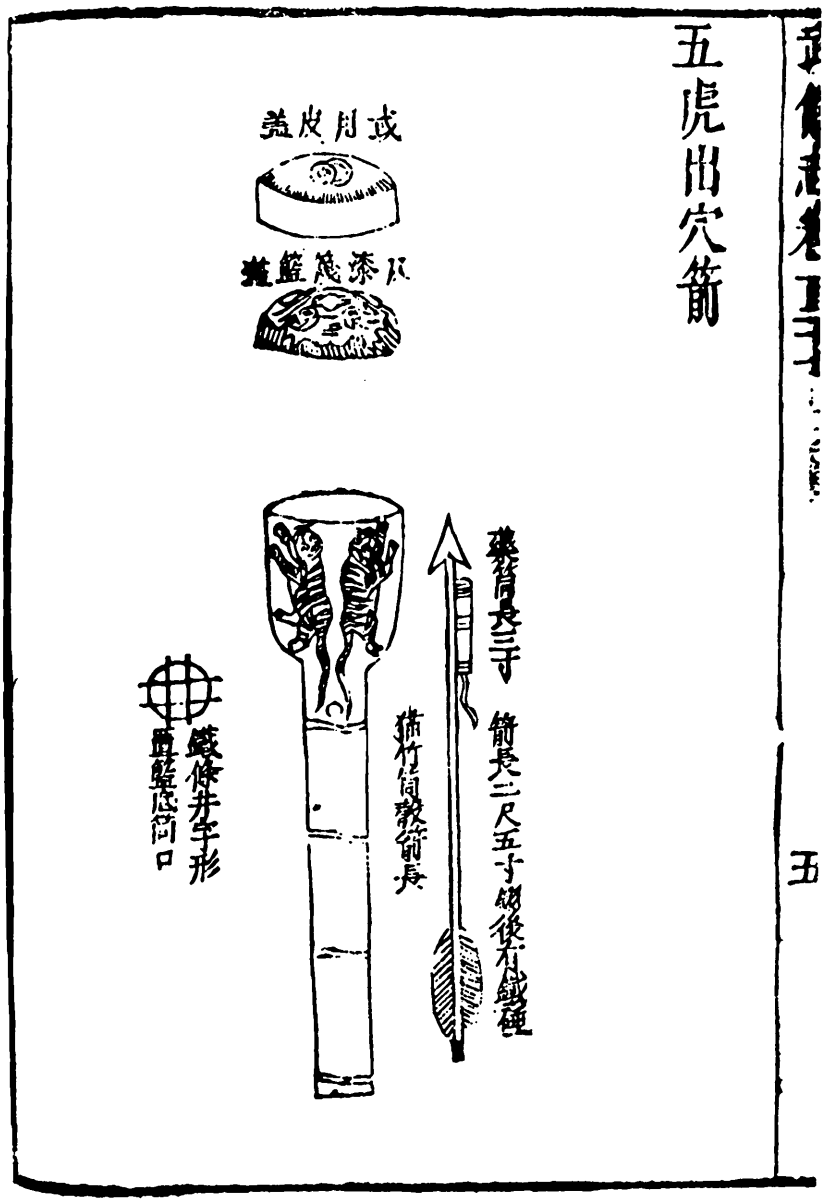

Fig. 199. Bamboo or wooden rocket-launcher with internal grid to keep the arrows apart (*WPC*, ch. 127, p. 5*b*).

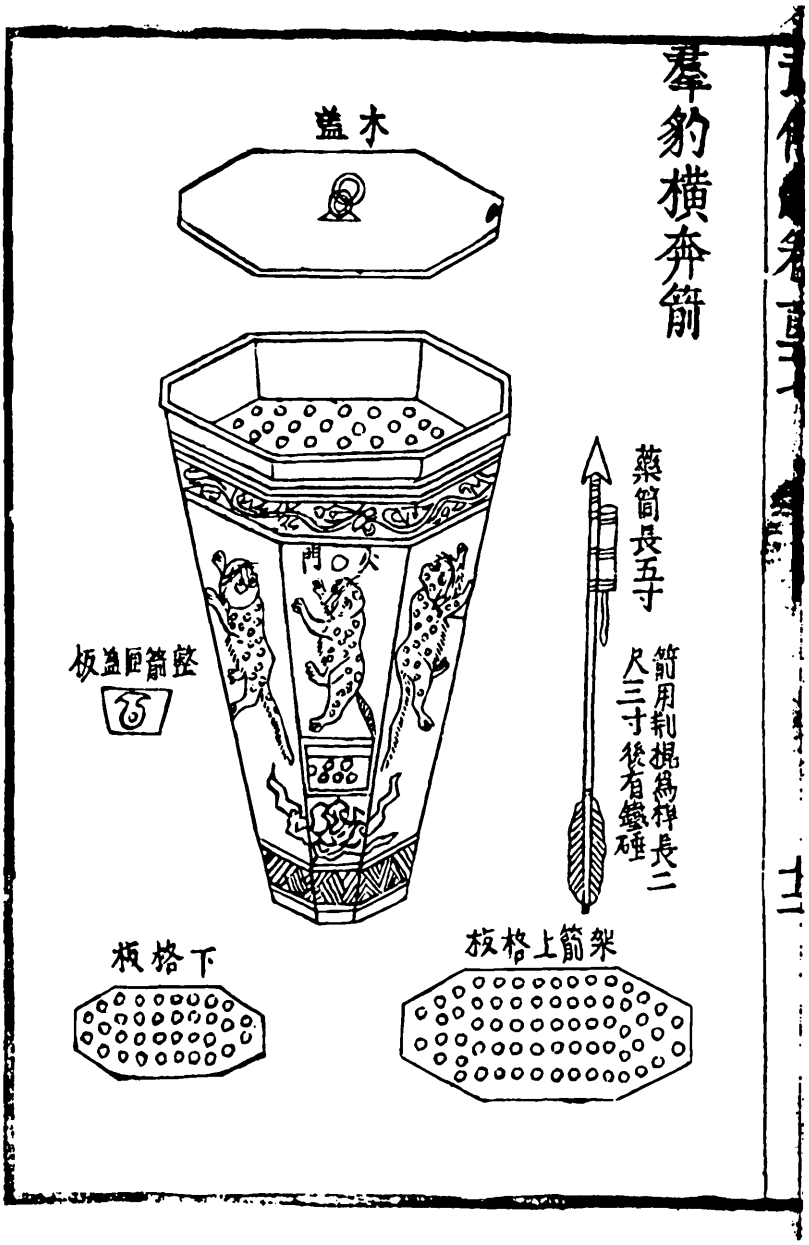

Fig. 200. Splayed conical rocket-launcher with internal diaphragm to keep the arrows apart (*WPC*, ch. 127, p. 12*b*).

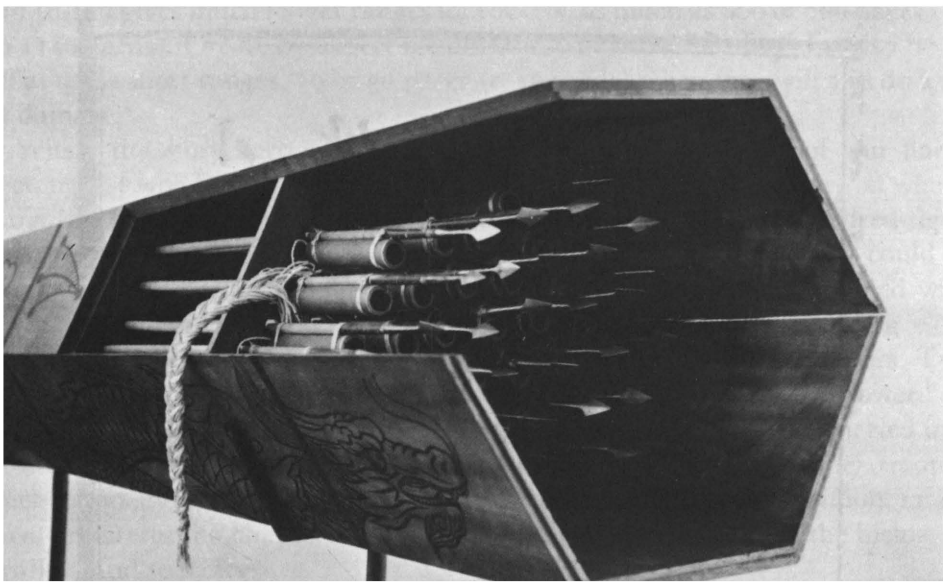

Fig. 201. Reconstruction of the same, showing the common fuse. Photo. Historical Military Museum, Peking.

conical in shape so as to ensure a wide area of dispersion of the points of impact (cf. Figs. 200, 201 and p. 483 above).[a] We translate but one passage, that concerning the portable bamboo rocket-arrow carrier with a sling (Fig. 202). The text says:[b]

The small bamboo rocket-arrow tube (*hsiao chu thung chien*[1]). Each tube holds ten short rocket-arrows, only 9 in. long, and poison is applied to the head of each. The total weight (of the tube and its contents) does not exceed 2 lb., and each soldier can carry four or five of them (on its sling) easily. The enemy would not know what exactly they were transporting. At a distance of some 100 paces (about 170 yards) away, the rocket-arrows are all fired as one. These arrows, though small, are fast, and the enemy cannot avoid them; so one soldier can do as much harm (with these arrows) as several dozen others (using more conventional arms). These rocket quivers can be carried by the personal guards of the commander, or by the detachment of soldiers surrounding the flag, or else by men scattered among ordinary fighting units. The rocket-arrows should be tested to ensure that they can penetrate thin wooden planks. If the bamboo tube is slightly raised at the time of firing, the arrows can reach over 200 paces (say 340 yards). This weapon should not be overlooked just because the arrows are so small.[c]

[a] This may have been suggested by the shape of the age-old quiver for carrying arrows about, as Mr Michael Rosen has intimated to us.

[b] *WPC*, ch. 126, pp. 14*b*, 15*a*; *PL*, ch. 12, pp. 49*b*, 50*a*, tr. auct.

[c] Rough translations of the entries for nos. 1, 9, 10, 12 and 13 have been given by Davis & Ware (1), pp. 532–3; Davis (10).

[1] 小竹筒箭

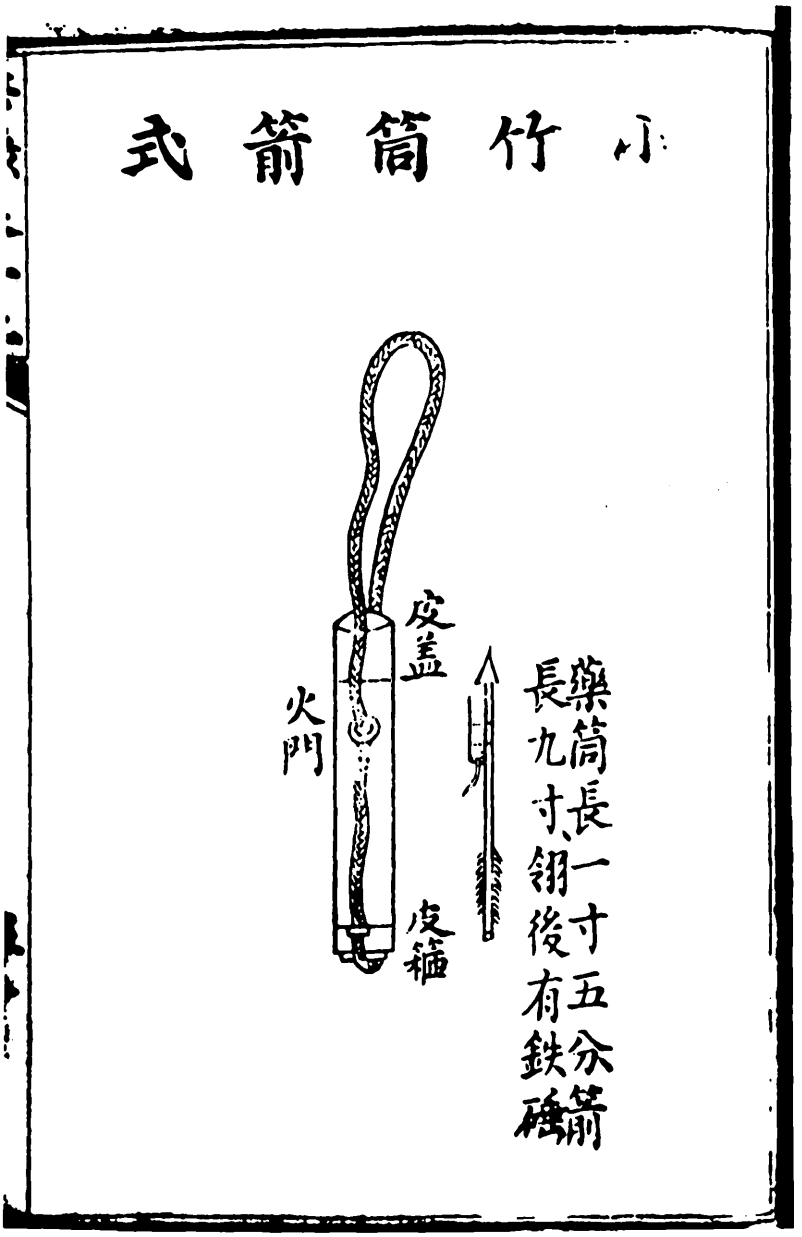

Fig. 202. Portable rocket-arrow carrier and launcher, with sling (*PL*, ch. 12, p. 50*a*).

Ho Ju-Pin gives much longer ranges for rockets, as much as 600 or 700 paces (up to 1150 yards) if made by expert technicians, but adds that they can also be let off at quite short ranges, 20 or 30 paces (*c.* 40 yards) when they will still do a lot of damage.[a]

Where the story becomes rather fascinating is the mounting of four flared rectangular wooden 'long-serpent' rocket-launchers (Fig. 203) in rows on wheelbarrows (Figs. 204, 205), together with two rectangular wooden 'hundred-tiger' rocket-launchers (Fig. 206), one on each side. Thus 320 rocket-arrows could be despatched almost at one time. Each wheelbarrow was further provided with three multiple-bullet proto-guns or fire-lances, two spears for repelling close attack, and curtains of leather for hiding the movements of the gunners. Two soldiers looked after the fighting and two others provided the motive power.[b] In this way veritable batteries of rocket-launchers (Fig. 207) could be wheeled into position, and (hopefully) away again, doubtless under cover of other troops.[c] Such manoeuvres, explicitly carried out in conjunction with true cannon, might form an interesting chapter, not yet written, so far as we know, in the history of artillery and rocketry.[d]

(iv) *Winged rockets*

Among the various stabilising devices which have been introduced in modern times for controlling rocket flight, fins and wings have been outstanding.[e] By +1741 fins were fitted to rocket-bombs by the pyrotechnist François Frézier,[f] and they have continued to be used in many recent types, such as the German 'V 2' of the Second World War.[g] But wings are also very often part of the design, as in the 'Styx',[h] 'Mace'[i] and 'Matador'[j] rocket-missiles, as well as the later

[a] *PL*, ch. 11, pp. 37*a* ff.

[b] A photograph of the scale model reconstruction of this combat-vehicle is given in Fig. 205.

[c] There is mention of a hundred such combat-vehicles working together as a battery. Cf. *Ming Shih*, ch. 92, p. 15*a*. On the history of the wheelbarrow (itself a Chinese invention) see Vol. 4, pt. 2, pp. 258 ff.; Vol. 1, p. 242.

[d] It may not be generally known that rocket frames or multiple launchers can still be seen at the present day if one goes to Yenshui[1] in Southern Taiwan at the time of the lantern festival (Yuan Hsiao[2]). The firework rockets are collected together in 'hives' (*fêng phao thai*[3] or *fêng tshai phao wo*[4]) and let off simultaneously. There is a graphic description by Jih Yüeh & Chung Yung-Ho (1, *1*).

[e] Topologically the two are closely connected, the fin being a wing of reduced size, and generally placed towards the tail of the rocket rather than half-way along its length. Cf. Humphries (1), pp. 133 ff., 139, figs. 69, 71, 76, 77, 79.

[f] Frézier (1); Taylor (1), pp. 8–9. Frézier had many Chinese connections (perhaps without knowing it), for he made much use of iron filings in his fireworks, specialised in *tourbillons* (rotating rockets), and called his Roman candles *lances-à-feu*. Perhaps Reinhart de Solms was the first European to put wings on rockets, as he did in +1547 (Duhem (1), p. 288).

[g] Taylor (1), pp. 24–5; von Braun & Ordway (2), pp. 106–7; Baker (1), pp. 43 ff.

[h] Taylor (1), pp. 34–5.

[i] Taylor (1), pp. 32–3; Baker (1), p. 179.

[j] Taylor (1), *loc. cit.*; Baker (1), p. 178.

[1] 鹽水 [2] 元宵 [3] 蜂炮台 [4] 蜂採炮窩

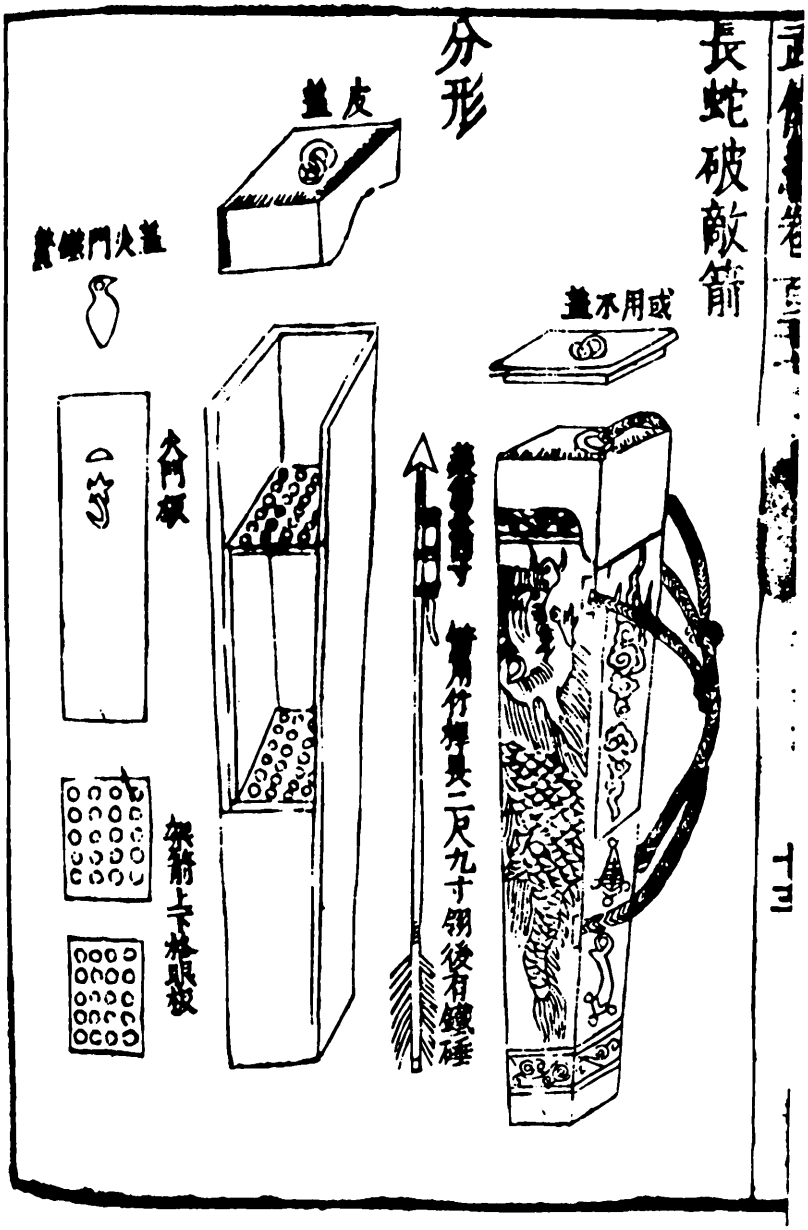

Fig. 203. The 'long-serpent enemy-liquidating arrow-launcher' (*chhang shê pho ti chien*), a slightly flared rectangular container, from *WPC*, ch. 127, p. 13*b*. The pierced frames for keeping the rocket-arrows separate are seen on the left, and above them the 'touch-hole' (*huo mên*) for the fuse which sets them all off at the same time. As the caption explains, each rocket-arrow is 2 ft 9 in. long, with a gunpowder tube 4 in. long, and an iron counter-weight just behind the feathering.

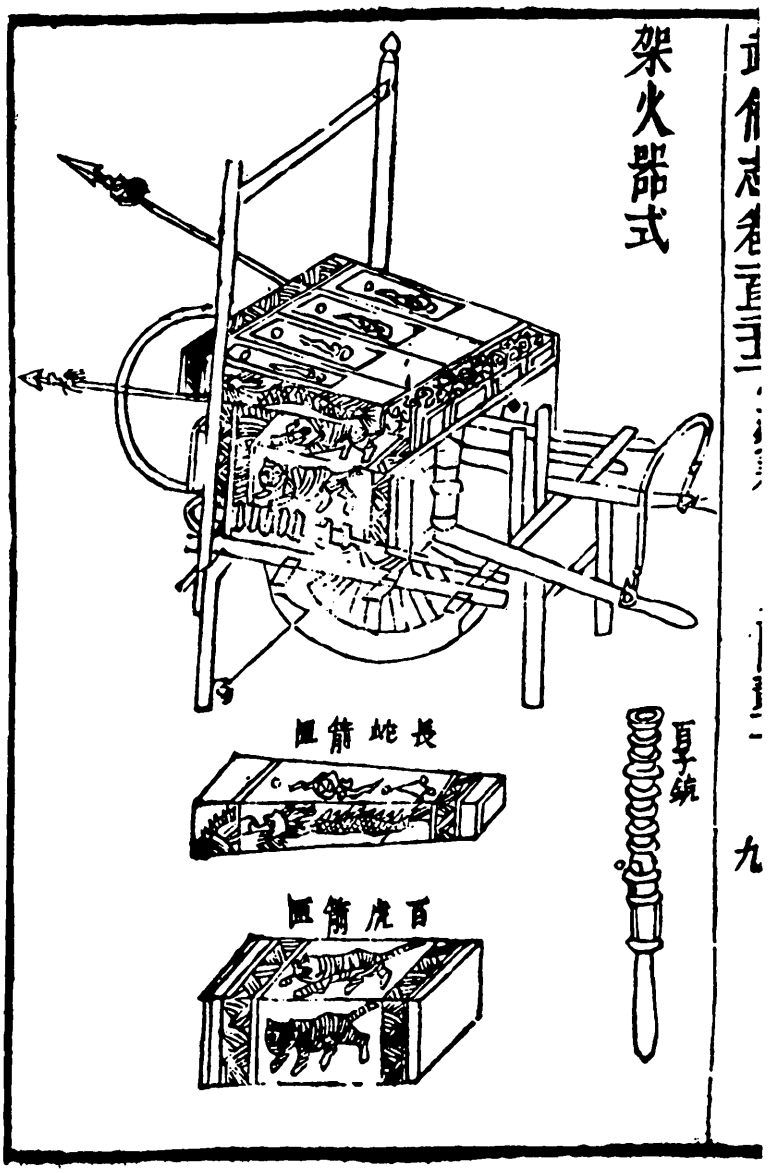

Fig. 204. Four of these 'long-serpent' rocket-launchers mounted side by side on a wheelbarrow (*WPC*, ch. 132, p. 9*b*). Underneath were two square-section 'hundred tigers' rocket-arrow launchers, and on each side a multiple-bullet proto-gun or fire-lance was carried (since this was ridged it may have been a true gun). Two spears were carried in case of close-quarter combat, and there were leather curtains for the protection of the soldiers operating the assault-barrow.

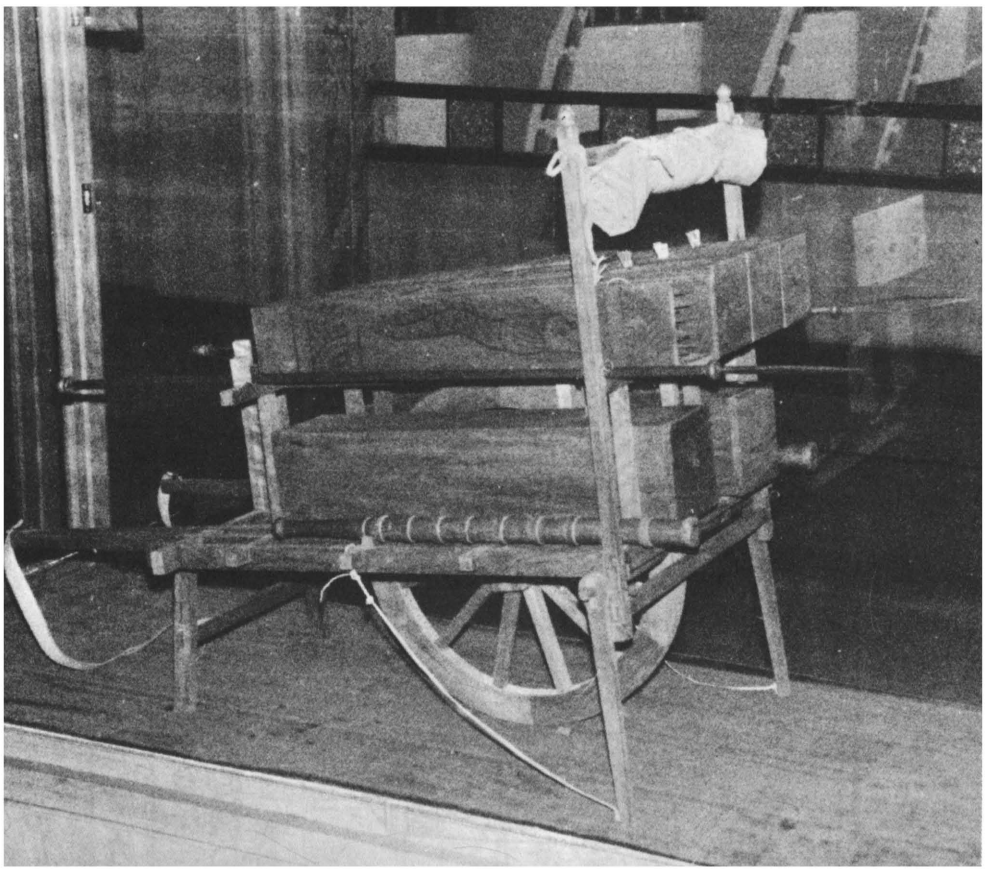

Fig. 205. Scale model reconstruction of the assault-barrow in the previous picture (orig. photo. 1964, in the Nat. Historical Military Museum, Peking).

'Thunderbird'[a] and 'Nike–Zeus'[b] types; and here must also be numbered the Ohka Kamikaze winged (and manned) rocket-aircraft, also of World War II.[c] The 'Space Shuttle' of our own times is another case in point, launched as a rocket but capable of returning to earth as an airplane.[d]

Consequently it is very reasonable to ask, who first gave rockets wings? We find it in the oldest stratum of the *Huo Lung Ching*, which must mean the middle of the +14th century, and quite possibly soon after +1300. The passage (cf. Fig. 208) runs as follows:[e]

[a] Von Braun & Ordway (2), p. 147; Baker (1), p. 130.
[b] Von Braun & Ordway (2), p. 146; Baker (1), p. 178.
[c] Baker (1), p. 92; von Braun & Ordway (2), pp. 87–9.
[d] Baker (1), pp. 215, 248.
[e] *HLC*, pt. 1, ch. 3, p. 18*a*, *b*; *HKPY ibid.*; Hsiangyang ed., *HCT*, p. 34*a*, tr. auct. Passages in square brackets are from the slightly expanded *WPC* version, ch. 131, pp. 12*b*, 13*a*.

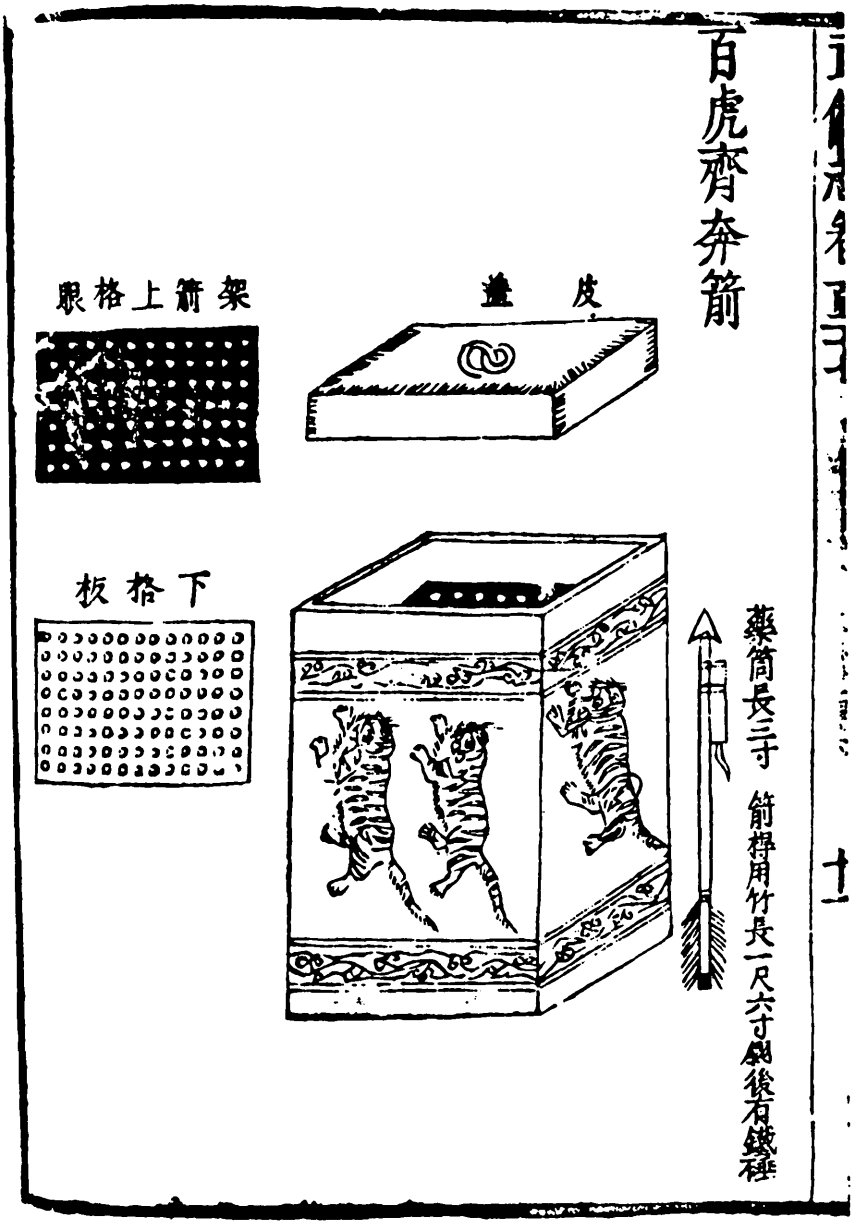

Fig. 206. The 'hundred-tigers running-side-by-side rocket-arrow launcher' (*pai hu chi pên chien*), from *WPC*, ch. 127, p. 11*b*. This is the type referred to in the caption for Fig. 204.

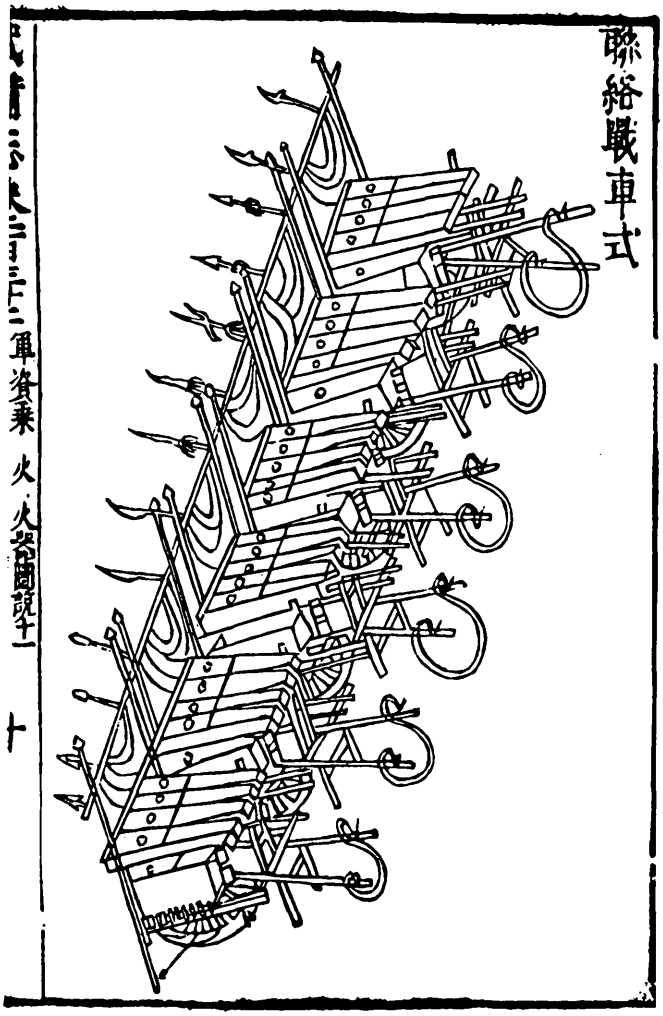

Fig. 207. A whole battery of the assault-barrow rocket-launchers facing to the left, from *WPC*, ch. 132, p. 10*a*. This drawing easily conduces to an optical illusion, but one must keep in mind that one is looking down upon the battery from a viewpoint high up and behind it to the right. Batteries of this kind must have been quite formidable when everything worked well.

The 'flying crow with magic fire' winged rocket-bomb (*shen huo fei ya*[1]).

The body (of the bird) is made of [fine] bamboo laths [or reeds] forming an elongated basketwork, in size and shape like a chicken, weighing over a catty (0·6 kilo.). It has paper glued over to strengthen it, and it is filled with explosive gunpowder (*ming huo cha yao*[2]). All is sealed up using more paper, with head and tail fixed on before and behind, and the two wings nailed firmly on both sides, so that it looks just like a flying crow.

Under each wing there are two [slanting] rockets (*ta chhi huo*[a] *erh chih*[3]). The fourfold (branching) fuse, connected with the rockets [and about a foot long], is put through a hole drilled on the back (of the bird). When in use, this [main fuse] is lit first.

[a] This refers to the 'rising' gunpowder rocket compositions; cf. p. 483 above.

[1] 神火飛鴉 [2] 明火炸藥 [3] 大起火二枝

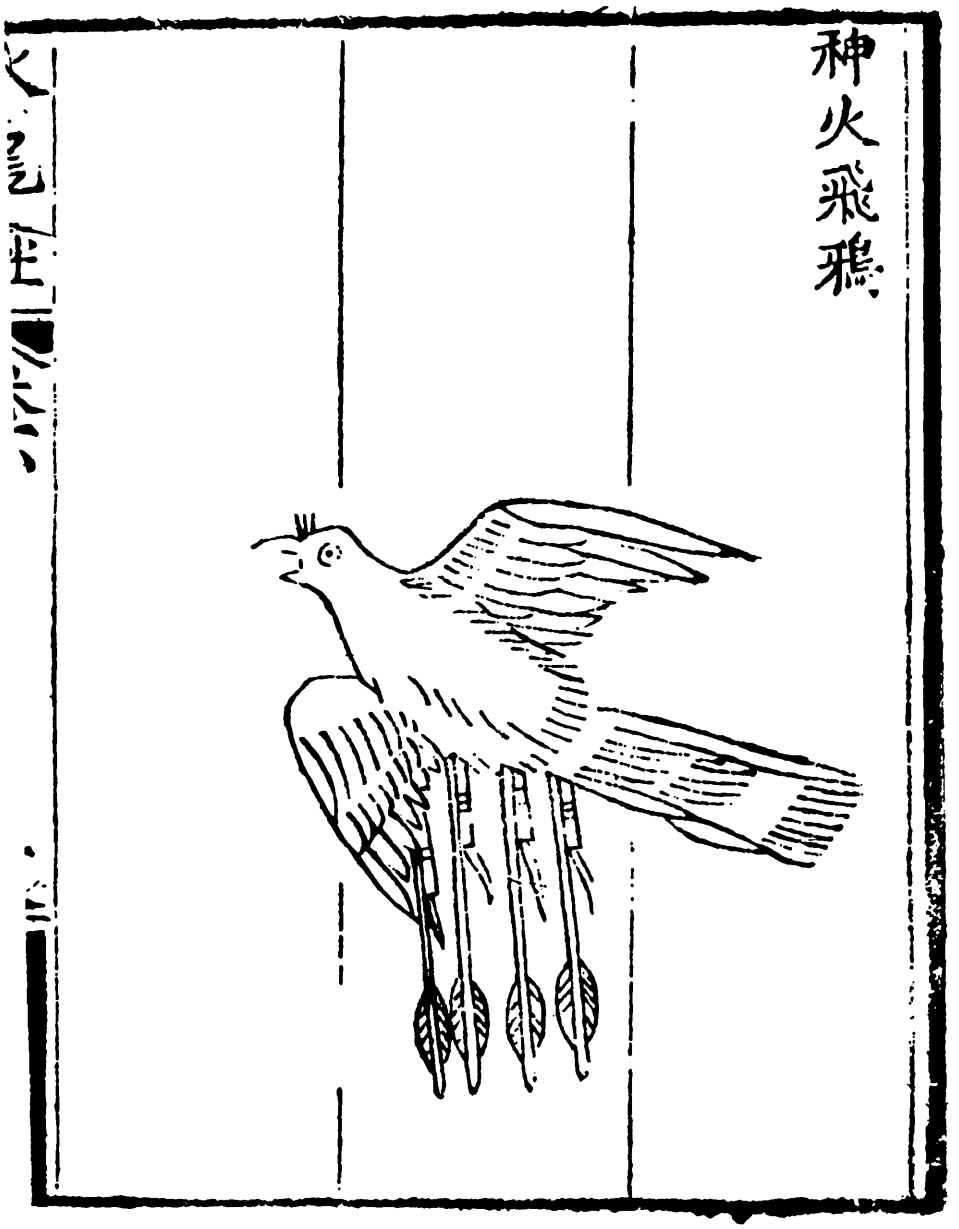

Fig. 208. A winged rocket-bomb, the 'flying crow with magic fire' (*shen huo fei ya*) from *HLC*, pt. 1, ch. 3, p. 18*a*, and therefore at least as early as +1350, probably a century earlier. The idea was doubtless derived from the use of expendable birds (Fig. 38) carrying glowing tinder wherewith to set on fire the roofs of the enemy city. But the provision of wings or fins for increasing aerodynamic stability long preceded anything of the same kind elsewhere in the world. And the provision of an explosive payload was also a new development.

The bird flies away more than 1000 ft, and when it eventually falls to the ground, the explosive gunpowder in the cavity of the bird is (automatically) lit, and the flash can be seen miles away. [This weapon is used against enemy encampments to burn them, but also at sea to set ships on fire. It should never fail to bring victory].[a]

The illustration suggests that the shafts and feathering of rocket-arrows were retained, but the text does not say so. In any case this must surely be the oldest account of the invention of the winged rocket in any civilisation.

One must naturally suppose that the wings were fitted with the four rockets to the weak-casing bomb because it was found that they gave added stability and accuracy to the flight. But what suggested them in the first place? The answer is immediately at hand—namely the use of expendable birds as incendiary carriers. It must be significant that these always accompany and precede the winged rocket-bomb in the military compendia. There were, for example, the 'fire-bird' (*huo chhin*[1])[b] and the 'nut sparrow' (*chhiao hsing*[2])[c] both carrying nutfuls of burning moxa tinder attached to their necks or legs, so that when they perched on the housetops of the enemy city they would set the roofs on fire. Both these had come down with little or no change from the *Wu Ching Tsung Yao* of +1044,[d] but again significantly they were there followed by no rocket-propelled artificial bird. Going back further, we can find the former easily in the *Hu Chhien Ching*[e] of +1004, and even in the *Thai Pai Yin Ching*[f] of +759. The practice was probably age-old, and there is no point in pursuing it further. Thus the winged rocket had to await the latter part of the +13th century at earliest—but even so it long preceded the winged rockets of the West.

There is another winged rocket-bomb, or rather grenade, in the *Wu Pei Chih*, the 'free-flying enemy-pounding thunder-crash bomb' (*fei khung chi tsei chen-thien-lei phao*[3]).[g] A rocket-tube (*sung yao thung*[4]) is contrived within the body of it, and when the wind is favourable the fuse is lit, whereupon it flies over to the enemy.[h] When the rocket-composition is nearly burnt out, the charge is automatically ignited, releasing a poisonous and irritating smoke as well as water-calthrops the thorns of which are tipped with tiger-poison. The whole thing is no more than 3·5 in. in diameter, made of dozens of layers of oiled paper, but on each side it has artificial wind-borne wings (*hsia fêng chhih*[5]) which will take it, in suitable conditions, right over a city wall (Fig. 211).[i]

[a] We also give in Figs. 209, 210 reconstructions made by the National Historical Military Museum in Peking.

[b] *HLC*, pt. 1, ch. 3, p. 16*a*, *b*, *HKPY*, *ibid.*, Hsiangyang ed., *HCT*, p. 33*a*; *WPC*, ch. 131, pp. 10*b*, 11*a*.

[c] *HLC*, pt. 1, ch. 3, p. 17*a*, *b*, *HKPY*, *ibid.*, Hsiangyang ed., *HCT*, p. 33*b*; *WPC*, ch. 131, pp. 11*b*, 12*a*.

[d] *WCTY*, ch. 11, pp. 21*a*, *b*, 22*a*, *b*.

[e] Ch. 54 (ch. 6), p. 5*a*, *b*. [f] Ch. 38 (ch. 4), p. 8*b*.

[g] *WPC*, ch. 123, pp. 22*b*, 23*a*. From p. 163 above we know that 'thunder-crash' was the key-word for a strong-casing bomb. Here perhaps it was loosely used.

[h] The stronger the wind the further it goes, says the text.

[i] We also give in Fig. 212 the reconstruction made by the National Historical Museum in Peking.

[1] 火禽 [2] 雀杏 [3] 飛空擊賊震天雷砲 [4] 送藥筒
[5] 轄風翅

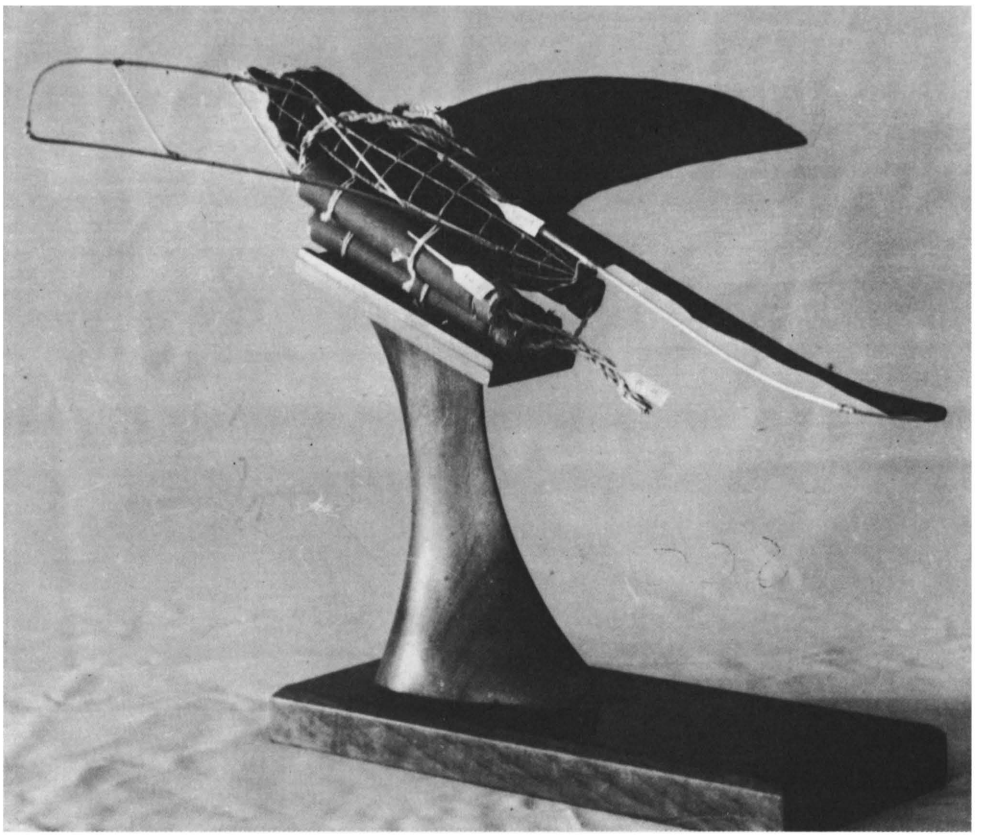

Fig. 209. Model of the winged rocket-bomb to show the structure and design (photo. Nat. Historical Museum, Peking, 1978).

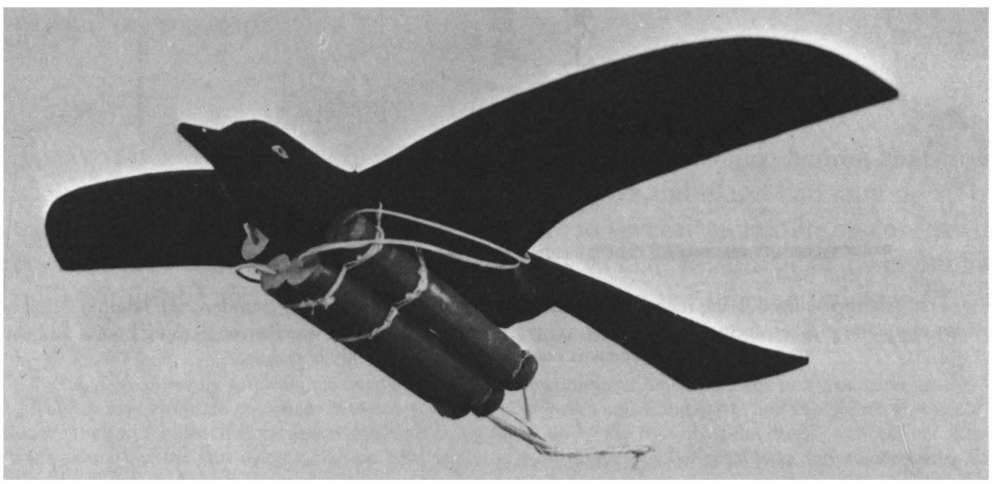

Fig. 210. Model of the complete winged rocket-bomb (photo. Nat. Historical Military Museum, Peking).

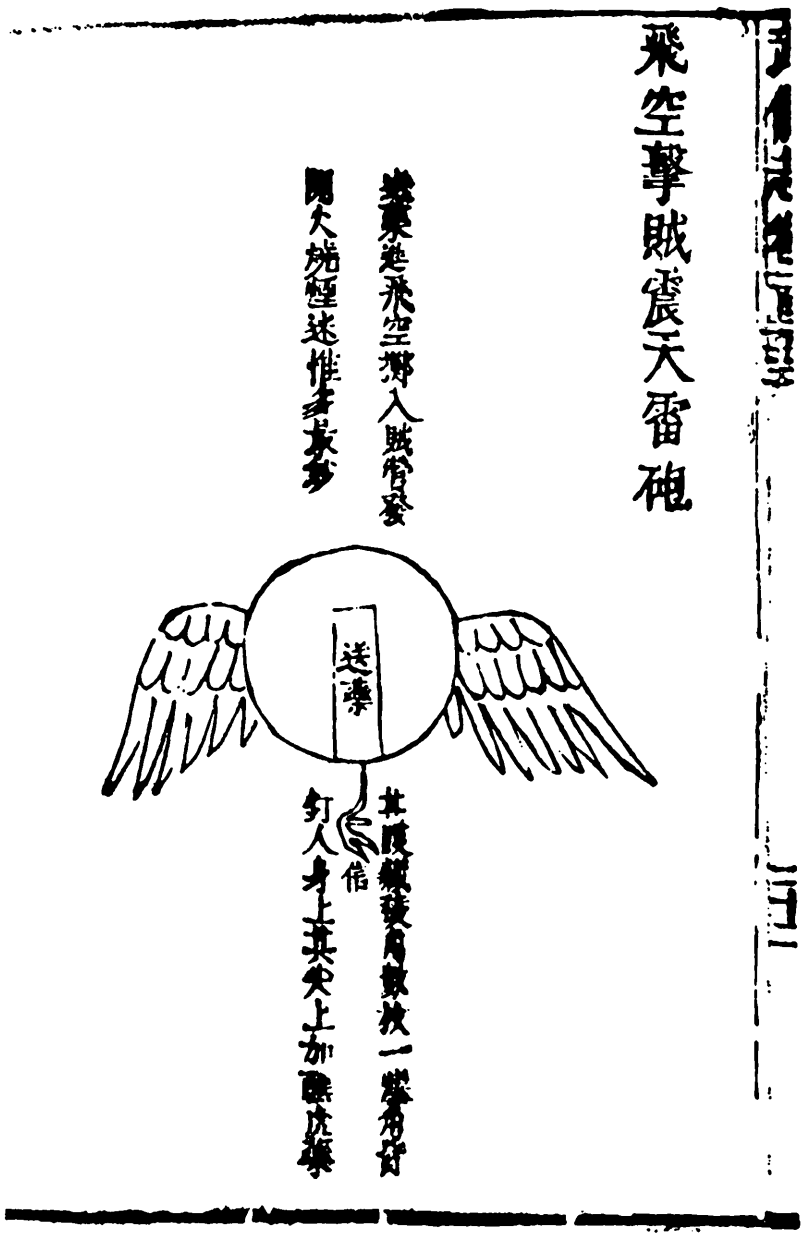

Fig. 211. Another winged flying rocket-bomb, the 'free-flying enemy-pounding thundercrash bomb' (*fei khung chi tsei chen-thien-lei phao*), from *WPC*, ch. 123, p. 22*b*. From its name this was a strong-casing bomb, and the rocket tube was contrived within the body of it.

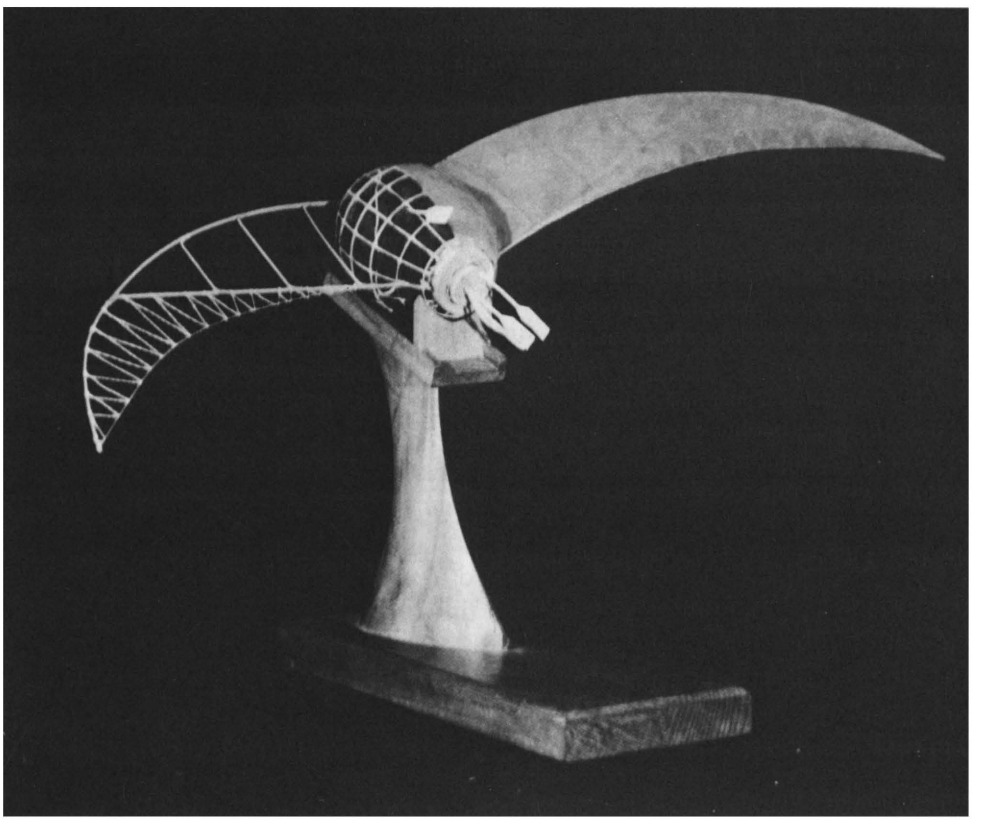

Fig. 212. Reconstruction of the rocket-containing flying bomb to show the structure of the wings. Photo. Nat. Historical Museum, Peking, 1978.

Such were the beginnings of the winged rockets of the present day that reach beyond the stratosphere.

(v) *Multi-stage rockets*

Today it is a commonplace, not only the pabulum of science fiction, that if we wish to leave the earth and travel into outer space, mankind can only do so by using rocket-craft with combustibles that fire in several successive stages, boosters to begin with, then smaller rockets, finally to take advantage of gravitational pulls within the emptiness, and cruise away among the stars and planets.[a] Artificial satellites launched by multi-stage rockets are now familiar to everyone,[b]

[a] Aided of course by small bursts from rocket-motors from time to time to change or adjust direction.

[b] They may circulate anywhere between 500 and 25,000 miles above the earth, and the higher they are the longer they will endure before descending and being burnt up by the friction of the earth's atmosphere. They must also avoid the van Allen radiation belt, which is most dangerous between 2000 and 12,000 miles. Cf. Taylor (1), pp. 82 ff.; von Braun & Ordway (2).

I shall always remember seeing the pin-point light of 'Sputnik I' crossing the sky, man's first artificial satellite, as we sat at dinner in the open air on the harbour mole at Valencia in Spain in 1957.

and space probes can be sent to remote inhospitable parts of the solar system where men are not yet ready to venture themselves.[a] In seeking for the origin of multi-stage rockets let us start from the present day and work backwards, tracing their development to its source.[b]

The 'Apollo' moon-landings of 1969 were accomplished by means of a three-stage rocket of enormous size, 'Saturn V'.[c] Such space projectiles have been developed along with those more menacing and dangerous missile carriers known as IRBM and ICBM.[d] Indeed it is an extraordinary fact that the very same rocket vehicles which can be, and have been, used for the exploration of extra-terrestrial space by human beings, can also be turned against themselves for fratricidal purposes of mass extermination—like fire itself, everything depends on what you do with it. The American 'Thor', 'Atlas', 'Titan' and 'Minuteman' have all been rockets of three or four stages, as also the Russian ones 'Scrag' and 'Sasin'.[e] It was the Russian pioneer Konstantin Tsiolkovsky about 1883 who first realised that space-flight would necessarily demand what he called 'rocket-trains' or multiple rockets firing in successive stages.[f] Only so could a sufficiently high speed be attained to overcome the pull of earth's gravity. Also in the nineteenth century came the application of Edward Boxer about 1855 of two-stage rockets for the purpose of life-saving at sea; they shot a cord over the endangered vessel so that a cable and a breeches-buoy could follow. By 1870 every British lifeboat station was equipped with these, and they are still in use at the present day, having saved many tens of thousands of lives.[g] Boxer based the design on the rockets of François Frézier, published in his book of +1741.

But the idea of two-stage rockets goes much further back, into the +17th and +16th centuries. It has long been known that the Lithuanian military engineer[h] Kazimierz Siemienowicz described them in his book *Ars Magna Artilleriae* pub-

[a] E.g. 'Mariner 4' and 'Venus 4'; Taylor (1), pp. 148–9.

[b] Dollfuss (1) suggests that the first payload-carrying rockets were those of French displays from +1772 onwards which shot live dogs and sheep high into the air, after which they descended safely by parachute (*parasol à feu*). Some of these seem to have been two- or three-stage rockets. Similar systems were used later on, for 'Verey lights' on battlefields from 1837, and for reconnaissance cameras from 1860. On the history of the parachute as such see Vol. 4, pt. 2, pp. 594 ff.

Duhem (1), pp. 292, 300, also describes the animal parachute experiments.

[c] This was eight years after the first human being had been put into space, Yuri Gagarin in 'Vostok I'. See Taylor (1), pp. 92 ff., 124 ff.; von Braun & Ordway (1), pp. 176 ff. By the time the last stage fell away, the 'Apollo' spacecraft was making 24,200 mph (Fig. 213).

[d] Intermediate-Range Ballistic Missiles and Inter-Continental Ballistic Missiles.

[e] Taylor (1), pp. 38, 72 ff.; Baker (1), pp. 109 ff.; von Braun & Ordway (2), pp. 135, 172–3 (1), pp. 175–6. China launched her first multi-stage carrier of modern type to a destined area in the South Pacific on 18 May 1980.

[f] See Baker (1), pp. 17 ff.; Olszewski (2); von Braun & Ordway (1), pp. 124–5; Ley (2), pp. 101 ff.; Taylor (1), pp. 14–5. Tsiolkovsky even envisaged liquid oxygen and hydrogen as fuels, the very solution adopted nearly a century later in 'Saturn V'.

[g] Taylor (1), pp. 11–2; Humphries (1), pp. 143 ff., 178. The second-stage rocket was lit by a small detonating charge of gunpowder.

[h] Siemienowicz spent his life in the Polish service.

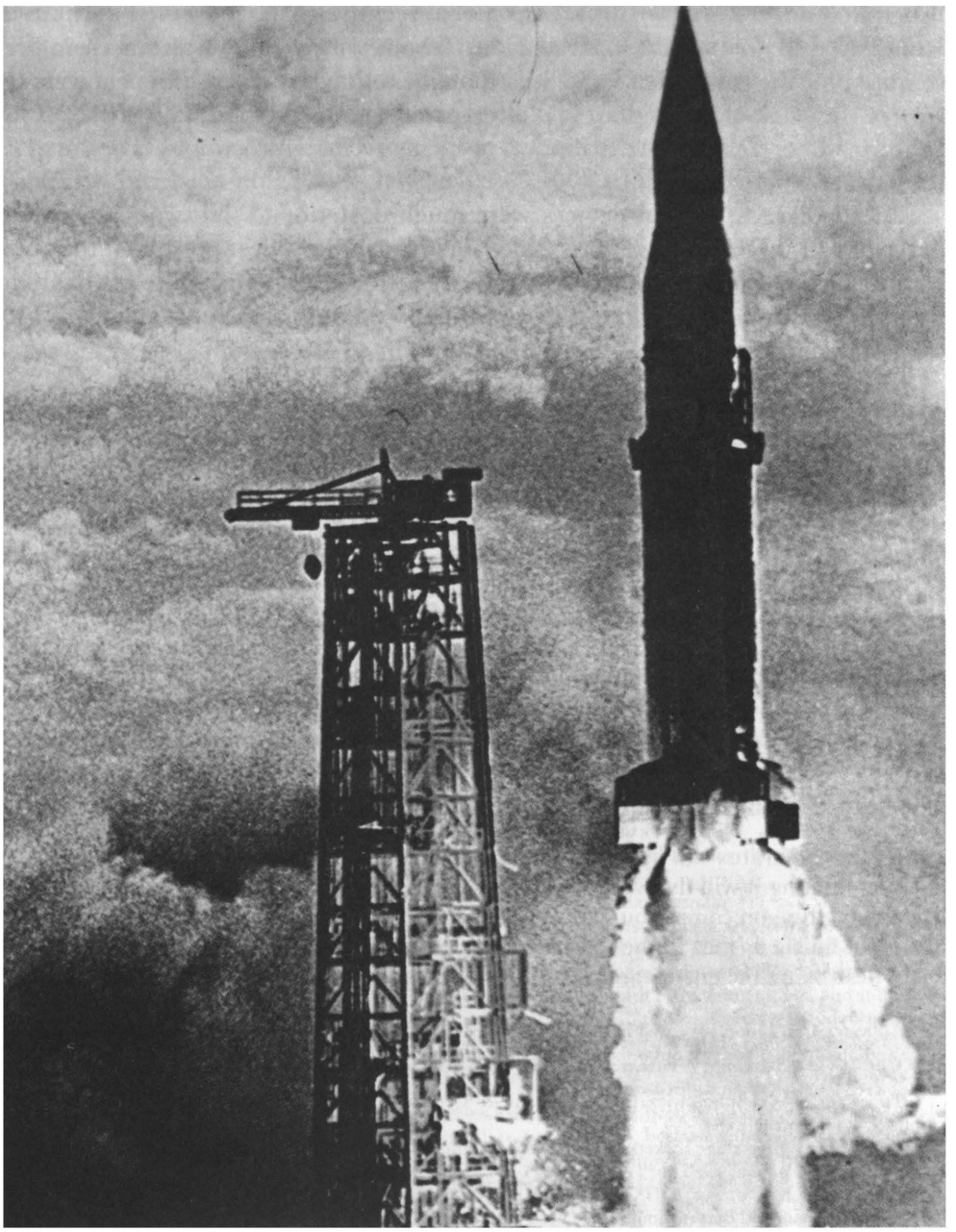

Fig. 213. Multi-stage rockets; the blast-off of Saturn I in 1961 (from Baker (1), p. 157).

lished at Amsterdam in +1650.[a] But more recently a MS. conserved at Sibiu in Rumania and written by Konrad Haas[b] about +1560 shows also a clear presentation of the same idea,[c] and it is thought to have reached Siemienowicz by way of the book of Schmidlap (1), often printed in the second half of the +16th century.[d] Less clear is the attribution to Biringuccio, which would take the matter back to +1540.[e]

But all these European devices were much posterior to the two-stage rocket described in the *Huo Lung Ching*.[f] Since it occurs in the oldest portion of the book it must be dated to the second half of the +14th century, and quite probably to the first half also.[g] Describing the 'fire-dragon issuing from the water' (*huo lung chhu shui*[1]), it says:[h]

A tube of bamboo (*mao chu*[2])[i] 5 ft long is taken, the septa removed, and the nodes scraped smooth [with an iron knife]. A piece of wood is carved into the shape of a dragon's head (and fitted on at the front) while a wooden dragon tail is made for the rear end. [The mouth must be facing upwards, and] in the belly of the dragon there are several 'mysterious mechanism rocket-arrows' (*shen chi huo chien*[3]).[j] At the dragon head there is an opening through which go all the fuses of the rockets (inside).

[Beneath the dragon head on both sides there are two (big) rocket-tubes weighing a catty and a half each. Their fuses (and orifices) should face downwards (and backwards), and their front ends must face upwards (and forwards); and they are fixed tight to the body by (bands of) hempen cloth secured with skin- and fish-glue. The fuses of the rocket(-arrows) within the belly lead out from the head of the dragon, and they are divided into two. Oiled paper is used to make them firm, and they are so arranged as to be connected with the front (ends) of the (outside) rocket-tubes (*huo chien thung*[4]). And under the tail of the dragon on each side there are also two (big) rocket-tubes, fastened in the same style. The fuses of the four rockets are twisted into a single one. In a naval battle] the apparatus can fly 3 or 4 ft above the water.

Upon lighting it will fly over the water as far as 2 or 3 *li*.[k] At a distance it really looks like a flying dragon coming out of the water. When the gunpowder in the rocket-tubes is nearly all finished (that in the rocket-arrows within the belly is ignited, so that) they fly forth, destroying the enemy and his ships. [It can be used either on land or sea.]

[a] A French translation appeared in the following year. See Olszewski (1), p. 251; Barowa & Berbelicki (1), p. 12 and opp. p. 9; Thor (2); Subotowicz (2); Berninger (1).

[b] +1529 to 69.

[c] Todericiu (1–5); Subotowicz (1); von Braun & Ordway (1), pp. 11 ff. Haas added delta-shaped fin-stabilisers to his rocket tails.

[d] He designed three-stage rockets, on which see Subotowicz (1), as did Siemienowicz later.

[e] (1), Eng. ed. p. 442; see Thor (1).

[f] *HLC*, pt. 1, ch. 3, p. 23*a*, *b*, *HKPY*, *ibid.*; Hsiangyang ed., *HCT*, p. 36*b*; *WPC*, ch. 133, pp. 3*a*, *b*, 4*a*.

[g] It was only natural that it should have been earlier, in view of the antecedent development of all gunpowder devices and weapons in China.

[h] Tr. auct. Passages in square brackets come from the rather longer version in the *Wu Pei Chih*.

[i] *Phyllostachys*, probably *edulis*; cf. Chhen Jung (1), p. 78; Steward (2), p. 437—but in any case one of the bamboos of large diameter.

[j] Cf. Table 6 above.

[k] This range is not so long as it sounds. The Yuan *li* was 0·344 mile, or 605 yards, so the maximum given would only be 1816 yards.

[1] 火龍出水 [2] 猫竹 [3] 神機火箭 [4] 火箭筒

Thus the automatic lighting of the second-stage rockets is clearly stated.[a] Although strangely prefiguring submarine-launched weapons of 'Polaris' type,[b] it was not in fact fired from under water, but rather from near the water-level on shipboard, and its trajectory was evidently kept very flat.[c] Fig. 214 shows the illustration from the *Huo Lung Ching*; those in later books simply re-draw it.[d] This invention has been noted by a few writers,[e] but its full significance has hardly ever been appreciated.

(vi) *The rise and fall, and rise again, of military rockets*

For reasons which have already been explained (p. 472), the origin and development of the rocket is an exceptionally difficult study in technological history. We must unravel it as best we can, but a definitive account will have to await further research.[f]

To begin with, we have two fixed points, +1264 when an empress was frightened by the 'ground-rats' or 'earth-rats' at a firework display (p. 135 above);[g] and the neighbourhood of +1280 when al-Rammāḥ in Syria described rocket-arrows as *sahm al-Khiṭāi*, 'arrows of China' (p. 41 above). Equally, in spite of arguments to the contrary, we do not believe that rockets were described in the *Wu Ching Tsung Yao* of +1044 (pp. 226 above); while on the other hand they were prominent among the fireworks mentioned by Fêng Ying-Ching and Shen Pang in +1592 (p. 134 above).[h] The details in the *Huo Lung Ching* affirm rockets clearly

[a] The same principle was even applied to fire-crackers in traditional China; cf. Ball (1), p. 282.

[b] Cf. Taylor (1), pp. 76–7. In Oct. 1982 the Chinese navy successfully tested a submarine-launched ballistic missile.

[c] It was thus the very model of a modern 'Exocet' missile (named from the flying fish *Exocetus*), so prominent in the Falklands campaign, as Dr Christopher Cullen remarked to us at Louvain.

[d] We also give in Fig. 215 the reconstruction made by Chiang Chêng-Lin for the National Historical Military Museum in Peking. Cf. Anon. (*209*).

[e] E.g. Hsi Tsê-Tsung (*6*); Hsü Hui-Lin (1); Chiang Chêng-Lin (1); Sandermann (1), p. 171.

[f] One meets from time to time in the Western literature with dubious stories about Chinese rocketry. For example, Hokeš (1) has written about 'Wan Hoo', a supposed official of the Ming period, who invented a kite-like monoplane powered by about 30 rockets, but perished in its first experimental flight. There is a whole series of uncritical references to this, as in Ley (2), pp. 84–5; Gibbs-Smith (10); Zim (1), etc. and it has even been entertained by Chinese writers such as Hsü Hui-Lin (1). But in spite of much correspondence, as with A. T. Philp in Australia, we have never been able to get any firm reference to Wan Hoo, and we suspect that he is a myth invented probably during or after the Chinoiserie period. The matter is reminiscent of a similar story about a dirigible airship ascribed to the Yuan (Vol. 4 pt. 2, p. 598) and probably equally without foundation.

The application of rocket-propulsion to land vehicles has never in fact been of much practical use (Taylor (1), pp. 18 ff.) except for test-track sleds (Humphries (1), p. 179, fig. 113), because although rocket thrust is so high per unit weight, and realisable with extreme rapidity, its fuel consumption is extremely great. But rocket-assisted take-off for aeroplanes has become commonplace (cf. Humphries (1), pp. 163 ff., fig. 100), and a glider like that ascribed to Wan Hoo was successfully flown by Fritz von Opel in 1928.

One can even find Wan Hoo in Norwegian; cf. Holmesland *et al.* (1), vol. 16, p. 508.

[g] Of course it does not follow that the ground-rats were a new invention of that year, nor that civil fireworks were their only employment. They may well have been a century or more old at the time. We have suggested (p. 474 above) that the incorporation of these mini-rockets in cavalry-confusing bombs was the most primitive form of the use of rockets in warfare.

[h] Their 'ascending fires' (*chhi huo*[1]) were undoubtedly rockets, and they also knew of the ground-rats (*ti lao shu*[2]) and the similar toys that whizzed about on water surfaces (*shui shu*[3]). Something like this last is in al-Rammāḥ (Partington (5), p. 203).

[1] 起火 [2] 地老鼠 [3] 水鼠

Fig. 214. The first of all multi-stage rockets, the 'fire-dragon issuing from the water' (*huo lung chhu shui*), a device from *HLC*, pt. 1, ch. 3, p. 23*a*. It therefore belongs to the middle, perhaps to the beginning, of the +14th century. It was a two-stage rocket, for when the carrier or booster rockets were about to burn out they automatically ignited a swarm of smaller rocket-arrows which issued through the dragon mouth and fell down upon the enemy. The design seems to have been for use mainly in naval warfare, and as the trajectory was very flat the weapon may be regarded as an ancestor of the modern 'Exocet'

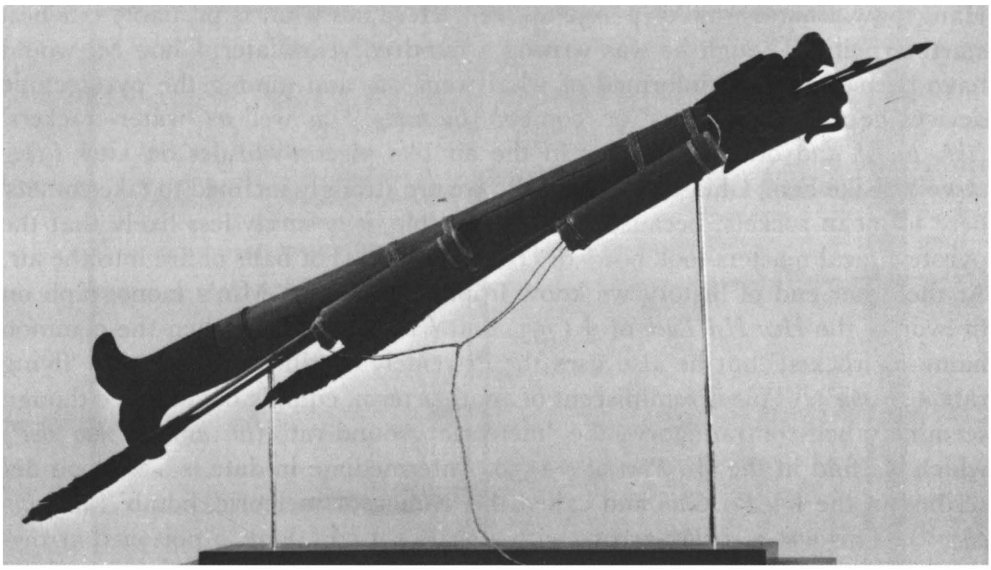

Fig. 215. Reconstruction of the two-stage rocket described in the previous illustration (photo. Nat. Historical Military Museum, Peking).

by about +1350 (p. 479 above),[a] so the period in which we mainly have to look lies between about +1050 and +1280.

Now it will be remembered (pp. 148ff. above) that between +969 and +1002 there was a crop of military inventions by Thang Fu, Yo I-Fang and others, in which new sorts of firearms figured, but we do not believe that these were rockets.[b] Fire-arrows were standard equipment on battleships in +1129, but again there is no justification for interpreting them as rockets.[c] By +1206 a term not previously used appears, 'gunpowder arrows' (*huo yao chien*[1]), fired off by Chao Shun's men during the defence of Hsiangyang against the Chin Tartars (p. 168 above), but though these may have been rockets the expression could easily have referred to low-nitrate gunpowder used on incendiary arrows, as it had been for at least a couple of centuries previously. On the other hand the 'fire-arrows' launched in +1245 during the military and naval exercises in the Chhien-thang estuary (p. 132 above) most probably were rockets. There is here a zone of probability which we can only assess in the light of the following circumstance.

This is the description of the fireworks used at festivals on the West Lake at

[a] And very complicated ones too, such as winged ones and two-stage ones.

[b] Wang Ling (1), pp. 165, 168; Goodrich & Fêng Chia-Shêng (1), p. 114, were uncertain about the nature of these. Průsek (4); Köhler (1), vol. 3, pt. 1, p. 169; and Hsü Hui-Lin (1), thought they were rockets.

[c] In spite of what we said in Vol. 4, pt. 3, pp. 575–6 above, which misled von Braun & Ordway (1), p. 41.

[1] 火藥箭

Hangchow around +1180 (p. 132 above).[a] Here lies what is probably our best starting-point. Though he was writing a hundred years later, Chou Mi would have been quite well informed of what went on, and among the pyrotechnic devices he named 'meteors' or 'comets' (*liu hsing*[1])[b] as well as 'water-crackers' (*shui pao*[2])[c] and others that flew in the air like pigeon-whistles on kites (*fêng chêng*[3]).[d] Like Fêng Chia-Shêng himself,[e] we are strongly inclined to take comets[f] here to mean rockets, because, though possible, it is surely less likely that the pyrotechnical masters took bows or crossbows and shot balls of fire into the air. At the other end of history we know from Chao Hsüeh-Min's monograph on fireworks, the *Huo Hsi Lüeh* of +1753, that *liu hsing*[1] was by then the common name for rocket;[g] but he also uses the extremely significant expression 'flying rats' (*fei shu*[5]).[h] This is reminiscent of another term, equally conjunctive though seemingly self-contradictory, the 'meteoric ground-rat' (*liu hsing ti lao shu*[6]) which we find in the *Wu Pien* of +1550.[i] Intermediate in date is a weapon described in the *Wu Pei Chih* and called the 'comet, or meteoric, bomb' (*liu hsing phao*[11]).[j] This was a rocket-arrow, with a shaft 4 ft 5 in. long, a poisoned arrowhead, and a small carton bomb about the same diameter as the rocket-tube fixed in front of it. As the rocket burnt out, it ignited the bomb (Fig. 216).

Unfortunately, it would be highly deceptive to take everything bearing the name *liu hsing* as a rocket. For example, we have already encountered (p. 180) the 'magic-fire meteoric bomb that goes against the wind' (*tsuan fêng shen huo liu hsing phao*[15]), certainly current by the mid +14th century;[k] it was probably thrown in antique style from a trebuchet, and perhaps got its name simply from

[a] In fact, the Shun-Hsi reign-period, +1174 to 89.

[b] *Wu Lin Chiu Shih*, ch. 3, p. 1*b*.

[c] This probably means the water-rats or rocket-skimmers, perhaps igniting a small explosive charge as they burnt out.

[d] This sounds like Verey lights suspended in that way—or of course live birds could have carried them. On pigeon-whistles, see Vol. 4, pt. 2, p. 578.

[e] Letter to J. N. of 1 Jan. 1956.

[f] Strictly speaking, 'meteors' is the better word, for properly comets were *hui hsing*[4] (cf. Vol. 3, pp. 431, 433).

[g] Cf. Davis & Chao Yün-Tshung (9), p. 104.

[h] *Ibid.* p. 103. Earth-rats and water-rats are mentioned many times (pp. 101–2, 103–4).

[i] Ch. 5, pp. 63*b* ff. Such names make one think of bats and other flying mammals. Indeed *fei shu* was an occasional synonymic name for the bat. 'Ground-rat' had always been a good term for the small rocket because it scuttled about at random. But there could never have been any confusion in the names of the airborne ones, partly because the flight was so different, and partly because they had long had their own special names. The commonest bat, *Vesperugo noctula*, was called *pien fu*[7] (or *thien shu*[8]); cf. *PTKM*, ch. 48, p. 43*b*; R 288; Tu Ya-Chhüan *et al.* (1), p. 1956·2. Other species, such as the flying squirrel *Pteromys xanthipes* also had their special names, in this case *lei shu*[9] or *fu shu*[10]; cf. *PTKM*, ch. 48, p. 47*b*; R 289.

[j] *WPC*, ch. 128, pp. 16*b*, 17*a*. The description says that the use of the weapon is a good way of causing commotion among enemy troops, especially cavalry, as well as doing some incidental damage, after which one should press the attack. But the artists forgot to put in the feathering (*ling*[12]), though it is mentioned in the text, and moreover the arm is called *chhiang*[13] rather than *chien*[14]—confusing features which led Davis & Ware (1), pp. 523–4 to regard it as a fire-lance or incendiary whip-arrow, i.e. javelin.

[k] Because of *HLC*, pt. 1, ch. 2, p. 7*a*, *b*. Lit. 'wind-piercing'.

[1] 流星 [2] 水爆 [3] 風箏 [4] 彗星 [5] 飛鼠
[6] 流星地老鼠 [7] 蝙蝠 [8] 天鼠 [9] 鼯鼠 [10] 蝠鼠
[11] 流星砲 [12] 翎 [13] 鎗 [14] 箭 [15] 鐵風神火流星砲

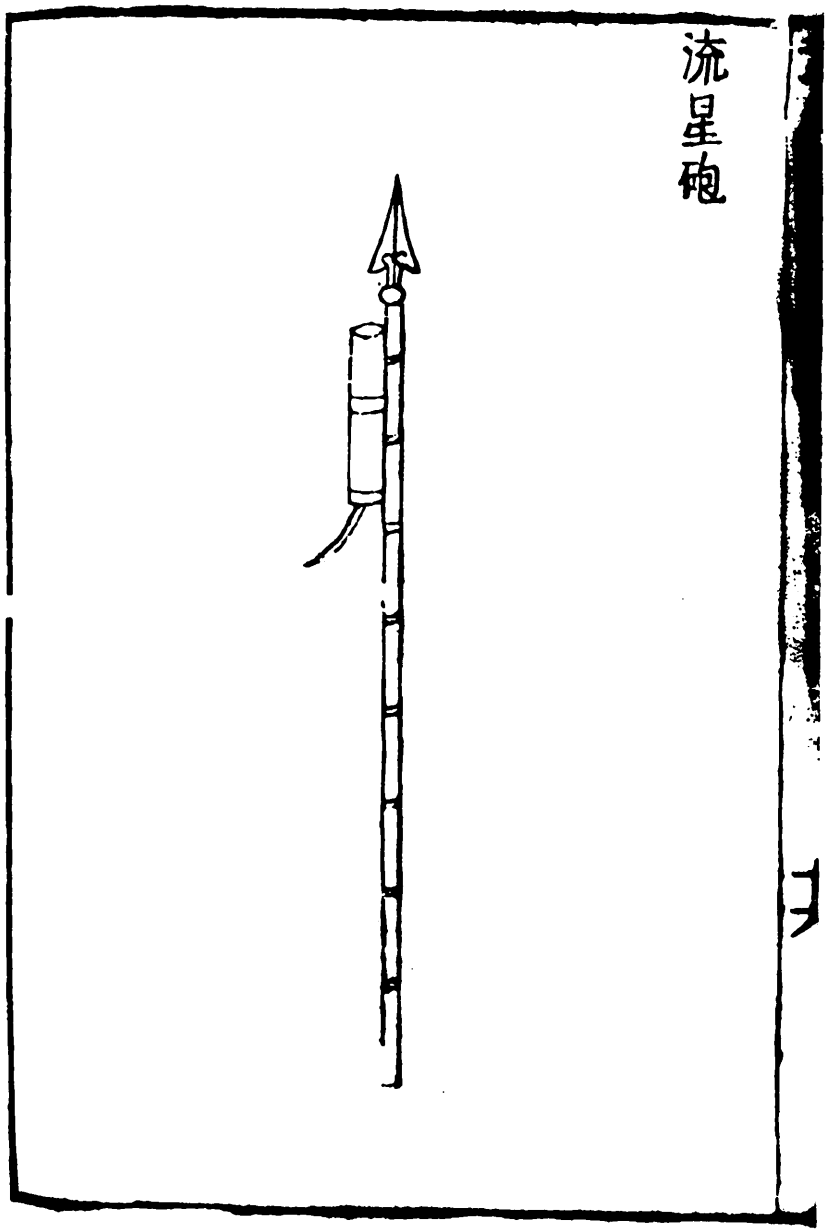

Fig. 216. That the earth-rat turned into the rocket is well illustrated by the expression 'meteoric ground-rat' (*liu hsing ti lao shu*) found in +1550, and another, the 'flying rat' (*fei shu*) of +1753. Here we have a confusing instance of similar nomenclature, the 'meteoric bomb' (*liu hsing phao*), from *WPC*, ch. 128, p. 16*b*. The bomb was simply a carton of gunpowder fixed forward of the rocket-tube head, which automatically set off the explosion as it was about to burn out.

the light of the burning fuse as it passed through the air. Equally there was the 'fire-crossbow meteoric arrow-(shooter)', (*huo nu liu-hsing chien*[1]).[a] This had nothing to do with crossbows either;[b] it was a bamboo proto-gun[c] firing ten poisoned arrows at a time, which came out 'like a flock of locusts' (Fig. 217). It happens that we can perhaps trace this weapon a long way back, because we read[d] that in +1049 a certain magistrate, Kuo Tzu[3], presented prototypes of a 'combat wheelbarrow'[e] and an 'invincible meteoric crossbow' (*wu ti liu hsing nu*[4]); at that time it would have been a fire-lance sending out the arrows as co-viative projectiles.[f]

The dearth of battle accounts specifically mentioning rockets has already been mentioned, but we can find a few, though not for the vital century that we have now been able to define, between +1180 and +1280. For example, bombs containing ground-rats are prominent in the account of the campaign of Liu Chi[5] in Chekiang against inland rebels and coastal pirates around +1340.[g] Launchers are in evidence around +1380, when 'wasps' nests' (*i wo fêng*[6]) are included in lists of army supplies.[h] And after the Ming had begun, they were much used in a battle of +1400 when the imperial army under Li Ching-Lung[7] was fighting the Prince of Yen[8] (the future Yung-Lo emperor), but though effective they did not save the day against him.[i]

Yet another relatively late reference concerns the Timurid Persian embassy from Shāh Rukh to China in +1419, when we find mention of rockets not so much for war as travelling on wires to light lamps and other fireworks at ceremonies to amaze glittering assemblies. In his diary Ghiyāth al-Dīn Naqqāsh wrote:[j]

[a] *HLC*, pt. 2, ch. 2, p. 20*a*, *b*; *WPC*, ch. 126, pp. 12*b*, 13*a*; *PL*, ch. 12, pp. 50*b*, 51*a*.

[b] The only similarity was that the handle was curved like a mark of interrogation.

[c] We say this because the caption mentions a plug (*tan ma*[2]), so that the bore was probably occluded in front of the propellant charge. The barrel was reinforced with iron straps.

[d] *YCLH*, ch. 226, p. 6*b*, quoting (via *Ping Lüeh Tshuan Wên*[9]) *Yü Hai* (+1267), ch. 150, p. 24*a*, *b*. Cf. Chou Chia-Hua (*1*), pp. 210–11.

[e] What relation this could have had with those just discussed (pp. 497ff. above) we do not know. But we doubt that they launched rockets. One is, of course, reminded of the ancient military connections of the vehicle (Vol. 4, pt. 2, p. 260).

[f] True, it was not called a 'fire-crossbow', but at the same time another official, Sung Shou-Hsin[10], presented other fire-weapons, so the identification is reasonable. Of course it may have been a real crossbow with flaming incendiary bolts.

[g] *Hsi Hu Erh Chi*, ch. 17 (pp. 335–6). Cf. p. 183 above. The 'great wasps' nest' (*ta fêng kho*[11]) is here described as including ground-rats, though not in *HLC*, pt. 1, ch. 3, p. 11*a*, *b*, or *WPC*, ch. 130, p. 14*b*. The 'fire-brick' (*huo chuan*[12]) always has them.

[h] *HWHTK*, ch. 134 (p. 3994·3).

[i] *Ming Shih Lu* (Thai Tsung sect. 6), p. 5*b* (p. 64); cf. Goodrich & Fêng Chia-Shêng (1), p. 122, who give further references. See also Chang Hsüan's[13] *Hsi Yuan Wên Chien Lu*[14] (Things Heard and Seen in the Western Garden), ch. 73, pp. 3*b*, 4*a*, *b*, 5*b*.

[j] Tr. Quatremère (3), p. 387; Rehatsek (1), the latter reproduced in Yule (2), vol. 1, p. 282. The log of the expedition formed the appendix to the *Ruẓat al-Safā* of Muḥammad Khāvend Shāh. An exactly similar passage occurs in the *Zubdatu't Tawārikh* of Hafīz-i Abrū, tr. Maitra (1), p. 90.

[1] 火弩流星箭 [2] 彈馬 [3] 郭諮 [4] 無敵流星弩 [5] 劉基
[6] 一窩蜂 [7] 李景隆 [8] 燕王 [9] 兵略纂聞 [10] 宋守信
[11] 大蜂窠 [12] 火磚 [13] 張萱 [14] 西園聞見錄

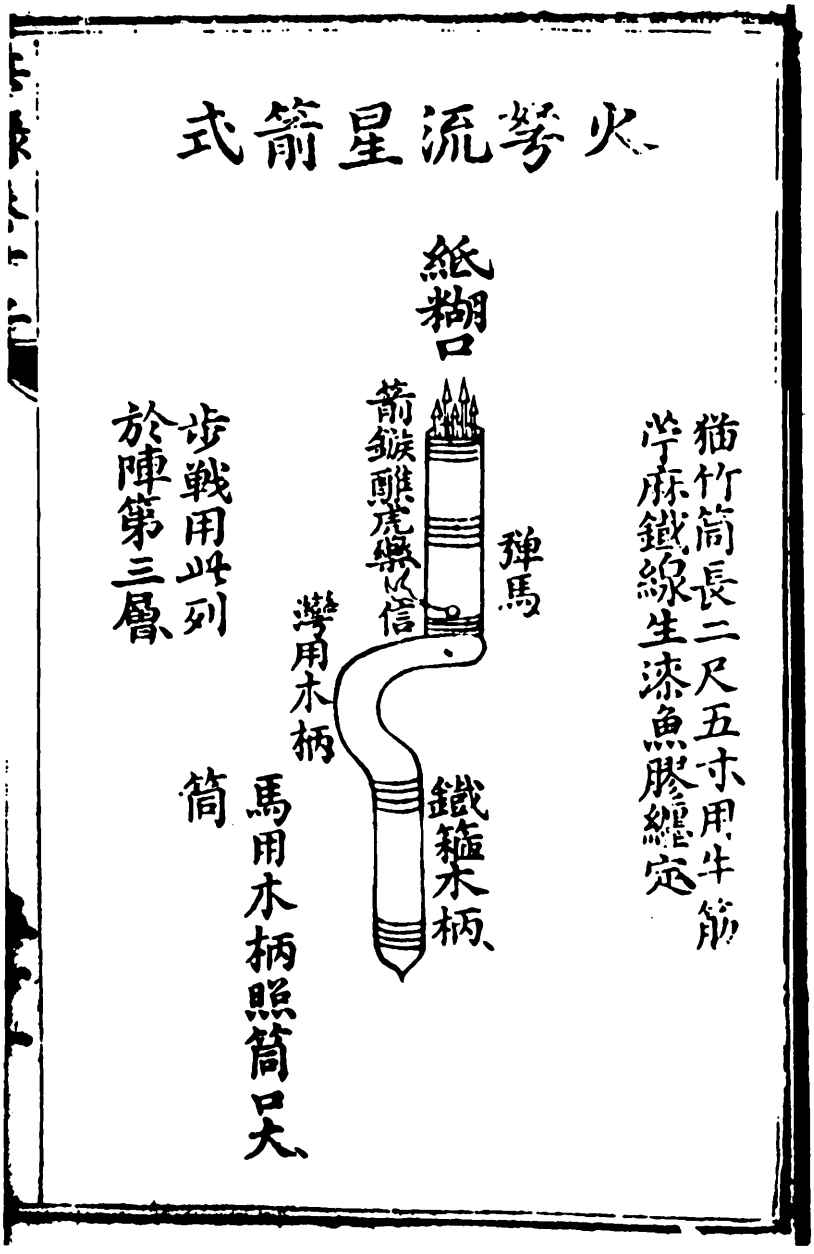

Fig. 217. Another example of a weapon which though called 'meteoric' had nothing to do with rockets, the 'fire-crossbow meteoric arrow-shooter' (*huo nu liu hsing chien*), nor did it have anything to do with crossbows either. It was a bamboo fire-lance or proto-gun which shot forth arrows as co-viative projectiles. *PL*, ch. 12, p. 51*a*.

At that season the Feast of Lanterns takes place, when for seven days and nights, in the interior of the imperial palace, a wooden ball is suspended from which numberless chandeliers branch out, so that it appears to be a mountain of emeralds; and thousands of lamps are suspended from cords. Rats of naphtha are then prepared, and when lit they run along the cords and light every lamp they touch, so that in a single moment all the lamps from the top to the bottom of the ball are kindled.[a]

Actually this use of rockets travelling along cords has come down as a ploy in China to our own time, under various names such as 'the phoenix flitting among the peonies' (*fêng chhuan mou tan*[1]).[b] And it got to the West as well, since we find dragons propelled in the same way in +17th-century European pyrotechnic books.[c]

All in all therefore we shall be fairly safe in placing the Chinese origins of the rocket in the second half of the +12th century, no doubt when Hangchow had entered that period of great peace and prosperity which it had as the capital of Southern Sung.[d] By the time that al-Rammāḥ got to know of them they had been in use for something like a century and a half. When, one may ask, did their history in the West begin?

It is generally agreed that rockets[e] are first mentioned in connection with the Battle of Chioggia between the Genoese and the Venetians in +1380, though they may well have been used a little before that.[f] From then onwards there are many references. By +1405 Konrad Kyeser in his *Bellifortis* knew that a rocket must be a tubular gas-tight container open at one end, with a hollow 'Seele' bored in its charge, and a stick or arrow-shaft 'to steer it'.[g] In +1440 Giovanni da Fontana knew rocket-propelled missiles well,[h] as did Leonardo da Vinci in his

[a] There is something here reminiscent of the 'lamp-trees' which we discussed in the fireworks sub-section (p. 136 above).

[b] Sun Fang-To (1), p. 8 (pp. 302–3).

[c] E.g. in +1633, Leurechon, Henriot & Mydorge (1), p. 272. Cf. Brock (1), pp. 186–7. Later these rocket-propelled 'cable-cars' were called *courantins* (von Braun & Ordway (1), pp. 67–8). And in +1765 unmistakable 'water-rats' were described by Jones (1) as well.

[d] And in this case it does look as if the 'flying rats' were initially a civilian pyrotechnic device applied to warfare only rather later. Yet if the rocket stick derived from the rocket-arrow shaft (cf. p. 477 above) the two uses perhaps grew up together.

We are glad to be able to report that our estimate of dating is shared by our friends Mr Hu Tao-Ching, the eminent historian of science at Shanghai, and Mr Phan Chi-Hsing, of the Institute of the History of Science in Peking.

[e] This would be a suitable place to mention the origin of our word 'rocket'. In old Italian *rocca* was a distaff, or a quill or bobbin for silk-winding, hence a long thin tube (Skeat), and the same word was also used to denote a wooden sheath that covered the sharp points of lances during combat exercises (v. Braun & Ordway).

[f] *Danduli Chronicon*, in Muratori (1), vol. 12, p. 448 (*igne imissio cum rochetis*), vol. 15, p. 769 (*furono tirate molte rochette*); cf. Partington (5), pp. 174, 184; Hime (1), pp. 144 ff. The date is just about what one would expect for Europe.

[g] Partington (5), pp. 147–8.

[h] *Ibid.* pp. 161–2. Fontana also proposed a rocket-driven vehicle on four wheels; cf. von Braun & Ordway (2). opp. p. 68. This strange device reappeared in actuality during the Indian Mutiny of 1857 (*ibid.* p. 116). Giovanni da Fontana may well have drawn directly from Chinese sources, because in a work of +1454 he makes a reference to 'my true friend Constantine of Venice, who for many years travelled about in the realm of the Great Khan'. See Birkenmaier (2); Thorndile (12); Clagett (4) and Lynn White (20), p. 8. Other +15th-century references are given by Brock (2) pp. 158 ff.

[1] 鳳穿牡丹

Codex Atlanticus (+1514) and other MSS.[a] Rockets applied both for war and for peaceful pyrotechnics were now commonplace, and in the +17th century there grew up a large literature on them, from which one need only mention Ufano (1) in 1613, Appier-Hanzelet (1) in 1625, and Furtenbach (1, 2) in 1629 and 1650.[b]

But for some reason or other, probably the early and rapid development of gunnery in Europe, rockets played no great part in warfare after that, being mainly confined to firework displays.[c] India was the part of the world where the rocket-arrow achieved greatest prominence, and from the time of the Mogul emperor Akbar (r. +1556 to +1605) onwards.[d] No records which would fix the date at which India received the rocket-principle from China have been found, but it must have been some time in the +14th or +15th century, for the oldest literary reference which Gode[e] could find was of about +1500, the *Kautukacintāmaṇi* by Prataparudradeva of Orissa.[f] This agrees with the earliest historical references which Winter noted, namely in +1499, possibly +1452;[g] and it is certain that Duarte Barbosa saw pyrotechnic rockets when attending a Brahmin wedding in Gujerat in +1515.[h] The word for rocket in Sanskrit is *bāṇ, bāṇa*;[i] which explains the following passage written by François Bernier concerning an event of which he was an eye-witness in +1658. After describing the battle-array, cannon, swordsmen, etc. of the prodigious great Mogul armies in the combat of Aurungzeb against Dara at Samugarh, he goes on to say that 'they hardly made use of any more art than what hath now been related; only they placed here and there some men casting *bannes*, which is a kind of granado fastened to a stick, that may be cast very far through the cavalry, and which extremely terrifieth horse, and even hurts and kills sometimes'.[j]

But it was in the late +18th century that military rockets became really prominent, especially in the Second, Third and Fourth Mysore Wars,[k] during the last twenty years from +1780 onwards. Haidar Ali, the Rājā of Mysore, then invaded the Carnatic, but soon dying, his struggle against the British was carried on by Tipū Sahib his son. Before the fall of Seringapatam and Tipū's death in 1799, these princes had had 6000 rocketeers in their armies, and the East India Company's troops suffered severely from them.

[a] Partington (5), p. 175. Interestingly, he describes various kinds of ground-rat bombs (McCurdy (1), vol. 2, pp. 198, 203–4, 219).

[b] Cf. Kalmar (1); Partington (5), pp. 167–8, 177.

[c] Brock (1), pp. 181 ff. [d] Cf. Elliott (1), vol. 6, p. 470.

[e] (7), pp. 12, 19.

[f] References continue in later works, such as the *Rukmiṇī Svayaṁvara* by Ekanātha (+1570) and the *Rāmadāsa Samagra Grantha* by Rāmadāsa (+1650).

[g] (1), pp. 9 ff. Winter lists fourteen other accounts, including the Battle of Gwalior in +1518, Akbar's expedition to Gujerat in 1572, Aurungzeb's campaigns of 1657 onwards, the fights against the French in 1750, the Maratha wars after 1792, and finally the last appearance of rocket-arrows in the attack on Jhānsi as late as 1858.

[h] (1), vol. 1, p. 117. Cf. Gode (7).

[i] Gode (7), p. 20, says that it may be connected with a similar earlier word meaning arrow, but suspects a borrowing from some other language for the meaning of rocket.

[j] (1), p. 40; 1671 ed., p. 109.

[k] See V. Smith (1), pp. 540 ff., 583 ff.

As Winter says,[a] the rocket became far more extensively employed in India than in any other nation during the +17th and +18th centuries, perhaps because of a certain lack of barrel firearms, especially light artillery. No one ever described it better than Quintin Craufurd, writing in +1790.[b]

> It is certain, that even in those parts of Hindostan that never were frequented by Mahommedans or Europeans, we have met with rockets, a weapon which the natives almost universally employ in war. The rocket consists of a tube of iron, about 8 in. long, and one and a half inches in diameter, closed at one end. It is filled in the same manner as an ordinary sky-rocket, and fastened toward the end of a piece of bamboo, scarcely as thick as a walking-cane, and about 4 ft long, which is pointed with iron. At the opposite end of the tube from the iron point, or that towards the head of the shaft, is the match. The man who uses it, points the end that is shod with iron, to which the rocket is fixed, to the object to which he means to direct it; and setting fire to the match, it goes off with great velocity. By the irregularity of its motion, it is difficult to be avoided, and sometimes acts with considerable effect, especially among cavalry.

Craufurd even used a pile of Indian rockets for the cut on the title-page of his book (Fig. 218). Their average weight was about 9 lb., though it could go up to 30, and their usual range was 1000 yards or more, though they could in certain conditions carry two and a half times that distance.[c] The usual armament was an arrow-head, but the rockets sometimes bore automatically fused bombs, and were often provided with various kinds of launchers.

This Indian rocketry led directly, and perhaps unexpectedly, to a great development of military rockets in Europe.[d] William Congreve (+1772 to 1828) who rose to the rank of Major-General in the Hanoverian service, and shone in the dignity of F.R.S., was directly inspired by the Indian example,[e] and engaged in many experiments with (and much propaganda for) rockets from 1804 onwards, to such good effect that a Rocket Brigade or Regiment was formed in 1808.[f] It was urged that since no wheeled carriages were needed, rockets[g] gave 'to cavalry the power of artillery', and that when provided, every carriage, because of the lightness of the projectiles, was 'a volley-carriage, instead of being armed with a

[a] (1), p. 21.

[b] (1), pp. 294–5, 2nd ed., vol. 2, pp. 54 ff. Craufurd was a Scot who made a fortune in Asia and died in Paris; cf. Partington (5), p. 232.

[c] Winter (1); Baker (1), p. 12; Gode (6), p. 222 quoting Moor (1), p. 509. The sticks were in fact often 10 or 12 ft long. One of Moor's remarks suggests a connection with the Chinese ground-rats, for he says that 'others called ground-rockets have a serpentine motion and on striking the ground rise again and bound along till their force be spent'.

[d] The story has been told many times, as by Corréard (1); Gibbs-Smith (10); Brock (2); Hime (1); Winter (3); Baker (1), pp. 13 ff.; von Braun & Ordway (1), pp. 69 ff., pp. 93 ff., (2). pp. 30 ff.; Reid (1), pp. 184, 186; Katafiasz (1).

[e] As he himself tells us in his introduction; Congreve (3), p. 15.

[f] Brock (2), pp. 158 ff. Other armies soon followed suit, e.g. those of Austria, Russia, Switzerland, Mexico and Bengal.

[g] The Congreve rockets went up to 32 lb. with balancing poles 16 ft long, and carried incendiary, explosive or shrapnel war-heads; their range could exceed 3000 yards. They were fired from tripod launchers, or from specially graded ramps in fortifications, or from 'scuttles' within the hulls of ships. Cf. Congreve (1, 2).

SKETCHES

CHIEFLY RELATING TO THE

HISTORY, RELIGION, LEARNING, AND MANNERS,

OF THE

HINDOOS.

WITH

A concise Account of the PRESENT STATE of the NATIVE POWERS of HINDOSTAN.

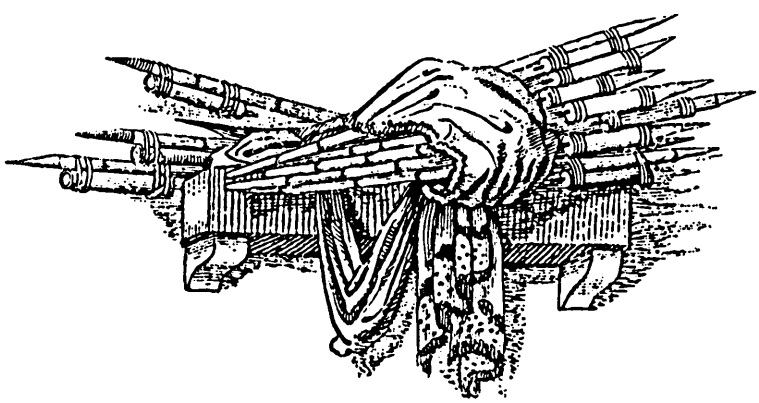

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Fig. 218. A pile of Indian rocket-arrows seen in a cut on the title-page of the book of Quintin Craufurd (1).

single *bouche-à-feu*'. Moreover, rockets carried their own recoil, as it were, with them, so that they were particularly suitable on shipboard for naval actions. In due course the Rocket Brigade saw a great deal of service,[a] including a considerable role at the Battle of Leipzig in 1813[b] and even a presence at Waterloo two years later. As time went on, further improvements were made, such as the invention of the spinning 'rotary' rockets (which needed no stick) by William Hale about 1840,[c] and these were used during the American–Mexican war of 1846–8. But the Achilles' heel of all the early nineteenth-century military rockets was their great inaccuracy of delivery, especially at long ranges,[d] as that after the thirties of the century the steadily increasing precision of conventional artillery and small-arms led to their virtual disappearance.[e] By 1850 the Rocket Brigades of most countries had been disbanded.

It was natural that rockets figured on both sides in China during the Opium Wars.[f] Stores of rocket-arrows were found when the Tinghai forts of Choushan were captured in 1840.[g] In the following year at Anson's Bay Congreve rockets were used, one of which set fire to the largest war-junk there, which blew up with all her crew on board.[h] A dozen years later, in the Canton River, in 1856, Admiral Kennedy wrote that 'as a rule the Chinese rockets did little harm, as often as not doubling back from whence they came', but 'one of our cutters was struck by a rocket, which burnt a large hole in her'.[i] Thus did the rockets of Europe contend with those of China seven hundred years after their first invention there.[j]

So now in our concluding discussion we come to the present century and the modern period, on which we must be very brief, even though advances almost incredible have been made. Neither the Chinese nor the British of the Opium Wars could have imagined it, but there is in fact only one vehicle known to man that can be navigated more easily in the vacuum of outer space than in our own

[a] Incendiary attacks, all too successful, occurred at Boulogne (1806), Copenhagen (1807), Callao (1809), Cadiz (1810), Washington and Baltimore (1814) hence the 'rocket's red glare' of F. Scott Key's poem; Danzig (1813), Algiers (1816) and Rangoon (1824).

[b] Cf. Whinyates (1).

[c] Hale (1); Winter (2); Taylor (1), p. 9; Baker (1), p. 14; von Braun & Ordway (1), p. 78, (2), p. 33.

[d] This was seen particularly clearly by Scoffern (1) in 1852. It accounts for their sparse use in the American Civil War (1861–5). There were also storage problems. Attempts were made to improve rockets, as by Boxer (1) in 1855, using two-stage ones, but these found permanent use only in life-saving equipment (p. 506 above), and for signalling, and whaling.

[e] They continued in use, however, in a sporadic fashion, in colonial African wars until the end of the nineteenth century (von Braun & Ordway (1), pp. 116 ff.). Here psychological effect was more important than actual destruction. Indeed, they might be said to live again in the anti-tank bazookas of contemporary times (Baker (1), p. 66; Reid (1), pp. 257–9; von Braun & Ordway (2), pp. 94 ff.)

[f] The first encounter of Europeans with Chinese war-rockets had occurred much earlier, in +1637, according to the journal of Peter Mundy, noted by Winter (5), p. 15. At 'Tayfoo' or Tiger Island, not far from Hongkong, a Chinese naval defence vessel assailed the English ship in that year. 'Balles of wyldefire, rocketts and fire-arrows flew thicke as they passed by us; butt God be praised, not one of us were toutched.'

[g] Jocelyn (1), p. 59.

[h] Ouchterlony (1), pp. 98–9.

[i] Kennedy (1), p. 51. His estimate of their inaccuracy may have been an exaggeration.

[j] Other descriptions will be found in Bingham (1), vol. 1, p. 345; Bernard (1), vol. 2, p. 20.

domestic atmosphere. This is the rocket, though far greater than those they knew. Jet-propulsion covers other engines, such as turbo-jets and ram-jets,[a] as well as rockets, but all the former need to take in air at the front so that it can burn the fuel and produce the exhaust that rushes out through the rear nozzle. The rocket alone needs no air to feed on, and carries within itself the oxidant and fuel necessary for combustion and the production of a powerful stream of exhaust gases. As a jet reaction motor it is thus absolutely independent of a surrounding atmosphere, and indeed in airless space it becomes much more efficient since it is free from the drag and resistance of a material medium. Moreover, its thrust is independent of its actual forward speed, and it gives full thrust at all altitudes, even in the near vacuum of space. With what amazement Chiao Yü or Mao Yuan-I would have learnt these things, could they have known of them. The rocket has been called the oldest of all practical heat-engines, yet the liquid-propellant type which is its modern form uses some of the most advanced engineering techniques and materials at present known.[b]

The words of this last sentence have taken us across a decisive step—beyond the classical solid charge of gunpowder. That notable mixture had its oxygen built in, as it were, but in the course of time it became clear that separately carried supplies of oxidant and fuel, held apart and combusted in an ignition chamber, would give far safer conditions and immeasurably more powerful thrusts. This was the gateway (it would not be too much to write) to the moon, the planets and the stars. The modern period of liquid propellants was ushered in by two great pioneers, a Russian and an American, and two engineer-propagandists, a German-Hungarian who worked in Rumania, and a Frenchman. The first we have had occasion to mention already (p. 506); he was Konstantin Eduardovitch Tsiolkovsky (1857 to 1936), a mathematician of deep insight, who was probably the first to work out the theory of rocket flight, and

[a] The history of jet-propulsion as such is a different question. As a principle it must have been obvious from the movements of coelenterates and cephalopods, but mankind seems to take many centuries to see the obvious. At an earlier point (Vol. 4, pt. 2, pp. 163–4, 575–6) we discussed possible explanations of the flying automata ascribed to many ancient thaumaturgical artisans, notably Archytas of Tarentum (*fl.* −380), the Alexandrian mechanicians, and Chang Hêng himself (*c.* +125); who might conceivably have used jet-streams of compressed air or steam, as Heron unquestionably did in his aeolipile (*ibid.* pp. 226, 407). Han Chih-Ho (+890) was almost too early for gunpowder, though Regiomontanus (*c.* +1450) could have used it. On Archytas and Regiomontanus see Duhem (1), pp. 125–8, 290 ff.

Duhem also tells us (pp. 295 ff.) of the Jesuit Honoratus Faber, who in +1669 proposed a flying-machine driven by a jet of air compressed by men working a pump inside. This idea was apparently continued in a notorious design by the Brazilian Jesuit Bartholomeu Lourenço de Gusmão, to which Duhem (1), pp. 297, 418 ff., (2), pp. 140 ff. has given minute attention. Then in +1715 Marc-Antoine Legrand turned to steam as the vapour to be employed in his jets (Duhem (1), p. 298). It is not quite clear how serious all these ideas were, but they certainly had a post-Renaissance character, and we have no Chinese parallels for them. In any case, the principle had no practical application until modern times, when large quantities of combustible fuel could be carried on board airplanes to provide the exhaust gases and their thrust.

It is interesting that we have a familiar example of the jet-principle, two thousand years after the aeolipile, in Segener's rotating garden-lawn water-sprinkler (Ley (2), p. 84).

[b] This paragraph is based on some formulations of Humphries (1) and Gibbs-Smith (10). Cf. Malina (1) and Anon. (161), vol. 1, pp. 578–9.

proposed as fuel liquid oxygen and kerosene or liquid hydrogen.[a] But if Tsiolkovsky can now be called the father of rocket motor science, the father of rocket motor engineering was the American, Robert H. Goddard (1882 to 1945),[b] also a university professor, who worked for many years from 1907 onwards with dogged concentration and very limited support in search of the means of reaching 'infinite altitudes' beyond the earth's atmosphere.[c] The world's first liquid-fuel rocket[d] was successfully launched by him in March 1926, and four years later a height of 2000 ft was attained. The one who wrote in German was Hermann Oberth (1894 to 1982),[e] who was associated with the Verein f. Raumschifffahrt (Space-Flight Society)[f] founded in 1927 and taken over by the Nazis in 1934.[g] They changed the name of the Verein's A 4 to the now universally known V 2, and it was one of these vehicles which was the first to leave earth's atmosphere and reach airless outer space in October 1942, at an altitude of 52 miles.[h] Lastly the French contributor was Robert Esnault-Pelterie, who was active and widely read in the late twenties and early thirties of the present century.[i]

Long before this time of course the gunpowder rocket had become a commonplace, universally familiar in pyrotechny. Congreve rockets had lingered on till almost the end of the nineteenth century, and they had acquired a tried and tested place for life-saving at sea, as also for averting hailstorms (cf. p. 528 below) from 1900 onwards. But rocket-borne aerial photography was being replaced by airplane cameras, rocket signalling was superseded by radio, war-rockets were almost entirely out-matched by more accurate artillery, and there was only a limited scope in World War I for rockets carrying Verey lights or making smoke-screens. It seemed as though there was little future for the use of rockets in war. And indeed we are told that the main aim of the German Verein was originally the designing of meteorological rockets.[j]

Now it is a remarkable fact that the whole of the new movement, the study of liquid propellants, derived not from military rocketry, nor from traditional pyrotechnics, but rather from the idea of the 'plurality of worlds', and the con-

[a] See von Braun & Ordway (1), pp. 121 ff.; Baker (1), pp. 17 ff. His works have been translated into English (1–4). Cf. Petri (7).

[b] See Baker (1), pp. 22 ff.; von Braun & Ordway (2), pp. 43 ff.; Ley (2), pp. 106 ff.; Taylor (1), pp. 16–18.

[c] His classical papers came in 1919 and 1936; cf. Goddard (1, 2).

[d] Using liquid oxygen and petrol.

[e] See Ley (2), pp. 113ff.; Baker (1), pp. 27ff.; Taylor (1), pp. 16–18. For his influential books, Oberth (1, 2).

[f] Ley (2), pp. 121 ff. He was later at the Peenemünde base, where the German war-rockets were developed; cf. Ley (2), pp. 184 ff., 204 ff. He alone lived to see the Cape Canaveral operations.

[g] Cf. von Braun & Ordway (1), p. 139; Taylor (1), p. 21.

[h] This 46-ft rocket was driven by liquid oxygen and ethyl alcohol, led to the combustion chamber by turbo-pumps working on steam formed from hydrogen peroxide catalysed with sodium permanganate. See Ley (2), p. 226; von Braun & Ordway (1), p. 147; Taylor (1), p. 22.

[i] See Esnault-Pelterie (1, 2). There were other names of some honour in this roll-call too. Nikolai Ivanovitch Kibalchich (d. 1882) developed the idea of vectored thrust, i.e. the swivelling of exhaust nozzles to change the direction of the rocket's flight-path. Hans Ganswindt, active about a decade later, designed (long ahead of its time) a reaction-powered space-ship. And Eugen Sänger continued the movement in the thirties. On these see Baker (1), p. 15; Ley (2), pp. 91 ff.

[j] Ley (2), pp. 169 ff. Cf. pp. 527 ff. below.

viction that reaction-motors were the only way that man could ever take to reach them. Goddard stands in a line of descent, not from Chiao Yü, Tipū Sahib and Congreve, but rather from Chang Hêng,[a] Lucian and de Fontenelle. At an earlier moment[b] we found a good deal to say about the role of Chinese thought in the dissolution of those so long dominant European notions, the Aristotelian crystalline celestial spheres, and the perfection and immutability of the heavens, after it became known in the West through the Jesuit mission in the +17th and +18th centuries.[c] Lucian's *True History* of the men in the moon, with Cicero's *Somnium Scipionis*, were written before these doctrines had become riveted on the world-view of Christendom, but in the +17th century Europe broke free, and a whole succession of writers described extra-terrestrial voyages.[d] Thus one could say that the Chinese invention of the rocket, coming to Europe in the +14th century, was complemented by Chinese ideas about infinite empty space which reached Europe by the end of the +16th.[e]

Indeed, as Schafer has put it, 'Tours of space were a commonplace in ancient China.'[f] Accounts of them[g] long preceded Chang Hêng; in the *Lun Hêng*[2], for instance (+83), we find one about a Taoist, Hsiang Man-Tu[3], who spent some years on the moon.[h] Recently, Cadorna (1) has translated one of the Tunhuang manuscripts in the Stein Collection[i] which tells how a famous Taoist astronautical master, Yeh Ching-Nêng[4], conducted the Thang emperor Hsüan Tsung, about +718, to view the palaces of the moon.[j] As Schafer says,[k] 'The great palace of the moon ... though not the abode of any deity of the first rank, was often rather fully portrayed in Chinese, both in poetry and prose, especially as a palace of ice crystals', an intensely cold, angular, crystalline, brittle habitation of extraordinary spirits, like, yet unlike, men. In spite of the appearance of

[a] The great +2nd-century astronomer himself wrote, in his *Ssu Hsüan Fu*[1], of an imaginary journey beyond the sun.

[b] Vol. 3, pp. 438 ff.

[c] There is an interesting recent book by Dick (1) on the notion of the plurality of worlds, though it ignores the role of Chinese thought in the liberation of European ideas.

[d] One need only name Francis Godwin, John Wilkins, F.R.S., Daniel Defoe and Miles Wilson. The genre of scientific romances has been brilliantly reviewed by Nicolson (1, 2). At the same time the ancient works, which had lain dormant during the millennium of dominance, were revived and broadened men's thinking once again.

[e] The case is reminiscent of some others previously encountered. For example, it has been said that 'just as Chinese gunpowder helped to shatter European feudalism [after the +15th century], so Chinese stirrups had originally helped to set it up' (Needham (47), pp. 286–9).

[f] (26), pp. 234 ff., cf. (27). Generally we are not told very much about the nature of the vehicles employed, and the extra-terrestrial travel is often magical, but the point is that for the ancient and medieval Chinese it was in no way unthinkable.

[g] Doubtless arising in the first place from the magic flights of shamans; cf. Vol. 2, pp. 132, 141; Vol. 4, pt. 2, pp. 568 ff.

[h] Tr. Forke (4), vol. 1, pp. 340–1. Wang Chhung[5] of course didn't believe it.

[i] S 6836. An earlier translation was that of Waley (31), pp. 139 ff.

[j] The same story is in the *Tao Tsang*'s *Thang Yeh Chen Jen Chuan*[6] (Biography of the Perfected Sage Yeh of the Thang), *TT* 771.

[k] (26), pp. 194–5.

[1] 思玄賦 [2] 論衡 [3] 項曼都 [4] 葉淨能 [5] 王充
[6] 唐葉眞人傳

some lunar beauties, the emperor could not stand the cold, and begged to be taken back home, which Master Yeh duly did.

In the nineteenth century all these traditions crystallised into what we now call science fiction, on which there is a large descriptive literature,[a] and it was works of this kind which, on their own explicit statements, had the greatest influence on the pioneers of modern rocketry. Reaction-motors, to be sure, were not the only means of inter-stellar flight envisaged;[b] there were also imaginary anti-gravity substances,[c] and of course great cannon pointing to the stars.[d] Tsiolkovsky was inspired by Eyraud, Jules Verne, Dumas and Greg; Goddard and Oberth in addition by Lasswitz and H. G. Wells. And not only was the cosmic navigational tradition primarily responsible; it would also be justifiable to say that the military rocket-missiles of World War II and subsequently were a spin-off or by-product of the peaceful urge for space research and exploration. May it be granted that the former do not overwhelm the latter.

In due course all the pioneers of liquid-fuel rocket flight were sucked into the maw of military preparations. Goddard was eventually aided by the American army and navy development establishment (1918), while the Verein's Berlin Raketenflugplatz was supported by the German military from 1932 onwards.[e] Four years later GALCIT[f] was formed, under the direction of Theodore von Kármán,[g] with Frank Malina and Chhien Hsüeh-Sên[1] among its staff;[h] significantly it became ORDCIT[i] in 1945, and applied itself almost entirely to war missiles. Among its achievements was the use of red fuming nitric acid and aniline or benzene as the self-igniting liquids;[j] as also the development of strange solid propellants such as mixtures of asphalt or polyurethane and potassium perchlorate, or sodium nitrate with ammonium picrate.[k] Other liquid propellants used today are fluorine, tetranitromethane, liquid ammonia, hydrazine hydrate, boron hydride, etc.[l] If the Russian 'Katyusha' and 'Stalin organ' war-rockets were so effective in World War II it was because they no longer used gunpowder charges, but rather guncotton[m] and nitroglycerine, still generally

[a] Cf. Flammarion (1); Ley (2), p. 41; Morgan (1); Anon. (162); Darko Suvin (1).

[b] But these occur in Achille Eyraud's *Voyage à Vénus* (1865) and Kurt Lasswitz' *Auf Zwei Planeten* (1908).

[c] As in Percy Greg's *Across the Zodiac* (1880) and H. G. Wells' *The First Men in the Moon* (1901). His *War of the Worlds* had appeared three years earlier.

[d] Here of course the type-specimen is Jules Verne's *De la Terre à la Lune* (1865). In the same year Alexandre Dumas wrote a novel with almost the same title.

[e] Taylor (1), p. 21; von Braun & Ordway (1), p. 138. Von Braun, Oberth and Ley, with many others, were all appropriated by the American rocketry organisation at the end of World War II.

[f] The Guggenheim Aeronautical Laboratory of the California Institute of Technology. On it see Malina (2, 5); Baker (1), pp. 2 ff.; Ley (3); von Braun & Ordway (2), pp. 84–5.

[g] Cf. Wattendorf & Malina (1).

[h] Alternatively, Tsien Hsue-Shen. Other Chinese scientists also worked there, notably W. Z. Chien and C. C. Lin.

[i] Ordnance Department Laboratory of the California Institute of Technology. See Malina (3, 4): Baker (1), pp. 73 ff.

[j] Ley (3).

[k] Humphries (1), p. 26; Anon. (161), vol. 1, pp. 580–1, vol. 2, pp. 363–4.

[l] Cf. Clark (1); Parker (1); Humphries (1), p. 40; Anon. (161), vol. 2, pp. 362–3.

[m] Nitrocellulose was discovered by Schönbein as long ago as 1845.

[1] 錢學森

with chemically built-in oxygen.[a] If the Russians were the first to launch a successful earth satellite (1957) and the first to put a man (Yuri Gagarin) into space (1961), it was perhaps because of their heavy atomic war-head payloads, which necessitated enormous rockets.[b] Yet nuclear energy may well be the ultimate answer to the demands of jet-propulsion for space-flight.[c] So here again we touch upon a paradox already mentioned (p. 506 above) that the very engines which would be capable of destroying civilisation itself are the same great rocket-motors as those which are opening the way to the planets and the stars.[d] It is common knowledge that space probes such as 'Mariner' have been sent out all over the solar system since 1962.[e] And finally the first Chinese artificial satellite went up in 1970, from the rocket's very homeland,[f] since when there have been at least eight more.

In the end the rocket motor could be the means of the preservation of the human race itself, removing it to other habitations as the sun of our solar system cools or overheats.[g] It might turn out that the rocket was the greatest single invention ever made by man. So in spite of all the perils of guided rocket missiles still impending, those Chinese who first experimented successfully with 'flying meteoric ground-rats', though we may never know their names, have been extraordinary benefactors of humanity, and citizens of no mean city.

(20) Peaceful Uses of Gunpowder

Since our mind has been running so much on rockets in the preceding pages, it will make an easy transition to begin with those same devices applied to religious observance and weather control, as also the exploration of the earth's upper atmosphere. Then we can go on to consider the even more universal role

[a] Taylor (1), pp. 23–5; Ley (2), pp. 190 ff.; von Braun & Ordway (1), p. 160; Popescu (1).

[b] Von Braun & Ordway (1), pp. 162, 176; Taylor (1), pp. 92, 144 ff.; Popescu (1). The American 'Apollo' moon landings followed from early 1963 onwards (Baker (1), pp. 165 ff.; von Braun & Ordway (2), pp. 172, 218–19). Fig. 219.

[c] Humphries (1), p. 194; Anon. (161), vol. 2, pp. 366–7.

[d] Sokolsky (1) takes the story to 1974, Buedeler (1) to 1979, and Cornelisse, Schöyer & Wakker (1) to 1981. Here we reach the truly professional level of current research. The reader equipped with mathematical, chemical or metallurgical expertise will find whole series of collective volumes which discuss the latest advances in our knowledge. For example, there is *Progress in Astronautics and Rocketry*, which began in 1960 and numbers some fifty volumes at the present time; all under the aegis of the American Rocket Society.

[e] Taylor (1), pp. 146 ff.; von Braun & Ordway (2), pp. 164 ff.; Baker (1), pp. 135 ff.; Ley & von Braun (1).

[f] The two-stage motors burnt dimethyl hydrazine as fuel and nitrogen tetroxide as oxidiser; they could reach at least 4000 miles in surface-to-surface flight, and with a third stage could put a satellite into geostationary orbit at an altitude of some 23,000 miles. Cf. Hewish (1); Anon. (163).

New launches of space rockets have taken place in 1982 (*Jen Min Jih Pao*, 14 Jan. reprinted in *CKKCSL*, 1982, no. 2, 90). And a submarine-based carrier rocket was successfully tested in October (*China Pictorial*, 1983, no. 1). On China's first communications satellite, lofted by a three-stage rocket on 16 April 1984, see Yang Wu-Min (1).

[g] Today the rocket vehicle looms very large in the imagination of all those who are conscious of the vastness of our universe, and inspires the engaging fantasies of eminent scientific men. For example, Francis Crick (1), the molecular biologist, finding difficulty in accounting for the origin of life on earth, imagines a rocket spacecraft which could have brought it (in the form of eukaryote bacteria) billions of years ago, from some other civilisation in our own, or some other, galaxy. Of course, this 'directed panspermia' only puts the problem back another remove.

BIBLIOGRAPHIES

A CHINESE AND JAPANESE BOOKS BEFORE + 1800

B CHINESE AND JAPANESE BOOKS AND JOURNAL ARTICLES SINCE + 1800

C BOOKS AND JOURNAL ARTICLES IN WESTERN LANGUAGES

In Bibliographies A and B there are two modifications of the Roman alphabetical sequence: transliterated *Chh-* comes after all other entries under *Ch-*, and transliterated *Hs-* comes after all other entries under *H-*. Thus *Chhen* comes after *Chung* and *Hsi* comes after *Huai*. This system applies only to the first words of the titles. Moreover, where *Chh-* and *Hs-* occur in words used in Bibliography C, i.e. in a Western language context, the normal sequence of the Roman alphabet is observed.

When obsolete or unusual romanisations of Chinese words occur in entries in Bibliography C, they are followed, wherever possible, by the romanisations adopted as standard in the present work. If inserted in the title, these are enclosed in square brackets; if they follow it, in round brackets. When Chinese words or phrases occur romanised according to the Wade–Giles system or related systems, they are assimilated to the system here adopted (cf. Vol. 1, p. 26) without indication of any change. Additional notes are added in round brackets. The reference numbers do not necessarily begin with (1), nor are they necessarily consecutive, because only those references required for this volume of the series are given.

Korean and Vietnamese books and papers are included in Bibliographies A and B. As explained in Vol. 1, pp. 21 ff., reference numbers in italics imply that the work is in one or other of the East Asian languages.

ABBREVIATIONS

See also p. xxiv

A	*Archeion*
AA	*Artibus Asiae*
AAA	*Archaeologia*
AAAG	*Annals of the Assoc. of American Geographers*
AAN	*American Anthropologist*
AAS	*Arts Asiatiques* (continuation of *Revue des Arts Asiatiques*)
ACANT	*Archaeologia Cantiana*
ACASA	*Archives of the Chinese Art Soc. of America*
ACP	*Annales de Chimie et Physique*
ACSS	*Annual of the China Society of Singapore*
ACTAS	*Acta Asiatica* (*Bull. of Eastern Culture*, Tōhō Gakkai, Tokyo)
ADVS	*Advancement of Science* (British Assoc. London)
AEHW	*Archiv. f. d. Eisenhüttenwesen*
AER	*Acta Eruditorum* (Leipzig, 1682 to 1731)
AGNT	*Archiv. f. d. Gesch. d. Naturwiss. u. d. Technik* (cont. as *AGMNT*)
AGWG/PH	*Abhdl. d. Gesell. d. Wiss. z. Göttingen* (Phil.-Hist. Kl.)
AHES/AESC	*Annales; Economies, sociétés, civilisations*
AHSNM	*Acta Historica Scientiarum Naturalium et Medicinalium*
AIMSS	*Annali dell'Istituto e Museo di Storia della Scienza* (Florence)
AJOP	*Amer. Journ. Physiol.*
AJP	*American Journ. Philology*
AJSC	*American Journ. Science and Arts* (Silliman's)
AM	*Asia Major*
ANA	*All-Nippon Airways In-Flight Magazine*
ANTIQ	*The Antiquary*
ANTJ	*Antiquaries Journal*
APAW/PH	*Abhandlungen d. preuss. Akad. Wiss. Berlin* (Phil.-Hist. Klasse)
AP/HJ	*Historical Journal, National Peiping Academy*
ARAB	*Arabica*
ARIL	*Atti* (*Annale*) *delli reale Istituto Lombardo*
ARJ	*Archaeological Journal*
ARLC/DO	*Annual Reports of the Librarian of Congress* (Division of Orientalia)
ARMA	*Armi Antiche* (Bull. dell'Accad. di San Marciano), Turin
ARO	*Archiv Orientalní* (Prague)
ARSI	*Annual Reports of the Smithsonian Institution*
ARUSNM	*Annual Reports of the U.S. National Museum*
AQ	*Antiquity*
AQR	*Asiatic Quarterly Review*
AS/BIHP	*Bulletin of the Institute of History and Philology, Academia Sinica*
ASKR	*Asiatick Researches* (Calcutta, 1788 to 1839)
ASTRA	*Astronautica Acta*
AX	*Ambix*
B	*Byzantion*
BAU	*Belleten Ankara Univ.*
BGP	*Bulletin Catholique de Pékin*
BE/AMG	*Bibliographie d'Études* (*Annales du Musée Guimet*)
BEC	*Bulletin de l'École des Chartes* (Paris)
BEDM	*Boletim Ecclesiástico da Diocese de Macao*
BEFEO	*Bulletin de l'École Française de l'Extrême Orient* (Hanoi)
BEO/IFD	*Bull. Études Orientales* (*Institut Français de Damas*)
BGTI	*Beiträge z. Gesch. d. Technik u. Industrie* (cont. as *Technik Geschichte*; see *BGTI/TG*)
BGTI/TG	*Technik Geschichte* (see above)
BLM	*Blackwood's Magazine*
BLSOAS	*Bulletin of the London School of Oriental and African Studies*
BMFEA	*Bulletin of the Museum of Far Eastern Antiquities* (Stockholm)
BMQ	*British Museum Quarterly*
BSRCA	*Bull. Soc. Research in Chinese Architecture*
BV	*Bharatiya Vidya* (Bombay)
BYZ	see *B*
BZJ	*Bonner Zeitschrift f. Japanologie*
CA	*Chemical Abstracts*
CAMR	*Cambridge Review*
CCL	*Chê Chiang Lu* (Biographies of Chinese Engineers, Architects, Technologists and Master-Craftsmen, by Chu Chhi-Chhien and collaborators, q.v. [a series, not a journal].)
CHEM	*Chemistry* (Easton, Pa.)
CHI	*Cambridge History of India*
CHJ	*Chhing-Hua Hsüeh Pao* (*Chhing-Hua* (*Ts'ing-Hua*) *University Journal of Chinese Studies*)
CHYM	*Chymia*
CHZ	*Chemiker Zeitung*
CIB	*China Institute Bulletin* (New York)

CJ — *China Journal of Science and Arts*
CKHW — *Chung-Kuo Hsin Wên* (= NCNA Bulletin)
CKKCSL — *Chung-Kuo Kho Chi Shih Liao*
CMS — *Chartered Mechanical Engineer*
CR — *China Review* (HongKong and Shanghai)
CRAS — *Comptes Rendus de l'Académie des Sciences* (Paris)
CREC — *China Reconstructs*
DCRI — *Bulletin of the Deccan College Research Institute* (Poona)
DHT — *Documents pour l'histoire des Techniques* (Paris)
DI — *Die Islam*
EAST — *The East*
EG — *Economic Geology*
EHR — *Economic History Review*
EMJ — *Engineering and Mining Journal*
ESA — *Eurasia Septentrionalis Antiqua*
ESCI — *Engineering and Science*
ETH — *Ethnos*
FCLT — *Fu-Chien Lan Than* (*Fukien Forum*)
FEQ — *Far Eastern Quarterly* (continued as *Journal of Asian Studies*)
FSH — *Fuji Chikurni Shokobutsu-en Hōkoku* (Bull. Fuji Bamboo Bot. Gdn.)
GLAD — *Gladius* (Études sur les Armes Anciennes, etc.)
GR — *Geographical Review*
GTIG — *Geschichtsblätter f. Technik, Industrie u. Gewerbe*
GUNC — *The Gun Collector* (U.S.A.)
GUND — *The Gun Digest*
HBAS — *Hauszeitschrift d. Badischen Anilin & Soda Fabrik AG*
HEM — *Hemisphere*
HHSTP — *Hua Hsüeh Thung Pao* (Chemical Intelligencer)
HJAS — *Harvard Journal of Asiatic Studies*
HKH — *Hanguk Kwahaksa Hakhoechi* (Journ. Korean Hist. of Sci. Soc.)
HMM — *Harper's Monthly Magazine* (New York)
HORIZ — *Horizon* (New York)
HOSC — *History of Science* (annual)
HOT — *History of Technology* (annual)
IAE — *Internationales Archiv f. Ethnographie*
IAQ — *Indian Antiquary*
IDSR — *Interdisciplinary Science Reviews*
IHQ — *Indian Historical Quarterly*
ILN — *Illustrated London News*
ISIS — *Isis*
ISL — *Islam*
ISP/WSFK — *I Shih Pao* (*Wên Shih Fu Khan*); Literary Supplement of "Benefitting the Age" Periodical.
JA — *Journal asiatique*
JAAS — *Journal of the Arms and Armour Soc.*
JAAR — *Journ. Amer. Acad. Religion*
JAEROS — *Journ. Aeronautical Sciences*
JAHIST — *Journ. Asian History* (*International*)
JANS — *Journ. Astronautical Sciences*
JAOS — *Journal of the American Oriental Society*
JATMOS — *Journ. Atmospheric Science*
JCE — *Journal of Chemical Education*
JCR(M) — *Journ. Chem. Research* (Microfiches)
JCR(S) — *Journ. Chem. Research* (Synopses)
JEPH — *Journ. Ethnopharmacology*
JGLGA — *Jahrbuch d. Gesellschaft. f. löthringen Geschichte u. Altertumskunde*
JHAS — *Journ. Hist. Arabic Science*
JHPHARM — *Journ. Hist. Pharmacol.*
JMATS — *Journ. Materials Science*
JOP — *Journal of Physiology*
JOS/HK — *Journal of Oriental Studies* (Hongkong)
JOSA — *Journ. Oriental Soc. Australia*
JPOS — *Journal of the Peking Oriental Society*
JRA — *Journal of the Royal Artillery*
JRAES — *Journal of the Royal Aeronautical Society* (formerly *Aeronautical Journal*)
JRAI — *Journal of the Royal Anthropological Institute*
JRAS — *Journal of the Royal Asiatic Society*
JRAS/B — *Journal of the* (*Royal*) *Asiatic Society of Bengal*
JRAS/HKB — *Journal of the Hong Kong Branch of the Royal Asiatic Society*
JRAS/KB — *Journal* (or *Transactions*) *of the Korea Branch of the Royal Asiatic Society*
JRAS/M — *Journal of the Malayan Branch of the Royal Asiatic Society*
JRAS/NCB — *Journal of the North China Branch of the Royal Asiatic Society*
JRI — *Journ. Royal Institution* (London)
JRUSI — *Journ. Royal United Services Institution* (London)
JS — *Journal des Savants*
JSCI — *Journ. Soc. Chem. Industry*
JSHS — *Japanese Studies in the History of Science* (Tokyo)
JWCBRS — *Journal of the West China Border Research Society*
JWH — *Journal of World History* (UNESCO)
JWM — *Journ. Weather Modification*
KGZ — *Kahei Gakkai Zasshi* (Journ. Soc. Technol. Arms and Ammunition Manufacture)
KHCK — *Kuo Hsüeh Chi Khan* (Chinese Classical Quarterly)
KHNT — *Kwartalnik Historii Nauki i Techniki* (Warsaw)
KKPT — *Kertas-Kertas Pengajian Tionghua* (Papers on Chinese Studies, University of Malaya)
KKJL — *Khao-Ku Jen Lei Hsüeh Chi-Khan*

	(Bull. Dept. of Archaeol. and Anthropol. Univ. Thaiwan)
KKTH	*Khao Ku Thung Hsün* (Archaeological Correspondent)
KKWW	*Khao-Ku yü Wên-Wu Chi Khan* (Journ. Cultural Archaeology)
KJ	*Korea Journal*
KMJP	*Kuang Ming Jih Pao*
KS	*Keleti Szemle* (Budapest)
KYHY	*Kung Yeh Huo Yao Hsieh Hui Chih* (Journ. of the Japanese Gunpowder Industry Association)
LHHP	*Li Hsüeh Hsüeh Pao* (Journal of Physics)
LI	*Listener* (B.B.C.)
LIFE	*Life* (New York)
LN	*La Nature*
LSCY	*Li Shih Yen Chiu* (Pkg.) J. Historical Research
MA	*Man*
MAF	*Mémorial de l'Artillerie de France*
MAI/NEM	*Mémorial de l'Académie des Inscriptions et Belles-Lettres*, Paris (Notices et Extraits des MSS.)
MART	*Memorial de Artilleria* (Madrid)
MAS/MPDS	*Mémoires de Mathématique et de Physique presentés à l'Académie Royale des Sciences* (Paris) *par Divers Sçavans et lus dans les Assemblées*
MBLB	*May & Baker Laboratory Bulletin*
MCHSAMUC	*Mémoires concernant l'Histoire, les Sciences, les Arts, les Mœurs et les Usages, des Chinois, par les Missionaires de Pékin* (Paris 1776–)
MC/TC	*Techniques et Civilisations* (originally *Métaux et Civilisations*)
MDGNVO	*Mitteilungen d. deutsch. Gesellschaft f. Natur. u. Volkskunde Ostasiens*
MEM	*Meteorological Magazine*
MGK	*Manshū Gakuhō* (Dairen)
MIE	*Mémoires de l'Institut d'Egypte* (Cairo)
MIMG	*Mining Magazine*
MINGS	*Ming Studies*
MJ/UP	see *MUJ*
MMI	*Mariner's Mirror*
MMO	*Mammō* (Dairen)
MPCASP	*Mélanges de Phys. et Chim. de l'Acad. de St. Petersbourg*
MRAS/P	*Mémoires de l'Académie des Sciences* (Paris)
MS	*Monumenta Serica*
MSOS	*Mitteilungen d. Seminar f. orientalischen Sprachen* (Berlin)
MUJ	*Museum Journal* (Philadelphia)
N	*Nature*
NCR	*New China Review*
NFR	*Nat. Fireworks Review*
NGM	*National Geographic Magazine*
NJKA	*Neue Jahrbücher f. d. klass. Altertum, Geschichte, deutsch. Literatur u. f. Pädagogik*
NKKZ	*Nihon Kagaku Koten Zensho*
NR	*Numismatic Review*
NS	*New Scientist*
NTM	*Schriftenreihe f. Gesch. d. Naturwiss. Technik, u. Med.* (East Germ.)
NYR	*New Yorker*
NYTHP	*Nan-Yang Ta-Hsüeh Hsüeh Pao* (Nanyang Univ. Journal, Singapore)
OAZ	*Ostasiatische Zeitung*
OLZ	*Orientalische Literatur-Zeitung*
OPO	*Oriente Poliano*
OR	*Oriens*
ORA	*Oriental Art*
ORD	*Ordnance*
ORE	*Oriens Extremus*
ORG	*Organon* (Warsaw)
OV	*Orientalia Venetiana*
PAA	*Progress in Astronautics and Aeronautics*
PAAAS	*Proceedings of the British Academy*
PAE	*Propellants and Explosives*
PAR	*Parabola* (*Myth and the Quest for Meaning*)
PFEH	*Papers on Far Eastern History* (Canberra)
PKCS	*Pai Kho Chih Shih* (Peking)
PKR	*Peking Review*
PP	*Past and Present*
PRAI	*Proc. Royal Artillery Institution* (contd. as JRA)
PRS	*Proceedings of the Royal Society*
PTRS	*Philosophical Transactions of the Royal Society*
PVS	*Preuves* (Paris)
QJRMS	*Quarterly Journal of the Royal Meteorological Society*
QJSLA	*Quart. Journ. Science, Literature and the Arts* (cont. as *JRI, Journ. Roy. Inst.*)
QSGNM	*Quellen u. Studien z. Gesch. d. Naturwiss. u. d. Medizin*
RBS	*Revue Bibliographique de Sinologie*
RC	*Revista de Universidade de Coimbra* (Portugal)
RDI	*Rivista d'Ingegneria*
RDM	*Revue des Mines* (later *Revue Universelle des Mines*)
REA	*Revue des Études Anciennes*
REG	*Revue des Études Grecques*
RHSID	*Revue d'Histoire de la Sidérurgie* (Nancy)
ROC	*Revue de l'Orient Chrétien*
ROL	*Revue de l'Orient Latin*
RQS	*Revue des Questions Scientifiques* (Brussels)

RRH — *Revue Roumaine d'Histoire* (Bucarest)
RROWC — *Research Reports of the Okasaki Women's Junior College*, near Nagoya
RTPT — *Revista Transporturilor* (Rumania)

SA — *Sinica* (originally *Chinesische Blätter f. Wissenschaft u. Kunst*)
SAM — *Scientific American*
SARCH — *Sovietskaya Archaeologia*
SBAW/PP & H — *Sitzungsberichte d. Bayerischen Akad. d. Wiss./Philos.-Philol. u. Hist. Kl.*
SCIS — *Sciences* (Paris)
SCSML — *Smith College Studies in Modern Languages*
SE — *Stahl und Eisen*
SHHH — *Shih Hsüeh Hsiao Hsi*
SHKS — *Shê Hui Kho-Hsüeh* (Chhinghua Journ. Soc. Sci.)
SHS — *Studia Historica Slovaca*
SINRA — *Sinorama* (= *Kuang Hua*)
SINT — *Sbornik Istorii Nauki i Techniki* (Moscow)
SKSL — *Skrifter som udi det Kjøbenhavnske Selskab af Laerdoms...*
SMC — *Smithsonian (Institution) Miscellaneous Collections* (Quarterly Issue)
SMITH — *The Smithsonian* (Magazine)
SOF — *Studia Orientalia* (Fennica)
SP — *Speculum*
SPAW/PH — *Sitzungsber. d. preuss. Akad. d. Wissenschaften* (Phil.-Hist. Kl.)
SPCK — *Society for the Promotion of Christian Knowledge*
SPFL — *Spaceflight*
SPMSE — *Sitzungsberichte d. physik. med. Soc. Erlangen*
SRFAOU — *Science Reports of the Faculty of Agriculture of Okayama University*
SUJCAH — *Suchow University Journ. Chinese Art History*
SV — *Studi Veneziani*
STC — *Studi Colombiani*
SWAW/PH — *Sitzungsberichte d. k. Akad. d. Wissenschaften Wien* (Phil.-Hist. Klasse), Vienna

TAIME — *Trans. Amer. Inst. Mining Engineers* (cont. as *TAIMME*)
TAIMME — *Trans. Amer. Inst. Mining and Metallurgical Engineers*
TBG — *Tijdschrift van het Bataavsche Genootschap van Kunsten en Wetenschappen* (later incorporated in *Tijdschrift voor Indische Taal-Land-*, en *Volkskunde*)
TBGZ — *Tōkyō Butsuri Gakko Zasshi* (Journ. Tokyo College of Physics)
TCC — *Tzu Chin Chhêng* (*Forbidden City*) Hongkong
TCULT — *Technology and Culture*
TFIME — *Trans. Federated Institution of Mining Engineers* (cont. as *TIME*)
TFTC — *Tung Fang Tsa Chih* (*Eastern Miscellany*)
TG/K — *Tōhō Gakuhō, Kyōto* (*Kyoto Journal of Oriental Studies*)
TGUOS — *Transactions of the Glasgow University Oriental Society*
TH — *Thien Hsia Monthly* (Shanghai)
THSH — *Ta Hsüeh Shêng Huo*
TIME — *Transactions of the Institution of Mining Engineers*
TJKHSYC — *Tzu-Jan Khao-Hsüeh Shih Yen-Chiu*
TJPCF — *Tzu-Jan Pien Chêng Fa Thung Hsün* (Dialectics of Nature)
TK — *Tōyōshi Kenkyū* (Researches in Oriental History)
TNS — *Transactions of the Newcomen Society*
TP — *T'oung Pao* (*Archives concernant l'Histoire, les Langues, la Géographie, l'Ethnographie et les Arts de l'Asie Orientale*, Leiden)
TR — *Technology Review*
TSHU — *Tu Shu*

UC/PAAA — *Univ. of Calif./Publications in Amer. Arch. and Anth.*
UM — *Universal Magazine of Knowledge and Pleasure*
USNIP — *United States Naval Institute Proceedings*
UZWKL — *Universitas; Zeitschr. f. Wissenschaft, Kunst und Literatur*
VBGA — *Verhandlungen d. Berliner Gesellschaft f. Anth., Eth. und Vorgeschichte* (*see ZFE*)
VH — *Voprosy Historii* (Moscow)
VIAT — *Viator*
VK — *Vijnan Karmee*
VS — *Variétés Sinologiques*

W — *Weather*
WW — *Wén Wu*
WWTK — *Wên Wu Tshan Khao Tzu Liao* (Reference Materials for History and Archaeology)
WWTLTK — *Wên Wu Tzu Liao Tshung Khan*

YCHP — *Yenching Hsüeh Pao* (Yenching University Journal of Chinese Studies)
YJBM — *Yale Journal of Biology and Medicine*

ZAC — *Zeitschr. f. angewandte chemie*
ZDMG — *Zeitschrift d. deutsch. Morgenländischen Gesellschaft*
ZFE — *Zeitschr. f. Ethnol.* (see *VBGA*)
ZGSS — *Zeitschr. f. d. gesamte Schiess- und Sprengstoffwesen; Nitrocellulose*
ZHWK — *Zeitschrift. f. historische Wappenkunde* (cont. as *Zeitschr. f. hist. Wappen- und Kostumkunde*)

A. CHINESE AND JAPANESE BOOKS BEFORE +1800

Each entry gives particulars in the following order:
(*a*) title, alphabetically arranged, with characters;
(*b*) alternative title, if any;
(*c*) translation of title;
(*d*) cross-reference to closely related book, if any;
(*e*) dynasty;
(*f*) date as accurate as possible;
(*g*) name of author or editor, with characters;
(*h*) title of other book, if the text of the work now exists only incorporated therein; or, in special cases, references to sinological studies of it;
(*i*) references to translations, if any, given by the name of the translator in Bibliography C;
(*j*) notice of any index or concordance to the book if such a work exists;
(*k*) reference to the number of the book in the *Tao Tsang* catalgoue of Wieger (6), if applicable;
(*l*) reference to the number of the book in the *San Tsang* (Tripitaka) catalogues of Nanjio (1) and Takakusu & Watanabe, if applicable.

Words which assist in the translation of titles are added in round brackets.

Alternative titles or explanatory additions to the titles are added in square brackets.

It will be remembered (p. 305 above) that in Chinese indexes words beginning *Chh-* are all listed together after *Ch-*, and *Hs-* after *H-*, but that this applies to initial words of titles only.

Where there are any differences between the entries in these bibliographies and those in Vols. 1–4, the information here given is to be taken as more correct.

An interim list of references to the editions used in the present work, and to the *tshung-shu* collections in which books are available, has been given in Vol. 4, pt. 3, pp. 913 ff., and is available as a separate brochure.

ABBREVIATIONS

C/Han	Former Han.
E/Wei	Eastern Wei.
H/Han	Later Han.
H/Shu	Later Shu (Wu Tai).
H/Thang	Later Thang (Wu Tai).
H/Chin	Later Chin (Wu Tai).
S/Han	Southern Han (Wu Tai).
S/Phing	Southern Phing (Wu Tai).
J/Chin	Jurchen Chin.
L/Sung	Liu Sung.
N/Chou	Northern Chou.
N/Chhi	Northern Chhi.
N/Sung	Northern Sung (before the removal of the capital to Hangchow).
N/Wei	Northern Wei.
S/Chhi	Southern Chhi.
S/Sung	Southern Sung (after the removal of the capital to Hangchow).
W/Wei	Western Wei.

Chang Tzu-Yeh Tzhu Pu I 張子野詞補遺.
Remaining Additional Poetical Works of Chang Tzu-Yeh.
Sung, *c.* +1080.
Cheng Tzu-Yeh 張子野.

Chao Chung Lu 昭忠錄.
Book of Examples of Illustrious Loyalty.
Yuan, *c.* +1290.
Writer unknown.
Cf. Balazs & Hervouet (1), p. 124.

Chao-Hua Hsien Chih 昭化縣志.
Gazetteer of Chao-hua (in Szechuan).
Chhing.
Chang Shao-Ling (ed.) 張紹齡.
Revised 1845, 1864.

Chao Hun 招魂.
The Calling Back of the Soul [perhaps a ritual ode].
Chou, *c.* −240.
Attrib. Sung Yü 宋玉.
Prob. by Ching Chhai (or Tsho) 景差.
Tr. Hawkes (1).

Chen Chi 陣紀.
Record of Army Drill and Tactics
Ming, *c.* +1546.
Ho Liang-Chhen 何良臣.

Chen-La Fêng Thu Chi 眞臘風土記.
Description of Cambodia.
Yuan, +1297.
Chou Ta-Kuan 周達觀.

Chen Yuan Miao Tao Yao Lüeh 眞元妙道要略.
Classified Essentials of the Mysterious Tao of the True Origin (of Things) [alchemy and chemistry].
Ascr. Chin, +3rd, but probably mostly Thang, +8th and +9th, at any rate after +7th as it quotes Li Chi.
Attrib. Chêng Ssu-Yuan 鄭思遠.
TT/917.

Chi Hsiao Hsin Shu 紀效新書.
A New Treatise on Military and Naval Efficiency.
Ming, +1560, pr. +1562, often repr.
Chhi Chi-Kuang 戚繼光.

Chi Jan
See *Chi Ni Tzu.*

Chia-Thai Kuei-Chi Chih 嘉泰會稽志.
Records of Kuei-Chi (Shao-hsing in Chekiang) during the Chia-Thai reign-period (+1201 to +1205).
Sung, not long after +1205.
Shih Hsiu 施宿.

Chiang-Nan Ching Lüeh 江南經略.
Military Strategies in Chiang-nan.
Ming, +1566.
Chêng Jo-Tsêng 鄭若曾.

Chien-Yen Tê-An Shou Yü Lu 建炎德安守禦錄.
An Account of the Defence and Resistance of Tê-an (City) in the Chien-Yen reign-period [+1127 to +1132], (by the Sung against the J/Chin).
Sung, +1172.
Liu Hsün 劉荀.
This book, now lost as such, was probably absorbed in that of the same name by Thang Tao (q.v.).
Cf. Balazs & Hervouet (1), p. 237.

Chien-Yen Tê-An Shou Yü Lu 建炎德安守禦錄.

Chien-Yen Tê-An Shou Yü Lu (cont.)
An Account of the Defence and Resistance of Tê-an (City) in the Chien-Yen reign-period [+1127 to +1132], (by the Sung against the J/Chin).
Sung, +1193.
Original name of the book by Thang Tao which was combined with the *Shou Chhêng Lu* as chs. 3 and 4 in +1225 (q.v.).
Cf. Balazs & Hervouet (1), p. 237.

Chih Shêng Lu 制勝錄.
Records of the Rules for Victory.
Ming, *c.* +1430.
Writer unknown.
Now extant only in quotations.

Chin Phing Mei 金瓶梅.
Golden Lotus [novel].
(Cf. *Hsü Chin Phing Mei*) Ming.
Writer unknown.
Tr. Egerton (1), Kuhn (2) (Miall). See Hightower (1), p. 95.

Chin Shih 金史.
History of the Chin (Jurchen) Dynasty [+1115 to +1234].
Yuan, *c.* +1345.
Tho-Tho (Toktaga) 脫脫 & Ouyang Hsüan 歐陽玄.
Yin-Tê Index, no. 35.

Chin Shih Pu Wu Chiu Shu Chüeh 金石簿五九數訣.
Explanation of the Inventory of Metals and Minerals according to the Numbers Five (Earth) and Nine (Metal) [catalogue of substances with provenances, including some from foreign countries].
Thang, perhaps *c.* +670 (contains a story relating to +664).
Writer unknown.
TT/900.

Chin Thang Chieh Chu Shih-erh Chhou 金湯借箸十二籌.
Twelve Suggestions for Impregnable Defence.
Ming, *c.* +1630.
Li Phan 李盤.
The first two words of the title recall the phrase *chin chhêng thang chhih*, adamantine walls and scalding moats, hence impregnable.

Ching Chhu Sui Shih Chi 荊楚歲時記.
Annual Folk Customs of the States of Ching and Chhu [i.e. of the districts corresponding to those ancient States; Hupei, Hunan and Chiangsi].
Prob. Liang, *c.* +550, but perhaps partly Sui, *c.* +610.
Tsung Lin 宗懍.
See des Rotours (1), p. cii.

Ching-Khang Chhuan Hsin Lu 靖康傳信錄.
Record of Events in the Ching-Khang reign-period [+1126, year of the fall of Khaifêng to the Chin Tartars].
Sung, *c.* +1130.
Li Kang 李綱.

Chiu Kuo Chih 九國志.
Historical Memoir on the Nine States (Wu, Nan Thang, Wu-Yüeh Chhien Shu, Hou Shu, Tung Han, Nan Han, Min, Chhu and Pei Chhu, in the Wu Tai Period).
Sung, *c.* +1064.
Lu Chen 路振.

Chiu Ming Shu 救命書.
See *Hsiang Ping Chiu Ming Shu* and *Shou Chhêng Chiu Ming Shu*.

Chu Chia Shen Phin Tan Fa 諸家神品丹法.
Methods of the Various Schools for Magical Elixir Preparations (an alchemical anthology).
Sung.
Mêng Yao-Fu 孟要甫 (Hsüan Chen Tzu) 玄眞子 and others.
TT/911

Chu Shih 麈史.
Conversations on Historical Subjects (lit. while yak's-tail fly-whisks are waving).
Sung, pref. +1115.
Wang Tê-Chhen 王得臣.

Chuang Lou Chi 妝樓記.
Records of the Ornamental Pavilion.
Wu Tai or Sung, *c.* +960.
Chang Pi 張泌.

Chung Hsi Pien Yung Ping 中西邊用兵.
Military Practice on the Central and Western (Fronts)
Sung, *c.* +1150.
Fang Pao-Yuan 方寶元.
Now extant only in quotations.

Chung Thang Shih Chi 中堂事記.
Personal Recollections of Affairs at the Court [of Khubilai Khan, +1260 and +1261].
Yuan, *c.* +1280.
Wang Yün 王惲.
Cf. H. Franke (20, 26)

Chhao Yeh Chhien Yen 朝野僉言.
Narratives of the Court and the Country.
Sung, +1126.
Hsia Shao-Tsêng 夏少曾.
Now extant only in quotations.

Chhê Chhung Thu 車銃圖.
Illustrated Account of Muskets, Field Artillery and Mobile Shields, etc. (Appendix to *Wo Chhing Thun Thien Chhê Chhung I* and *Pei Pien Thun Thien Chhê Chhung I*, q.v.)
Ming, *c.* +1585.
Chao Shih-Chên 趙士禎.
(In *I Hai Chu Chhen, i chi*, pt. 1 藝海珠塵, 乙集).

Chhêng Chai Chi 誠齋集.
Collected Writings of (Yang) Chhêng-Chai (Yang Wan-Li).
Sung, *c.* +1200.
Yang Wan-Li 楊萬里.

Chhi Hsiu Lei Kao 七修類稿.
Seven Compilations of Classified Manuscripts.
Ming, +1555 to +1567.
Lang Ying 郎瑛.

Chhi Hsiu Lei Kao (*cont.*)
Cf. W. Franke (4), p. 106.

Chhi-tan Kuo Chih 契丹國志.
Memoir of the Liao (Chhi-tan Tartar Kingdom).
Sung & Yuan, mid. +13th century.
Yeh Lung-Li 葉隆禮.

Chhi Tung Yeh Yü 齊東野語.
Rustic Talks in Eastern Chhi.
Sung, *c.* +1290.
Chou Mi 周密.

Chhien Hung Chia Kêng Chih Pao Chi Chhêng 鉛汞甲庚至寶集成.
Complete Compendium on the Perfected Treasure of Lead, Mercury, Wood and Metal [with illustrations of alchemical apparatus].
On the translation of this title, cf. p. 116. Has been considered Thang +808; but perhaps more probably Wu Tai or Sung. Cf. p. 116.
Chao Nai-An 趙耐菴.
TT/912.

Chhien-Thang I Shih 錢塘遺事.
Memorabilia of Hangchow and the Chhien-thang River.
Yuan.
Liu I-Chhing 劉一清.

Chhing Hsiang Tsa Chi 青箱雜記.
Miscellaneous Record on Green Bamboo Tablets.
Sung, *c.* +1070.
Wu Chhu-Hou 吳處厚.

Chhing Shih Kao 清史稿.
Draft History of the Chhing Dynasty.
See Chao Erh-Hsün & Kho Shao-Min.

Chhing-Tai Chhou-Pan I-Wu Shih-Mo 清代籌辦夷務始末.
See Anon. (*212*).

Chhiu Chien Hsien-sêng Ta Chhüan Wên Chi 秋澗先生大全文集.
Complete Literary Works of Mr Autumn-Torrents [Wang Yün].
Yuan, *c.* +1304.
Wang Yün 王惲.
Cf. H. Franke (20, 26).

Chhiu Shêng Khu Hai 求生苦海.
Saving Souls from Hell.
Chhing, +18th.
Writer unknown.

Chhou Hai Thu Pien 籌海圖編.
Illustrated Seaboard Strategy and Tactics.
Ming, +1562. Repr. +1572, +1592, +1624, etc.
Chêng Jo-Tsêng 鄭若曾.
Cf. W. Franke (4), p. 223; Goodrich & Fang Chao-Ying (1), p. 204.

Chhu Tzhu 楚辭.
Elegies of Chhu (State) [or, Songs of the South].
Chou, *c.* −300 (with Han additions).
Chhü Yuan 屈原 (& Chia I 賈誼 Yen Chi 嚴忌 Sung Yü 宋玉 Huainan Hsiao-Shan 淮南小山 *et al.*).
Partial tr. Waley (23); tr. Hawkes (1).

Fan Tzu Chi Jan 范子計然.
See *Chi Ni Tzu*.

Fêng Shen Pang 封神榜.
Pass-Lists of the Deified Heroes.
Popular form of the title *Fêng Shen Yen I*, q.v.

Fêng Shen Yen I 封神演義.
Stories of the Promotions of the Martial Genii [novel].
Ming.
Hsü Chung-Lin 許仲琳.
Tr. Grabe (1).

Fêng Su Thung I 風俗通義.
The Meaning of Popular Traditions and Customs.
H/Han, +175.
Ying Shao 應劭.
Chung-Fa Index, no. 3.

Fu Hung Thu 伏汞圖.
Illustrated Manual on the Subduing of Mercury.
Sui, Thang, Wu Tai, J/Chin (or possibly, in some parts, Ming).
Shêng Hsüan Tzu 昇玄子.
Survives now only in quotations.

Fu kien Thung Chih 福建通志.
Gazetteer of Fukien Province.
Chhing, completed 1833, pr. 1867.
See Chhen Shou-Chhi (*1*), (ed.).

Hachiman Gudō-Kun (or *-Ki*) 八幡愚童訓(記).
Tales of the God of War told to the Simple [a military history, including details of the Mongol invasions of +1274 and +1281].
Japan, late +14th or somewhat earlier ed. used dates from between +1469 and +1486.
Writer unknown.
In *Gunsho Ruiji* collection (ch. 13, p. 328) 羣書類從.

Hai-Chhiu Fu Hou Hsü 海鰍賦後序.
Postface to the Rhapsodic Ode on the 'Sea-Eel' (Warships) [and their role at the Battle of Tshai-Shih, +1161].
Sung, *c.* +1170
Yang Wan-Li 楊萬里.
In *Chhêng-Chai Chi*, ch. 44, pp. 6*b* ff.

Hai Fang Tsung Lun 海防總論.
A General Discourse on Coastal Defence.
Ming, before +1621.
Chou Hung-Tsu 周宏祖.

Hai Kuo Thu Chih 海國圖志.
See Wei Yuan & Lin Tsê-Hsü (*1*).

Ho-Hsien Thuan Lien Thiao Kuei 賀縣團練條規.
Rules for Training the Militia Bands at Ho-hsien.
Ming, *c.* +1615.
Author uncertain.

Hōjō Godai-Ki 北條五代記.
Chronicles of the Hōjō Family through Five Generations.
Japan, *c.* +1600.
Writer unknown.
In *Shiseki Shūran* 史籍集覽.

Hōjō Godai-Ki (cont.)
(Collection of Historical Materials).
Ed. Kondō Heijō 近藤瓶城.
3rd. ed. Kondō Shuppan-bu, Tokyo, 1907.

Honchō Gunkikō 本朝軍器考.
Investigation of the Military Weapons and Machines of the Present Dynasty.
Japan preface +1709, postface +1722, printed +1737.
Arai Hakuseki 新井白石.
Autobiography tr. J. Ackroyd (1).

Hou Han Shu 後漢書.
History of the later Han Dynasty [+25 to +220].
L/Sung, +450.
Fan Yeh 范曄.
The monograph chapters by Ssuma Piao 司馬彪 (d. +305), with commentary by Liu Chao 劉昭 (*c.*+510), who first incorporated them in the work.
A few chs. tr. Chavannes (6, 16); Pfizmaier (52, 53).
Yin-Tê Index, no. 41.

Hu Chhien Ching 虎鈐經.
Tiger Seal Manual [military encyclopaedia]
Sung, begun +962, finished +1004.
Hsü Tung 許洞.
Cf. Balazs & Hervouet (1), p. 236.

Hu Khou Yü Shêng Chi 虎口餘生記.
Record of Life Regained out of the Tiger's Mouth.
Chhing, +1645.
Pien Ta-Shou 邊大綬.
Cf. Hummel (2), p. 741.

Hua I Hua Mu Niao Shou Chen Wan Khao 華夷花木鳥獸珍玩考.
A Useful Examination of the Flowers, Trees, Birds and Beasts found among the Chinese and neighbouring Peoples (lit. Barbarians).
Ming, +1581.
Shen Mou-Kuan 愼懋官.
WY/135.

Huang Chhao Ma Chêng Chi 皇朝馬政記.
Record of Army Remount Organisation in the Ming Dynasty.
Ming, +1596.
Yang Shih-Chhiao 楊時喬.

Huang Hsiao Tzu Wan Li Chi Chhêng 黃孝子萬里紀程.
Memories of the Thousand-Mile Peregrinations of a Filial Son named Huang.
Ming and Chhing, pref. of +1643, but not finished till *c.* +1652.
Huang Hsiang-Chien 黃向堅.

Huang Ming Ching Shih Shih Yung Pien 皇明經世實用編.
Political Encyclopaedia of Ming Dynasty Materials (down to the Wan-Li Reign-Period, including border defence and maritime defence); or, Imperial Ming Handbook of Practical Statesmanship.
Ming, +1603.
Fêng Ying-Ching (ed.) 馮應京.
Cf. W. Franke (4), p. 195; *GF*/1141.

Huang Ming Shih Fa Lu 皇明世法錄.
Political Encyclopaedia of the Ming Dynasty (containing imperial edicts, military history, and treatises on astronomy and calendar, music and ceremonies, financial administration, economics, agriculture, communications, etc.).
Ming, +1630, pr. after +1632.
Chhen Jen-Hsi (ed.) 陳仁錫.
Cf. W Franke (4), p. 196; *WY*/420; *GF*/162.

Huang Ti Chiu Ting Shen Tan Ching Chüeh 黃帝九鼎神丹經訣.
The Yellow Emperor's Canon of the Nine-Vessel spiritual Elixir, with Explanations.
Early Thang or early Sung, but incorporating as ch. 1 a canonical work probably of the +2nd century
Writer unknown.
TT/878. Also, abridged, in *YCCC*, ch. 67, pp. 1*a* ff.

Hui-An Hsien-sêng Chu Wê Kung Chi 晦菴先生朱文公集.
Collected Writings of Chu Hsi (lit. Mr. (Chu) Hui-An's Records of the Ven. Chu Wên Kung).
Sung, *c.* +1200.
Chu Hsi 朱熹.

Hui-chán Ryōsa 彙纂麗史.
Collected, Compiled and Edited History of Korea, especially the Koryō Kingdom.
Korea, +18th.
Hong Yeha 洪汝河.
Courant (1), no. 1863.

Huo Chhê Chen Thu Shuo 火車陣圖說.
Illustrated Accounts of the Formations in which Mobile Shields should be used with Guns and Cannon.
Ming, prob. +16th.
Chhen Phei 陳裴.
Cf. Lu Ta-Chieh (1), p. 138.

Huo Chhi Chen Chüeh Chieh Chêng 火器眞訣解證.
Analytical Explanations of Firearms and Instructions for using them.
Chhing.
Shen Shan-Chêng 沈善蒸.
Now extant only in quotations.
Cf. Lu Ta-Chieh (1), p. 164, (2), p. 19.

Huo Chhi Lüeh Shuo 火器略說.
(= *Tshao Shêng Yao Lan*)
Classified Explanations of Firearms.
Chhing.
Wang Ta-Chhüan 王達權 & Wang Thao 王韜.
Cf. Lu Ta-Chieh (1), p. 161, (2), p. 18.
Now extant only in quotations.

Huo Chhi Ta Chhüan 火器大全.
Everything one needs to know about Gunpowder Weapons.

Huo Chhi Ta Chhüan (*cont.*)
Date unknown.
Writer unknown.
Title known only from *Tu Shu Min Chhiu Chi*, q.v.
Cf. Lu Ta-Chieh (*1*), p. 169.

Huo Chhi Thu 火器圖.
Illustrated Account of Gunpowder Weapons and Firearms.
Running-head title of the Hsiang-yang edition of *Huo Lung Ching* (q.v.).

Huo Chhi Thu 火器圖.
Illustrated Account of Gunpowder Weapons and Firearms.
Ming, *c.* +1620.
Ku Pin 顧賦.
Cf. Lu Ta-Chieh (*1*), p. 128.

Huo Chhi Thu Shuo 火器圖說.
Illustrated Account of Fire- (and Gunpowder-) Weapons.
Ming, prob. +16th.
Huang Ying-Chia 黃應甲.
Lu Ta-chieh (*1*), p. 122.

Huo Kung Chen Fa 火攻陣法.
Troop Formations for Combat with Firearms.
Title of the book which was given to Chiao Yü, the writer of the *Huo Lung Ching* (pt. 1) by the old Taoist of Thien-thai Shan.
Cf. *CCL* (7), p. 86.

Huo Kung Chen Fa 火攻陣法.
Tactical Formations for Attack by Fire- (including Gunpowder-) Weapons.
Ming.
Writer unknown.
Cf. Lu Ta-Chieh (*1*), p. 149.

Huo Kung Chhieh Yao 火攻挈要.
[or, Tsê Kho Lu 則克錄].
Essentials of Gunnery.
[or, Book of Instantaneous Victory].
Ming, +1643.
Chiao Hsü 焦勗.
With the collaboration of Thang Jo-Wang (J.A. Schall von Bell) 湯若望.
Bernard-Maître (18), no. 334; Pelliot (55).

Huo Kung Pei Yao 火攻備要.
Essential Knowledge for the Making of Gunpowder Weapons.
Alt. title of Pt. 1 of the *Huo Lung Ching*, q.v.

Huo Kung [*Wên*] *Ta* 火攻問答.
Answers (to Questions) on Fire-Weapons and Firearms.
Ming, *c.* +1598.
Wang Ming-Hao 王鳴鶴.
In *Huang Ming Ching Shih Shih Yung Pien*, ch. 16 (p. 1287).

Huo Lung Ching 火龍經.
The Fire-Drake (Artillery) Manual (of Gunpowder Weapons).
Ming, +1412.
Chiao Yü 焦玉.
The first part of this book, in three sections, is attributed fancifully to Chuko Wu-ou (i.e. Chuko Liang), and Liu Chi 劉基 (+1311/+1375) appears as co-editor, really perhaps co-author.
The second part, also in three sections, is attributed to Liu Chi alone, but edited, probably written, by Mao Hsi-Ping 毛希秉 in +1632.
The third part, in two sections, is by Mao Yuan-I 茅元儀 (fl. +1628) and edited by Chuko Kuang-Jung 諸葛光榮. whose preface is of +1644, Fang Yuan-Chuang 方元壯 & Chung Fu-Wu 鍾伏武.
This work should be considered a main nucleus with two supplements, summarising the development of successive gunpowder weapons between about +1280 and +1644. The first part, i.e. the book itself, is the work of Chiao Yü, who had been a leading artillery officer in the army of Chu Yuan-Chang which finally conquered China for the Ming dynasty in +1367.

Huo Lung Ching Chhüan Chi 火龍經全集.
Complete Materials of the 'Fire Drake Manual' (Nanyang edition).
= *Huo Kung Pei Yao*, q.v.

Huo Lung Shen Chhi Chen Fa 火龍神器陣法.
Fire-Drake Manual of Military Formations using Magically (Efficacious) Weapons (i.e. Muskets).
Date uncertain; a +16th century MS.
Perhaps an early version of *Huo Lung Ching* (q.v.) copied and re-copied.

Huo Lung Shen Chhi Thu Fa 火龍神器圖法.
Fire-Drake Illustrated Technology of Magically (Efficacious) Weapons.
Yuan, perhaps *c.* +1330.
Writer unknown.
Listed in the *Liao, Chin, Yuan, I Wên Chih* of Lu Wên-Chhao, *c.* +1770.
Possibly the earliest form of the *Huo Lung Ching*, q.v.
Now extant only in quotations.
Cf. Lu Ta-chieh (*1*), p. 108.

Huo Lung Shen Chhi Yao Fa Pien 火龍神器藥法編.
Fire-Drake Book of Magically (Efficacious) Weapons, with the Method of Making Gunpowder.
Date uncertain, perhaps Yuan.
Writer unknown.
MS in the Library of the History of Science Institute, Academia Sinica, Peking, with illustrations more delicate and precise than those in any printed edition of the *Huo Lung Ching*, of which it may represent an early version.

Huo Lung Wan Shêng Shen Yao Thu 火龍萬勝神藥圖.
Illustrated Fire-Drake Technology for a Myriad Victories using the Magically (Efficacious) Gunpowder.
Date unknown.
Writer unknown.
Title known only from *Tu Shu Min Chhiu Chi*, q.v.
Cf. Lu Ta-Chieh (*1*), p. 169.

Huo Yao Fu 火藥賦.
Rhapsodic Ode (or, Poetical Essay) on Gunpowder.
Ming, *c.* +1620.
Mao Yuan-I 茅元儀.
In *TSCC*, Jung chêng tien, ch. 96, i wên i, p. 2*a*, *b*, 3*a*.

Huo Yao Miao Phin 火藥妙品.
The Wonderful Uses of Gunpowder.
Ming.
Writer unknown.
Cf. Lu Ta-Chieh (*1*), p. 149.

Hsi Chhi Tshung Hua 西溪叢話(語).
(*SKCS* has *Yü*.)
Western Pool Collected Remarks.
Sung, *c.* +1150.
Yao Khuan 姚寬.

Hsi Chou Yen Phu 歙州硯譜.
Hsichow Inkstone Record.
Sung, +1066.
Thang Chi 唐積.

Hsi Hu Chih Yü 西湖志餘.
Additional Records of the Traditions of West Lake (at Hangchow).
Ming, *c.* +1570.
Thien I-Hêng 田藝蘅.

Hsi Hu Erh Chi 西湖二集.
Second Collection of Materials about West Lake [at Hangchow, and the neighbourhood].
Ming, *c.* +1620.
Chou Chhing-Yuan 周清源.

Hsi-Yang Huo Kung Thu Shuo 西洋火攻圖說.
Illustrated Treatise on European Gunnery.
Ming, before +1625.
Chang Tao 張燾 & Sun Hsüeh-Shih 孫學詩.
Cf. Pelliot (55).
Now extant only in quotations.

Hsi Yuan Wên Chien Lu 西園聞見錄.
Things Seen and Heard in the Western Garden (the Imperial Library), [a work of notes for the history of the Ming, +1368 to +1620].
Ming, +1627; first printed 1940.
Chang Hsüan 張萱.
Cf. Goodrich & Fang Chao-Ying (1), p. 79.

Hsiang Ping Chiu Ming Shu 鄉兵救命書.
On Saving the Situation by (the Raising of) Militia.
Ming, +1607.
Lü Khun 呂坤.
Cf. Goodrich & Fang Chao-Ying (1), p. 1006.

Hsiang-Yang Shou Chhêng Lu 襄陽守城錄.
An Account of the Defence of Hsiang-yang (City) [+1206 to +1207], (by the Sung against the J/Chin).
Sung, *c.* +1210.
Chao Wan-Nien 趙萬年.
This siege was not by the Mongols, as in the more famous one of +1268/+1273.
Cf. Balazs & Hervouet (1), p. 95.

Hsin-Ssu Chhi Chhi Lu 辛巳泣斬錄.
The Sorrowful Record of (the Siege of) Chhi (-chou) in the Hsin-Ssu Year (+1221), (by the Chin Tartars).
Sung, *c.* +1230.
Chao Yü-Jung 趙與懋.

Hsin Wu Tai Shih 新五代史.
New History of the Five Dynasties [+907 to +959].
Sung, *c.* +1070.
Ouyang Hsiu 歐陽修.
For translations of passages see the index of Frankel (1).

Hsin Yuan Shih 新元史.
See Kho Shao-Min (*1*).

Hsing Chün Hsü Chih 行軍須知.
What an Army Commander in the Field should Know.
Sung, *c.* +1230; repr. +1410, +1439.
Writer unknown.
Preface by Li Chin (Ming ed.) 李進.
Appended to the Ming ed. of *Wu Ching Tsung Yao, Hou Chi*.
Cf. Fêng Chia-Shêng (*1*), p. 61.

Hsü Chin Phing Mei 續金瓶梅.
Golden Lotus, Continued [novel] (cf. *Chin Phing Mei*).
Chhing, +17th century.
Tzu Yang Tao-Jen 紫陽道人.
Tr. Kulm (1).

Hsü Hou Han Shu 續後漢書.
Supplement to the History of the Later Han.
Sung.
Hsiao Chhang 蕭常.

Hsü I Chien Chih 續夷堅志.
More Strange Stories from I-Chien.
J/Chin, *c.* +1240.
Yuan Hao-Wên 元好問.

Hsü Sung Chung Hsing Pien Nien Tzu Chih Thung Chien 續宋中興編年資治通鑑.
Continuation of the 'Mirror of History for Aid in Government' for the Sung Dynasty from its Restoration onwards [i.e. Southern Sung from +1126].
Sung, *c.* +1250.
Liu Shih-Chü 劉時舉.
Cf. Balazs & Hervouet (1), p. 77.

Hsü Sung Pien Nien Tzu Chih Thung Chien 續宋編年資治通鑑.
Alt. title of *Hsü Sung Chung Hsing Pien Nien Tzu Chih Thung Chien*, q.v.

Hsü Tzu Chih Thung Chien Chhang Pien 續資治通鑑長編.
Continuation of the *Comprehensive Mirror (of History) for Aid in Government* [+960 to +1126].
Sung, +1183.
Li Tao 李燾.

Hsü Wên Hsien Thung Khao 續文獻通考.
Continuation of the *Comprehensive Study of (the History of Civilisation)* (cf. *Wên Hsien Thung Khao* and *Chhin Ting Hsü Wên Hsien Thung Khao*).
Ming, +1586; pr. +1603.
Ed. Wang Chhi 王圻.

Hsüan Kuai Hsü Lu 玄怪續錄.
The *Record of Things Dark and Strange*, continued.
Thang.
Li Fu-Yen 李復言.

I Hai Chu Chhen 藝海珠塵.
Pearls from the Dust; a Collection (of Tractates) from the Ocean of Artistry [*a tshung-shu*].
Chhing, *c.* +1760.
Ed. Wu Shêng-Lan 吳省蘭.

Inatomi-ryu Teppō Densho 稻富流鐵砲傳書.
Record of Matchlock Muskets current in the Inatomi Family.
Japan, +1595; never printed.
Nagasawa Shigetsune 長澤七右衛 for Kawakami Mosuke 河上茂介殿.
An MS. of +1607 is in the New York Public Library (Spencer Colln. no. 53).

Kai Wên Lu 該聞錄.
Things Heard Worthy of Record.
Sung, *c.* +990.
Li Thien 李畋.

Kai Yü Tshung Khao 陔餘叢考.
Miscellaneous Notes made while attending his aged Mother.
Chhing, +1790.
Chao I 趙翼.

Kaisan-ki 改算記.
Book of Improved Mathematics.
Japan, +1659.
Yamada Shigemasa 山田重正.

Kaisan-ki Kōmoku 改算記綱目.
Comprehensive Summary of Integration [early calculus].
Japan, +1687.
Mochinaga, Toyotsugu 持永豐次 & Ôhashi, Takusei 大橋宅清.

Keisei Hisaku 經世秘策.
A Secret Plan for Managing the Country.
Japan (Yedo) +1798, pr. after 1821.
Honda Toshiski 本多利明.
Cf. Keene (1).

Khai-Hsi Tê-An Shou Chhêng Lu 開禧德安守城錄.
An Account of the Defence of Tê-an (City) in the Khai-Hsi reign-period [+1206 to +1207], (by the Sung against the J/Chin).
Sung, +1224.
Wang Chih-Yuan 王致遠.
Tr. K. Hana (1).

Kho Chai Tsa Kao, Hsü Kao Hou 可齋雜藁, 續稿後.
Miscellaneous Matters recorded in the Ability Studio, Second Addendum.
Sung, *c.* +1265.
Li Tsêng-Po 李曾伯.

Khua Ao Chi 跨鼇集.
Collected Memorabilia of Mr Khua-Ao.
Sung, *c.* +1100.
Li Hsin 李新 (Khua Ao chü shih 跨鼇居士).
He called himself the Recluse of the Atlas-bestriding stone steles, because such monuments are generally placed upon sculptures of tortoises, and one of these was in mythology the supporter of the world, hence a symbol of longevity.

Kikai Kanran.
See Aoji Rinsō (*1*).

Ko Chih Ku Wei.
See Wang Jen-Chün (*1*).

Ko Wu Hsü Chih 格物須知.
What One should Know about Natural Phenomena.
Chhing, +18th.
Chu Pên-Chung 朱本中.

Kōrai Sensenki 高麗船戰記.
A Record of the Sea-Fights against Korea.
Japan, +1592.
Soto-oka Jinjaimon 外岡甚左衛門.
MS preserved in the Nabeshima family, and now in the Library of Kyushu University.
Cf. Pak Hae-ill (*2*).

Koryŏ-sa 高麗史.
History of the Koryō Kingdom [+918 to +1392].
Korea, first compiled in +1395; oldest extant version commissioned +1445, completed +1451.
Ed. Chŏng Inji 鄭麟趾.
Courant (1), no. 1846.

Ku Chin Shuo Hai 古今說海.
Sea of Sayings Old and New [florilegium].
Ming, +1544.
Lu Chi (ed.) 陸楫.

Kuang Po Wu Chih 廣博物志.
Enlargement of the *Records of the Investigation of Things* (by Chang Hua, *c.* +290).
Ming, +1607.
Tung Ssu-Chang 董斯張.

Kuang-Yang Tsa Chi 廣陽雜記.
Collected Miscellanea of Master Kuang-Yang (Liu Hsien-Thing).
Chhing, *c.* +1695.
Liu Hsien-Thing 劉獻廷.

Kuei Chhien Chih 歸潛志.
On Returning to a Life of Obscurity.
J/Chin, +1235.
Liu Chhi 劉祁.

Kuei Hsin Tsa Chih 癸辛雜識.
Miscellaneous Information from Kuei-Hsin Street (in Hangchow).
Sung, late +13th-century, perhaps not finished before +1308.
Chon Mi 周密.
See des Rotours (1), p. cxii; H. Franke (14).

Kuei Thien Shih Hua 歸田詩話.
Poems of Return to Farm and Tillage.
Ming, +1425.
Chhü Yu 瞿佑.

Kuei Tung 鬼董.
The Control of Spirits.
Sung, prob. *c.* +1185; pub. +1218 or later.
Mr Shen 沈氏.

Kukcho Orye-ŭi 國朝五禮儀.
Instruments for the Five Ceremonies of the (Korean) Court.
Korea (Chosŏn), +1474.
Sin Sukju 申叔舟 & Chŏng Ch'ăk 鄭陟.
Cf. Trollope (1), p. 21; Courant (1), no. 1047.

Kukcho Pogam 國朝寶鑑.
The Precious Dynastic Mirror [official history of the Yi Dynasty, +1392 to 1910].
Korea (Chosŏn), begun *c.* +1460, commissioned by King Sejo.
Kwŏn Nam 權擥 and many subsequent writers.
Courant (1), no. 1894, 1897.

Kukcho Sok Orye-ŭi 國朝續五禮儀.
A Continuation of the *Instruments for the Five Ceremonies of the* (Korean) *Court.*
Korea (Chosŏn) +1744.
Ed. Courant (1), no. 1047.

Kukcho Sok Orye-ŭi Po 國朝續五禮儀補.
An Extension of the *Continuation of the Instruments for the Five Ceremonies of the* (Korean) *Court.*
Korea (Chosŏn), +1751.
Ed. Courant (1), no. 1047.

Kung Khuei Chi 攻媿集.
Bashfulness Overcome; Recollections of My Life and Times.
Sung, *c.* +1210.
Lou Yo 樓鑰.

Kung Pu Chhang Khu Hsü Chih 工部廠庫須知.
What should be known (to officials) about the Factories, Workshops and Storehouses of the Ministry of Works.
Ming, +1615.
Ho Shih-Chin 何士晉.

Kung-Sha Hsiao Chung Chi 公沙効忠紀.
Eulogy of the Loyal and Gallant Gonçalvo [Teixeira-Correa, Captain of Artillery in the Chinese Service].
Ming, +1633.
Lu Jo-Han (João Rodrigues, S. J.) 陸若漢.
Pfister (1), p. 25* (add.)

Kuo Chhao Ming Chhen Shih Lüeh 國朝名臣事略.
Biographies of (47) Famous Statesmen and Generals of the Present Dynasty (Yuan)
Yuan, *c.* +1360.
Su Thien-Chio 蘇天爵.
Cf. H. Franke (14), p. 119

Kuo Chhao Wên Lei 國朝文類.
Classified Prose of the Present Dynasty (Yuan).
Yuan, *c.* +1340.
Ed. Satula (Thien Hsi) 薩都拉(天錫) & Su Thien-Chio 蘇天爵.
Cf. H. Franke (14), p. 119.

Kuo Chhao Wu Li I.
See *Kukcho Orye-ŭi.*

Lang Chi Tshung Than 浪跡叢談.
See Liang Chang-Chü (*1*).

Lao Hsüeh An Pi Chi 老學庵筆記.
Notes from the Hall of Learned Old Age.
Sung, *c.* +1190.
Lu Yu 陸游.

Li Shao Phien 蠡勺編.
Measuring the Ocean with a Calabash-Ladle [title taken from a diatribe against narrow-minded views in the biography of Tungfang Shuo in *CHS*].
Chhing, *c.* +1799.
Ling Yang Tsao 淩揚藻.

Li Wei Kung Wên Tui 李衛公問對.
The Answers of Li Wei Kung to Questions (of the emperor Thang Thai Tsung) (on the Art of War).
Supposedly Thang, but more probably produced in the Sung, +11th.
Writer unknown.
Perhaps composed by Juan I 阮逸.

Liao, Chin, Yuan I Wên Chih 遼金元藝文志.
Bibliography of the Liao, J/Chin and Yuan Dynasties [the official histories of which lack *i wên chih*].
Chhing.
Huang Yü-Chi (+1629 to +1691) 黃虞稷.
Ni Tshan (+1704 to 1841) & 倪燦.
Chhien Ta-Hsin (+1728 to 1804) 錢大昕.
and others.

Liao Shih 遼史.
History of the Liao (Chhi-tan) Dynasty [+916 to +1125].
Yuan, +1343 to +1345.
Tho-Tho (Toktaga) 脫脫 & Ouyang Hsüan 歐陽玄.
Partial tr. Wittfogel, Fêng Chia-Shêng *et al.*
Yin-Tê Index, no. 35.

Lieh Hsien Chuan 列仙傳.
Lives of Famous Immortals (cf. *Shen Hsien Chuan*).
Chin, +3rd or +4th century, though certain parts date from about −35 and shortly after +167.
Attrib. Liu Hsiang 劉向.
Tr. Kaltenmark (2).

Lien Ping Shih Chi 練兵實紀.
Treatise on Military Training.
Ming, +1568; pr. +1571, often repr.
Chhi Chi-Kuang 戚繼光.

Lien Ping Shih Chi Tsa Chi 練兵實紀雜集.
Miscellaneous Records concerning Military Training (and Equipment) [the addendum to *Lien Ping Shih Chi*, q.v., in 6 chs. following the 9 chs. of the main work].
Ming, +1568; pr. +1571.
Chhi Chi-Kuang 戚繼光.

Lien Yüeh Huo Chhi Chen Chi 練閱火器陣紀.
An Examination of Training in the Use of Gunpowder Weapons, Cannon and Catapults.
Chhing, +1696.
Hsüeh Hsi 薛熙.

Liu Pin-Kho Wên Chi 劉賓客文集.
Literary Records of the Imperial Tutor Liu.
Thang, after +842.
Liu Yü-Hsi 劉禹錫.

Liu Po-Wên Chien Hsien Phing Chê Chung 劉伯溫薦賢平浙中.
The Pacification of central Chekiang by the Able Officers recommended by (Commander) Liu Po-Wên [Liu Chi, in +1340 to + 1350, acting as a Yuan officer against the rebels and pirates of the region.]
Ch. 17 of Chou Chhing-Yuan's *Hsi Hu Erh Chi*, q.v.

Liu Thao 六韜.
The Six Quivers [treatise on the art of war].
H/Han, +2nd century, incorporating material as early as the −3rd.
Writer unknown:
See Haloun (5); L. Giles (11).

Lo-Yang Chhieh Lan Chi 洛陽伽藍記.
(or '*Loyang Ka-Lan Chi*'; *sêng ka-lan* transliterating *sanghārāma*).
Description of the Buddhist Temples and Monasteries at Loyang.
N/Wei, *c.* +547.
Yang Hsüan-Chih 楊衒之.

Lü Li Yuan Yuan 律曆淵源.
Calendrical and Acoustic, Ocean of Calculations (compiled by Imperial Order) [includes *Li Hsiang Khao Chhêng*, *Shu Li Ching Yün*, Lü Lü Chêng I, q.v.].
Chhing, +1723; printing probably not finished before +1730.
Ed. Mei Ku-Chhêng 梅毂成 & Ho Kuo-Tsung 何國宗.
Cf. Hummel (2), p. 285; Wylie (1), pp. 96 ff.

Lü Lü Chêng I 律呂正義.
Collected Basic Principles of Music (compiled by Imperial Order) [part of *Lü Li Yuan Yuan*, q.v.].
Chhing, +1713 (+1723).
Ed. Mei Ku-Chhêng 梅毂成 & Ho Kuo-Tsung 何國宗.
Cf. Hummel (2), p. 285.

Lun Hêng 論衡.
Discourses Weighed in the Balance.
H/Han, +82 or +83.
Wang Chhung 王充.
Tr. Forke (4); cf. Leslie (3).
Chung-Fa Index, no. 1.

Lung Hu Huan Tan Chüeh 龍虎還丹訣.
Explanation of the Dragon-and-Tiger Cyclically Transformed Elixir.
Wu Tai, Sung, or later.
Chin Ling Tzu 金陵子.
TT/902.

Man-Chou Shih Lu Thu 滿州實錄圖.
Veritable Records of the Manchus, with Illustrations [depicting the martial exploits of Nurhachi, Thai Tsu of the Chhing, d. +1626].
Alt. title of *Thai Tsu Shih Lu Thu*, q.v.

Man Shu 蠻書.
Book of the Barbarians [itineraries].
Thang, *c.* +862.
Fan Chho 樊綽.

Mêng Hua Lu
See *Tung Ching Mêng Hua Lu*.

Mêng Liang Lu 夢粱錄.
Dreaming of the Capital while the Rice is Cooking [description of Hangchow towards the end of the Sung].
Sung, +1275.
Wu Tzu-Mu 吳自牧.

Môko Shūrai Ekotoba 蒙古襲來繪詞.
Illustrated Narrative of the Mongol Invasions (of Japan) [+1274 and +1281].
Japan, +1293; facsim. ed. ed. Kubota Beisan (Kubota Yonenari), Tokyo, 1916.
Painted by some unknown master to illustrate the experiences of Takezaki Sueriaga 竹崎季長.

Mu An Chi 牧菴集.
Literary Collections of (Yao) Mu-An.
Yuan, *c.* +1310.
Yao Sui 姚燧.

Muye Tobo T'ongji Ŏnhae 武藝圖譜通志諺解.
Illustrated Encyclopaedia of Military Arts (the Korean translation of the *Wu I Thu Phu Thung Chih*).
Korea, after +1790.
Editor not known.
Courant (1), no. 2467.

Nan Thang Shu 南唐書.
History of the Southern Thang Dynasty [+923 to +936].
Sung, +11th.
Ma Ling 馬令.

Nan Thang Shu 南唐書.
History of the Southern Thang Dynasty [+923 to +936].
Sung, +12th.
Lu Yu 陸游.

Nihon Kokujokushi 日本國辱史.
History of Japan's Humiliation [the Mongol invasions of +1274 and +1281].
Japan, *c.* +1300.
Writer unknown.

No Kao Chi 諾皐記.
Records of No-Kao [collected popular beliefs concerning spirits, genii and Taoist gods].
Thang, *c.* +850.
Tuan Chhêng-Shih 段成式.
No-Kao was a Taoist military archangel analogous to St Michael, mentioned in *Pao Phu Tzu*, ch. 17, p. 4*b* (Ware tr. (5), p. 285).

Nung Chi 農紀.
Agricultural Record.
Sung, Yuan or Ming.
Writer unknown.
Not in Wang Yü-Hu (*1*).

O Yu Hui Phien.
See Miu Yu-Sun (*1*).

Pa Pien Lei Tsuan 八編類纂.
Classified Florilegium of Eight Literary

Pa Pien Lei Tsuan (*cont.*)
Collections.
Ming, *c.* +1620.
Chhen Jen-Hsi 陳仁錫.
Now extant only in quotations.

Pa Shih Ching Chi Chih 八史經籍志.
Bibliography of the Eight Histories (includes the lists in six dynastic histories and four supplementary bibliographies compiled during the Chhing period).
Chhing, pr. 1825 and 1883.
See Têng & Biggerstaff (1), 1st ed. p. 15, 2nd ed. p. 10.

Pai Chan Chi Fa 百戰奇法.
Wonderful Methods for (Victory in) a Hundred Combats.
Sung, *c.* +1260.
Writer unknown.

Pai Chan Ching.
See *Ping Fa Pai Chan Ching.*

Pai Pien 稗編.
Leaves of Grass [encyclopaedia].
Ming, +1581.
Ed. Thang Shun-Chih 唐順之.

Pao Yüeh Lu 保越錄.
The Defence of the City of Yüeh (Shao-Hsing) [+1358].
Yuan, +1359.
Hsü Mien-Chih 徐勉之.

Pei Mêng So Yen 北夢瑣言.
Fragmentary Notes Indited North of (Lake) Mêng.
Wu Tai (S/Phing), *c.* +950.
Sun Kuang-Hsien 孫光憲.
See des Rotours (4), p. 38.

Pei Pien Thun Thien Chhê Chhung I 備邊屯田車銃議.
Discussions on the Use of Military-Agricultural Settlements, Muskets, Field Artillery and Mobile Shields in the Defence of the Frontiers.
Ming, *c.* +1585.
Chao Shih-Chên 趙士禎.

Phing Han Lu 平漢錄.
Records of the Pacification of Han [the campaign of Chu Yuan-Chang and his generals in +1363 which overthrew the Han State of Chhen Yu-Liang in the Yangtse Valley and established the power of the Ming dynasty].
Ming, *c.* +1521.
Thung Chhêng-Hsü 童承敘.

Phing Hsia Lu 平夏錄.
Records of the Pacification of Hsia [the campaign of Chu Yuan-Chang and his generals in +1371 which overthrew the Hsia State of Ming Shêng in Szechuan and established the power of the Ming Dynasty].
Ming, *c.* +1544.
Huang Piao 黃標.
Cf. W. Franke (4), p. 56.

Phing Phi Pai Chin Fang 洴澼百金方.
The Washerman's Precious Salve; (Appropriate) Techniques (of Successful Warfare) [military encyclopaedia].
Ming, after +1626.
Ed. Hui Lu 惠麓.
The title is taken from a story in *Chuang Tzu*, ch. 1, tr. Legge (5), Vol. 1, p. 173; Fêng Yu-Lan (5), p. 39. A man of Sung State invented a salve for chapped hands, and it was used in his family, professional washers of silk, for several generations. A stranger bought the formula for 100 pieces of gold, went down to Wu State, and being made Admiral there, employed it for the sailors so that they gained a great victory over Yüeh. One application brought little gain; the other won great reward and a noble title.
The work seems to be rare (not in *SKCS/TMTY*).

Phing Wu Lu 平吳錄.
Records of the Pacification of Wu [the campaign by Chu Yuan-Chang and his generals in +1366 which overthrew the Chou State of Chang Shih-Chhêng and established the power of the Ming Dynasty].
Ming, *c.* +1472.
Wu Khuan 吳寬.
Cf. W. Franke (4), p. 57.

Pi Chou Kao Lüeh 敝帚稿略.
Classified Reminiscences swept up by an Old Broom.
Sung, *c.* +1250.
Pao Hui 包恢.

Ping Chhien 兵鈐.
Key to Military Affairs; or, Key of Martial Art.
Chhing, +1675.
Lü Phan 呂磻 & Lu Chhêng-Ên 盧承恩.

Ping Fa Pai Chan Ching 兵法百戰經.
Manual of Military Strategy for a Hundred Battles.
Ming, *c.* +1590.
Wang Ming-Hao 王鳴鶴.
Ed. Ho Chung-Shu 何仲叔.

Ping Lu 兵錄.
Records of Military Art.
Ming, +1606; pr. +1628. Later eds. have prefaces of +1630 and +1632.
Ho Ju-Pin 何汝賓.
Cf. Wang Chung-Min & Yuan Thung-Li (*1*), i, pp. 472, 475.

Ping Lüeh Tshuan Wên 兵略纂聞.
Classified Compendium of Things Seen and Heard on Military Matters.
Ming, late +16th.
Chhü Ju-Chi 瞿汝稷.
Cf. Lu Ta-Chieh (*1*), p. 127.

Pu Liao Chin Yuan I Wên Chih 補遼金元藝文志.
Additional Bibliography of the Liao, Chin and Yuan Dynasties.
A continuation of *Liao Chin Yuan I Wên Chih*, q.v. by many Chhing scholars especially Lu Wên-Chao 盧文弨 (or Chhao 弨) *c.* +1770. In *Pa Shih Ching Chi Chih*, q.v.

San Chhao Pei Mêng Hui Pien 三朝北盟會編.
Collected Records of the Northern Alliance during Three Reigns.
Sung, +1196.
Hsü Mêng-Hsin 徐夢莘.

San Kyūkai 算九回.
Mathematics in Nine Chapters [in each of three volumes or parts].
Japan, +1677.
Nozawa Sodanaga 野沢定長.
Cf. Itakura (1).

San Tshai Thu Hui 三才圖會.
Universal Encyclopaedia.
Ming, +1609.
Wang Chhi 王圻.

Shan Tso Chin Shih Chih 山左金石志.
Record of Inscriptions on Metal and Stone from the Left-hand Side of the Mountain.
Chhing, +1796.
Pi Yuan 畢沅 & Juan Yuan 阮元.

Shen Chhi Phu 神器譜.
Treatise on Extraordinary (lit. Magical) Weapons [musketry].
Ming, +1598.
Chao Shih-Chên 趙士禎.
Cf. W. Franke (3) no. 255, (4), p. 208; Goodrich (15).

Shen Chhi Phu Huo Wên 神器譜或問.
Miscellaneous Questions (and Answers arising out of) the Treatise on Guns.
Ming, +1599.
Chao Shih-Chên 趙士禎.
Cf. W. Franke (3) no. 255, (4), p. 208; Goodrich (15).

Shen Chi Chih Ti Thai Pai Ying Ching 神機制敵太白陰經.
Secret Contrivances for the Defeat of Enemies; the Manual of the White Planet.
Full title of *Thai Pai Yin Ching*, q.v.

Shen I Chi 神異記.
(Probably an alternative title of *Shen I Ching*, q.v.)
Records of the Spiritual and the Strange.
Chin, *c.* +290.
Wang Fou 王浮.

Shen I Ching 神異經.
Book of the Spiritual and the Strange.
Ascr. Han, but prob. +3rd, +4th or +5th century.
Attrib. Tungfang Shuo (−2nd.) 東方朔.
Probable author, Wang Fou 王浮.

Shen Wei Thu Shuo 神威圖說.
Illustrated Account of the Magically Overawing (Weapon, i.e. the Cannon).
Chhing, +1681.
Nan Huai-Jen (Ferdinand Verbiest, S. J.) 南懷仁.
This book, if it still exists at all, must be exceedingly rare; we know of no copy either in China or elsewhere.

Shih Chin Shih 試金石.
On the Testing of (what is meant by) 'Metal' and 'Mineral'.
See Fu Chin-Chüan (5).

Shih Hu Shih Chi 石湖詩集.
Collected Works of the Lakeside Poet.
Sung, *c.* +1190.
Fan Chhêng-Ta 范成大.

Shih Kuo Chhun Chhiu 十國春秋.
Spring and Autumn Annals of the Ten Kingdoms (the States of the Five Dynasties Period, +10th cent.).
Chhing, +1678.
Wu Jen-Chhen 吳任臣.

Shiseki Shūran 史籍集覽.
Collection of Historical Materials.
+15th to +18th centuries.
Ed. Kondō Heijō 近藤瓶城.
Kondō Shuppan-bu, Tokyo, 1907.

Shou Chhêng Chiu Ming Shu 守城救命書.
On Saving the Situation by the (Successful) Defence of Cities.
Ming, +1607.
Lü Khun 呂坤.
Cf. Goodrich & Fang Chao Ying (1), p. 1006.

Shou Chhêng Lu 守城錄.
Guide to the Defence of Cities [lessons of the sieges of Tê-an in Hupei, +1127 to +1132].
Sung, *c.* +1140 and +1193 (combined in +1225).
Chhen Kuei 陳規 & Thang Tao 湯璹.
Cf. Balazs & Hervouet (1), p. 237.

Shu Nan Hsü Lüeh 蜀難叙略.
Collected Records of the Difficulties of Szechuan.
Chhing, *c.* +1663, but dealing with events in +1642 and after.
Shen Hsün-Wei 沈荀蔚.
Cf. Struve (1), pp. 346, 362.

Shu Yü Chou Tzu Lu 殊域周咨錄.
Record of Despatches concerning the Different Countries.
Ming, +1574.
Yen Tshung-Chien 嚴從簡.

Shui Hu Chuan 水滸傳.
Stories of the River-Banks [novel 'All Men are Brothers' and 'Water Margin'].
Ming, first collected *c.* +1380, but derived from older plays and stories. Oldest extant 100-ch. version, +1589, a reprint of an original earlier than +1550. Oldest extant 120-ch. version, +1614.
Ascr. Shih Nai-An 施耐庵.
Tr. Buck (1); Jackson (1).

Shui Lei Thu Shuo 水雷圖說.
Illustrated Account of Sea Mines.
See Phan Shih-Chhêng (1).

Ssu Hsüan Fu 思玄賦.
Thought the Transcender [ode on an imaginary journey beyond the sun].
H/Han, +135.
Chang Hêng 張衡.

Ssuma Fa 司馬法.
The Marshal's Art (of War).

Ssuma Fa (cont.)
Chou (late), prob. −4th or −3rd.
Writer unknown.

Su-a Munjip 西崖文集
Essays from the Western Cliff (one of Yu's names).
Korea, *c.* +1605, preface of +1633.
Yu Sŏngnyong 柳成龍
Courant (1), no. 624.

Suan Fa Thung Tsung 算法統宗.
Systematic Treatise on Arithmetic.
Ming, +1592.
Chhêng Ta-Wei 程大位.

Sun Tzu Ping Fa 孫子兵法.
Master Sun's Art of War.
Chou (Chhi), *c.* −345.
Attrib. Sun Wu 孫武, more probably by Sun Pin 孫臏.

Sung Chi Chao Chung Lu 宋季昭忠錄.
Records of Distinguished Patriots of the [Second Half of the Southern] Sung Dynasty.
Alt. title of *Chao Chung Lu*, q.v.

Sung Chi San Chhao Chêng Yao 宋季三朝政要.
The Most Important Aspects of Government as seen under the Last Three Courts of the (Southern) Sung Dynasty.
Yuan, *c.* +1285.
Writer unknown.
Cf. Balazs & Hervouet (1), p. 83.

Sung Hsüeh Shih Chhüan Chi 宋學士全集.
Complete Record of Sung Scholars.
Ming, *c.* +1371.
Sung Lien 宋濂.

Sung Hsüeh Shih Chhüan Chi Pu I 宋學士全集補遺.
Additions to the Complete Record of Sung Scholars.
Ming, *c.* +1375.
Sung Lien 宋濂.

Sung Hui Yao Kao 宋會要稿.
Drafts for the *History of the Administrative Statutes of the Sung Dynasty*.
Sung.
Collected by Hsü Sung (1809) 徐松.
From the *Yung-Lo Ta Tien*.

Sung Shih 宋史.
History of the Sung Dynasty [+960 to +1279].
Yuan, *c.* +1345.
Tho-Tho (Toktaga) 脫脫 & Ouyang Hsüan 歐陽玄.
Yin-Tê Index, no. 34.

Sung Shu 宋書.
History of the (Liu) Sung Dynasty [+420 to +478].
S/Chhi, +500.
Shen Yo 沈約.
A few chs. tr. Pfizmaier (58).
For translations of passages see the index of Frankel (1).

Sung Thung Chien Chhang Phien Chi Shih Pên Mo 宋通鑑長編紀事本末.
Comprehensive Mirror Chronological History of the Sung Dynasty from Beginning to End.
Sung, +1253.
Yang Chung-Liang 楊仲良.

Ta Chhing Shêng Tsu Jen Huang Ti Shih Lu 大清聖祖仁皇帝實錄.
Veritable Records of the Benevolent Emperor of the Great Chhing Dynasty Shêng Tsu [Sage Ancestor = Khang-Hsi, r. +1661 to +1722].
Chhing, *c.* +1729.
Ed. Chiang Thing-Hsi *et al.* 蔣廷錫.
Hu/143, 327.

Ta Hsüeh Yen I 大學衍義.
Extension of the Ideas of the Great Learning [Neo-Confucian ethics].
Sung, +1229.
Chen Tê-Hsiu 眞德秀.

Ta Hsüeh Yen I Pu 大學衍義補.
Restoration and Extension of the Ideas of the *Great Learning* [contains many chapters of interest for the history of technology].
Ming, *c.* +1480.
Chhiu Chün 丘濬.

Taiheiki 太平記.
Records of the Reign of Great Peace [a romance history of one of the most troubled periods of Japanese history, +1318 to +1368].
Japan, *c.* +1370.
Attrib. Kojuma (monk) 小嶋.

Tê-An Shou Chhêng Lu 德安守城錄.
See *Shou Chhêng Lu*.

Têng Than Pi Chiu 登壇必究.
Knowledge Necessary for (Army) Commanders.
Ming, +1599.
Wang Ming-Hao 王鳴鶴.
Cf. W. Franke (4), p. 208.

Têng Wu Shê Phien 登吳社編.
Records of a Journey up to the Cities of Wu (Chiangsu).
Sung.
Wang Chih 王稚.

Teppō-ki 鐵砲記.
Record of Iron Guns.
Japan, +1606; pr. +1649.
Nampo Bunshi 南浦文之.
Cf. Arima (*1*), pp. 617 ff.

Thai-Chhing Ching Thien-Shih Khou Chüeh 太清經天師口訣.
Oral Instructions from the Heavenly Masters [Taoist Patriarchs] on the Thai-Chhing Scriptures.
Date unknown, but must be after the mid +5th cent. and before Yuan.
Writer unknown.
TT/876.

Thai-Chhing Tan Ching Yao Chüeh 太清丹經要訣. (= *Thai-Chhing Chen Jen Ta Tan*)
Essentials of the Elixir Manuals, for Oral Transmission; a Thai-Chhing Scripture.
Thang, mid +7th (*c.* +640).
Prob. Sun Ssu-Mo 孫思邈.
In *YCCC*, ch. 71.
Tr. Sivin (1), pp. 145 ff.

Thai Pai Yin Ching 太白陰經.
Manual of the White (and Gloomy) Planet (of War; Venus) [military encyclopaedia]
Thang, +759.
Li Chhüan 李筌.

Thai Tsu Shih Lu Thu 太祖實錄圖.
Veritable Records of the Great Ancestor (Nurhachi, d. +1626, retrospectively emperor of the Chhing), with Illustrations.
Ming +1635; revised Chhing, +1781.
Writer unknown.
MS of +1740 reproduced by NE University, Mukden, 1930; in Chinese with captions in Chinese and Manchu for the illustrations.

Thang Yeh Chen Jen Chuan 唐葉眞人傳.
Biography of the Perfected Sage Yeh (Ching-Nêng) of the Thang.
Prob. Sung.
Chang Tao-Thung 張道統.
TT/771

Thien Kung Khai Wu 天工開物.
The Exploitation of the Works of Nature.
Ming, +1637.
Sung Ying-Hsing 宋應星.
Tr. Sun Jen I-Tu & Sun Hsüeh-Chuan (1)

Thien Wên 天問.
Questions about Heaven ['ode', perhaps a ritual catechism].
Chou, generally ascr. late +4th, but perhaps −5th century.
Attrib. Chhü Yuan, but probably earlier 屈原.
Tr. Erkes (8); Hawkes (1).

Thing Hsün Ko Yen 庭訓格言.
Talks on Experiences in the Hall of Edicts.
Chhing, *c.* +1722.
Aihsin-chüeh lo Hsüan-Yeh (Khang-Hsi emperor of the Chhing) 愛新覺羅玄燁.

Thung Tien 通典.
Comprehensive Institutes [a reservoir of source material on political and social history]
c. +812 (events down to +801).
Embodied the earlier *Chêng Tien* of Liu Chih.
Tu Yu 杜佑.
Têng & Biggerstaff (1) p. 148.

Thung Ya 通雅.
Helps to the Understanding of the *Literary Expositor* [general encyclopaedia with much of scientific and technological interest].
Ming and Chhing, finished +1636, pr. +1666.
Fang I-Chih 方以智.

Tiao Chi Li Than 釣磯立談.
Talks at Fisherman's Rock.
Wu Tai (S/Thang) & Sung, begun *c.* +935, finished after +975.
Shih Hsü-Pai 史虛白.

Tsao Chia Fa 造甲法.
Treatise on Armour-Making.
Sung, *c.* +1150.
Writer unknown.
Now extant only in quotations.

Tsao Shen Pei Kung Fa 造神臂弓法.
Treatise on the Making of the Strong Bow.
Sung, *c.* +1150.
Writer unknown.
Now extant only in quotations.

Tsê Kho Lu 則克錄.
Book of Instantaneous Victory.
Alt. title of *Huo Kung Chhieh Yao*, (q.v.) given only to the reprint of 1841 (Pelliot (55), p. 192), which introduced many mistakes and suppressed some of the illustrations.

Tshao Shêng Yao Lan 操勝要覽.
Important Perspectives for the Attainment of Victory.
= *Huo Chhi Lüeh Shuo*, q.v.

Tso Mêng Lu 昨夢錄.
Dreaming of the Good Old Days [written in the South after the victory of the Chin Tartars, recalling life in the former capital city of Khaifêng (Pien-ching) under the Northern Sung].
Sung, *c.* +1137.
Khang Yü-Chih 康譽之.

Tu Chhêng Chi Shêng 都城紀勝.
The Wonder of the Capital (Hangchow).
Sung, +1235.
Mr Chao 趙氏 [Kuan Pu Nai Tê Ong 灌圃耐得翁; The Old Gentleman of the Water-Garden who achieved Success through Forbearance]

Tu Shih Ping Lüeh 讀史兵略.
Accounts of Battles in the Official Histories.
See Hu Lin-I (*1*).

Tu Shu Min Chhiu Chi, Chiao Chêng 讀書敏求記校證.
Record of Diligently Sought for and Carefully Collated Books.
Chhing, +1684; first pr. +1726.
Chhien Tsêng 錢曾.
Cf. Têng & Biggerstaff (1), 1st ed. p. 42.

Tung Ching Chi 東京記.
Records of the Eastern Capital.
Sung, *c.* +1065.
Sung Min-Chhiu 宋敏求.
Now extant only in quotations.

Tung Ching Mêng Hua Lu 東京夢華錄.
Dreams of the Glories of the Eastern Capital (Khaifêng).
S/Sung, +1148 (referring to the two decades which ended with the fall of the capital of N/Sung in +1126 and the completion of the move to Hangchow in +1135).
Mêng Yuan-Lao 孟元老.

Wan Shu Chi 宛署記.
See *Yuan Shu Tsa Chi*.

Wang Wên Chhêng Kung Chhüan Shu 王文成公全書.
Collected Writings of Wang Shou-Jen (Wang Yang-Ming).
Ming, +1574.
Ed. Hsieh Thing-Chieh 謝廷傑.
Cf. Franke (4), p. 138.

Wei Kung Ping Fa Chi Pên 衛公兵法輯本.
Military Treatise of (Li) Wei-Kung.
Thang, +7th.
Li Ching 李靖.
Fragments collected by Wang Tsung-I (Chhing) 汪宗沂.

Wei Lüeh 魏略.
Memorable Things of the Wei Kingdom (San Kuo).
San Kuo (Wei) or Chin, +3rd or +4th century.
Yü Huan 魚豢.

Wên Li Su 問禮俗.
Questions on Popular Ceremonies and Beliefs.
San Kuo/Wei, *c.* +225.
Tung Hsün 董勛.
In *YHSF* ch. 28, pp. 72*a* ff.

Wo Chhing Thun Thien Chhê Chhung I 倭情屯田車銃議.
Discussions on the Use of Military-Agricultural Settlements, Muskets, Field Artillery and Mobile Shields against the Japanese (Pirates).
Ming, *c.* +1585.
Chao Shih-Chên 趙士禎.
Chhê Chhung Thu is a supplement to this.

Wu Ching Shêng Lüeh 五經聖略.
The (Essence of the) Five (Military) Classics, for Imperial Consultation.
Sung, *c.* +1150.
Wang Shu 王洙.
Now extant only in quotations.

Wu Ching Tsung Yao 武經總要.
Collection of the Most Important Military Techniques [compiled by Imperial Order].
Sung, +1040 (+1044). Repr. +1231 and *c.* +1510. This Ming edition is the oldest extant now.
Ed. Tsêng Kung-Liang 曾公亮 assisted by Yang Wei-Tê 楊惟德 and Ting Tu 丁度.

Wu Ching Yao Lan 武經要覽.
Essential Readings in the Most Important Military Techniques (lit. Classics).
Title of one of the Wan-Li editions of *Wu Ching Tsung Yao*.

Wu Hsien Chih 吳縣志.
Local History and Geography of Wu-hsien (Suchow in Chiangsu).
Chhing, +1691 (2nd ed.).
Ed. Sun Phei 孫佩.

Wu I Thu Phu Thung Chih 武藝圖譜通志.
Illustrated Encyclopaedia of Military Arts.
Korea (Chosŏn), +1790.
Ed. Pak Chega 朴齊家 & Yi Tŏngmu 李德懋.
Based on an earlier draft by Han Kyo 韓嶠 done in the +1590s in consultation with Chinese military technologists then in Korea fighting the Japanese under Hideyoshi (*Chongjo Sillok*, 30/31*a*).
Cf. *Muye Tobo T'ongji Ŏnhae*, the Korean version of the text.

Wu Li Hsiao Shih 物理小識.
Small Encyclopaedia of the Principles of Things.
Chhing, +1664.
Fang I-Chih 方以智.
Cf. Hirth (17)

Wu Lin Chiu Shih 武林舊事.
Institutions and Customs of the Old Capital (Hangchow).
Sung, *c.* +1270 (but referring to events from about +1165 onwards).
Chou Mi 周密.

Wu Lüeh Huo Chhi Thu Shuo 武略火器圖說.
Illustrated Account of Gunpowder Weapons and their Use in Various Tactical Situations.
Ming, *c.* +1560.
Incorporated in *Wu Pei Chhüan Shu*, q.v.
Hu Tsung-Hsien 胡宗憲.

Wu Lüeh Shen Chi 武略神機.
The Magically(Effective) Arm in Various Tactical Situations [musketry].
Ming, *c.* +1550.
Hu Hsien-Chung 胡獻忠 (perhaps Hu Hsien-Chung 胡憲仲).
Cf. Lu Ta-Chieh (*1*), p. 139.

Wu Lüeh Shen Chi Huo Yao 武略神機火藥.
On Gunpowder for Muskets and their Use in Various Tactical Situations.
Ming, *c.* +1560.
Incorporated in *Wu Pei Chhüan Shu*, q.v.
Hu Tsung-Hsien 胡宗憲.

Wu Pei Chhüan Shu 武備全書.
Complete Collection of Works on Armament Technology (including Gunpowder Weapons).
Ming, +1621.
Ed. Phan Khang 潘康.

Wu Pei Chih 武備志.
Treatise on Armament Technology.
Ming, prefaces of +1621, pr. +1628.
Mao Yuan-I 茅元儀.
Cf. Franke (4), p. 209.

Wu Pei Chih Lüeh 武備志略.
Classified Material from the Treatise on Armament Technology.
Chhing, *c.* +1660.
Fu Yü 傅禹.

Wu Pei Chih Shêng Chih 武備制勝志.
The Best Designs in Armament Technology.
Ming, *c.* +1628.
Mao Yuan-I 茅元儀.
MS of 1843 in the Cambridge University Library.
Cf. Franke (4), p. 209.

Wu Pei Hsin Shu 武備新書.
New Book on Armament Technology [very similar to *Chi Hsiao Hsin Shu*, q.v.].
Ming, +1630.
Attrib. Chhi Chi-Kuang 戚繼光.
True compiler unknown.

Wu Pei Huo Lung Ching 武備火龍經.
The Fire-Drake Manual and Armament Technology [gunpowder weapons and firearms].
Ming, completed after +1628, but containing

Wu Pei Huo Lung Ching (cont.)
much material from earlier versions of the *Huo Lung Ching*.
Attrib. Chiao Yü 焦玉.
Cf. Ho Ping-Yü & Wang Ling (1).

Wu Pei Pi Shu 武備秘書.
Confidential Treatise on Armament Technology [a compilation of selections from earlier works on the same subject].
Chhing, late +17th; (repr. 1800).
Shih Yung-Thu 施永圖.

Wu Pien 武編.
Military Compendium [technology and equipment, including Western-influenced firearms].
Ming, *c.* +1550.
Thang Shun-Chih 唐順之.

Wu Shih Pên Tshao 吳氏本草.
Mr. Wu's Pharmaceutical Natural History.
San Kuo (Wei), *c.* +235.
Wu Phu 吳普.
Extant only in quotations in later literature.

Wu Shih Thao Lüeh 武試韜略.
A Classified Quiverful of Military Texts.
Ming, before +1621.
Wang Wan-Chhing 汪萬頃.

Wu Shu Ta Chhüan 武書大全.
Complete Collection of the Military Books.
Ming, +1636.
Ed. Yin Shang 尹商.
Cf. Lu Ta-Chieh (2), p. 12.

Wu Tai Shih Chi 五代史記.
See *Hsin Wu Tai Shih*.

Wu Ti Chen Chhüan 無敵眞詮.
Reliable Explanations of Invincibility.
Ming, *c.* +1430.
Writer unknown.
Now extant only in quotations.

Wu Tu Fu 吳都賦.
Ode on the Capital of Wu (Kingdom).
Chin, *c.* +270.
Tso Ssu 左思.
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