

# **History of Rocketry and Astronautics**

**Proceedings of the Twelfth, Thirteenth and Fourteenth History  
Symposia of the International Academy of Astronautics**

**Dubrovnik, Yugoslavia, 1978**

**München, Federal Republic of Germany, 1979**

**Tokyo, Japan, 1980**

**Å. Ingemar Skoog, Volume Editor**

**R. Cargill Hall, Series Editor**

**AAS History Series, Volume 10**

**A Supplement to Advances in the Astronautical Sciences**

**IAA History Symposia, Volume 5**

Copyright 1990

by

AMERICAN ASTRONAUTICAL SOCIETY

AAS Publications Office  
P.O. Box 28130  
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science  
Member of the International Astronautical Federation

*First Printing 1990*

ISSN 0730-3564

ISBN 0-87703-329-3 (Hard Cover)  
ISBN 0-87703-330-7 (Soft Cover)

*Published for the American Astronautical Society  
by Univelt, Inc., P.O. Box 28130, San Diego, California 92198*

Printed and Bound in the U.S.A.

## Chapter 1

**THE GENESIS OF THE ROCKET IN CHINA  
AND ITS SPREAD TO THE EAST AND WEST\***

Frank H. Winter<sup>†</sup>

At the time of presentation of this paper in 1979, the bulk of investigations on the origins of the rocket in China were not specialized studies of the rocket *per se* but overall studies of the earliest artillery or the history of gunpowder and pyrotechnics. Even J. R. Partington's excellent and scholarly *History of Greek Fire and Gunpowder* (Cambridge, 1960) mentioned the earliest Chinese rockets only in passing in his chapter "Pyrotechnics and Firearms in China." Then, the best studies yet made, but still not *specifically* treating "ancient" Chinese rockets, were a series of articles on early firearms and gunpowder in China by L. Carrington Goodrich, Fêng Chia-shêng and Wang Ling, appearing in *Isis* in 1946-1947, cited in the references. The late Professor Tenney L. Davis also wrote articles about this time, at least specifically on Chinese rockets, but derived his data from standard sources.<sup>1</sup>

**OTHER CLAIMANTS TO THE PRIORITY OF THE ROCKET**

Is there any evidence to refute the Chinese claim to the priority of the rocket? The author has made extensive studies of Indian claims for the priority of the rocket with the conclusion that the Chinese still enjoy their priority. Indian claims cannot be substantiated because:

- a. Mythological or mystical interpretations of rockets and other devices *thousands* of years ago or long before the development of requisite technologies are unacceptable as proof.
- b. Certain Sanskrit words taken to be rockets are too often misinterpreted.

---

\* Presented at the 13th History Symposium of the International Academy of Astronautics, Munich, Federal Republic of Germany, September, 1979. **Author's Remark:** Since the presentation of this paper, world renowned Sinologist, Joseph Needham, produced the long-awaited Volume V of his monumental Science and Civilisation in China which contains the most thorough historical analysis of both gunpowder and the rocket to be found anywhere. It is felt that this paper is still of some value, especially the interpretation of the spread of rocket technology throughout the East (the Orient) and the West. Professor Needham's new work has only been used here in identifying and properly dating hitherto vague early Chinese references. For further interpretations of early Chinese rocketry, the reader of course is directed to Professor Needham's book as well as the other paper on this subject included in the present volume. **Editor's Note:** The spelling used by the author for Chinese words is the one used in the references in English, and it might differ slightly from other papers based on the original Chinese manuscript.

† Curator of Astronautics, National Air and Space Museum, Smithsonian Institution, Washington, D.C., U.S.A.

- c. Indian sources or claims are generally undated or over-exaggerated.
- d. The true rocket and other firearms do not appear to have been fully established upon the sub-continent of Asia until the 15th Century, long after the appearance of more substantial and datable Chinese evidence of firearms, including rockets.

Thus far no adequate challenges have emerged from the West for a European priority or even independent discovery or invention of the rocket before the Chinese.<sup>2</sup>

It has been believed--though incorrectly--by several 19th and even mid-20th Century authorities on early arms, notably Lalanne, Reinaud and Favé, Hoefer, Ellis and Mercier, that the so-called "Greek Fire" of the Byzantine Greeks of the 17th Century A.D. were rockets. One anonymous writer of an article entitled "Greek Fire--Congreve Rockets," in the *Asiatic Journal* for September 1825, goes so far as to assert that the 19th Century British rocketeer Sir William Congreve was wrong in claiming the invention of the rocket as his because of the Byzantine priority. The Byzantine claims can be safely dismissed as invalid simply because of the absence of saltpeter or potassium nitrate in their mixtures which were incendiary and not propulsive. They were essentially quicklime compositions with pitch, Naptha, sulfur and perhaps charcoal and other ingredients. Further, the hand tubes for "firing" Greek Fire or the catapults which sent Greek Fire pots sailing into the air are now identified as bellows or mouth-operated siphons or catapults. Yet even in 1823 J. MacCulloch, in his "Conjectures respecting the Greek Fire of the Middle ages," suspected that Greek Fire devices could not have been rockets because of the mechanical aids necessary for their launch, whereas the rocket is self-propelled.

It is thus evident that there has been much confusion amongst the earliest (and later) investigators of gunpowder and firearms. To be sure there are occasional very early references to potential rockets or rocket-like devices such as the supposed fireworks of the Roman emperor Caligula (A.D. 12 - A.D. 41) who allegedly used his notorious feast and orgies and supposed (rocket-propelled) "fire wheels" of Claudianus of Alexandria (A.D. 399). But as Sharpe suggests, these claims are questionable as without potassium nitrate, true gunpowder could not have occurred this early. Partington, moreover, says the fire wheel may have been "some optical effect produced by mirror." Early Arabic claims to the rocket still have not been fully investigated, though in any case the earliest known Arabic writer who speaks of rockets, Hassan-Al-Rammah (d. 1280), made extensive use of Chinese materials. Other Arab writers called saltpeter "al-sichem al-Khatai," "snow from Cathay," or "snow from China." The Chinese, then, still stand pre-eminent, so far as we know, as the inventors or discoverers of the rocket.<sup>3</sup>

## POTASSIUM NITRATE

Much has been made of the alleged employment of the "flying Chinese fire arrow" at the siege of K'ai-feng-fu in 1232 A.D. This single instance, improperly studied, has been touted in encyclopedias and in all manner of popular and more

authoritative works as "proof" both as to the actual use and antiquity of the rocket in China. Before examining the K'ai-feng-fu fire arrows at closer hand, however, it is more appropriate to start at the very beginning: determining the appearance of saltpeter in the early Chinese pyrotechnic compositions, then seeking the earliest unequivocal mention of the rocket in Chinese literature.

First, as with Indian and other claimants to the priority of the rocket, attributed dates of as far back as 3,000 B.C., suggested by Rynin, are unrealistic because of the apparent lack of knowledge of potassium nitrate as an oxidizer for combustion. This is not to say that potassium nitrate was unknown altogether. Partington devotes an entire chapter to "saltpeter" and relates how it was known even to the ancient Egyptians as a soap, food preservative, medicine for the eyes (when combined with other ingredients), cooking agent (and sometimes confused with non-oxygen bearing potassium chloride) and so on. The other constituents of gunpowder, sulfur and charcoal, have equally ancient pasts. The Chinese, for example, long knew of sulfur as an essential part of a wide variety of medicines including ointments and laxatives. Charcoal, it goes without saying, has been used by all peoples from time unrecorded as an aid in cooking. Now, just when the three ingredients of gunpowder--saltpeter, sulfur and charcoal--were first combined by the Chinese is impossible to say, except that perhaps, contrary to popular belief, ancient Chinese alchemists were not knowledgeable of the true nature of chemical behavior. Like their counterparts in the West, Chinese alchemists began as more philosophers than chemists. They were originally concerned primarily with seeking a means to longevity. Professor Li Ch'iao-p'ing says "chemistry in the modern sense did not exist in China before the 19th Century..." For hundreds of years, even well into the 17th Century, the traditional Chinese alchemical interpretation of the explosive property of gunpowder was regarded as the interaction of "ying," the negative element, and "yang," the positive element. Everything in the universe was explained by this simple principle of "ying" and "yang." Devils and gods were introduced when certain phenomena could not otherwise be explained. Based upon this level of "science," it seems improbable that the ingredients of saltpeter, sulfur and charcoal were *deliberately* brought together as their true chemical reaction upon ignition was hardly predictable. Rather, it is more likely that the introduction of saltpeter into sulfur and charcoal mixtures was more accidental, or at best, empirical. Thus, the Chinese more probably "discovered" rather than "invented" gunpowder. The same *accidental* discovery could also be said of the rocket.<sup>4</sup>

Still another explanation may be offered for the probable accidental discovery of the rocket by the Chinese. This was the apparent ignorance of the principle of the rocket. It has been shown that in the West Sir Isaac Newton's classic Third Law of Motion was generally disregarded for more than three centuries as correctly explaining the motion of a rocket. Rather, it was generally believed that the rocket moved because its exhaust "pushed" against the atmosphere. A similar misunderstanding regarding rocket motion was probably also prevalent in China. It thus may be generally deduced that the true nature of both the chemical and physical nature of the rocket was almost wholly misunderstood in the East and West

until the 20th Century and that both Chinese and Western rocket-makers of pyrotechnics evolved their "art" through trial and error, or through borrowing of trade secrets. It need only be added that technological development of the rocket was extremely slow in East and West and that by the 18th Century both Chinese and Westerners had a comparable state-of-the-art.<sup>5</sup>

火  
箭

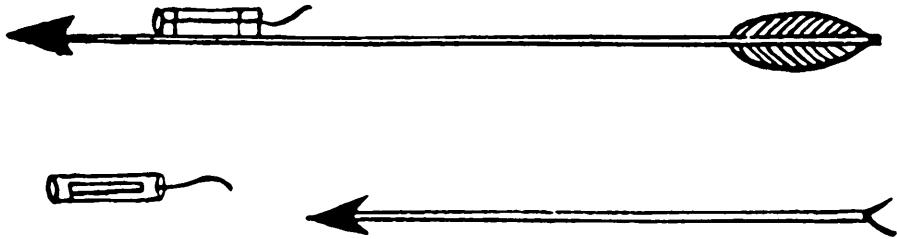


Figure 1 Single Chinese rocket arrow and rocket broken down to show the stick or arrow, and possibly a rocket body. From the *Wu Pei Chih (Treatise on Military Equipment)* by Mao Yuan-i, ca. 1621. Copied from *The Technology Review* December 1948, p. 101.

## SEARCH FOR THE FIRST CHINESE ROCKETS

We may only conjecture how the Chinese--and presumably the world's first--rocket was created. At least one historian, S. J. von Romocki, in his *Geschichte der Explosivstoffe* (Hannover, 1895), suggested that the Chinese rocket arrow, literally an arrow with a rocket tied to the shaft, evolved accidentally when an early Chinese Bowman attempted to strengthen an incendiary mixture of probably tar, resin and perhaps sulfur, so that it would not be extinguished during its short flight. Salt was added, or what was thought was salt, so that the flame would become "hotter." Actually, ordinary salt would only have made the flame brighter. Upon the addition of not salt but saltpeter, however, it was discovered that the flame was not only "hotter," but more explosive. Successive trial and error experimentation eventually led to true gunpowder, and gunpowder projectiles as the rocket. Goodrich and Feng's earlier-cited article also seems to point to a successive development of incendiary arrows, though the nature of these weapons is not clearly delineated. In the year 1000 a lieutenant of the Sung imperial guard, T'ang Fu, presented the Emperor with a newly invented *huo'chien* ("fire arrow") and other arms. A military work of Hsu Tung,\* of 1004 mentions *huo-p'ao* ("fire projectile"), but similarly omits details. In 1044 appeared the book, the *Wu Ching Tsung Yao (Essentials of the Military Classics, or Collection of the Most Important Military Techniques)*, edited by Tseng Kung-Liang and compiled by imperial order, which unequivocally identifies and stabilizes the term *huo-pao* as an explosive powder (i.e. gunpowder) weapon and *huo-yao* as the explosive powder itself. Within this same work, there is at least one device that has been identified as a rocket.<sup>6</sup>

\* *Hu-ch'ien Ching (Tiger Seal Manual)*.

The device is the *huo yao chien*, or "whip fire arrow." All authorities agree that it used gunpowder, though Partington says incendiary powder (*huo yao*). Five ounces (141.7 grams) were placed at the *end* of the arrow. Because of this, Wang Ling emphatically concluded that "it was really a rocket weapon." Wang Ling also reproduced an illustration of it from the *Wu-ching Tsung-yao* but was hasty in this judgment. The picture not only fails to show a propellant-container attached to the shaft, or anything rocket-like, but an almost identical picture appears in the celebrated later military Chinese classic, *Wu Pei Chih (Treatise on Military Equipment)* of 1621 (1628 following Partington) and is clearly shown *not* to have been a rocket. Davis and Ware produced the *Wu Pei Chih* picture a few months after Wang Ling's article, also in the same journal *Isis*, and translated it as "Incendiary Arrow for Throwing by a Whip or by a Throwing Stick." The ring beneath the barb appears to be a catch for a throwing stick. Von Braun and Ordway in their *History of Rocketry & Space Travel* (New York, 1966, 1969), include a stylized rendering of the *huo yao chien*, but remain non-committal and do not identify the arrow as a rocket. The first Chinese rocket thus remains elusive. Numerable mentions of "fire arrows" are found in Goodrich, Feng, Wang Ling and others but none are distinctly rocket-like. If anything, as concluded by Partington, the *Wu-ching Tsung-yao* of 1044 indicates that there was at least a proto-gunpowder by that time. (Needham places it earlier, in a Taoist alchemical work of the 8th or 9th Century. Perhaps it was then too weak to have been discovered as a rocket propellant.)

The next and most famous "proofs" of the early Chinese rocket, is the K'ai-feng-fu "flying fire-arrow" of 1232. Before this time, say between 1044 and 1232, there were, as stated earlier, many instances of *p'ao* devices and fire arrows. Sometimes there were explosions, suggesting the beginnings of guns--but no recognizable rockets. In the 1232 engagement the Mongols under the third son of Genghis Khan, Ogotai, besieged the capital city of Hunan Province of Pienking, now K'ai-feng-fu, but met a "heaven shaking thunder" weapon, apparently a bomb. Another weapon was a *Fei-ho-tsiang*, the arrow of flying fire. The usual description of this device comes from the *Tung Chien Kang Mu (Mirror of History)*, started between 1019 and 1086 by Ssu-ma Kuang and continued by several other authors up to the 15th Century. The pertinent passage was translated by Stanislas Julien in *Journal Asiatique* for October, 1849; "Furthermore, the besieged had at their disposal some 'flying fire arrows.' They attached to the arrow a material susceptible to catching fire; the arrow flew off abruptly in a straight line, and spread the incendiary over a width of ten paces. No one dared approach it. The fire *pao* and the flying fire arrows were greatly feared by the Mongols." The same account is repeated in the *Chin Shih (History of the Chin [Dynasty])*, written by T'o-T'o and Ouyang Hsuan in 1345.<sup>8</sup>

Strangely, the significance of the *Fei-ho-tsiang* is not always caught. Partington does not dwell upon it and mentions that the Jesuit missionary, Father Joseph Anne Maria de Moryiac de Mailla, in China from 1703 to 1737, who interpreted the term as "javelot of flying fire" in his own translation of the *Tung Chien Kang Mu, Histoire Générale de la Chine...traduite du Tong-kien-kang mou* (Paris, 1777-1783). Ludovic Lalanne, in 1845, relied on de Mailla's version, quoting it *verbatim*, and was "impressed by the similitude" with earlier descriptions of Greek Fire. He also said, quite wrongly, that the javelot could not have been a rocket because the fire of

a rocket "*by its nature* [italics, his] elevates itself in the air." Rockets, of course, may be directed horizontally as well as vertically. Though Lalanne does note that the 18th Century rocket of the Indian Tippoo Sahib had sharp points at the front for similarly wounding or killing the enemy. Reinaud and Favé were sure the *Fei-ho-tsiang* was a rocket: "this arrow carried an attached rocket near the point; the fuse was lit; the composition enclosed in the rocket took flame; and the arrow was able to both wound and to burn." Von Romocki was also convinced it was a rocket, mainly because it flew "in a straight line." He also noted the absence of bows for shooting the arrows, though von Romocki is often inaccurate, and supposed that the original accounts came from a Chinese *Firework Book* of 1232.

The possibility of a rocket in 1232 is lost to Hime, who, as a retired lieutenant-colonel of the Royal Artillery, was wholly wrapped up with establishing the early existence of an explosive shell (the heaven-shaking thunder). Goodrich and Fêng, in their 1946 survey of the whole range of early Chinese firearms, missed mentioning the 1232 *Fei-ho-tsiang* altogether. Wang Ling also missed it, but mentions a "flying fire gun" of 1231 (*Fei Huo Chiang*) which name apparently signified the strong *recoil* of the gun and nothing to do with actual flying. Wang Ling also concludes, but without properly backing his claim, that "Gunpowder seems first to have been used for its incendiary properties, on arrows (970-1040 A.D.), some of which may have used the rocket principle, and in flamethrowers (919-1000 A.D.)." Davis and Ware, who concentrate their study upon the *Wu Pei Chih*, label the *Fei-ho-tsiang* "flying fire spears." These, they say, also defended the city of Lo-yang (Hunan) just west of K'ai-feng-fu, against the Mongols in 1232. The spears "were evidently used for thrust, like a bayonet, not as thrown missiles, and were contrived in such manner that they spurted fire in the same direction as the spear point was aimed." This description, of course, precludes the rocket entirely. And Davis and Ware clarify their position further when they say, ten paces, or [30 ft., 9 meters] is a reasonable distance for fire to be thrown from a small tube but it is an unreasonably short trajectory for a rocket and one which would yield but little military advantage." But what of a close range projectile? Willy Ley, whose *Rockets, Missiles and Space Travel* (various editions, 1944-1969) is still one of the most widely read popular histories of the rocket and space travel, favors fellow-German von Romocki's strict interpretation of the "flying fire arrow" as a rocket. He adds that the ten paces referred to the area over which the weapon spilled its fire and that "whether that was 50 or 100 or 200 paces from the point of origin is simply not mentioned." Finally, a modern Chinese study, *The Invention of Gunpowder* by Chao Tieh-han, and published by the National Historical Museum of Taipei, renders the *Fei-ho-tsiang* as a "fire throwing gun," but does not date this usage nor cite its source.<sup>9</sup>

The interpretations of the device at K'ai-feng-fu thus often at variance with each other. Ley, Davis and Ware were correct at least in expressing curiosity about the ten paces mentioned in the account. The *Chin Shih* of 1345, mentioned above, describes a *huo ch'iang*, or "fire lance" of ca. 1231-1233 and seems to fit Davis and Ware's argument. The text has been modernized: "In or about the year 1213 fire-arms were used by the Nuchens. Their make is thus described: 'Yellow paper to a thickness of sixteen layers is made into a tube over two feet [0.6 meter] long. In this



is placed willow charcoal, iron slag, powdered porcelain, sulphur, arsenic, and such. A string is made fast to the point of the weapon. The soldiers each hang on a small iron can containing fire [to their carts], as they approach the enemy's ranks they light up [the paper tubes with the ready ignition fire from the can]. The flame goes out of the front part of the weapon for over ten feet [3.05 meters]. The powder is spent but the tube is uninjured. These were used in the attack upon the [Chinese] capital of Pien [K'ai-feng-fu], and again on this occasion." Could the *Fei-ho-tsiang* have been another (earlier?) name or another version of the "fire lance," the *huo ch'iang*? Evidentially, the fire lance was a forward-firing Roman candle weapon as clearly depicted in several *Wu Pei Chih* illustrations. Similar offensive weapons were known in the West. But the *Chin Shih* description does not quite match the original description of the "flying fire arrow," incendiary matter being attached to an arrow shaft instead of being placed inside a sixteen-layered paper tube, and so on. The range of the flying arrow was short to be sure, but the ten paces (about 30 feet or 9.14 meters) could have been correctly explained by Ley or could have referred to a very crude, weak, and short-ranged rocket. But the term "flying" in the old texts is not always to be taken literally (like "heaven-shaking thunder"). It may have meant fire flying suddenly forward from a stationary or hand-held tube, or the flying properties it apparently gave to the tube. The puzzle of the *Fei-ho-tsiang* must therefore remain a puzzle until more concrete evidence surfaces as to its true nature. From the above, it could have been either a rudimentary rocket, or, as Davis and Ware contend, spears that shot fire forward.<sup>10</sup>

## SEARCH FOR THE EARLIEST CHINESE FIREWORK ROCKETS

If the first Chinese war rockets are too elusive, then perhaps something more positive may be found in accounts of the earliest Chinese fireworks. After all, the firework rocket is the same as the military, but with festive, instead of death and destruction-producing warheads. The Chinese expression for fireworks, *Yen Huo*, or literally "smoke fire," is found as early as the 4th Century B.C. but referred only to the festive burning of straw and wood. Marco Polo--who, contrary to popular belief, never apparently saw nor mentioned rockets during his stay in China (1273-1292)--graphically described the explosion of bamboo joints by throwing them into a fire. These were the first firecrackers (*p'ao chu*) which can actually be traced to the 6th Century A.D. as a New Year's custom in Hupeh and Hunan to drive away malignant spirits. (Wang Lings says, the 1st Century.) The *Wu Yuan* of (*Origins of Things*) of Lo Ch'i (14th-13th Century) says that gunpowder was introduced into fireworks by the Sui Emperor Yang Ti (603-617 A.D.) which Partington finds "unbelievable." Wang Ling translates the term for pyrotechnics in the *Wu Yuan* as "fire drug play," which is more reasonable as it does not signify explosives. Wang Ling also ascribes gunpowder crackers (*Pao Chang*) as starting in the Northern Sung Dynasty (1060-1126). In any event, there is a poem written by a high official of Emperor Yang Ti's time--in the 7th Century--that seems to describe not only fireworks but one that worked by rockets. As quoted by Wang Ling: "Flames of fire move around the wheel, peach blossoms spring forth from the falling branches. Clouds of smoke move around the house, and the fairy lake reflects the floating lights." Wang Ling also says, perhaps again presumptuously, that "Here there can be no doubt that the

poet alludes to a firework, apparently something like the present-day Catherine wheel." Now the Catherine wheel is moved around by a chain of small rockets tied or affixed around a wheel, each rocket unit facing the same direction. It is a form of jet propulsion. But was the poem really describing an optical effect produced by mirrors, and perhaps with smoke, something like Claudianus of Alexandria's supposed fire wheels of the 4th Century A.D.? Or was the poet describing a dream or a vision? The poem is therefore not admissible as evidence. Nambo mentions a "rocket ring" and also a "rotation ring," types of fireworks in the late 13th Century, but he does not describe exactly what they are. While Mayers quotes from an alleged T'ang Dynasty work (618-906 A.D.), the *Yuan Shu-ki* that: "Among the various kinds of fireworks those that produce a noise are called 'resounding catapults;' those that rise in the air [i.e. skyrockets or rocket propelled] are called 'ascending fires';--and those that neither make a noise nor ascent, but twist about on the ground, are called 'ground rats.'" Mayers admits in his footnote, however, that he had "no positive evidence" that the *Yuan Shu-ki* was written in the T'ang Dynasty. Partington cites this work but makes no comment on it. Following Needham, the work is now properly identified as Shen Pang's *Yuan Shu Tsa Chi* [*Records of the Seat of Government at Yuan*], written about 1593. At any rate, the Chinese used and probably introduced gunpowder by the Sung Dynasty (960-1279 A.D.) and were capable of rocket technology by that period.<sup>11</sup>

## SPREAD OF GUNPOWDER/ROCKET TECHNOLOGY TO THE WEST

It is ironic that we can speak of the spread of a technology--rocketry--when its historicity has not been definitely established. However, all available evidence points to its start in China by the Sung Dynasty, and certainly of gunpowder; though independent discoveries or inventions can not be overlooked. It is known for certain that the rocket had already penetrated to or was known in Arabia and probably southern Europe by the end of the 13th Century. However, Willy Ley is wrong in complacently asserting that "Thanks to the patient work of several historians the story of the introduction of rockets into Europe is now reasonably well known." We do not know the means of technological transference, the route, and nor do we know the chronology with any exactness. We may only speculate. In so doing we must first bear in mind that there was not necessarily any linkage between the gun and the rocket. Knowledge of one did not necessarily mean knowledge and presence of the other. The same may be said of gunpowder itself.<sup>12</sup>

Soon after the Mongols encountered the dreaded new fire weapons of the Chinese so they in turn used them in the completion of their conquest of China (South Sung) and in their sweep through much of Western and Eastern Europe and Near East. By one means or another the Mongols even had squads of Chinese artificers attached to their armies in order to build and instruct the Mongols in these machines. Martin, Prawdin and other writers on the Mongols mention mangonels, cannons, and flame-throwers, but no rockets (excluding the supposed rockets at the siege of Delhi in 1399, but which devices may have merely been new types of incendiary arrows). In short, there is not one shred of evidence to date showing direct transference of Chinese rocket secrets to the Mongols or in turn to the Europeans.

Knowledge and spread of the rocket may have also come from other sources. The "secret" may have been communicated via a trading caravan or by trading vessel. The individual missionary or adventurer-traveler-writer may be considered too. There are several candidates. Did Roger Bacon derive his famous cryptic gunpowder formula in his *Epistola* of ca. 1260 from the crusader Peter of Maricourt or some other traveler or from his wide range of reading from Arabic and alchemical books? But Bacon spoke only of a kind of firecracker and not a rocket. Bacon's contemporary, the German Albertus Magnus (1206?-1280), did write about rockets, in his *De Mirabilibus Mundi* (*Of the Wonders of the World*). But his recipe for a "flying fire" came *verbatim* from the *Book of Fires* (*Liber Ignium*) of Mark the Greek (Marcus Graecus) whose identity and dates are wholly unknown. The work has been generally dated to the latter half of the 13th Century and its author theorized as a Greek of Constantinople, familiar with Arabic and probably a traveler there. He is also said to have been an Arab himself or one who lived in Spain, then under Arab (Moorish) domination.

Still another contemporary to Bacon and possible agent for imparting knowledge of the rocket to Europe was a Spanish monk by the name of Ferrarius, whom one authority identifies as Adam Ferrarius (d. 1383). His recipe for "flying powder," which is conveyed in a letter to one Anselm, is likewise taken from the *Liber Ignium*.

Just where the Chinese fit into these earliest of European rocket recipe exchanges still remains a mystery except that we agree with Sarton somewhat who says that "the Chinese may have discovered saltpeter [i.e. gunpowder], or else that discovery may have been transmitted to them by the Muslims whom they had plenty of opportunities of meeting either at home or abroad." Here Sarton is referring to Arab (Muslim) traders to China, as well as Arab inhabitants in China. As early as 880, according to Li, an estimated 120,000 Muslims, Jews and Persians lived in Canton alone, though the once lucrative trade suffered mightily during the time of the Mongol incursions.

The Arabs, in any event, appear to have been the first to inherit (and possibly originate) the secret of the rocket and it was through Arabic writings--rather than the Mongols--that Europe came to know the rocket. Two notable examples of Arabic knowledge of the rocket are the so-called "self-moving and combusting egg" of the Syrian Al-Hassan al Rammah (d. 1294-1295), details of which may be found in Ley's popular *Rockets, Missiles and Space Travel*, and physician Yusuf ibn Isma'il al-Kutubi's description (ca. 1311) of saltpeter ("They use it to make a fire which rises and moves, thus increasing it in lightness and inflammability"). Von Braun and Ordway say the Mongols employed rocket arrows in their capture of Baghdad on February 15, 1258, but this has been unsubstantiated and the rockets may have been nothing more than misinterpreted incendiary arrows.<sup>13</sup>

In addition to the transference of knowledge by travelers or books, word of the rocket could likewise have reached Europe *simultaneously* by trading ship. Here the logical point of entry was Italy. Indeed, one of the earliest known employments of the rocket in Europe is alleged to have been at the siege of Forlie, in Emilia, Italy

in 1281. A century later several other reputed rocket attacks were known in northern Italian ports, namely the island fortress of Chioggia in 1379, during the Chioggia war, and Mestre in 1380. Earlier, a war machine called "una rochetta" is mentioned in the *War Book* (1330) of the doctor and military engineer of Pavia, Guido da Vigevano (1280-1350).

Spain too was allegedly early exposed to the rocket. King Jaime I of Aragon is said to have deployed "cohetes" (the Spanish word for rockets) in his siege of Valencia in 1238. Closer examination, however, indicates more conventional incendiary or ballistic arms in this and other early Spanish-Moorish confrontations. They appear to have been catapults hurling Greek Fireballs, etc. It was only natural for the ancients to report something "flying through the air," accompanied by fire and smoke.

One should be similarly wary of other questionable claims. M. Subotowicz's contention that "In Europe rockets were used for the first time by the Tartars [Mongols] probably during the battle of Legnica (Dolny Slask - Silesia [Poland]) in 1241, as reported in a book by the Polish IVth Century history writer, Jan Dlugosz," is not valid because, in this case, the reported "flying dragon" was nothing more than a clever, if frightening, pyrotechnic smoking device. As Prawdin interprets the Dlugosz account: "Then, against the [Polish] infantry, there was suddenly raised (so it is reported), 'a bearded human head of hideous aspect, mounted upon a long lance. This sent forth evil-smelling vapours and smoke which threw Duke Henry's army into confusion, and hid the Tartars from their eyes.' Under cover of the smoke-screen, the Mongols fell upon the enemy." There is also the claim of the Dutch that "there is overwhelming evidence of widespread and general use [of rockets in warfare], even before the birth of the Netherlands Navy, such as the use of rockets by the (Dutch) crusaders in the 13th Century during the siege of Ptolemy. These were of coarse crude instruments, more resembling 'fire-bombs' for incendiary purposes." This and other Dutch "rocket" engagements await further research. Though at this juncture it is worth noting that the expression for rocket in Dutch is "Vuurpijlen," literally "fire-arrows." Were the supposed first Dutch rockets actually incendiary arrows, or were they in fact direct descendants of the old Chinese "fire-arrow rockets?" Finally, we should add one more instance of very early rockets in Europe which likewise bears investigation. This is the assertion, posed by Ley and others, that the chronicle of Cologne, Germany, speaks of rockets in 1258. Were these true rockets or only incendiary arrows?<sup>14</sup>

## **SPREAD OF GUNPOWDER/ROCKET TECHNOLOGY TO THE EAST**

Our knowledge of the spread of the rocket to the West, though still uncertain, is far more extensive than what we know of developments in the East, that is to say the rest of Asia. The historical and especially linguistic problems are much more complex. However, the sweep of the Mongols through much of Asia by the end of the Sung Dynasty is well known; they repeatedly invaded what is now Burma and Vietnam and attempted to conquer Korea and Japan. Perhaps in the process, as in Europe, they also introduced gunpowder warfare in these regions. Whether this included rockets we still cannot say. Arakawa suggests that rockets possibly reached

his country, Japan, for the first time during the Mongol invasion of 1274. He bases his findings upon a well known painting of a scene in the invasion of 1281 by a Japanese soldier who served in that campaign, and appearing in the scroll *Mokoshurai ekotoba*, (*Illustrated Narrative of the Mongol Invasions of Japan*) compiled in 1292. The illustration depicts three steadfast Japanese warriors letting off ordinary arrows while a fearsome looking incendiary or explosive device, trailing smoke behind it, heads toward them. The illustrator unfortunately does not delineate the launching device in this painting. This same picture appears in Goodrich and Feng's article cited above. Arakawa considers the 1281 device essentially the same as that in the first attempted invasion of 1274. He admits the painting was executed some twenty years after the event but this does not trouble him too greatly. Nor is he bothered by the modern translation of the original word used to describe this device, *Teppo*, or *gun* (projectile). Finally, Arakawa is not at all concerned that the device does not in the least resemble a rocket, and in fact appears to be spherical and without a guidestick. Goodrich and Feng, in their own assessment of both the picture and the available Japanese chronicles do not mention any rocket and refer only to iron *p'ao* projectiles. Standard histories of the invasions, such as Yamada's *Ghenko The Mongol Invasion of Japan*, likewise mention no rockets.

Von Lippmann's contention that "primitive war rockets" were used in the invasion of 1283 seems equally unfounded. Brock, the well known historian of pyrotechnics, cites a Japanese Board of Tourist Industry pamphlet of 1939 that seems to preclude the introduction of Chinese (or Mongol) pyrotechnics into Japan altogether: "Regarding the introduction of fireworks to Japan, one would, on the analogy of the hundreds of things we imported from China long ago, imagine that they also came from China. But the sober fact is that we got them from some Dutchmen in 1600, or thereabouts, although it is usually stated that fireworks were known in China in remote antiquity." We may assume that fireworks also included rockets and that it was therefore the Dutch too who introduced rockets (skyrockets). Heizo Nambo's article in the *Japanese Journal of the Explosives Society* (Tokyo), Vol. 28 (1967): pp.322-329, 403-413, "Who Invented Explosives?" adds not much new to the historical development of gunpowder in general and considers no early rockets in Japan.

Another suspect claim for Mongol rockets in Asia is made by Groenveldt, cited by Schlegel, who says that in Kublai Khan's expedition to punish the King of Java in 1293 "the army was divided into three bodies in order to attack Kalang; it was agreed that on the 19th they should meet at Daha [Kediri, East Java] and commence the battle on hearing the sound of the *p'au*." Groenveldt, says Schlegel, "dared not translate this character *p'au* by 'cannon,' although he wonders that the sound this *p'au* produced was strong enough to be audible to three bodies of troops (who were each at a great distance one from the other). So he thought it was some kind of rocket." Signal rockets were possible in 1293 but it is doubtful the *p'au* was anything more than a gun.<sup>15</sup>

Also at this time, Chou Ta-Kuan, a Chinese merchant, was sent by the Mongols to Kambuja (Cambodia) as part of a mission to extract homage from the Khmers, the people of that Southeast Asian kingdom. The Mongol-Chinese mission

spent 11 months amongst the Khmers, from 1296-1297, with Chou Ta-Kuan fortunately making a complete journal. At the fabulous city of Angkor, if we can believe the translations of the Chou Ta-Kuan account, fireworks were already known there and fired for feast days, such as the New Year. Tall masts were placed in front of the palace for launching rockets and artificial stupas erected festooned with crackers. These poles were some 120 feet (36.6 meters) high. "Every night," Chou wrote, (following the Paul Pelliot translation) "from three to six of these structures arise. Rockets and firecrackers are placed on top of these--all this is great expense to the provinces and the noble families. As night comes on, the King is besought to take part in the spectacle. The rockets are fired, and the crackers touched off. The rockets can be seen at a distance of thirteen kilometers; the fire-crackers, large as swivel-guns [sic], shake the whole city with their explosions." Another rendering of this account is found in Groslier's *Recherches sur les Cambodgines*: "They let off rockets and petards. The rockets went to more than one hundred li; the petards are as large as stone guns and their explosion shook the whole town." In all the marvelous bas-reliefs of Angkor Wat, Groslier comments, no firearms are found though Chou-Ta-Kuan's observations certainly "place the utilization of powder arms between the epoch of the bas-reliefs and the 15th Century" in Cambodia.<sup>16</sup>

The rockets of the 13th Century Khmers are indeed both a surprise and a mystery. It may be assumed that they originally came from China. But on the other hand this find opens up another possibility. That is that since India and China both exerted enormous cultural and technological influence in this region, particularly the former, then India too must now be considered as a possible origin of rockets and fireworks in this part of the world. It may be that India derived its knowledge of the rocket from China--or developed it independently--and in turn "exported it" to client states. Indian acculturation is especially marked in Thailand, Laos, Burma and Java, where rockets--and some most unusually developed ones as we shall soon see--are known from a very early period.

On May 22, 1977, in the village of Nong Song Hong, about 12 kilometers east of Nong Khai, Northeastern Thailand, the author witnessed a celebration of the annual Boun Bang Fei rocket festival. Gigantic gunpowder rockets, covered with brightly colored paper and sometimes decorated with wooden cutouts of a snake's head, are let off for the purpose of satiating the rain gods in order to assure a fertile rice harvest. The author measured the bamboo guidestick of one of these rockets at 45 feet (13.7 meters). The trip was made especially to witness and investigate the historical origins of this phenomena and its religious and cultural significance to the region. In 1987, a paper was presented on these findings. It suffices to say that, the Boun Bang Fei festival is celebrated throughout sixteen or so provinces of Northeastern Thailand and in and around Vientaine, Laos, just across the Mekong. The origin of the Bang Fei is known imperfectly only in legends, but is believed to have originated as much as 1,000 years ago. The Boun Bang Fei, literally meaning "Deed of Firing Rockets," presents a most important and interesting challenge for the historian of technology: How did the technology of making huge rockets originate amongst agrarian peoples? Or did it originate in China or India?

Both the Thais and the Lao are descendants of tribes who migrated from Yunnan in Southern China to the upper Mekong where they intermarried with a local people of the Khmer type. The area passed under Chinese suzerainty and by the 14th Century became the kingdoms of Siam and Laos. In the meantime a steady process of Indianization took place in which all facets of culture, including the written languages of Siamese and Lao, were decidedly of Indian influence. Trade between Siam and Laos and India flourished. Again, could the Boun Bang Fei rockets have originally come from India or China? The evidence seems to point to India, not only because of the enculturization but also because throughout the centuries Chinese war and firework rockets were known to be very small. Moreover, in India, as shown by Mitra in his study of fireworks and fire festivals in ancient India, there are "beautiful ritual *Mantras* going back to remote antiquity, [and] are at once, most appropriate for the practical purpose of shooting rockets towards the sky and the spirits hovering the earth." (One must always be cautious in the reading of "remote antiquity").<sup>17</sup> On the other hand, the Tai or Dai people of the Hsi-shuang-bana region in Yunnan, China, also practice the custom. More research on the Bang Fei is therefore required.

Whether the Siamese (Thais) or Lao or other peoples of Southeast Asia employed their rockets for war, as well as for religious or cultural celebrations, also needs to be explored. Cowper, without citing his sources, indicated that from a very early time "Fireballs called *Phlo* and *Tok Fai* (child of fire), rockets and even fire rafts, were used by the Siamese." In 1593, during one of many Thai wars against Cambodia, the Siamese used an elaborate signaling system which included rockets in their attack and eventual capture of Lovec. In the 19th Century the Burmese are known to have fired crude rockets against the English during various colonial campaigns. Elsewhere in Asia, Montross says the Koreans won a great naval engagement against the Japanese in the vicinity of Noryang in 1592 when they used copper-armored warships mounting bronze rocket guns. But Hagerman, in his detailed study of these engagements, mentions no rockets, only cannons, a sulphur and saltpeter smoke generator, a flame thrower (*Punt'ong*) and an arrow-shaped gun (*Ho chon*). Partington does not mention Korean rocket weapons either but does quote a Chinese source to the effect that in 1593 the Chinese Ming Emperor is said to have used cannon and rockets against the Japanese in P'ingyang, Korea.<sup>18</sup>

Of other large peacetime rockets in Asia comparable to the Boun Bang Feis of Thailand and Laos, there is a most unusual one. This is the Burmese funeral rocket. As with the Bang Feis, nobody can really trace its antiquity or origin though it is generally believed to be quite old. William Carey, writing in the *Asiatik [sic] Researches* of the Asiatic Society of Bengal in 1816, relates the funeral customs upon the death of a *Pongee*, or priest, in which the *Pongee* is cremated in a specially made house which is set afire by decorated rockets sliding on ropes. Larger rockets are also fired on this occasion. "Some of these rockets," wrote Carey, "were from seven to eight feet [2.1 to 2.4 meters] in length, and from three to four [0.9 to 1.2 meters] in circumference made of strong timber, and secured by iron hoops, and rattan lashings. The last of them, when discharged ran over a boy of ten or twelve years old, who died in a few minutes; three or four grown-up persons were also much hurt. Towards the evening a great number of fire-works [sic] were discharged,

which made a very fine appearance." Malcom, writing in 1839, reports Burmese rockets up to twelve feet (3.6 meters) long and cites another author that one contained ten thousand pounds (4,535 kgs) of powder. The rockets Malcom saw were made of "mahogany logs, or other rough wood, hollowed out, and well hooped in this century. Hart wrote about them in 1897 and Kelly in 1910. In a trip to Rangoon in 1977, following the witnessing of the Boun Bang Fei, the author was informed by a librarian of the University of Rangoon that these rockets are still known. No opportunity presented itself to see them.<sup>19</sup>

Are these rockets in any way related to the Boun Bang Fei types and are they of Chinese or Indian origin? The paper on the Bang Fei phenomena cannot conclusively answer this, though it appears there is nothing in the Chinese pyrotechnic or other literature that relates to them. Ordinary fireworks may still have been spread throughout Asia by the Chinese. Certainly the Chinese took their firework customs with them wherever they settled. The Ming Dynasty (1368-1644) was especially noted for its far-flung maritime expeditions which, as historian Dunn J. Li writes, included Korea, Japan, Annam (Vietnam), Cambodia, Siam, Borneo, Java, Sumatra, several Maylay states, and some small kingdoms on the southeast coast of Asia. These were for the purpose of imposing Ming's overlordship and "for the ostensible purpose of 'glorifying Chinese arms in the remote regions and power of the central Kingdom.'" Here it is enough to add that early records of fireworks throughout Asia, especially during the 17th-19th Centuries, in traveller's accounts are numerous. The Frenchman Jean Baptiste Tavernier, for example, observed an exhibit in western Java during his third journey in 1643-1649. As cited by Gode, "There were five or six captains seated round the room [of the King of Bantam, Java] who were looking at some fireworks which the Chinese had brought such as grenades, fusees [The French word *Fusée* means rocket], and other things of that kind to run on the water [rocket-propelled]; for the Chinese surpass all the nations of the world in this respect."<sup>20</sup>

## LATER CHINESE ROCKETS AND TECHNICAL DEVELOPMENTS

In speaking of the possible spread of Chinese rockets throughout Asia, it has been remarked that Chinese rockets were actually small and that there is nothing to compare with the Boun Bang Fei and Burmese funeral projectiles. While travellers' accounts of Chinese fireworks are usually highly complimentary, as in Tavernier's comment, closer examination reveals that the rocket whether for war or recreation fireworks had apparently improved but little over the centuries. Chinese pyrotechnists were more concerned with purely aesthetic effects. Sir John Francis Davis, a former Governor of Hong Kong, writing in 1836 and quoted by Brock, observed: Chinese fireworks "are sometimes ingenious and entertaining, rather, however, on account of the variety of moving figures which they exhibit, than the brilliancy or skill of the pyrotechny, which is inferior to our own... Their rockets are bad, but blue lights they manufacture sufficiently well for the use of European ships." To this Brock adds: "There can be little doubt that the popular legend of the superiority of Chinese fireworks over those to be seen in Europe...was based to a great degree on the stories of...travellers, assisted, perhaps, by that general air of mystery attaching



to anything connected with the East." Brock also quotes the famous French pyrotechnist Claude-Fortuné Ruggieri who wrote in 1821: "An agent arrived a year ago with twelve cases of Chinese fireworks...these were no different from what the Chinese have been making for three or four centuries..." Earlier Ruggieri had said that any superiority on the part of the Chinese fireworks was due "partly by the minuteness of the work and more by the possession of materials we lack." As to military pyrotechnics (including rockets) and artillery in general the state of the art appears to have been more evidently stagnant. Du Halde wrote in the 18th Century: "Tho' the Use of Gunpowder is very ancient in China, Artillery is but modern, and they have seldom made use of [gun] Powder since it was invented but for Fireworks, in which the Chinese excel." Many 17th-19th Century authors speak in the most disparaging terms of Chinese artillery and military art in general, the *United Service Journal* for January 1840 saying that the Chinese naval force has undergone "no change whatever during the last 200 years." So it is not surprising that Chinese war rockets of the 17th Century should apparently be no different from those that may have been fired in the 13th Century. On September 10, 1637, according to the journal of Peter Mundy, the Chinese assailed an English ship with rockets and other fireworks at Tayfoo (Tai' fu), or Tiger Island, not far from present Hong Kong: "Balles of wyldre fire [i.e. Greek Fire], Rocketts [sic] and Fire-arrows Flew thicke as they passed by us, Butt God bee praised, not one of us all were touched." This was the earliest known British (and perhaps European) encounter with Chinese war rockets. It was not the last. During the 19th Century they were levied not only against the English, but also the French and Americans too. By that time also, there had been almost no technological changes.<sup>21</sup>

A few instances only will suffice to show the extent and effectiveness of Chinese war rockets in the last century. Commander J. Elliot Bingham of the Royal Navy reported in his narrative of the Anglo-Chinese War of 1840: "Their rockets, which were neatly arranged, were the most childish weapon that can be imagined; in size about equal to a two-ounce [56.7 gram] skyrocket, with a small iron barb at the end. They generally discharge them in showers of thousands at a time, which were much admired for their beauty, but never dreaded by us from any injury they were likely to do. The guns were of the most miserable description..." W. D. Bernard wrote of the same war the capture of a battery at Canton "...a vast number of matchlocks were found in the city, with upwards of five hundred tubs of powder some bamboo rockets, and about one hundred cases of leaden balls." The French encountered these curious projectiles in their expedition of 1860. Cordier published a dispatch from Baron Gros to the Minister of Foreign Affairs, dated August 5, 1860, in which it is reported that French forces likewise found "a great quantity of iron rockets."

There was, at least, some improvement in the adaptation of metal. *Harper's Weekly* for February 7, 1857 reported "one man injured by a rocket from the retreating Chinese" during the capture of the Barrier Forts by sailors of the American sloop *Levant*. *Harper's* for March 7, 1857 told its American readers: "The [Chinese] rocket might remind one of the 'fiery darts' of biblical parlance. A feathered arrow, six feet [1.8 meters] long, with a long, flat steel or copper head, has a rocket attached, it cleaves the air with great rapidity, with an irregular motion,

and the red-hot steel head inflicts a painful and dangerous wound, the rocket continuing to hiss and seethe and spit out fire after it has fastened on its poor victim." There were also reports from time to time of the rockets being sent back to Europe but none thus far, have been located. *Littell's Living Age* for June 17, 1854, for example, reported Chinese rockets captured at the siege of Amoy were placed on display at London's Adelaide Gallery. "To all intents of a barbed arrowhead... Nevertheless, one of them would undoubtedly have killed a man at the distance of 200 yards [182.8 meters]..." The *Illustrated Naval and Military Magazine* (London) for September 1, 1884 even depicted a captured specimen, then in possession of the Royal United Service Institution, Whitehall Yard. This is seen as nothing more than a rocket arrow, differing little from those depicted in the *Wu Pei Chih*.<sup>22</sup>



Figure 2 Chinese skyrocket vendor selling his wares to customers for Chinese New Year festivities, 18th Century. Detail of a color handscroll of New Year scenes by Ting Kuan-P'eng, an artist of the Ch'ien-Lung Period, Republic of China. Copied from a National Palace Museum postcard, China Color Printing Co., Taipei, ca. 1975.

Actual technical developments were therefore minimal. The literature based upon the *Wu Pei Chih* are very extensive and need not be dealt with here in any great detail and one may consult several authors already cited, including Davis and Ware, Mayers, Partington, Reinaud and Favé, Hime and von Romocki. The *Wu Pei Chih*, with an emphasis on details of rocket construction, or at least descriptions, may also be found in the pioneering work of the Jesuit missionary Joseph Amiot (1718-1794), who was perhaps the first to describe it to western readers and translate portions of it. These are found in his *Mémoires concernant l'Histoire des Sciences, les Arts, les Moeurs, les Usages &c des Chinois par les Missionnaires de Pe-kin* (1776-1814), Vol. 8 (1782): pp.327-375. For the time being it is enough to state that

the pictures of various fire arrows in the *Wu Pei Chih* helped early writers obtain a good idea of what the original Chinese "flying fire arrows" might have looked like. Two more works should be mentioned here as providing detail of rocket manufacture. These are Father Pere D'Incarville's *Manière de faire les feux d'Artifice Chinois*, in *Mémoires de Mathématique et de Physique, Présentés à l'Académie Royale des Sciences, par Divers Savans* (Paris), Vol. IV (1763); pp.66-94; and Tenney L. Davis and Chao Yün-t'ung's "Chao Hsüeh-Min's Outline of Pyrotechnics A Contribution to the History of Fireworks," in *Proceedings of the American Academy of Arts and Sciences*, Vol. 75, May 1943: pp.95-107. Thanks to the work of Mr. Tong-Chih Rhee and the author's friend, Lola Wu, additional details from the *Wu Pei Chih* are related here that are not found in the works cited above.

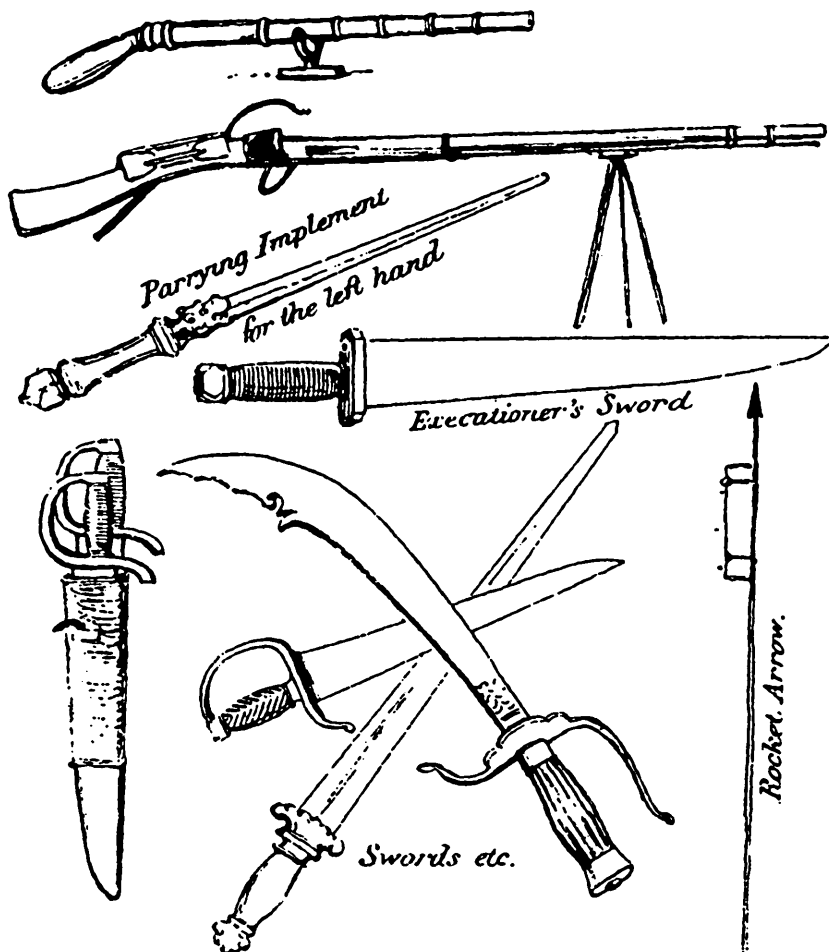


Figure 3 Chinese arms, including, right hand side, a "rocket arrow", late 19th Century. These weapons, including the rocket, were the same sort used against the British during the Opium wars of 1839-1842, and against the British and French in 1860 during the Anglo-Chinese War of 1860. The crudeness of design of the rocket shows virtually no design change from the rocket arrows depicted in the *Wu Pei Chih* of 1621. From: The Illustrated Naval & Military Magazine (London), Vol. I, 1 September 1884, p.200. This drawing is said by this source to have been "taken from a number of arms in possession of the Royal United Service Institution, Whitehall Yard, by permission of the Secretary."

It should be noted that Davis and Ware reproduced a picture of a "tool for making the central cavity in the rocket's propelling charge." To this they add the brief description found in the *Wu Pei Chih*: "It does a better job than the drill preferred by the artisans. If the rocket arrow is to fly straight, the hole must be straight otherwise it will go off at a tangent." The significance of this simple tool is overlooked by Davis and Ware, yet it represents the identical pyrotechnic hardware then used in the West, though in much cruder form. The tool, called a "spindle," was the essence of the rocket-making process. By means of it the central cavity of the rocket charge was hollowed out at the end, thereby forming a conical cavity which Western pyrotechnics called the "the soul" of the rocket because to them it literally made the rocket fly. In actuality the cavity provided maximum burning upon ignition, thus generating more pressure and the greatest possible thrust. This was critically important for rockets propelled by gunpowder which is a relatively weak or low-impulse fuel. The enticing question which cannot be answered is how the Chinese knew of this technique which was identical in "Western" technology. Was it a technological transference from East to West or *vice versa*? Davis and Ware did not translate the characters within the picture of the spindle itself, though these do not add much to the overall description. The characters on the upper right-hand corner merely read "naturally made hammer." This refers to a simple mallet by which the casing of the rocket was pounded over the point of the spindle. The characters across the top of the spindle read: "The clay is located in the middle." This refers to a cushion of clay which was also packed around the spindle to better hold the rocket to prevent splitting. The final characters, on the bottom of the spindle, merely inform the reader: "This is the square side."

Another detail found in the *Wu Pei Chih*, but missed by the usual sources, is that the Chinese placed iron balances on the ends of the rocket shafts. Obviously a knowledge and practice of archery was useful as well in making and letting off the rockets. It is also stated that the manufacture of arrows requires "good talent" and that one person can make three to four or five to six quiver's worth a day. Also interesting to note is the suggestion of a copper tube as a launcher, an improvement not seen in the West until the age of Congreve. There are also rockets meant for maritime use, poisonous-headed rockets, rockets for infantry attacks, for "working a havoc in the enemy camp" as a "surprise weapon," for use on a chariot, and for piercing "sturdy leather." Thus, Davis and Ware are right in assessing that "the Chinese turned their genius toward improving the military use of rocket-propelled arrows [but], they do not appear to have tried greatly to improve the rockets themselves, but seem...to have remained contented with small rockets of inferior workmanship and performance."<sup>23</sup>

## CONCLUSION

It is still not certain whether the Chinese did create the first rockets. If they did, the technology was bound to suffer because of several factors found deep within the Chinese mentality: (1) the low regard the Chinese had for the military profession; (2) esteem for the cerebral or intellectual pursuits over the mechanical or scientific; and (3) complacent attitude about sharing knowledge with others,

leading to technological stagnation. Over a century ago these attitudes were already easily recognized by one who studied the Chinese and their military equipment firsthand, the Marquis de Moges who was the attaché to the French mission (embassy) in Peking. He was both annoyed and frustrated that they refused to fight the Western way. He wrote: "In China the military profession is not held in honor. No one attempts to introduce improvements on the present system. A distinguished wit says, in speaking of gunpowder, that, if the Chinese discovered it, they have not yet discovered the use of it. As for the Minié rifle, that is out of the question. They seem to depend for success in war on various fantasia--to runs they make forward, and runs backward, and loud shouts of defiance. They flourish their double-headed swords, they wave their flags, they shoot their rockets and arrows into the ranks of the enemy, but never do they come to close quarters with cold steel." Perhaps in the long run it was the Chinese who were more civilized for not necessarily questing for war or for "progress" in war-making machines but to be ever-suspicious of others who do so. In any event, it is part and parcel of the story of Chinese civilization.<sup>24</sup>

## REFERENCES

1. See Chapter 6, "Pyrotechnics and Firearms in China," in J.R. Partington, *A History of Greek Fire and Gunpowder* (Cambridge, England: W. Heffer & Sons, 1960), pp.237-297; L. Carrington Goodrich and Fêng Chia-Shêng, "The Early Development of Firearms in China," *Isis*, Vol. 36, January 1946: pp.114-123; Wang Ling, "On the Invention and Use of Gunpowder and Firearms in China," *Isis*, Vol. 37, July 1947; pp.160-178; Tenney L. Davis and James R. Ware, "Early Chinese Military Pyrotechnics," *Journal of Chemical Education*, Vol. 24, November 1947; pp.522-537; and T.L. Davis, "Early Chinese Rockets," *The Technology Review*, Vol. 51, December 1948; pp.101-102, 120, 122. The new work alluded to above is: Joseph Needham, *Science & Civilization in China* (Cambridge, England; Cambridge University Press, 1986), Vol. V, *Chemistry and Chemical Technology Part 7: Military Technology; The Gunpowder Epic*.
2. See Frank H. Winter, "On the Origin and Development of the Rocket in India," paper presented at the 14th International Congress of the History of Science, Tokyo and Kyoto, 1974, published in abbreviated form in *Proceedings of the 14th International Congress of the History of Science*, pp.360-363; and Frank H. Winter, "On the Origin of Rockets," *Chemistry*, Vol. 49 pp.8-12; a more expanded and footnoted version of original paper appears as "The Rocket in India from 'Ancient' Times to the 19th Century," in *British Interplanetary Journal*, Vol. 32, December 1979, pp.467-471.
3. Ludovic Lalanne, *Recherches sur le Grégeois* (Paris: J. Corréard, 1845), pp.65-71; Ludovic Lalanne, "Essai sur le feu grégeois et sur la poudre à canon," *Annales de Chimie et de Physique*, 3rd series, Vol. 4, April 1842, pp.445-447; [Joseph Toussaint] Reinaud and [Ildephonse] Favé, *Histoire de l'Artillerie 1ère Partie. Du Feu Grégeois* (Paris: J. Dumaine, 1845), pp.106-110; Ferdinand Hoefer, *Histoire de la Chimie* (Paris: Librairie de Firmin Didot, Frères, Fils et Cie, 1866), Vol. I, p.302; Oliver C. Ellis, *A History of Fire and Flame* (London: Simpkin Marshall Ltd., 1932), p.249; Maurice Mercier, *Le Feu Grégeois* (Paris: Librairie Orientaliste, 1952), *Passim*; "Greek Fire--Congreve Rockets," *Asiatic Journal* (London), Vol. 19, Sept. 1825, p.265; J. MacCulloch, "Conjectures respecting the Greek Fire of the Middle Ages," *The Quarterly Journal of Science, Literature, and the Arts* (London), Vol. 14, 1823, pp.29, 37-38; Mitchell R. Sharpe, "Non-Military Applications of the Rocket Between the 17th and 20th Centuries," paper presented at the Fourth History Symposium, International Academy of Astronautics, Constance, German Federal Republic, 1970, and published, in a shorter version, without this note, in R. Cargill Hall, editor, *Essays on the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics*, NASA Conference Publication 2014 (Washington, D.C.: National Aeronautics and Space Administration, 1977) Vol. I, pp.51-72, Reprinted as Vol. 7, *AAS History Series*, 1986; Partington, 10, p.202.

4. Li Ch'iao-p'ing, *The Chemical Arts of Old China* (Easton, Pennsylvania: *Journal of Chemical Education*, 1948), pp.2-3.
5. Frank H. Winter and Mitchell R. Sharpe, "William Moore: Pioneer in Rocket Ballistics," *Spaceflight*, Vol. 18, May 1976, p.180.
6. Von Romocki's theory is summarized in Willy Ley, *Rockets, Missiles and Space Travel* (New York: The Viking Press, 1959), p.52.
7. Wang Ling, p.165; Davis and Ware, p.523; Wernher von Braun and Frederick I. Ordway, III, *History of Rocketry & Space Travel* (New York: Thomas Y. Crowell, 1966, 1969), p.24; Partington, pp.262, 269, 287; letter to author, Joseph Needham, 21 March 1962.
8. Partington, p.240, 243; Ley, p.51; Wernher von Braun and Frederick I. Ordway, III, *The Rockets' Red Glare* (New York: Anchor Press, 1976), p.35.
9. Partington, pp.238, 243, 258; Lalanne, pp.74-75; Reinaud and Favé, quoted in von Braun and Ordway (1976), p.35; von Romocki, Vol. I, p.56; Lt. Col. Henry W. L. Hime, *Gunpowder and Ammunition Their Origin and Progress* (London: Longmans, Green, and Co., 1904), pp.127-130; Wang Ling, pp.172-173; Davis and Ware, pp.525, 531; Ley, p.51; Chao Tieh-han, *Collected Papers on History and Art of China (First Collection) 4 The Invention of Gunpowder* (Taipei: National Historical Museum, n.d.), pp.5-6; Letter to the author, Professor Joseph Needham, 21 March 1962.
10. Goodrich and Feng, p.117; Partington, p.245.
11. Partington, p.239; Oscar Guttman, *The Manufacture of Explosives* (London: Whitaker and Co., 1895), p.4; Davis and Ware, p.523; Wang Ling, p.164; Heizo Nambo, (English translation), "Who Invented Explosives?" *Journal of the Industrial Explosives Society* (Tokyo), Vol. 28 (1967), pp.18, 32 (translation copy); W.F. Mayers, "On the Introduction and Use of Gunpowder and Firearms Among the Chinese," *Journal of the North-China Branch of the Royal Asiatic Society*, New Series No. VI, 1871, p.82.
12. Ley, p.53; Needham, pp.134-135.
13. H. Desmond Martin, *The Rise of Ghingis Khan and His Conquest of North China* (New York: Octagon Books, 1971), pp.30-31; Michael Prawdin, *The Mongol Empire Its Rise and Legacy* (London: George Allen and Unwin Ltd., 1952), pp.129-130, 157-158, 191-193, 259, 350, 482; Dun J. Li, *The Ageless Chinese A History* (New York: Charles Scribner's Sons, 1965), p.178; George Sarton, *Introduction to the History of Science* (Baltimore: Carnegie Institution, 1931), Vol. II, p.1037; Capt. Jervis-White Jervis, *Our Engines of War and How We Got to Make Them* (London: Chapman & Hall, 1859), pp.8-9; Partington, pp.158, 312.
14. Frank H. Winter, "A History of Italian Rocketry During the 19th Century," *Armi Antiche, Bollettino dell'Accademia di S. Marignano* (Turin), N. for 1965, pp.181, 195; "Apuntes Historicos sobre la Invencion de la Polvora," *Memorial de Artilleria* (Madrid), Vol. III, 1847, p.19; consult Partington for early incendiary and gunpowder warfare in Spain, especially, pp.190-193; M Subotowicz, "Development of the Technology of Rocketry and Space Research in Poland," paper presented at the Sixth History Symposium of the International Academy of Astronautics at the 23rd International Astronautical Federation Congress, Vienna, October 1972, and published in R. Cargill Hall, editor, *Essays on the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics*, NASA Conference Publication 2014 (Washington, D.C.: NASA, 1977), Vol. II, p.135, reprinted as Vol. 7, *AAS History Series*, 1986; Prawdin, p.259; Letter to the author, Nederlandsch Historisch Scheepvaart Museum (signature illegible), December 4, 1962; Ley, p.55.

15. Hideyoshi Arakawa, "Bunkyo no Eki ni Mokogun wa Roketto o Riyo Shita Ka? (in Japanese), *Nihon Rekishi* (Tokyo), No. 148 (1960), pp.86-89; Goodrich and Feng, pp.120-121; Nakaba Yamada, *Ghenko The Mongol Invasion of Japan* (New York: E.P. Dutton, 1916), pp.108-122, 145; Prof. Dr. Edmund O. Von Lippmann, *Abhandlungen und Vorträge zur Geschichte der Naturwissenschaften* (Leipzig: Verlag von Veit & Co., 1913), Vol. II, p.286; G. Schlegel, "On the Invention and Use of Fire-Arms and Gunpowder in China, Prior to the Arrival of the Europeans," *T'oung Pao*, Series II, Vol. II (1902), pp.1-2. Alan St. H. Brock, *A History of Fireworks* (London: George G. Harrap & Co., 1949), p.25.
16. Malcolm MacDonald, *Angkor* (New York: Frederick A. Praeger, 1959), pp.65, 73; Chou Ta-Kuan, *Notes on the Customs of Cambodia--Translated from the French Version of Paul Pelliot by J. Gilman D'Arcy Paul* (Bangkok: Social Science Association Press, 1967), p.29; George Groslier, *Recherches sur les Cambodgines* (Paris: Augustin Challamel, 1921), p.89.
17. Haridas Mitra, *The Fire Works and Fire Festivals in Ancient India* (Calcutta: Abhedananda Academy of Calcutta, 1963), p.17.
18. H.S. Cowper, *The Art of Attack* (Uliverston: W. Holmes Ltd., 1906), p.283; Brig. Gen. M.L. Manich Jumsai, *History of Thailand & Cambodia* (Bangkok: Chalermnit, November 1970), pp.40-41; Lynn Montross, *War Through the Ages* (New York: Harper & Brothers, 1944), p.661; Capt. George M. Hagerman, "Lord of the Turtle Boats," *United States Naval Institute Proceedings*, Vol. 93, December 1967, pp.69, 75; Partington, p.277.
19. William Carey, in Asiatic Society of Bengal, *Asiatick Researches* (Calcutta: The Calcutta Gazette Office, 1816), Vol. 12, pp.188-190; Howard Malcom, *Travels in Southeastern Asia* (Boston: Gould, Kendall, and Lincoln, 1839), Vol. I, pp.208-209; Mrs. Ernest Hart, *Picturesque Burma* (London: J. M. Dent & Co., 1897), p.124; Talbot Kelly *Burma The Land and the People* (Boston: J. B. Millet Company, 1910), Vol. 17, p.174.
20. Li, p.283; P. K. Gode, *The History of Fireworks in India Between A.D. 1400 and 1900* (Basavangudi, Bangalore, India: The Indian Institute of Culture, May 1953), p.20.
21. Brock, pp.20-23; P. Du Halde, *The General History of China* (London: J. Watts, 1741), p.78; "Discipline of the Chinese," *United Service Journal* (London), January 1840, Part 1, p.23; Lt. Col. Sir Richard Carnac Temple, editor, *The Travels of Peter Mundy in Europe and Asia, 1608-1667* (Nendeln, Lichtenstein: Kraus Reprint Limited, 1967), Vol. III, pp.228-229.
22. Commander J. Elliot Bingham, R.N., *Narrative of the Expedition to China* (London: Henry Colburn, 1842), Vol. I, p.345; W. D. Bernard, *Narrative of the Voyages and Service of the Nemesis, from 1840 to 1832* (London: Henry Colburn, 1844), Vol. II, p.201; Henri Cordier, *L'Expédition de Chine de 1860* (Paris: Félix Alcan, Editeur, 1906), pp.245-249; *Harper's Weekly* (New York), Vol. I, February 7, 1857, p.87; *Harper's Weekly*, Vol. I, March 7, 1857, p.153; "What is a Congreve Rocket?" *Littell's Living Age* (London), Vol. XLI, June 17, 1854, p.556; "The Chinese Army," *Illustrated Naval & Military Magazine* (London), Vol. I, September 1, 1884, p.200.
23. Davis and Ware, pp.531-532; Mao Yuan-i, *Wu Pei Chih* (1621 or 1628), *passim*, available in Library of Congress.
24. The Marquis de Moges, *Recollections of Baron Gros's Embassy to China and Japan in 1857-58* (London: Richard Griffin and Company, 1860), pp.120-122.