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The Guns of Khaifeng-fu
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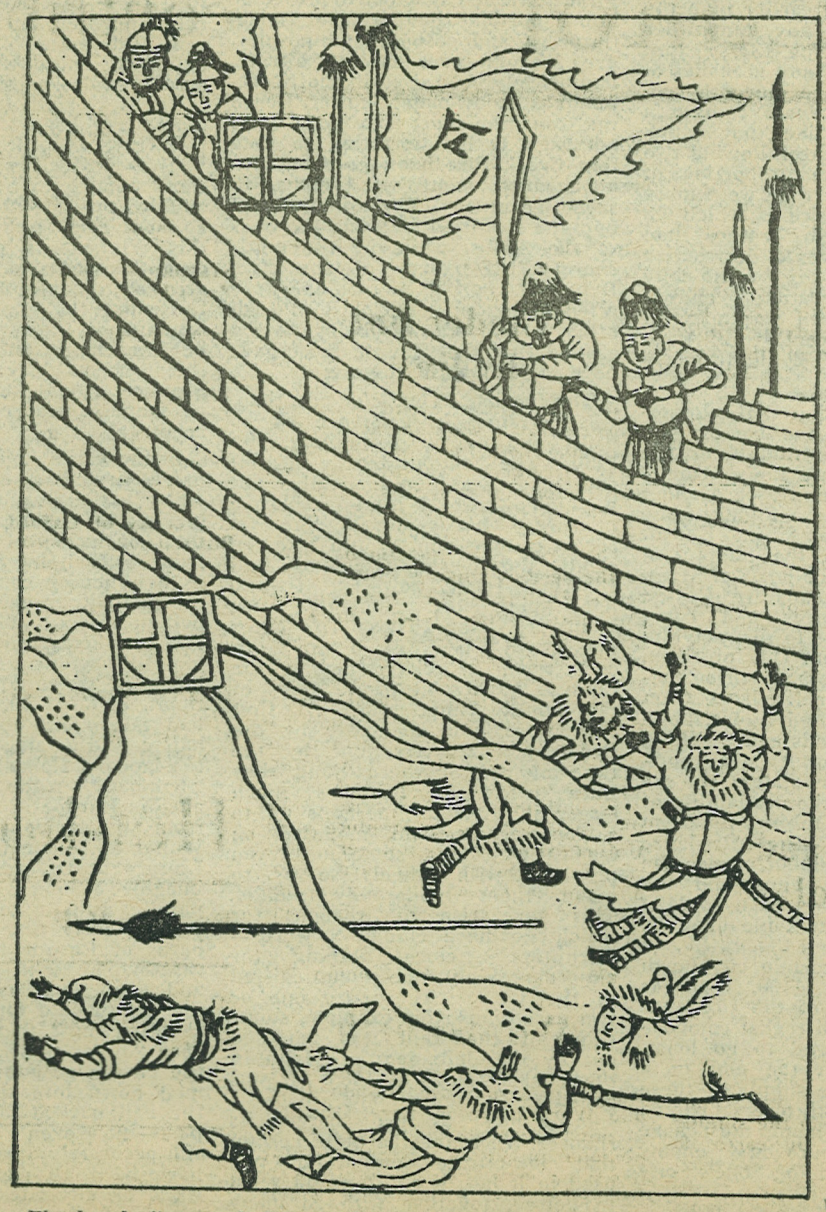
By Joseph Needham

This is the text of "The Guns of Khaifêng-fu; China's Development of Man's First Chemical Explosive", the Creighton Lecture, delivered at the University of London last November.



The bomb, "a match for ten thousand men" (*wan jen ti i*) from *Thien Kung Khai Wu*. All the other illustrations to this article are from *Wu Pei Chih*.

The development of gunpowder weapons was certainly one of the greatest achievements of the medieval Chinese world. One finds the beginning of it towards the end of the Thang, in the ninth century AD, when the first reference to the mixing of charcoal, saltpetre (ie, potassium nitrate), and sulphur is found. This occurs in a Taoist book which strongly recommends alchemists not to mix these substances, especially with the addition of arsenic, because some of those who have done so have had the mixture deflagrate, singe their beards, and burn down the building in which they were working.

The beginnings of the gunpowder story take us back to those wilder shores of religion and liturgy which involved the "smoking out" of undesirable things in general. The burning of incense was only part of a much wider complex in Chinese custom, fumigation as such (*hsün*). That this type of procedure, carried on for hygienic and insecticidal reasons, was much older than the Han, appears at once from a *locus classicus* in the *Shih Ching* (Book of Odes), where the annual purification of dwellings is referred to in an ancient song. It says:

In the tenth month, the crickets
Chirp, chirp beneath our beds.
Chinks are filled up, and rats are
smoked out,
Windows that face the north are
stopped up
And all the doors are plastered...
The Changing of the Year requires
it....

This could be dated in the seventh century BC or somewhat earlier. It is perhaps the oldest mention of the universal later custom of "changing the fire" (*kuan huo, huan huo*), a "new fire" ceremony annually carried out in every home. The medical fumigation of houses, after sealing all the apertures, with catalpa wood, is referred to in the *Kuan Tzu* book not many centuries later, and the *Chou Li*, of archaizing tendency even if an Early Han compilation, has several descriptions of officials superintending fumigation with the insecticidal principles of the plants *Illicium* and *Pyrethrum*. From later literature we know that Chinese scholars regularly fumigated their libraries to keep down the depredations of bookworms, a great pest, especially in the centre and south.

Such techniques being so old, it is not perhaps surprising to find that the uses of scalding steam in medical sterilization were appreciated as early as the tenth century AD. Thus in his *Ko Wu Tshu Than* (Simple Discourses on the Investigation of Things) about AD 980, Tsan-Ning wrote: "When there is an epidemic of febrile disease, let the clothes of the sick persons be collected as soon as possible after the onset of the malady and thoroughly steamed; in this way the rest of the family will escape infection". This would have intrigued Pasteur and Lister.

Not only in peace, moreover, but also in war, the ancient Chinese were great smoke-producers. Toxic smokes and smoke-screens generated by pumps and furnaces for siege warfare occur in the military sections of the *Mo Tzu* book (fourth century BC), especially as part of the techniques of sapping and mining; for this purpose mustard and other dried vegetable material containing irritant volatile oils were used. There may not be sources much earlier than this, but there are certainly abundant sources later, for all through the centuries these strangely modern, if reprehensible, techniques were elaborated ad infinitum. For example, another device of the same kind, the toxic smoke-bombs (*huo chhiu*) of the fifteenth century AD, recall the numerous detailed formulae given in the *Wu Ching Tsung Yao* of AD 1044. The sea-battles of the twelfth century AD between the Sung and the Chin Tartars, as well as the civil wars and rebellions of the time, show many further examples of the use of toxic smokes containing lime and arsenic. Indeed, the earth-shaking invention of gunpowder itself, some time probably in the ninth century AD, was closely related to these, for it certainly derived, as they did, from incendiary preparations, and its earliest formulae sometimes contained arsenic.

The whole story from beginning to end illustrates a cardinal feature of Chinese technology and science, the belief in action at a distance. In the history of naval warfare, for instance, one can show that the projectile mentality dominated over ramming or boarding, with its close-contact combat. Smokes, perfumes, hallucinogens, incendiaries, flames, and ultimately the use of the propellant force of gunpowder itself, form part of one consistent tendency discernible throughout Chinese culture from the earliest times to the transmission of the bombard, gun and cannon to the rest of the world about AD 1300.

Next we have to think about the limiting factor of saltpetre, potassium nitrate. Written by an anonymous author probably during the time of Sun Ssu-Mo (in the seventh century AD or soon after) is an important alchemical text entitled *Chin Shih Pu Wu Chiu Shu Chüeh* (Explanation of the Inventory of Metals and Minerals according to the Numbers Five and Nine). It is particularly interesting because it tells how substances can be identified, and says that their "quality" must be known before they can be used for making elixirs, besides mentioning the occurrences and properties of some of them. Of special interest are the names of foreign countries, such as Persia, Annam and Udyāna, and the names of outlandish Buddhist monks mentioned in it. The following passage illustrates this:

Saltpetre (*hsiao shih*).

Originally this was produced in I-chou by the Chiang tribespeople, Wu-tu and Lung-hsi (but now) that which comes from the Wu-Chhang country (Udyāna) is (also) of good quality. In recent times, during the Lin-Tê reign-period of the Thang, in a chia-tzu year (664 AD), a certain Saka or Sogdian monk (lit. Brahmin) called Chih Fa-Lin (came to China from Central Asia), bringing with him (some sūtras in) the Sanskrit (language) for translation. He asked if he might visit the Wu-thai Shan mountains to study (Buddhist) customs (and was allowed to do so). When he reached the Ling-shih district in Fên-chou he said: "This place abounds in saltpetre. Why is it not collected and put to use?" At that time this monk was in the company of twelve persons, among whom were Chao Ju-Kuei and Tu Fa-Liang. Together they collected some of the substance and put it to the test, but found it unsuitable (for use) and not comparable to that produced in Wu-Chhang. Later they came to Tsê-chou, where they found a mountain covered with beautiful trees. (The monk) said once again: "Saltpetre should also occur in this region. I wonder whether it will be as useless as (what we came across) before?" Whereupon together with the Chinese monk Ling-Wu they collected the substance, and found that upon burning it emitted copious purple flames (lit. smoke). The foreign monk said: "This marvellous substance can produce changes in the Five Metals, and when the various minerals are brought into contact with it they are completely transmuted into liquid form (*chin pien chhêng shui*). And the fact that its properties were indeed the same as those of the material from Wu-Chhang was confirmed by testing it several times on different metals. Compared to that from Wu-Chhang this from Tsê-chou was a little softer".

Here we have mention of the potassium flame, and of the use of saltpetre as a flux in smelting. This passage raises several important questions, notably the appearance of close chemical contacts between China and Central Asia during the Thang period, and the exact time when potassium nitrate was reliably discovered, identified and used.

If one thing more than any other emerges clearly from this and many other accounts, it is that methods for the collection and purification of potassium nitrate were steadily developing during the seven centuries preceding the first knowledge of the salt in Islam or the West, i e, between AD 500 and 1200, and probably during the last three or four of these. That is, from the late part of the Thang period, it was being turned out on a manufacturing scale by artisans who achieved a fairly constant product but were not able to explain to the scholars exactly how they did so. Why should one then be surprised that formulae for proto-gunpowder began to appear during the last half of the ninth century AD?

Hsiao shih (which goes back as a name to the fourth century BC) is often said to give a bluish-purple flame when put in the fire, a statement which immediately rules out salts of sodium and magnesium. The oldest description of this test comes from about AD 500, but it could safely be placed a couple of centuries earlier, as far back as Ko Hung. Many alchemical and pharmaceutical texts from the second century BC onwards also say that *hsiao shih* can liquefy ores, acting as a flux, and dissolve minerals to form aqueous solutions. There are also instances where *hsiao shih* is said to produce explosions or deflagrations, and we have of course the gunpowder formulae with *hsiao shih* in them. In such circumstances one can feel fully justified in extrapolating back the results of analyses of modern samples of *hsiao shih* which show it to be saltpetre. Rightly therefore was it called in Arabic *thalj al-Sīn* (Chinese snow) for it was recognized and used in China long before anywhere else.

The oldest extant Arabic mention is in the *Kitāb al-Jāmi' fī al-Adwiya al-Mufrada* (Book of the Assembly of Medical Simples) finished by Abū Muhammad al-Mālaqī Ibn al-Baytar about AD 1240. Others follow shortly after, for example Ibn Abū Usayb'ia, in his history of medicine, but as he refers to the otherwise unknown Ibn Bakhtawayhi and his *Kitāb al-Muqaddimāt* (Book of Introductions), it would be wise to place the first knowledge of saltpetre among the Arabs in the earliest decades of the thirteenth century AD. On the other hand their understanding of its use in war, especially for gunpowder, belongs to the latest decades of the same century, as we know from the book of al-Hasan al-Rammāh, *Kitāb al-Furūsiya wa'l-Munāsab al-Harbiya* (Treatise on Horsemanship and Stratagems of War), which cannot have been composed before about AD 1280. The same date, as near as makes no matter, can be accepted for the completion of the *Liber Ignium ad Comburendos Hostes* of Marcus Graecus (whether or not there was ever any such individual person), and by this time both saltpetre and gunpowder, or at least proto-gunpowder, had become acclimatized in the Latin West.

Some discoveries that may have been Sun Ssu-Mo's are embodied in short extracts quoted in other collections. For example, the *Chu Chia Shen Phin Tan Fa* appears to quote him as follows:

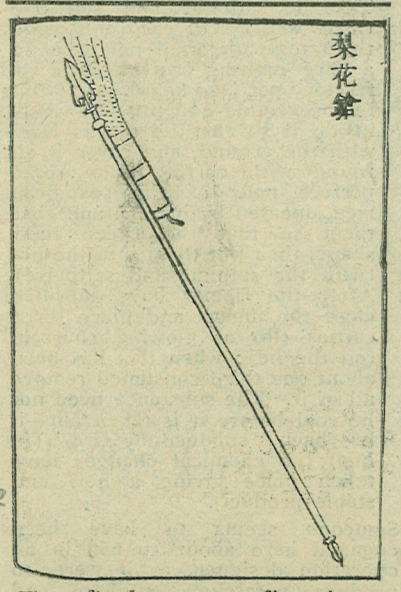
> Take of sulphur and saltpetre (*hsiao shih*) 2 oz each and grind them together, then put them in a silver-melting crucible or a refractory pot (*sha kuan*). Dig a pit in the ground and put the vessel inside it so that its top is level with the ground, and cover it all round with earth. Take three perfect pods of the soap-bean tree, uneaten by insects, and char them so that they keep their shape, then put them into the pot (with the sulphur and saltpetre). After the flames have subsided close the mouth and place three catties (lb) of glowing charcoal (on the lid); when this has been about one third consumed remove all of it. The substance need not be cool before it is taken out—it has been "subdued by fire" (*fu huo*) (i e chemical changes have taken place giving a new and stable product).

Someone seems to have been engaged here about AD 650 in an operation designed, as it were, to produce potassium sulphate and therefore not very exciting; but on the way he stumbled upon the first preparation of a deflagrating (and later explosive) mixture in the history of all civilization. Exciting must have been the word for that.

Chao Nai-An's *Chhien Hung Chia Kêng Chih Pao Chi Chhêng*, whether of AD 808 or later, is a florilegium of alchemical writings in five chapters. It is full of interesting things; it uses an empty hen's egg suitably supported as an aludel or "chaos vessel" (*hun tun*), it preserves an alchemical *mantram* in an Indian language, and most of its formulae include vegetable ingredients. For this reason it takes its place naturally as another of the earliest known records of a proto-gunpowder mixture, describing, under the heading *Fu huo fan fa* (Method of Subduing Alum—or Vitriol—by Fire), a composition of sulphur, saltpetre, and dried aristolochia (*ma tou ling*) as the carbon source. This would have ignited suddenly, bursting into flames, without actually exploding. The exact sequence of these first accounts has yet to be determined, but if Sun Ssu-Mo was really the experimenter of the *Chu Chia Shen Phin Tan Fa* the middle of the seventh century AD would have seen that first beginning; and it does look like the most archaic procedure, for the carbon source in the shape of the soap-bean pods was doubtless added with far different intention. The *Chen Yuan Miao Tao Yao Lüeh*, with its use of dried honey, is dated plausibly by Fêng Chia-Shêng between the mid-eighth century AD and the end of the ninth century. If our present text, which uses another kind of plant material for the carbon, is rightly placed at the beginning of the ninth century, it could be the second oldest reference, but if it should turn out to be rather of Wu Tai or early Sung it could belong to the first or second half of the tenth century or even the first half of the eleventh century. In any case it must surely precede by some time the first regular gunpowder formulae in the military encyclopedia *Wu Ching Tsung Yao* of 1044. And most probably it will also be older than 919, the first appearance of gunpowder (*huo yao*) in a military context.

The text entitled *Chen Yuan Miao Tao Yao Lüeh* (Classified Essentials of the Mysterious Tao of the True Origin of Things) is attributed to Chêng Yin (third century AD). Although the text available to us in the *Tao Tsang* is probably mostly of the eighth or the ninth century, the putative author himself may have been responsible for the older parts of the book. It mentions no less than thirty-five different elixir formulae which the writer points out

be wrong or dangerous, though popular in his time. It tells of cases where people died after consuming elixirs prepared from cinnabar, mercury, lead and silver; other cases where people suffered from boils on the head and sores on the back after ingesting cinnabar obtained from heating mercury and sulphur together; and cases of serious illness when people drank "black lead juice", possibly a hot suspension of graphite. Among the erroneous methods mentioned are the following: (1) boiling the ash obtained from burning mulberry wood and regarding it as *chhiu shih* (urinary hormones), (2) mixing common salt, ammonium chloride and urine, evaporating to dryness and regarding the sublimate from that as *chhien hung* (literally "lead and mercury"), (3) digesting nitre (or saltpetre) and quartz (for a long time) in a gourd and using the product as an elixir, (4) boiling nitre (or saltpetre) and blue-green rock-



The fire-lance or five-minute flame-thrower (*h'hua chhiang*, pear-flowers spear).

salt (*chhing yen*) in water, (5) making an egg-shaped container of silver to hold cinnabar, mercury and alum, (6) using iron rust and copper as ingredients for an elixir called "golden flower" (*chin hua*), (7) heating mercury together with malachite and azurite (copper carbonate and basic copper carbonate), (8) heating realgar and orpiment, (9) heating black lead with silver, and (10) burning together dried dung and wax. The book also warns against a very interesting procedure, saying that some of the alchemists had heated sulphur together with realgar, saltpetre and honey, with the result that their hands and faces had been scorched when the mixture deflagrated, and even their houses burnt down. This passage is of outstanding importance because it is one of the first references to an explosive mixture, proto-gunpowder, combining sulphur with nitrate and a source of carbon, in any civilization. The book also gives a test for saltpetre. Exactly how much of all this material goes back to the days of Chêng Yin himself is extremely difficult to determine, but future research may be expected to throw more light on the problem. In the meantime, having regard to the general pattern of development of chemical knowledge and use of explosives, we place the essential passages in the Thang period.

After that, things happened rather rapidly. The "fire drug" or "fire-chemical" (*huo yao*), which is the characteristic term for gunpowder mixtures, occurs as igniter or slow-match in a flame-thrower in AD 919, and by the time we reach the year 1000 the practice of using gunpowder in simple bombs and grenades was coming into use, especially thrown or lobbed over from trebuchets (*huo phao*).

For example, in the *Ching-Khang Chhuan Hsin Lu* by Li Kang, we hear how he ordered the use of *phi-li-phao* by the defenders of Khaifêng against the Chin Tartars in 1126.

> First Tshai Mou gave orders to the soldiers that (even) when the Chin troops came near the city, the catapults should not be used. So those who were in charge of the trebuchets (*phao*) and the crossbow-catapults on frames were very angry and beat him up. I myself then took over the command and ordered them to shoot off all the artillery, as to each gunner might seem good, and those who hit their marks best were well rewarded. At night the *phi-li-phao* were set off, which hit and destroyed many, so that they were all howling with fright.

The first composition formulae for gunpowder appear in AD 1044. This is a good deal earlier than the first references to any gunpowder composition in Europe, 1327, at best 1265. These bombs and grenades of the beginning of the eleventh century did not of course contain a brisant explosive like that which became known in the following two centuries when the proportion of nitrate was raised; they were more like rocket compositions which go off with a "whoosh" rather than anything which gives a destructive explosion. This is technically known as "deflagration", and if the source of carbon was material other than charcoal, the term "proto-gunpowder" could properly be applied to it.

Thence there followed the important transition to the barrel gun. It occurred in the middle of the tenth century, as we know from a silk banner in the Musée Guimet in Paris, one of those found at the Tunhua cave-temples in Kansu. The scene depicts the temptation of the Buddha by the hosts of Mara, many of whose demons are dressed in military uniforms and carry weapons, all aiming to distract him from his meditation. One of them, wearing a head-dress of three serpents, is directing a fire-lance (*huo chhiang*) at the seated figure, holding it with both hands and watching the flames shooting out horizontally. Here immediately we see the importance of the availability of a natural form of tubing, the stem of the bamboo. The fire-lance played a very prominent part in the wars between the Sung and the Jurchen Chin Tartars from AD 1100 onwards. In a remarkable book by Ch'en Kuei, the *Shou Ch'êng Lu*, on the defence of a certain city north of Hankow about 1130, there is described the use of the fire-lance—a tube filled with rocket composition but not allowed to go loose, held instead upon the end of a spear. An adequate supply of these five-minute flame-throwers, passed on from hand to hand, must have effectively discouraged enemy troops from storming one's city wall.

By about AD 1230 the proportion of nitrate was raised, and we begin to have descriptions of really destructive explosions in the later campaigns between the Sung and the Yüan Mongols. City gates could be broken in, and walls blown up. Now the technical terms "explosion" and "detonation" become applicable, but the powder is still not strictly propellant. Then about 1280 comes the appearance of the metal-barrel bombard, cannon or gun, somewhere in the Old World. In these the full propellant force of the explosive is used to launch a projectile which fills fully the diameter of the mouth or muzzle. There has been great doubt as to where this first occurred, whether among the Arabs with their *madfa'a*, or whether possibly among the Westerners. Between 1280 and 1320 is the key period for the appearance of the metal-barrel cannon. I have no doubt whatever that its real ancestry was the substantial bamboo tube of the Chinese fire-lance.

Indeed the tube could also be of paper—another Chinese invention. By appropriate treatment paper can be made so hard that it was actually used for armour. In the *Chin Shih* (History of the Chin Tartar Dynasty) we read that

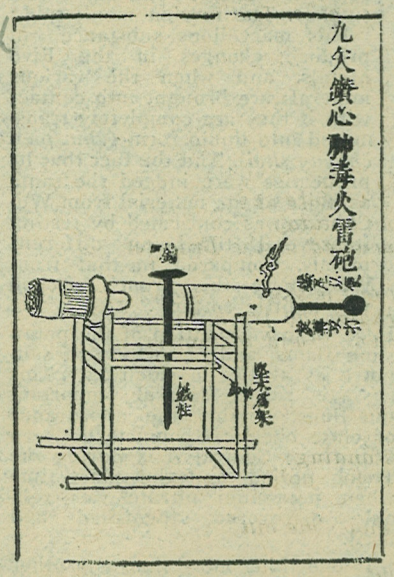
> The method of making (fire-) lances was to take (thick) "imperial yellow" paper and to make it into a tube (with walls composed of) sixteen layers, about two feet long. It was then filled with (a mixture of) willow charcoal, iron in the form of powder, sulphur, (saltpetre), arsenious oxide (*phi shuang*) and other things. It was tied with cords to the end of the lance. Each soldier carried with him, hanging down (from his belt) a small iron fire-box (of glowing tinder). At the appropriate time he lit (the fuse) and the flames shot forth from the lance more than ten feet. After the composition had burnt out the tube was not damaged. When Khaifêng was being besieged (in 1126) these (fire-lances) were used a great deal, and they still are.

Here then was one of the sorts of "guns of Khaifêng-fu".

We must follow this through several further developments of great significance before we can talk about other important inventions connected with gunpowder. To begin with, I should like to point out how easy and logical was the development of the fire-lance from the flame-thrower (the "fierce fire oil machine", *mêng huo yu chi*, using "Greek Fire", i e, naphtha, or distilled light petroleum fractions). First, it turned that petrol-projector into a portable hand-weapon flame-thrower; and secondly gunpowder, even though very low in nitrate, had already been used in that force-pump as a slow-match igniter. Hence the transition must have been quite natural. It is interesting to note that Greek Fire itself goes back to a chemist named Callinicus in seventh-century Byzantium, and naphtha was used freely in the wars of the Arabs, while by the tenth century the rulers of the Five Dynasties period in China were often giving presents of it to each other. So much was being passed around that the Chinese must have been distilling it themselves.

The fire-lance (*huo chhiang*) then, was certainly in existence by AD 950, and very prominent by 1110. The gunpowder which it contained was emphatically not a high-nitrate brisant explosive mixture, but more like a rocket composition, as in a "Roman candle", deflagrating violently and shooting forth powerful flames, not going off suddenly with a mighty bang. These fire-lances lasted in use down to our own time, especially among the Chinese naval and pirate ships of the South China seas. At first they were held manually by the fire-weapon soldiers, but by the time of the Southern Sung they were made of bamboos much larger in diameter, perhaps up to a foot across, and mounted on frames with legs, sometimes even provided with wheels so as to make them moderately mobile. This gave rise to weapons for which we have coined a word—"eruptors", since nothing (or almost nothing) like them existed in the West. There are one or two exceptions: for example, something of the kind was trundled out by the defenders of Malta in the Turkish siege of 1565. It was called a "trump" and made a snoring noise as it discharged its flames. We cannot be quite certain that low-nitrate gunpowder was used in it but, if so, it would seem to betray, together with so many other things, a direct indebtedness to East Asian origins.

Even more remarkable, the Chinese eruptors were so constructed as to shoot out projectiles along with the flames. Once again we need a new word for this, and we have decided to call these objects "co-viative projectiles". They could be just bits of old iron, or even broken pottery or glass. This system was quite different, however, from the "chain-shot" of later Napoleonic Europe, because there the function of the gunpowder was explosively propellant and the chain-shot took the place of the normal solid cannonball. The co-viative projectiles of the eruptors of the Sung and Yuan were more like "case-shot", which Mainwaring in 1644 defined as "any kind of old iron, stones, musket-bullets or the like, which we put into cases to shoot out of our great ordnance"; but again the difference was that in the older Chinese system the pieces of hard sharp-edged rubbish were actually mixed with the rocket-composition gunpowder. Other names for case-shot were "canister-shot", and "langrel" or "lan-



An eruptor or large frame-mounted fire-lance (*chui-shih tsuan-hsin shen-tu huo-lei phao*, nine-arrows heart-penetrating, magically-poisonous fire-thunderer).

grage", but none of these things was co-viative, since that belonged to a much earlier stage of the story.

Generally the eruptors were made of bamboo barrels and mounted on carriages, but it was in connection with these that the first metal barrels appeared, cast in bronze or iron. One extraordinary fact is that before the end of the eruptor period actual explosive shells were fired forth as co-viative projectiles; this must have been the time of their first invention. Eruptors with co-viative projectiles could also be small enough to be held manually; and by the late thirteenth century and the early fourteenth, when all this was in its prime, co-viative arrow-launchers were also used. The arrows probably did not fly very far, since the gunpowder was not exerting its full propellant force, but for close combat on city walls their effects may have been impressive enough, especially against personnel armoured lightly or not at all.

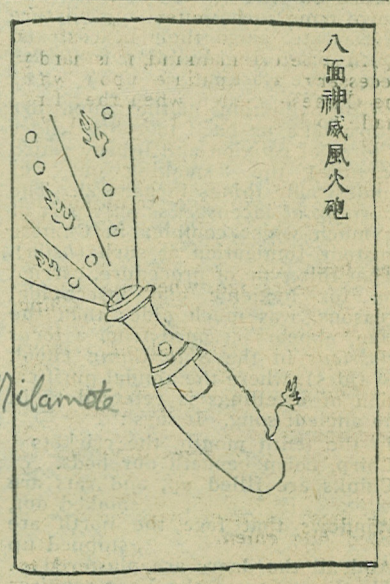
Lastly there appeared the metal-barrel firearm characterized by two other basic features; the use of high-nitrate gunpowder, and the total occlusion of the muzzle (or front orifice) by a projectile such as a bullet or cannon-ball, so that the gunpowder exerted its full propellant effect. This type of fire-arm may be described as the "true" gun or cannon, and if, as we believe, it appeared in early Yuan times, about 1290, its development had taken just about three and a half centuries since the first of the fire-lance flame-throwers. The "bombard" made its first appearance in Europe in 1327, as we know from the famous manuscript of Walter de Milamete in the Bodleian Library at Oxford. We must not imagine a long smooth bore with parallel walls to guide the projectile at this early time; the first bombards of Europe were distinctively vase-shaped, with a rounded belly and a muzzle splayed outwards like the mouth of a blunderbuss. The shooting must therefore have been very "hit-or-miss", but presumably the charge of gunpowder was rammed down into the bombard, and the ball packed into the narrowest part—then even if they could not aim accurately at anything it would have been all right against castle walls or city-gates, or the massed troops of men in close order that probably moved about in those times.

The interesting thing is that we find Chinese drawings of such bombards, exactly similar in shape to the first European fourteenth century ones; so the probability is that they originated in China and were copied exactly in the West, where the beginnings of knowledge of gunpowder itself go back only to 1285 or so. This would mean that the purely propellant phase of gunpowder and shot, the culminating stage of all the gunpowder uses, was attained in China with these bottle-shaped bombards just as the first knowledge of gunpowder itself was beginning to reach Europe. The whole development, from the earliest experiments of Sun Ssu-Mo and his friends onwards, would have taken just on seven centuries—not bad going for the Middle Ages.

Here it is important to realize that archaeological finds of bronze and iron bombards and cannon in China have revealed more than twenty examples self-dated by inscriptions, all between AD 1280 and 1380; therefore much older than any yet found in Europe. This straddles the year 1327, and there are many from the last seven decades of that same century.

The bombards with metal barrels were generally mounted on gun-carriages, but it was not long before they were reduced in size to form hand-guns which could be carried and fired by a single person, hence the line ran straight to the arquebus and the musket. Later on, in the sixteenth century, the Chinese were deeply impressed by the hand-guns of the Portuguese, which they called *fo-lang-chi* (Frankish devices). They were also much taken with their light swivelling shipboard cannon, or breech-loading culverins, *niao tsui chi*, with removable metal cartridge-holders. Finally, long before that, the bombards and the hand-guns both were mounted on stands in multiple batteries. But these innovations all fall outside the crucial periods we are discussing.

The difficulty of knowing whether the vase-shaped bombards first appeared in China or in Europe arises largely from the peculiarities of the literature at both ends of the Old World. The Western chroniclers do not provide very much information until a rather later date, so that the iconographic evidence has particular importance; while in China we are faced with the difficulty that the technical books come at rather widely spaced intervals, and in several different versions which differ among themselves, and are not always precisely datable. We have already mentioned the *Wu Ching Tsung Yao* (Compendium of the Most Important Military Techniques) assembled by Tsêng Kung-Liang in 1044. I once found a Ming edition of this in the Liu-li-chang in Peking from which the whole of the gunpowder chapter was missing, so the information at that time was evidently still "restricted"; eventually I presented it to the Library of Academia Sinica. Then the next landmark was the *Huo Lung Ching* (Fire Drake Manual). This comes in half-a-dozen different parts and versions, associated with a variety of authors'



One of the earliest vase-shaped bombards or metal-barrel cannon (*pa-mien shen-wei fêng huo-phao*, eight-sided magical awe-inspiring wind-and-fire cannon).

names, some evidently fictitious such as Chuko Liang, others quite likely, such as Liu Chi, a learned technical general of the early Yuan time. The bibliography and contents of this work, perhaps the most important of all for the history of gunpowder in Chinese culture, have been brilliantly elucidated of late by Ho Ping-Yü and Wang Ching-Ning in Australia. The various versions of the book can be dated, I believe, between AD 1280, the end of the Sung, and about 1380, well after the establishment of the Ming. It thus covers the period of the Yuan dynasty and the time when the new emperor-to-be Chu Yuan-Chang, was conducting his campaign to overthrow the Mongolian dominance, a campaign in which he made use of guns and cannon, especially the new bombards. One of his master-gunners, Chiao Yü, was probably an ancestor of another of the same family, Chiao Hsü, who lived much later in the Ming, and both were associated with the *Huo Lung Ching* tradition. Next we have to turn to the *Wu Pei Chih* (Record of Arsenal Preparations), a very important work compiled by Mao Yuan-I in 1621, with abundant illustrations and also extant in several versions, some with slightly different titles. Besides these primary sources, some information about gunpowder weapons may also be found in other technical books, for example the celebrated *Thien Kung Khai Wu* (Exploitation of the Works of Nature), written by Sung Ying-Hsing in 1637. And further information can of course be picked up in the many encyclopedias of all dates.

The curious thing about this literature is that it looks both backwards and forwards. For example, there are insertions which are clearly anachronistic, such as pictures of bombards and culverins in the *Wu Ching Tsung Yao*, without accompanying textual references, and these must have been put in by later editors. Conversely, the *Huo Lung Ching* and the *Wu Pei Chih* illustrate and describe, presumably for the sake of completeness, a large number of gunpowder weapons which were almost certainly obsolete long before their time. Consequently, in delineating the rise and development of gunpowder weapons we have to do a certain amount of conjectural reconstruction, arranging the differ-

ent forms in the order most likely to have been that in which they actually appeared, aided now and then by certain dates which the texts themselves vouchsafe. This is the kind of reason which makes it difficult to say with complete certainty that the final bombard stage appeared in China before it appeared in Europe. But it does look as if the entire line of development, from the first mixing of sulphur, saltpetre and a source of carbon, to the metal-barrel gun and cannon, took place in China first, and passed to Islam and Christendom only afterwards. In any case, the principle of the gun-barrel is unquestionably Chinese, and its origin lay in that natural tubing which had been so convenient for all kinds of scientific and technological purposes, the stem of the bamboo.

Until now nothing has been said about the rocket, but in this day and age, when men and vehicles have landed on the moon, and when the exploration of outer space by means of rocket-propelled craft is opening before mankind, it is hardly necessary to expatiate upon what the Chinese started when they first made rockets fly. After all, it was only necessary to attach the bamboo tube of the fire-lance to an arrow, in the reverse direction, and let it fly free, in order to obtain the rocket effect. Exactly when this first "great reversal" happened has been the debatable question. Twenty years ago, when our contribution to *The Legacy of China* was written, we thought that rocket arrows were developed first about the year AD 1000 in time for the *Wu Ching Tsung Yao*. Unfortunately the lack of an adequate descriptive terminology here was deceptive, because this work gives drawings of *huo chien* (fire-arrows) which look quite like later drawings of rockets; and these in their turn were also called *huo chien*.

But as the former are stated to have been launched like spears or javelins by means of an *atlatl* or spear-thrower, it is unlikely that they were rockets, but rather tubes filled with incendiary substances designed for setting on fire the thatch and other roofs of the enemy's city. This is not at all the first time that we have encountered situations where a fundamentally new thing did not generate a new name. That was the case, for example, with hydro-mechanical clockwork.

So which came first, the fire-lance or the rocket? The discovery of the Tunhuang banner of about AD 950 settled the question in one sense. It now seems that we have to look in another direction for the beginnings of the rocket, and at a considerably later date. Towards the end of the twelfth century, in the Southern Sung, there are descriptions of a firework used in some displays at court, the "earth rat" or *ti lao shu*, a bamboo tube filled with low-nitrate rocket composition and allowed to rush freely about on the floor. It was capable of frightening people, and we have a record that one of the Sung empresses was "not amused" thereby. This civilian use would have reminded the wielders of fire-lances of the recoil effect which they must always have had to withstand, whereupon someone tried a fire-lance fitted backwards on an arrow, with the result that it whizzed away into the air towards a target. This would have come about, we suppose, at some time during the thirteenth century, and rockets were certainly well established as firearms during the Yuan time in the fourteenth century.

Many further developments of great interest followed during the Ming and Ch'ing. First of all there were large two-stage rockets, reminiscent of the Apollo spacecraft, where propulsion rockets were ignited in two successive stages, releasing automatically towards the end of the trajectory a swarm of rocket-propelled arrows to harass the enemy's troop concentrations. Rockets were also provided with wings and given a bird-like shape, in early attempts to give some aerodynamic stability to the rocket flight. Then there were multiple rocket-arrow launchers, where one fuse would ignite as many as fifty projectiles; and later these were mounted on wheelbarrows, so that whole batteries could be trundled into action positions like regular artillery later on. It is not generally known that rocket artillery played a considerable part in the military and naval history of the eighteenth and early nineteenth centuries in the Western world. The city of Copenhagen was set on fire by rockets from the British Navy during the Napoleonic wars, and rocket troops were prominent in the days of the (so-called) Hon. East India Company contending with princes like Tippoo Sahib. But it was a phase which came and went, for high explosive shells and incendiary shells could be fired from more advanced artillery with much greater accuracy of aim; so that the rocket batteries of the West died out after about 1850. Only in our own time did rocket propulsion come back into its own with the determination of man to leave the earth's atmosphere altogether—high explosive could do nothing to help that, in spite of Jules Verne's vast cannon pointed upwards at the moon.

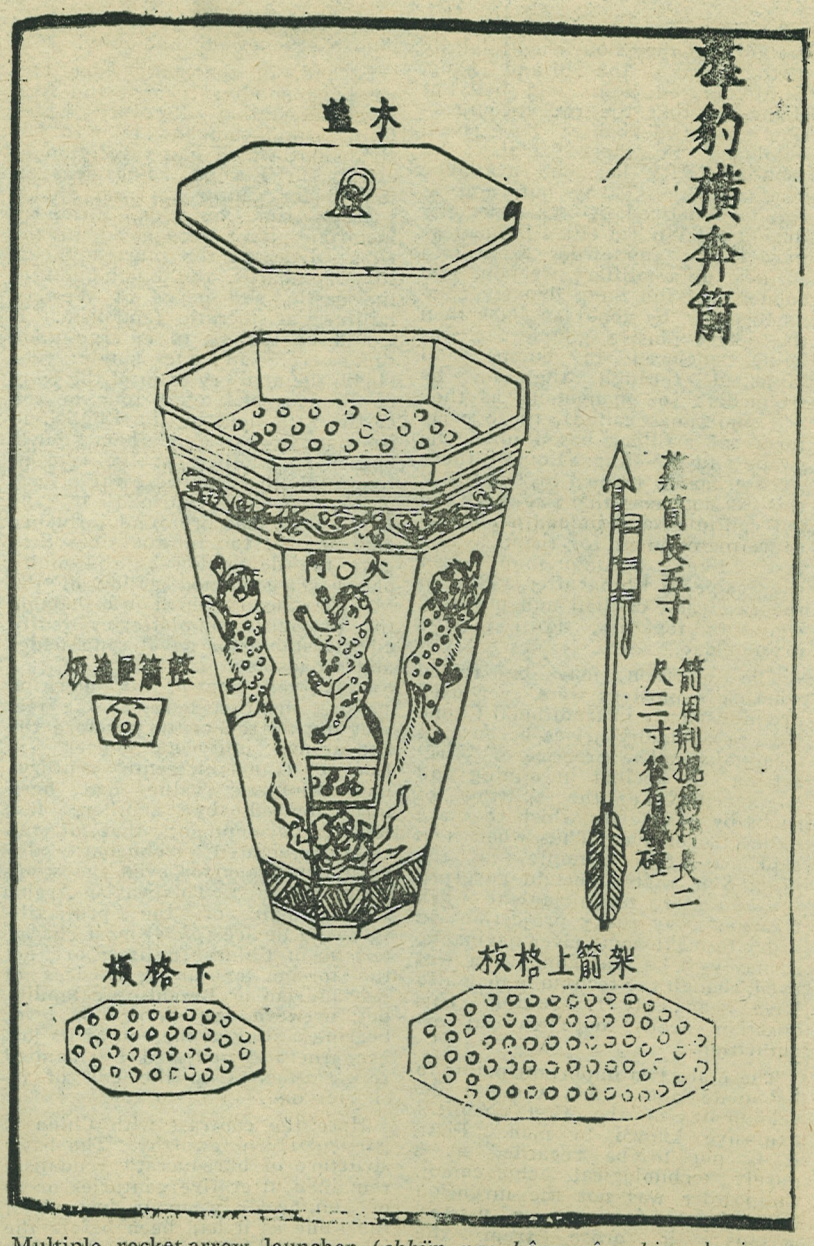
Now what of the transmission to the Western world? We can be fairly sure of one thing, namely that it must have occurred at some time during the second half of the thirteenth century. This was just the period of the massive penetration of eastern Europe by the Mongolian people under Bātū Khan, yet paradoxically they do not seem to have been responsible for the transmission. They valued gunpowder greatly later on, especially in the fighting which put Khubilai Khan on the Chinese throne, but in their earlier phases, when as nomadic mounted archers and consummate horsemen they routed the knightly chivalry of Europe at the Battle of Liegnitz in 1241, firearms had not yet reached the state of development, when they would have been useful for cavalry operations. The pistol, carbine or revolver was still far in the future. The probabilities lie in rather different directions.

Let us review for a moment the course of events in this turbulent century. The Mongols were on the up and up. First the Khwarizmian lands were annexed. The Jurchen Chin dynasty was overthrown in 1234, and far away to the west, Mangu Khan invaded Armenia in 1236. The following year saw the fall of Russian Ryazan, and the Mongols invaded Poland. In 1241, along with the victory of Liegnitz, there was the siege and taking of Budapest, but also the death of Ogotai Khan, to be succeeded by Mangu ten years later. Around 1253 came the journeys of William de Rubruquis and a number of other Franciscan friars to the Mongolian court at Karakoron; they were diplomatic envoys more than missionaries, commissioned to seek the help of the Mongols against the Muslims, the traditional foes of the Frankish Christians.

It was a classic case of that circling strategy by which one seeks to mobilize the forces of allies whose lands lie beyond those of one's immediate enemy. One would give a good deal to know what exactly the Franciscans saw of gunpowder and firearms during their wanderings in Mongolia and China; although such interests consorted ill with their habit, they may have felt it their duty to bring back knowledge and skills which might conserve the safety and power of Christendom against the infidel. Thus the activities of the friars need looking at more closely than hitherto, with this transmission in mind. One of them might even have been accompanied by a Chinese gunner who knew the multifarious devices of the previous half-dozen centuries as well as the latest inventions, and was not averse to seeking his fortune in strange foreign lands — but so far history has not heard of him.

As for the strategy, it succeeded beyond all expectation, apart from the fact that the Mongols did it for themselves and formed no alliances with the Christians. Having subdued Persia, they invaded Iraq beyond the Persian Gulf, and Baghdad fell in 1258. Soon afterwards the Mongolian Ilkhānate, centred on Iran, was established, and the great astronomical observatory of Marāghah was founded. Then came a second possible medium of transmission, the travels of Rabban Bar Sauma and his friend, the account of which was translated from the Syriac long ago by Wallis Budge. These young men were two Chinese Christian (Nestorian) priests of Uighur stock, born and educated in Peking, who pined to go on a pilgrimage to Jerusalem. Neither of them ever got there, but they did travel the whole length of the Old World before one of them returned home (1278 to 1290). The friend was unexpectedly elected a Bishop, and Catholicos of all the Nestorian Churches, when in Tabriz or somewhere in Persia, and his duties therefore detained him there indefinitely. But Bar Sauma travelled on to the West, visited Italy and in 1287 was warmly received at Rome (where no inconvenient doctrinal questions were asked); finally he reached Bordeaux (where he celebrated the liturgy in the presence of the King of England) and eventually got all the way back to China. The purpose of this pilgrimage may also have been partly political, possibly to get Western assistance for the Sung against the Mongols, and if so it never had the slightest chance of success; but once again, our shadowy Chinese gunner might have come along with the two priests, and handed on his knowledge to discreet persons in Europe who were capable of receiving it.

Lastly in the thirteenth century there were not only Franciscan friars and Nestorian priests but also —even more famous—the travelling merchants, of whom the most celebrated was of course Marco Polo, "Il Milione" (the man who affirmed that there were millions of ships on China's rivers, and millions of bridges in Hangchow—and fundamentally he was not wrong). The crucial date at which Marco Polo eventually left China was 1292. He had served Khubilai Khan (1216 to 1294) for twenty years or so, sometimes on secret service missions, more often in the salt administration, and when he left it was by sea, accompanying a Chinese princess proceeding with a great fleet to wed a Middle Eastern potentate. This might have been an even more appropriate scenario for the Chinese gunner we have in mind, but unfortunately it is a little late, for the gunpowder formula was first given in Europe just about that same time, by Roger Bacon (in an anagram) and Albertus Magnus, a Franciscan and a Dominican respectively. However, Marco Polo was by no means the only Italian merchant in China during the thirteenth century; there was also Francesco Pegolotti, who wrote a book on how to get there and back; and there was a whole settlement of European merchants and their wives at Yangchow, to say nothing of the famous French artisan, Guillaume Boucher, serving the Khan at Karakoron. So there are many possibilities, and much may yet emerge from them. By 1355, the time when Chu Yuan-Chang was crowning his successes in China, the moment is far too late, for the Europeans were certainly firing off bombards by 1327. The peak point at which we need to visualize our Chinese *huo shou* as coming West lies rather between 1260 and 1300, that is to say a time at which both the eruptors and the true cannon in China were undergoing rapid development. Further research will doubtless bring us more light.



Multiple rocket-arrow launcher (*chhün pao hêng pên chien*, horizontally-raining pack-of-leopards arrows).

It may also be fruitful to consider the environment or accompanying circumstances in which the transmission occurred. From all our work we have been enabled to distinguish particular "transmission clusters", when several important inventions and discoveries came westwards together. For example, there were several which accompanied the transmission of the magnetic compass, the windmill, and the axial rudder in the twelfth century; and there were others which went along with the mechanical clock, the blast furnace for cast iron, the segmental arch bridge, and the helicopter top, in the fourteenth century. It remains to be seen what transmissions exactly we should place with gunpowder in the thirteenth century; probably certain forms of textile machinery were among them, but above all there was that deep conviction emanating from China that if men knew more about chemistry untold longevity could be achieved. Roger Bacon (1214 to 1292), the first European to talk like a Taoist, represented this outstandingly—and yet paradoxically he was also one of the first Europeans to record the gunpowder formula.

There is one more point which should be raised, a cliché perhaps, an *idée reçue*, a vulgarism, a false impression. The somewhat gloomy aspect of our whole subject is considerably relieved by the reflection that the oldest chemical explosive known to man has been of immeasurable importance not only in war, but also in the arts of peace. Without it, the innumerable products of mining needed by modern civilization could not have been won; without it, the cuttings and tunnels that have been necessary for our lines of communication by river, canal, rail and road could never have been formed. What a pity it was, as Shakespeare wrote, "that villainous saltpetre should be digg'd" out of the earth, to decimate the ranks of armoured knights and longbowmen in Lincoln green; but he was never able to converse with the engineers of the Industrial Revolution, who had a totally different conception of the function of explosives, and the high explosives that followed on, as a natural consequence of modern chemistry. We must take, therefore, a more balanced view of the discovery of explosives, and not be obsessed by their warlike murderous uses.

The cliché is one still often heard in the rest of the world, namely that although the Chinese discovered gunpowder, they never used it for military weapons but only for fireworks. This is often said with a patronizing undertone, suggesting that the Chinese were just simple-minded; yet it has an aspect of admiration too, stemming from the Chinoiserie period of the eighteenth century, when European thinkers had the impression that China was ruled by a "benevolent despotism" of sages. And indeed it was quite true that the military were always —at least theoretically—kept subservient in China to the bureaucratic officials. Like scientists in the England of the Second World War, they were supposed to be "on tap, but not on top". So the cliché could have been right, but unfortunately it isn't.

If we place the final experiments which led to the correct gunpowder formula (even though low in nitrate) somewhere between AD 800 and 850 then, as we know, the mixture was already used as slow-match in the flame-thrower pump by 919, and fully operative in the rocket-composition flame-thrower of 950. For recreational fireworks of course it must have been used too. So far as we are aware, no adequate history of fireworks in China has ever been written, though Amiot did something in the eighteenth century, and Fêng Chia-Shêng much

Tea

"Last night I saw Petrov in a dream.
It was as though he was alive. He stood by my bed.
I thought of asking him how he was feeling,
but then I realised that would be rather tactless."

She sighed and I looked away
at the engraving in the wooden frame,
where a man in a straw panama
was ploughing with a sullen ox.

Petrov had been married to her sister.
But he loved his sister-in-law. He confessed
this to her before he went off on holiday
the summer before last. He drowned in the Dniester.

An ox. A rice field. The vault of the sky.
A ploughman. A plough. Under the fresh furrow
like little seeds: "For Ivanova. Fond memories."
and almost illegible: "From . . ."

The tea's finished. I get up from my chair.
The dot of a star flashes momentarily
in her pupils—and that understanding
which she'd have shown him if he could come back.

She comes down with me and shows me out,
and turns and gazes tenderly,
more challenging than secretive,
at a mathematically distant star.

Joseph Brodsky

Translated by Richard McKane

more in our own; but still it is certain that they flourished mightily at the courts of the Sui and Thang, with coloured lights and balls of flame, so that the rocket-composition gunpowder must have been employed in these displays as soon as it became available. That saw the Thang out, and as we have noticed, it was especially during the Wu Tai (Five Dynasties) period that gunpowder came into its own as a military weapon. No sooner had the Sung dynasty commenced, i e, by about AD 1000, than the semi-explosive gunpowder was being enclosed in bombs and launched through the air by trebuchets (or mangonels, as they are sometimes called), those early forms of artillery based upon the swape and the sling. Equally there were grenades thrown by hand. But this did not mean that fireworks did not continue, and indeed China became pre-eminent for them, as the Jesuits like J. J. Amiot found when they came to China after 1584. So the two uses, civilian and military, went on together, down to the present day.

The question may be raised whether explosives were ever used pre-industrially in traditional China. Here a difficulty arises because of terminology. The practice of "fire-setting" is ancient in mining and engineering, i e, the splitting of rocks by heat, after which they are easier to remove. Thus when it is said, as for example in the *Ming Shu*, that a certain governor set *huo kung* technicians to work clearing away rocky projections in order to make some river navigable, it may well be that gunpowder was used, though the technique may also have been only fire-setting. This question needs more careful examination.

There are two important points to be made about this Chinese development of the first chemical explosive known to man. First, it is not to be regarded as a purely technological achievement. Gunpowder was not the invention of artisans, farmers, or master-masons; it arose from the systematic if obscure investigations of Taoist alchemists. I say "systematic" most advisedly, for although in the sixth and eighth centuries they had no theories of modern type to work with, that does not mean that they worked with no theories at all; on the contrary Ho Ping-Yü and I have shown that an elaborate doctrine of categories or affinities had grown up by the Thang, reminiscent in some ways of the sympathies and antipathies of the Alexandrian proto-chemists, but more developed and less animistic. Those first chemists of Hellenistic times, whose writings are preserved in the *Corpus Alchemicorum Graecorum*, though very interested in counterfeiting gold, and in all kinds of chemical and metallurgical transformations, were not as yet in pursuit of a "philosopher's stone" which would give a medicine of immortality or an "elixir of life". There is every reason for believing that the basic ideas of Chinese alchemy, which had been "longevity-conscious" from the beginning, made their way to the West through the Arabic world. Indeed, one cannot really speak of alchemy in the strict sense before the contribution of the Arabs, and it is even claimed that the word itself, and also other alchemical terms, were derived from Chinese originals.

Many pieces of chemical apparatus from the Han period have come down to us, such as bronze vessels with two re-entrant arms probably used for the sublimation of camphor, vapour rising through the two tubes and condensing in the centre above. Certain forms of distilling apparatus are also typically Chinese, and quite different from those in use in the West. The distillate, condensed by the vessel of cold water above, drips down not into an annular rim peripherally but into a cup or receiver centrally, and flows out through a side-tube. This is an ancestor of apparatus used in modern chemistry. One can easily imagine the Taoist alchemists mixing everything off the shelves in all kinds of permutations and combinations to see what would happen—once saltpetre had been recognized and isolated as it was at least since Thao Hung-Ching's time about AD 500, the inevitable was going to happen. In sum, the first compounding of an explosive mixture arose in the course of a systematic exploration of the chemical and pharmaceutical properties of a great variety of substances, inspired by the hope of attaining longevity or material immortality. The Taoists got something else, but in its way also an immense benefit to humanity.

Second, in the gunpowder epic we have another case of the socially devastating discovery which China could somehow take in her stride but which had revolutionary effects in Europe. For decades, indeed for centuries, from Shakespeare's time onwards, European historians have recognized in the first salvoes of the fourteenth-century bombards, the death-knell of the castle, and hence of Western military aristocratic feudalism. It would be tedious to enlarge upon this here. In one single year (1449) the artillery train of the King of France, making a tour of the castles still held by the English in Normandy, battered them down, one after another, at the rate of five a month. Nor were the effects of gunpowder confined to the land; they had profound influence also at sea, for in due time they gave the death-blow to the multi-oared slave-manned galley of the Mediterranean, which was unable to provide gun-platforms sufficiently stable for naval cannonades and broadsides.

Less well known, but meriting passing mention here, is the fact that during the century before the appearance of gunpowder in Europe (the thirteenth century) its poliorcetic value had been foreshadowed by another, less lasting development, that of the counter-weighted trebuchet, also most dangerous for even the stoutest castle walls. This was an Arabic improvement of the projectile-throwing device (*phao*) most characteristic of Chinese military art, not the torsion or spring devices of Alexandrian or Byzantine catapults, but the simpler swape-like lever bearing a sling at the end of its longer arm and operated by manned ropes attached to the end of its shorter one.

Here the contrast with China is particularly noteworthy. The basic structure of bureaucratic feudalism remained after five centuries or so of gunpowder weapons just about the same as it had been before the invention had developed. The birth of chemical warfare had occurred in the Thang but it did not find wide military use before the Wu Tai and Sung, and its real proving-grounds were the wars between the Sung empire, the Chin Tartars, and the Mongols, in the eleventh to thirteenth centuries. There are plenty of examples of its use by the forces of agrarian rebellions, and it was employed at sea as well as on land, in siege warfare no less than in the field. But as there was no heavily armoured knightly cavalry in China, nor any aristocratic or manorial feudal castles either, the new weapon simply supplemented those which had been in use before, and produced no perceptible effect upon the age-old civil and military bureaucratic apparatus, which each new foreign conqueror had to take over and use in his turn.

Finally, the sting in the tail, which shows once again how unstable Western medieval society was in comparison with that of China, is the foot or boot-stirrup (*têng*). After many discussions involving the nomadic peoples, the conclusion now is that it was a Chinese invention, for tomb-figures of about AD 300 clearly show it, and the first textual descriptions come from the following century (477), about which time there are numerous representations — Korean as well as Chinese. Foot-stirrups did not appear in the West (or Byzantium) until the eighth century, but their sociological influence there was quite extraordinary; for it welded the horseman and the horse together, and applied animal-power to shock combat. Such horsemen, equipped with the spear or the heavy lance, and more and more enveloped in metal armour, came in fact to constitute the familiar feudal chivalry of nearly ten European medieval centuries—that same body of knights which the Mongolian mounted archers had overcome, as before mentioned, on the field of Liegnitz. There is no need to stress all that the equipment of the knights had meant for the institution of medieval military aristocratic feudalism. Thus one can conclude that just as Chinese gunpowder helped to shatter this form of society at the end of the period, so Chinese stirrups had originally helped to set it up. But the mandarinate went on its way century after century unperturbed, and even at this very day the ideal of government by a non-hereditary, non-acquisitive, non-aristocratic élite holds sway among the thousand million people of the Chinese culture-area.

Wheres and whyfores

By S. S. Frere

A. L. F. RIVET and COLIN SMITH :
The Place-Names of Roman Britain
526pp. Batsford. £50.
0 7134 2077 4

The meanings of place-names are always interesting and often suggestive; those of Roman Britain are no exception, and many of them present in addition the puzzle of location on the ground. The student will use this magisterial book as a work of reference, but there are plenty of passages which will give informed pleasure to the intermittent reader too, who will find that he need not venture out of his depth into abstruse realms of Celtic philology unless he wishes. There are stimulating discussions of the principal sources for Romano-British place-names; and then, after a certain amount of sifting and elimination of "doubles", the authors assemble an alphabetical list of some 460 names, each with a discussion of its source, meaning and identification. These names form the earliest surviving stratum of toponymy in this country, reminding us of its Celtic past and in some few instances of its pre-Celtic background.

Although some names are recorded for us in contemporary inscriptions, the great majority have come down in versions of works written in antiquity. Many ancient writers had occasion to mention Britain; the authors give a list of 114 of them, together with details of the information they provide; few, alas, do more than mention the island itself. The chief sources are four in number: the Antonine Itinerary (a list of places along various main roads: 110 names); Ptolemy's Geography (listing the latitude and longitude of capes, islands, rivers and places: *c* 150 names), the Notitia Dignitatum (cataloguing mainly military officials and the names of their stations: forty-six names); and the Ravenna Cosmography (a long list of rivers, places and islands throughout the then known world compiled about AD 700: *c* 300 names). The compiler of the Cosmography can be shown to have made his lists from a map or maps, and one ancient map, the so-called Tabula Peutingeriana, still survives in the form of a medieval copy of the original; unfortunately a large part of its British section is missing, leaving only sixteen names.

The authors show how complications may arise because of faulty original transcribing, particularly from maps (giving rise to confusion of river-names with those of places, for instance), and also because of scribal errors in successive re-copying. Our largest source, the Cosmography, shows these sorts of corruption in an extreme form; not only good judgment but much knowledge both of the principles of textual criticism and of Celtic philology is required if anything like a reliable version is to be presented. A fundamental study of the British part of the Cosmography was published by Richmond and Crawford thirty years ago. A. L. F. Rivet and Colin Smith treat the text much more ruthlessly, and their view of the abilities of the compiler is far more devastating; they show conclusively that he was often capable of confusing features with places and that he lacked logical method in ordering his lists. This makes location much more difficult.

Manuscript sources can sometimes be checked or supplemented from information preserved on inscriptions. Although these also may confuse us with spelling mistakes — sometimes wanton, but often caused by the pronunciation of "vulgar" Latin—they are more likely to disappoint us by the extremely abbreviated formulae employed. And unfortunately few inscriptions of Roman Britain record place-names at all: the "literary" sources accordingly assume a major role, and their correct assessment is a vital task. *The Place-Names of Roman Britain* marks a great advance.

The book contains 526 pages, which are divided almost equally between the alphabetical catalogue and the preliminary chapters which discuss the sources and problems. There have been individual studies before: it is the comprehensiveness of this one which clearly destines it to be a major source of reference for years to come. All the more unfortunate therefore is the pricing of the work beyond the reach not only of students and of amateur antiquarians but even of professional scholars. It is hard for the man in the street to comprehend the economies of book-production; but, since this one has been offered by a book-club for £29, it would seem that each copy sold at £50 makes at least a £22 profit. This cannot be justified. In a book so costly we should at least expect the maps to be legible; several are so grossly over-reduced as to be illegible even under a lens.

Among so many chapters of absorbing interest perhaps one of the most valuable is that on Ptolemy, which also provides a text and translation of his British section; it has been hard for students to work on Ptolemy hitherto, so this is a great gain. The chapter on the Notitia also breaks new ground, building upon a number of recent studies. Only very occasionally do the authors nod. They have overlooked two place-names attested on potters' stamps, Lugudunum (long known to be in the St Albans region and recently located at Brickets Wood) and Vianuacae (site unknown, but somewhere in the same region); they have also missed two diplomas issued to a Dobunnus and a Belgus respectively, an inscription from Cologne mentioning a Dumnonius, and one from the Antonine Wall mentioning a Brigans. Occasionally they adopt too rigidly academic an approach, as in their discussion of Anava or in their controversial treatment of Pinnata Castra and Inchtuthil; and sometimes their ruthless treatment of the Cosmography yields unnecessarily harsh results, as in their dismissal of Richmond's interpretation of the *loca* in southern Scotland as tribal meeting-places. But these are matters about which there will be much debate. We must be grateful to the authors for providing this firm foundation for future work.

Queen of the desert

By Malcolm Colledge

IAIN BROWNING :
Palmyra
223pp. Chatto and Windus. £8.95.
0 7011 2266 8

Ever since Wood and Dawkins published their great book *The Ruins of Palmyra otherwise Tedmor in the Desert* in 1753, these romantic remnants of Palmyrene glory have excited western curiosity. Here in the centre of the Syrian desert lies a palm-clad oasis, known to orientals as Tadmor and to westerners as Palmyra, and inhabited since at least the third millennium BC. By about 1100 BC the population was primarily Aramaean; later, numbers of Arabs arrived. For long it was unimportant, a plaything of empires. Change began, however, in the wake of the conquests of Alexander the Great, when the Greek kings of Seleucus' line struggled to control and Hellenize a largely resistant Asia. Prosperity spread, reaching even Tadmor. But the Seleucids were increasingly threatened both from the east by the Iranian Parthians, whose empire eventually reached the Euphrates, and from the west by the expanding might of the Romans, who in 64 BC transformed their last possessions into the Roman province of Syria.

For many decades, however, the Romans seemingly refrained from imposing control on Palmyra. The oasis dwellers used their comparative independence to advantage. Finding themselves on a commercial route of growing importance, a short desert crossing, they promoted both trade, by policing the wastes, and their own prosperity, by taxing passing caravans, a practice they continued after being absorbed by Rome in the first century AD.

As profits multiplied from the mid-first century BC onwards, architects and artists were increasingly commissioned to produce buildings and sculptures in the fine white local limestone, such as the magnificent temple of the god Bel, colonnaded streets, a monumental civic area and, outside, the strange tower tombs that to this day give Palmyra its unique skyline. Curiously, while stone architecture owed much to Hellenistic Greek and Roman inspiration, sculpture and painting exemplified the Semitic culture of the western Parthian empire, or "Parthian" art. Unfortunately prosperity bred overconfidence; during the disturbances of the mid-third century the Palmyrenes briefly regained independence and under their dynamic queen Zenobia conquered much of the Roman east, only to find themselves crushed and their city wrecked by the emperor Aurelian in 272 and 273. Palmyra never really recovered.

Iain Browning's account is clearly intended for the layman; its plan recalls that of his previous book, *Petra*. An opening sketch of Near Eastern trade routes and commodities is followed by a historical outline interspersed with remarks on art and iconography. The rediscovery of Palmyra by western visitors and scholars is charted, including such figures as Wood and Dawkins, the unstoppable Lady Hester Stanhope and a British army moonlight patrol. The main features of Palmyrene (stone) architecture are established, and the architectural influence of Wood and Dawkins's publication is traced. Finally we are guided round the significant remaining monuments; each is succinctly described, and arranged in an order suitable for visitors to follow.

Sadly, however, despite its good intention, the volume betrays a fatal lack of familiarity with the ancient world in general, and with Palmyra in particular. The range of reading has been narrow; one recent work has been relied on so heavily as to be closely paraphrased or quoted verbatim in nearly a score of passages without acknowledgment. Confusion exists over the careers of Julius Caesar and Mark Antony, Trajan's campaigns, Palmyra's status and the dates of some of its monuments. Palmyrene architecture is sometimes described as western in inspiration, sometimes as eastern. The relationship of Palmyrene art to Roman and "Parthian" is misunderstood. Funerary effigies are called "portraits" throughout, wrongly. Spellings of oriental names are bizarre. The illustrations, however, are interesting, and include some attractively drawn reconstructions of Palmyrene buildings.

Mr Browning rightly deplores the restoration and reconstruction, often in concrete, which at Palmyra as elsewhere in the Middle East is damaging ancient buildings. Worse still is an event that has overtaken even his text—the erection right over the Efqa spring of a gigantic concrete hotel of breathtaking ugliness, which now entirely blocks out the first, romantic view of the city that visitors previously had from the Damascus road. Mammon, in this guise, has ironically destroyed the beauty that Mammon, too, had created.

The American playwright Arthur Miller and his photographer wife, Inge Morath, have produced a personal record of a six-week trip they made to China in 1978, *Chinese Encounters*, (Secker and Warburg, £12.50. 0 436 28007 8). The photographs are of whatever took Inge Morath's fancy and include such curiosities as the pony (now stuffed) which Mao rode during the Long March. Naturally enough, Arthur Miller went to the theatre several times and was in general impressed by the verve of the plays he saw, though he had a frightening moment when an old director of the Peking People's Art Theatre insisted that he should tell him and the cast what he thought of the play. Miller summoned his courage and told them why he thought it was boring. To his astonishment they were delighted and exclaimed "Here we are for six months trying to figure out why this play is so boring and he sees it at once and tells us!". The photographs, which form the second half of the book, are accompanied by long explanatory captions.

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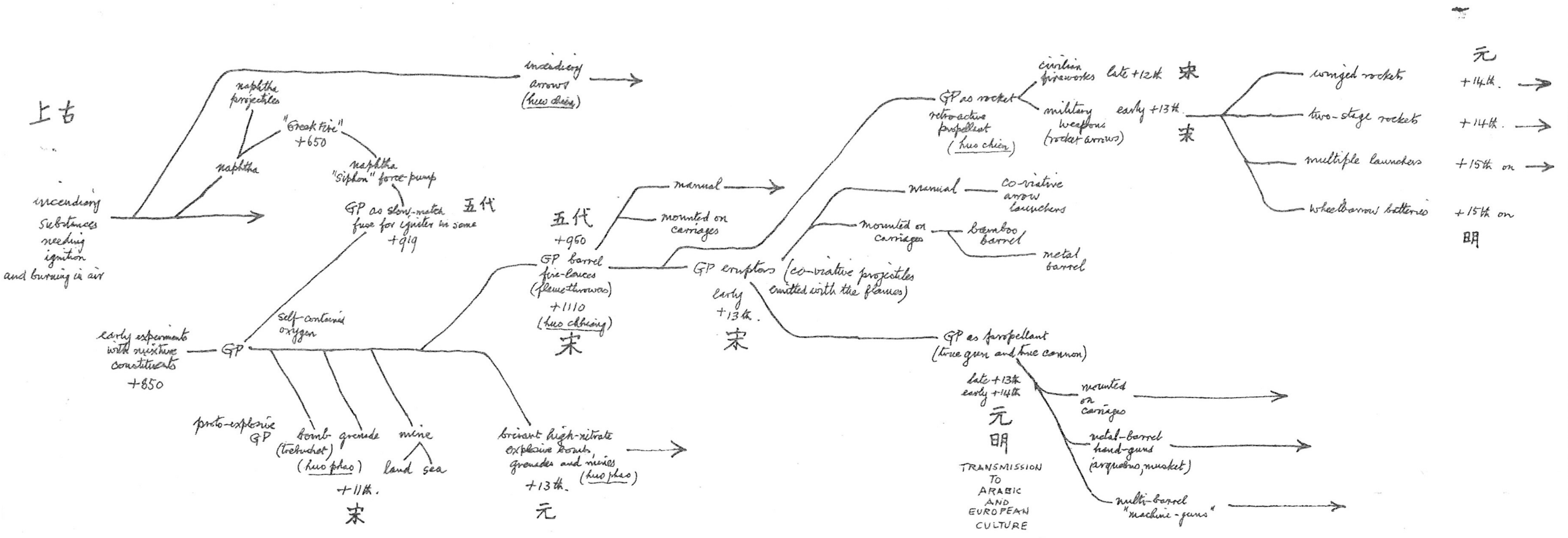
上古
incendiary substances needing ignition and burning in air
naphtha projectiles
naphtha
"Greek Fire" +650
naphtha "Siphon" force-pump
incendiary arrows (huo chien)
GP as slow-match fuse for igniter in some +919
五代
early experiments with mixture constituents +850
GP
self-contained oxygen
proto-explosive GP
bomb (trebuchet)
grenade
(huo phao)
mine
land
sea
+11th.
宋
brisant high-nitrate explosive bombs, grenades and mines (huo phao)
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元
五代
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GP barrel fire-lances (flame-throwers)
+1110
(huo chhiang)
宋
manual
mounted on carriages
GP eruptors (co-viative projectiles emitted with the flames)
early +13th.
宋
GP as rocket
retro-active propellent
(huo chien)
civilian fireworks
late +12th
宋
military weapons (rocket arrows)
early +13th
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manual
co-viative arrow launchers
mounted on carriages
bamboo barrel
metal barrel
GP as propellant (true gun and true cannon)
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TRANSMISSION TO ARABIC AND EUROPEAN CULTURE
mounted on carriages
metal-barrel hand-guns (arquebus, musket)
multi-barrel "machine-guns"
winged rockets
two-stage rockets
multiple launchers
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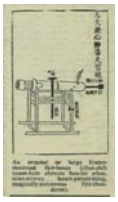

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