A SKETCH OF THE SALTPETER MANUFACTURING MILLENNIUM IN WORLD HISTORY

by

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War, unfortunately, has long been a favored occupation of the human species. Consequently, the articles by which warfare may be conducted have been important items of commerce through the history of the world. As military technology developed over the centuries, from stone axes to satellite killers, the acquisition and regulation of contemporary ordnance supplies has usually been of paramount importance. For nearly one thousand years, gunpowder and its major constituent, saltpeter, were critical items.

Saltpeter, or niter, is a nitrate mineral that was known to the Chinese as early as the 1st century B.C., and long used for medicinal purposes and in chemical processes. Although Chinese science was far in advance of the western world, nearly a thousand years would pass before the deflagatory properties of this chemical led to the first development of gunpowder in China, and its adaptation to the ways and means of warfare. Saltpeter was readily available in many parts of China, reported by Sogdian Buddhist monks in the +6th century as an encrustation on certain soils. The incendiary nature of saltpeter was known by the 7th century A.D., as recorded in the Taoist book *Explanation of the Inventory of Metals and Minerals according to the Numbers Five and Nine*. According to this account, the monk Chih Fa-Lin traveled to the Ling-Shih district in Fên-chou about the year 664, and there declared:

"This place must be full of saltpetre, why isn't it collected and put to use?" At that time he was in the company of twelve persons, and together they collected some of the substance but found it unsuitable for use, and not comparable with that produced in Wu-Ch'ang. Later they came to Tsê-chou and the monk said again that saltpetre must also occur in this region... Whereupon they collected the substance, and on burning it emitted copious purple flames.[1]

Rather than the transmutation of base metals to gold as sought by their later counterparts of medieval Europe, Chinese alchemists often pursued elixirs of eternal life. Also in the +6th century, one of the earliest accounts of the mixing of saltpeter and sulfur comes from a related Taoist volume titled *Methods of the Various Schools of Magical Elixer Preparations*, in a formula attributed to the alchemist Sun Szu-Mo, The first proto-gunpowders were made accidentally in China in the +9th century as results of such experimentations, when mixtures of saltpeter, sulfur, and carbon sources such as dried honey or herbs were heated in crucibles. The result of instant deflagration must have been quite startling to these scholars; some suffered scorched hands and faces, and even had their houses burnt down.[2]

The technology of gunpowder, known as *Huo yao*, swiftly developed. Early mixtures of Chinese gunpowder had relatively low proportions of saltpeter to other ingredients and thus were not explosive. The first published formula for gunpowder appeared in Chinese writings in +1044, and over the next three centuries military uses diversified. Among the first applications was the invention of chemical warfare. Chinese trebuchets lobbed poison smoke bombs that contained toxic and odious mixtures of saltpeter, sulfur and such ingredients as powdered human excrement, arsenic, antimony and tung oil. Metal-cased shrapnel bombs followed, and with increased saltpeter content, high-explosive bombs and mines. The first weapon resembling a gun came early, beginning about +950; this was the fire-lance, a barrel-gun that shot rocket-propelled arrows or spears. Development of metal bombards or cannon occurred at about the same time in China and Europe, during the 14th century, in probability originating in China and quickly adopted in the west. Smaller, personal arms were developed as gunpowder composition was perfected.[3]

Knowledge of gunpowder had spread to Europe by the twelfth century, though its exact composition remained unknown for at least another century. Saltpeter was evidently known to ancient western civilization, as mention of "nitrum" is made in the writings of Pliny and others, referring to several sorts of nitrate salts obtained from surface soils. They failed, however, to discover its properties as an explosive component. It was the Arabs, late in the 12th century, who first learned that saltpeter was the primary ingredient. The Arabs called saltpeter, *bauraekh* and were reported to have obtained it from Armenia and Africa.

Another Arabic term for saltpeter, "Thelg as Sin," translates as "Snow of China" and is an indication of export of this material from the east. The first known mention of gunpowder in Europe was by Roger Bacon in his *De Mirabili Potestate Artis et Naturae* written in 1242; in this text he mentions *sal petrae* though no description of its manufacture is given. Mention of saltpeter was also made at about this time by Albertus Magnus of Germany, a Dominican monk and alchemist. An apocryphal account is that of *der schwartze Berthold*, or Berthold the Black, a Franciscan friar and alchemist who was said to have invented

the gun circa 1380 after heating in his laboratory an enclosed mixture of saltpeter, sulfur, and charcoal with explosive results. A history of saltpeter manufacture written in the mid-17th century discredits this, however, and correctly reports that "Brass Ordnance have been used by the Chinoies many ages ago."[4]

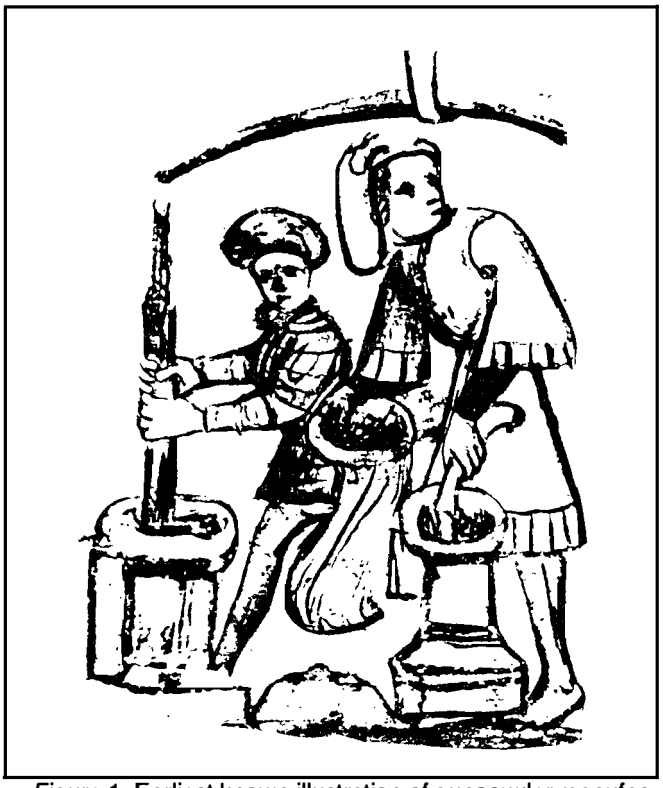

Figure 1. Earliest known illustration of gunpowder manufacture, circa 1350, cited from the *Codex Germanicus #600* and published in Oscar Guttman, *Monumenta Pulveris Pyrii* (privately printed, 270 copies, 1906). Accompanying text, translated: "If thou wouldst make a simple powder of three parts, only then take four pounds of saltpeter, which must be good and well refined and one pound of sulfur and one of charcoal and pound it in good wine in which camphor has been boiled and dry it in the sun. If no camphor is in it, the powder easily falls to dust but the camphor holds all together and is powerful and quick in all powder into which it be put." (Illustration courtesy of Hagley Museum and Library, Wilmington, Delaware).

Two centuries after Berthold purportedly won the battle of Fossa Claudia for the Venetians over the Genoese by his introduction of guns, Georgius Agricola described saltpeter manufacture in his *De Re Metallica* (1556), "made from a dry, slightly fatty earth, which, if it be retained for a while in the mouth, has an acrid and salty taste." Pietro Sardi, writing in 1629, states that "*Sal nitri* is Extracted from the Earth in great quantities, and from Walls in small...but not in all places, but such as are Proper, as those are, that are obscure and Cavernous, where the rain falls not." Sardi reported three tests for niter: "putting a little on the tongue, if there be sense of a biting taste"; thrusting a hot iron into suspect earth, allowing it to cool and examining it for a whitish color; and sprinkling over burning coals, "...if there be perceived any crackling noise, and any sparkles issues forth speedily, it shall be a sign of Saltpetre-Earth." Henry Stubbe in 1670 observed that saltpeter-earth might be found in English cellars and vaults, and even on the stone walls of his room at Oxford, which were below ground level. Stubbe also relates several accounts of discoveries of saltpeter occurrence in caves. Near a certain town, "there was a deep and close Grott under the Appenine, in which Millions of Owles did lodge themselves, their dung had been accumulated there for many centuries of years; out of this the Salt-Petre-men extracted so much of Nitre as amounted to an inestimable summe of money." Another account is quite grisly: "And not long ago, whereas in the Warrs betwixt the Crim Tartar and Polovians towards Muscovy [Moscow], great numbers of people being slain in battails were buryed for hast together in great cavernes in the Mountains, & so rotted there; out of that Earth in the Cavernes there was extracted a great quantity of Salt-Petre."[5]

Nathaniel Nye, also writing in 1670, traces the development of gunpowder in Europe in his text on the *Art of Gunnery*, and reports that though various persons had experimented with additional components, the essential ingredients of gunpowder were "Saltpeter, Brimstone, and Charcole." The proportions, however, had varied considerably (Table 1).

COMPONENT	PROPORTION/YEAR A.D.				
	1380	1410	1480	1520	1670
Saltpeter	1	3	8	4	6
Sulfur	1	2	3	1	1
Charcoal	1	2	3	1	1

Table 1. Composition of Gunpowder 1380-1670 A.D.

Note that the proportion of saltpeter in the mix was gradually increased and, correspondingly, the explosive force of the final product. The intended use, whether for cannon or for small arms, also influenced the proportions.[6]

As saltpeter was a relatively scarce commodity in Europe, until the development of the saltpeter trade in India by the British in the eighteenth century, the manufacture of gunpowder in Europe was greatly limited prior to this time. When the British began to dominate the trade of India, they found themselves in control of the world's major source of the most important ingredient, saltpeter. In the Bengal region, rich deposits of nitrate salts occurred naturally in the soils.

During the earlier period of Moghul rule, a lucrative trade in this item had been developed by British and other shippers. An entire caste arose, the Nuniah, their labor based upon the simple extraction of saltpeter from these soils. Due to the widespread occurrence of the mineral, the trade was never very highly organized, but control of international shipment remained almost exclusively in the hands of the British East India Company during the period of British political domination. It was this control of the world saltpeter market, and thus largely of the commercial manufacture of gunpowder, that led to the development of domestic saltpeter supplies in the United States during the American Revolution and later during the War of 1812.[7]

The exact origin of saltpeter is still unknown, though subject to wide speculation. It apparently is a mineral of organic derivation, due to the various circumstances under which it is found. Saltpeter has been extracted or produced by several methods. In ancient China and in India, nitrate-rich soil could be simply scraped up off the ground and concentrated through a simple procedure. This purification process involved leaching of the nitrates with water and boiling the liquid collected to crystallize the niter; a procedure essentially the same regardless of the original source of nitrate. Saltpeter could also be found in the soils under old houses, in barns, privies, and similar locations. The British Parliament in 1641 passed an ordinance allowing saltpetermen to dig for this substance wherever they pleased throughout the kingdom, provided that any damage was repaired. Similar laws were passed in eighteenth- century France, giving the saltpetermen *droit de fouille*, or right of entry and search, permitting them to ransack entire provinces for the mineral. Any who refused assistance to them were subject to heavy fines. In the early 19th century in Sweden, a form of rural property tax known as *salpetergärd* was instituted, requiring farmers to pay the tax with refined niter.[8]

In the United States, the outbreak of the Revolution in 1776 embroiled a country in desperate need of ordnance supplies. With the British controlling the major international source of saltpeter, and blockading the coast with an unchallengeable navy, a fledgling nation found itself without the means of waging war. The production of saltpeter had begun in the American colonies as early as 1642, with orders that every plantation should erect a house "to make saltpetere from urine of man, goates, henns, and horses' dung, etc." Niter production by these methods remained very limited even more than a century later on the eve of the Revolution. As the conflict loomed, Committees of Safety began hastily to promote manufacture of saltpeter by every means possible. At this time, the numerous niter-rich caverns of the land west of the Appalachians were still virtually unknown, and thus extraction of saltpeter from cavern soils was of relatively minor significance during this period.[9]

As the writings of Sardi and Stubbe indicate, it was commonly known that saltpeter could be obtained from certain caverns. Nye, in his 1670 gunner's handbook, also had observed that saltpeter might be found "loose within Vaults, Tombs, or desolate Caves, where rain can not come in," though he thought that the very best was made from animal manure. Suitable caves, however, were generally lacking in the New England colonies. About the only region of the colonies where niter might be found in caves was in western Virginia. In June of 1775, the *Virginia Gazette* published a short notice that Thomas Lynch of Bedford County had erected a gunpowder mill, and was making his own saltpeter. A few months later, Lynch wrote to the Virginia delegates at the Continental Congress in Philadelphia that he had purchased Reed Island on the New River (present Wythe County), where he had found niter interbedded in the rock layers and on the surface of the earth. Some few caves of this region were utilized.[10]

As caves were not yet the niter supply they would become during the second war with Britain forty years later, only the traditional means of production were generally available to the country; meaning of course that every household was encouraged to begin the scraping of their cellar walls and the overturn of their manure heaps. Many of the newspapers of the day published recipes for saltpeter production, so that the technology would be widespread. In the *Boston Gazette* for New Years' Day, 1776, the "Committee for propagating the manufacturing of SALT PETRE" published a typical discourse:

(T)ake earth from under any old building (whether meeting house, dwelling house, barn, stable, or other building), where the earth has been long covered from the weather; dig not above six or eight inches deep, and a little experience will teach you to chusz [sic] that which is loose, light, and crumbly, and has a bitterish or sourish ailum like salte upon the tongue; light sandy or loomy earth, such as water easily penetrates, works the kindest. Fill your leech-tubs with those earths...

As spring advanced in 1776, the country's leaders were becoming almost panicky regarding the impoverishment of ordnance. In a letter to Thomas Jefferson on April 26, John Page of Virginia complained that only one powder mill had been set up at the public expense, and that what little saltpeter was being made was of poor quality. "Could you believe it," he wrote, "the Salt petre Works are but little attended to. Some Money it is true has been advanced to different People but I kn[ow] of no grand Work..."[11]

Within a few months, following the Declaration of Independence, the situation had greatly improved. Every colony but Georgia enacted legislation to promote saltpeter and gunpowder production, and several of the works established were highly successful. In addition, gunpowder and saltpeter were then being brought into the country from France, Spain and

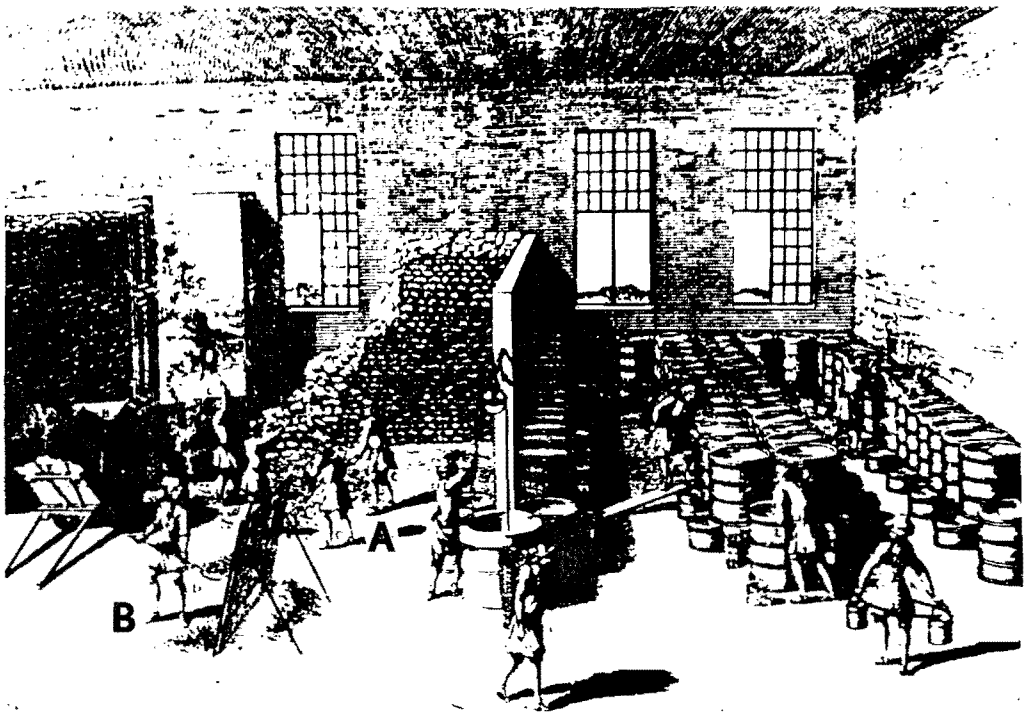

Figure 2. The saltpeter works of the City of Paris, 1697. Bags of partly refined saltpeter stacked at upper left, leach tubs to the right. Workers at "A" are pulverizing the raw material with hammers, while man at "B" is sieving it to remove rough impurities. (From M. Denis Diderot, *Encyclopédia ou Dictionnaire des Artes et Métiers*, multivolume, Paris Briasson, 1751-[?]. Illustration courtesy of Hagley Museum and Library, Wilmington, Delaware).

the West Indies, so that the situation was no longer as critical as it had been in 1775.[12]

In France, beginning at about at this time, the technology of gunpowder manufacture was far advanced under the astute guidance of Antoine-Laurent Lavoisier, directing the operations and experiments of the *Regie des poudres*. Among those working with Lavoisier was Claude-Louis Berthollet, who attempted to develop chemicals such as potassium chlorate and various fulminates as substitutes for saltpeter. In this he was unsuccessful, though in 1807 Alexander John Forsyth, a Scott, patented the percussion lock firearm using fulminates to ignite gunpowder charges and constituting a major advance over the flintlock mechanism. The need for a saltpeter substitute was felt keenly by countries such as France who did not have access, as did the British, to the India trade. In 1792, the British East India Company, at the request of Prime Minister William Pitt, tried to corner the available supply of saltpeter in Europe, to keep it out of the hands of rival France. France was at the time having difficulty procuring sufficient saltpeter to safeguard national interests, and attempted to develop methods of artificial production such as used in Sweden. This would have to be on a huge scale to provide all the national requirement of France. The scale was too large for the government, and carried too much risk for entrepreneurs; consequently the program never got much beyond the trial stage. Though Lavoisier was guillotined during the excesses of the French Revolution, it was from this fertile atmosphere that new technology spread to the United States, typified in the persons of Eleuthère Irénée du Pont and John James DuFour.[13]

Du Pont came to America in 1800, and soon established the Eleutherian Mills on Delaware's Brandywine River, destined to become the largest manufacturer of gunpowder in the country and the largest single consumer of domestic saltpeter manufactured from cavern soils. Du Pont had been apprenticed to Lavoisier as a young man and had learned both scientific method and the craft of explosives manufacture.[14]

John James DuFour had arrived in the United States in 1796, just a few years before du Pont, and traveled to Kentucky to take up residence and subsequently establish American viticulture in what was essential a frontier state. It was in Kentucky that DuFour met Dr. Samuel Brown of Lexington and developed an efficient system of extraction of niter from Kentucky caves.[15]

As explorers had moved westward across the mountains into the frontier regions that would become Kentucky and Tennessee, they could not fail to take note of the abundance of caverns and rockshelters, many of which possessed rich deposits of nitrates. As gunpowder was needed for defense and hunting in the wilder-

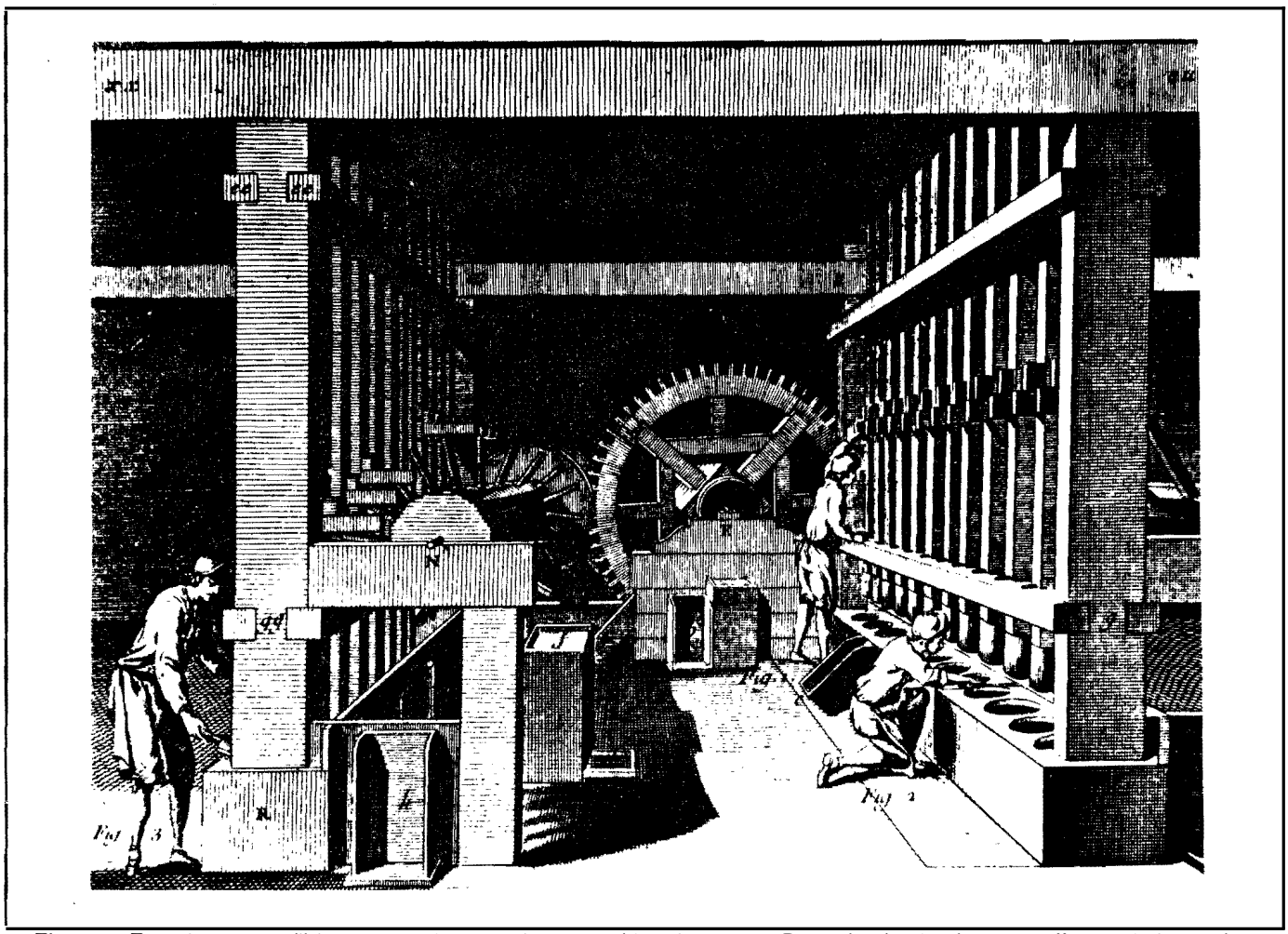

Figure 3. French stamp mill for gunpowder manufacture, mid-18th century. Pre-pulverized saltpeter, sulfur, and charcoal were incorporated with a small amount of water in this camshaft-operated mortar and pestle arrangement. The mechanism was probably water-powered. This was the standard manufacturing technology for nearly 500 years. (From M. Denis Diderot, *Encyclopédia ou Dictionnaire des Artes et Métiers,* multivolume, Paris Briasson, 1751-[?]. Illustration courtesy of Hagley Museum and Library, Wilmington, Delaware).

ness, the early pioneers were soon making saltpeter from the dry caves of the region. As the area become more settled, commercial powder mills became an important early complementary industry. Centrally located Lexington, Kentucky became the western market focus for both industries, and shipped large quantities of niter to the larger eastern powder makers.[16]

The domestic saltpeter industry reached its zenith shortly after the nineteenth century began, with the greatest production occurring in Kentucky and Tennessee. Two Kentucky caves were particularly dominant in production, Great Saltpetre Cave in present Rockcastle County and Mammoth Cave in present Edmonson. Great Saltpetre had been discovered in 1798 and over the next three years was exploited on small scale for its large nitrate reserves, operations greatly expanded thereafter. Mammoth Cave, well-known today as central attraction of a national park, was brought into major production about 1810. The operations at these two caves represented state-of-the-art technology in saltpeter manufacture.[17]

The extraction of saltpeter from cave soils was largely a cottage industry, produced in small quantities on a sporadic basis by the rural hill-dwellers and taken to market as convenient, there to be traded for cash or supplies. Major production, however, would require dedicated effort. Dr. Brown of Lexington formed a partnership to purchase Great Saltpetre Cave in 1804 and soon hired DuFour as his engineer to construct a saltpeter works. DuFour proved his merit and provided Brown with a highly efficient system after the labor of three months. Saltpeter earth was mined in the cave and placed within large rectangular vats for leaching. The style of these vats were one of many DuFour-Brown refinements, with a large capacity and an effective piping system to transport the leachate or "liquor" to the exterior for concentration. The leachate was boiled in kettles, and then run through the vats again, this time with wood ashes included for a necessary chemical conversion, as the first extraction had

produced calcium nitrate. Potassium nitrate was needed, and was thus provided in a substitution reaction.[18]

A cruder version of this process was used by less ambitious operations; less efficient, but with a similar advantage of using materials at hand (timber) for construction and fuel. In addition, caves were not the only source of saltpeter on the frontier. A large number of sandstone rockshelters provided conditions suitable for nitrate formation, and not being formed in calcium carbonate, these deposits were already predominantly potassium nitrate and needed no further chemical conversion. Thomas Jefferson wrote to Pierre Samuel du Pont (father of Irénée) in 1806 that

It has lately been ascertained that the supplies of saltpeter which the Western country can furnish are immensely beyond what had been expected... The caves are numerous. But an important discovery has been made: that there are immense precipices of sandy rock, which pulverized yields about 20 lbs. of salt petre to the bushel, whereas the earth of the Caves yields but 1 lb to the bushel. Your son is setting out on a visit to that country to inform himself from his own view of the subject.

The discovery to which Jefferson alluded was the consequence of researches by Dr. Brown, who had sent Jefferson a memoir on niter production from such sites. The saltpeter mining industry in the "west" therefore had two aspects, extraction from caves and also from rockshelters; so productive were these sites that traditional sources such as animal waste and from beneath the flooring of houses were seldom utilized in the region.[19]

Brown is credited in part with promoting that cavern soils would renitrify if replaced after processing, and thus being a naturally renewable resource, but this aspect of saltpeter manufacture was well known long before. Nearly two centuries before, Sardi, in describing methods of saltpeter manufacture, had instructed that:

Having taken out the Earth from the Vessels, after that the water hath extracted the Nitrous substance therefrom, let it be spread on the face of the Earth, but not exceeding a foot thick, and in some covered place, that it be subject to neither Rain nor the sight of the Sun...at two years end, that Earth will be impregnated, with as much Nitre as ever...[20]

As the first decade of the new century drew to a close, a second war with Great Britain appeared inevitable. Saltpeter manufacture, in ordinary times an important commodity, suddenly became invaluable and was seen by many men as a means to quick wealth. Importation of saltpeter and gunpowder from abroad was again cut off, requiring hasty development of domestic sources on large scale. Speculation, particularly in saltpeter, was rampant, and saltpeter caves suddenly became valuable properties. Saltpeter works and gunpowder mills were quickly established in numerous locations, primarily in Virginia, Kentucky and Tennessee. Mammoth Cave was among the most important niter mines of this era, and the technology earlier developed by Brown and DuFour was duplicated there on large scale. Most of the saltpeter processed at Mammoth was contracted to eastern powder manufactories, primarily to du Pont's Eleutherian Mills. Saltpeter brokers congregated in Lexington and purchased the commodity as quickly as it could be brought in. A significant proportion of Kentucky saltpeter production was manufactured into gunpowder in the Bluegrass, and used to supply United States Ordnance depots along the Ohio River. Kentucky gunpowder was used in several important battles of the Northwest Territory, and was also shipped to New Orleans and used in the famous concluding battle of the war there on 8 January, 1815.[21]

The wholesale middlemen and eastern manufacturers typified by du Pont made an error potentially fatal to the country; in an effort to keep manufacturing costs at minimum, saltpeter brokers in the west were instructed to maintain a price ceiling on saltpeter. This artificial limit bypassed the normal workings of supply and demand, so that even as niter became scarcer during the course of the war, the price paid to the miners was reduced to the point where saltpeter extraction became unprofitable and the miners refused to work at an unrewarding profession. Additionally, failure of miners to practice conservation of a normally renewable resource had resulted in exhaustion of the richest cave deposits, so that the niter industry had moved from Kentucky and Virginia to west Tennessee and Missouri. Had the war continued yet another year, it seems certain that the ceiling would have been overturned and the price of niter jump dramatically, as it had done during the earliest part of the conflict.[22]

With the end of the 1812 war and the renewal of importation of foreign gunpowder and saltpeter, an ailing industry in the interior of America collapsed. Saltpeter from British India was received in eastern ports at a total cost less than the cost of transportation alone for western saltpeter. Foreign powder, particularly that from Britain, was also available at low cost and of high quality. Large domestic manufacturers such as the Du Pont company, with established markets, were able to cope with gunpowder competition from abroad,and the availability of saltpeter at very low cost was all to their advantage. Interior powdermakers, such as the industry that had sprung up during wartime in the Bluegrass, could no longer obtain locally produced saltpeter and would be forced to import foreign supplies with shipping costs tacked on that doubled their costs over their eastern competition. The powder mill industry lingered in the interior states a few more decades, but it was moribund and eventually vanished.[23]

Though the war with Mexican in 1849 did little to stimulate saltpeter mining in the United States, the

Civil War served to temporarily revitalize a defunct industry. The industrial North possessed the capacity to produce gunpowder and arms in great quantity. The DuPont firm was located in Delaware, firmly in the North in both situation and commitment. The North also possessed several other major powder mill manufactories. In the South at the beginning of the war, there existed only two small powder mills of relatively low production. A fairly effective blockade of Southern ports by the North interfered with ordnance shipments to the Confederacy. Of the states containing substantial cavern saltpeter reserves, Kentucky and Missouri were border states not completely dedicated to the Southern cause, Strong Unionist sentiments in western Virginia led that region, with numerous saltpeter caves, to separate in 1863 and thus remove a source of great capacity. Although blockade runners would manage to bring in a fairly substantial amount of both gunpowder and saltpeter to southern ports, it was an uncertain method of supply. The South was left with cavernous Tennessee and the remaining portion of Virginia, and a scattering of saltpeter caves in northern Alabama and Georgia, to secure domestic saltpeter.[24]

These latter states together contained substantial reserves, and the South, out of dire necessity, turned to exploit it on large-scale. President Jefferson Davis addressed the Confederate Congress in January, 1862, stating that "Our present necessity is not for an increase of powder mills, but for a supply of the material for the manufacture of gunpowder. The mills now in existence, and which could readily be put to work, far exceed in their capacity to manufacture our ability to supply the requisite material." Two months later, he again spoke on the subject: "In addition to the mills now established a very extensive one has been constructed in Georgia, which we have not started because the supply of saltpeter did not justify it." Bills were quickly passed by the Congress to encourage the manufacture of saltpeter and small arms, and to organize a corps of officers to "work nitre caves and establish nitre beds." The Secretary of War directed that the highest transportation priority would be given to saltpeter and gunpowder. In April, 1863, an overworked Confederate Ordinance Department relinquished control of the industry to the newly established Nitre and Mining Bureau.[25]

The production of saltpeter continued to increase throughout the duration of the war, being considered a vital industry, and in fact exceeded that of the 1812 boom. Workers in the saltpeter and gunpowder industries were exempted from military service. An exemption issued by Captain W. M. Deitrich at Knoxville, Superintendent of the Seventh District for the Nitre and Mining Bureau, for G. W. McGee, stated that McGee, a resident of Eagles Nest on the Holston River in Tennessee, was "authorized to engage in the Manufacture of Nitre and while so engaged cannot be interfered with by Enrolling or Recruiting Officers." The saltpeter caves were generally in rather isolated areas, and often continued to operate even when Union advances placed them behind enemy lines. In Kentucky, a border state with mixed sympathies that had remained within the Union, a number of saltpeter caves in the Cumberland region near Tennessee were actively if surreptitiously mined at various periods during the war, and numerous others were subject to sporadic utilization by clandestine operations.[26]

The Civil War was the last gasp of the domestic saltpeter industry in the United States, and had then only been stimulated (as in earlier wars) by the disruption of international saltpeter and gunpowder commerce through blockade and adversarial political negotiation. The death blow was about to fall, as the Industrial Revolution swept the country late in the 19th Century and rapid advances were made in chemical technology.

On the west coast of South America was a region where, for countless generations, millions of seabirds had deposited thick layers of droppings. This deposition had resulted in a rich layer of sodium nitrate; unfortunately, gunpowder made from this form of saltpeter contained numerous impurities and was of poor quality. In 1857, Lammot du Pont, a grandson of Irénée, discovered a way to process this Chilean nitrate to produce a high grade saltpeter at very low cost. The new explosive was known as "soda powder" and quickly replaced black powder made with saltpeter from British India. This new blasting powder found widespread use in the fever of iron ore and coal mining then beginning to sweep the nation. Saltpeter lost still more ground as an industrial commodity when, in 1866, Alfred Nobel discovered that nitroglycerin could be rendered stable and useful by saturating a porous material with this formerly precarious chemical. The resulting product, dynamite, was the most powerful explosive yet invented and was soon in great demand.[27]

Rifle and cannon powder, however, still required the use of potassium nitrate, and although Indian saltpeter was still plentiful and relatively inexpensive, national security required a source of ordnance that was not subject to embargo or blockade. The Swiss chemist Christian Friedrich Schöenbein had saturated cotton with nitric and sulfuric acids in 1845 and invented "guncotton," but it had proved too violent to use in weapons. By the 1880's, European chemical laboratories had found ways to use guncotton in powdermaking, and researchers in the United States hastened to duplicate this effort. The Du Pont Company succeeded in producing this new "smokeless powder," which by 1900 had become the standard charge for large and small weapons throughout the world. The Mannlicher rifle model 1886 was the last of the bigbore military rifles designed for the use of black powder. The smoke-filled battlefield now belonged to a past era.[28]

Saltpeter had occupied an important place in the commerce of the world for almost exactly one thousand years, but was relegated to an historic perspective by modern developments in chemical technology.

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NOTES

1. Wang Lin, "On the Invention and Use of Gunpowder and Firearms in China," *Isis* 34(July 1947):160-161; *Chin Shih Pu Wu Chiu Shu Chüeh* (Explanation of the Inventory of Metals and Minerals according to the Numbers Five and Nine), quoted in Joseph Needham *Science in Traditional China: A Perspective* (Cambridge, Mass., and Hong Kong, 1981) 28-29.

2. Chu Chia Shên P'in Tan Fa (Methods of the Various Schools of Magical Elixer Preparations), *Chên Yüan Miao Tao Yao Lüoh* (Classified Essentials of the Mysterious Tao of the True Origin of Things), quoted in Needham, 29-30, 30-31; Robert G. Temple, *China: Land of Discovery* (Wellingborough, G.B., 1987) 226.

3. Needham, 31-32, 37-45.

4. Georgius Agricola, *De Re Metallica*, Herbert Clark Hoover and Lou Henry Hoover, translators (1912; New York, 1986) 562n; Henry Stubbe, "Animadversions upon the History of making Salt-Petre, which was Penned by Mr. Henshaw," *Legends no Histories: or, a Specimen of some Animadversions Upon the 'History of the Royal Society'* (London, 1670) 35-36,38,53, 56-57, University of Kentucky, microfilm B 77-100, Reel 298; Wang Lin, 174; Harold L. Peterson, *Treasury of the Gun* (New York, 1962) 24-26.

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