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Early modern military technology: new trends and old ideas (a bibliographical essay)

Kelly DeVries

Early modern military technology, as Geoffrey Parker's book, *The Military Revolution*, and its supporters and critics have so recently reminded us, almost exclusively pertained to the invention, evolution and proliferation of gunpowder weapons. Indeed, this new technology defined all aspects of the warfare of this era, from fortification construction to naval combat and from the fall of feudal armies to the rise of national forces.

Yet, despite this almost universally agreed upon fact, the study of early gunpowder weapons is but a recent scholarly avocation. Historians contemporary to the early modern period itself credited the change from the medieval to their 'modern' world to many events: the rebirth of classical education and the rediscovery of classical texts, the rise of humanism, the establishment of absolute states, the rise of cities, the exploration of new worlds and the proliferation of non-Catholic Christianity. Surprisingly missing from their analysis is a discussion of the technological changes which occurred in the later Middle Ages. Only a few early modern historical commentators seem to have been impressed by the invention of gunpowder weapons, including Polydore Vergil, Panciroliius, Sebastian Franck, Achilles Pirminius Gasser, Sebastian Munster, Bernard Caesius, James Lesmore Gordon, Athanasius Kircher, Becher, Theodore Janssen ab Almeloveen, Hans Gram and Christian Friderich Temler. But their records are primarily brief discussions of engineering or scientific phenomena which are more concerned with identifying the creation of gunpowder with its fictitious monastic inventor, Berthold Schwartz, than with analyzing the historical use of the technology in warfare.¹

It was not until the middle of the nineteenth century that scholarly interest in the invention and proliferation of gunpowder weapons began to escalate. However, what would eventually become a flood of academic works began as but a trickle with the publication in 1844 of Leon Lacabane's twenty-nine page article, 'De la poudre à canon et de son introduction en France'.² Although Lacabane's work was rather limited in its scope, it did introduce into historical literature a more scholarly discussion of the origins of gunpowder, one which did not try to argue either for or against the legendary Berthold Schwartz. The article did not, however, consider what weapon systems were available which could use this new scientific discovery. Nor did it attempt a broad geographical survey of the subject, choosing instead to limit its geographical range to the borders of France.

This latter problem was corrected somewhat the following year, 1845, when Joseph T. Reinaud and Ildéphonse Fave published their two-volume *Dufeu grégeois, des feux de guerre et des origines de la poudre à canon* in Paris. Like Lacabane's article, this work was an investigation into the scientific history of gunpowder, with the addition of a discussion on Greek fire and other incendiary weapons, some real and some more fantastic. In it, Reinaud and Fave tried to show a connection between the older, medieval incendiaries and the newer gunpowder, a connection which has largely been dismissed by later scholarship. Also like Lacabane's article, this work did not extend itself into an argument of what weapon systems might use gunpowder.

Beginning in 1846 and appearing periodically until 1871 the massive and highly important *Études sur le passé et l'avenir de l'artillerie* was written by no less than the President of the French Republic, Louis-Napoleon Bonaparte, better known in the annals of history as Napoleon III, as assisted by (and some contend written solely by) Ildéphonse Fave, the co-author of the scientific history of gunpowder which appeared in 1845. Published in Paris in six volumes, with a historical scope which extended from medieval catapults and trebuchets to gunpowder artillery in the nineteenth century, this work may have been the most important study of gunpowder weapons ever published. Certainly it has continued to be used by scholars, who have been largely unable to find fault with the authors' evidence or with their conclusions. This comes largely from the fact that Bonaparte and Fave used not only late medieval and early modern scientific and technological treatises, but also narrative and archaeological evidence, gathered from both chronicles and extant pieces. As well, they derived much of their analysis from vast archival sources; transcriptions and, if needed, translations of many of these documents, and of pertinent narrative sources, were included in the work. Perhaps most importantly, and most interestingly considering that Napoleon III's name appears alone on the title page of the first two volumes, the authors did not limit their study to France alone, although it must be admitted that most of their examples did come from that country.

So influential was this work that even before it was completed in 1871 other scholarly volumes on the history of gunpowder weaponry began to appear. The earliest of these treatises was Robert Mallet's lengthy article 'On the Physical Conditions Involved in the Construction of Artillery, and on some Hitherto Unexplained Causes of the Destruction of Cannon in Service', which appeared in 1856.³ While mostly concerned with cannons faced by contemporary British armies, Mallet was also intrigued by the fact that an ancient Turkish cannon, not unlike those used at the siege of Constantinople, had fired a stone gunshot on a British frigate in 1806 and had nearly destroyed it. This caused him to ponder in

an added, lengthy note to the work, entitled the 'Discovery of Gunpowder and Cannon', which, while erroneous on most points, is nonetheless interesting in a historical context.

Paul Henrard's *Histoire de l'artillerie en Belgique depuis son origine jusqu'au règne d'Albert et d'Isabelle*, published in Brussels, followed in 1865. Henrard, then a captain of Belgian artillery and a member of the Académie d'archéologie de Belgique (the organization responsible for publishing this work), attempted with this study to reproduce the effort of Bonaparte and Fave, but to limit his sources to what had been southern Low Countries' areas principally under the control of the Burgundian dukes or the Habsburg monarchs of the Holy Roman Empire and Spain during the time in question. That he does not entirely succeed is not a slight to his scholarly ability, but rather a compliment to work done by the two French authors he was using as examples.

Also appearing before the completion of Bonaparte and Fave's study was F.W.H. Kuypers's *Geschiedenis der Nederlandsche artillerie van de vroegste tijden tot op heden*, published from 1869 to 1874 in Nijmegen. With this work, written in four volumes, with a separate volume for illustrations, Kuypers did essentially the same thing for the Netherlands that Henrard had done for Belgium, although in this case the work was far more elaborate than was the Belgian's. It was also far more devoted to the study of early modern gunpowder weapons, principally those of the Eighty Years War, than either Bonaparte and Fave's or Henrard's studies had been.

Of other middle and late nineteenth-century studies on early gunpowder artillery⁴ two works should be singled out for their excellence and later influence on scholarship. The first, Essenwein's *Quellen zur Geschichte der Feuerwaffen*, is, after Bonaparte and Fave's publication, perhaps the most impressive nineteenth-century analysis of the history of early gunpowder weaponry. Accompanied by a large number of excellent depictions of early gunpowder weapons, made from paintings, manuscript illuminations and engineering drawings as well as from extant exemplars, this work provided fewer source materials about this early technology than Bonaparte and Fave, but more analysis on the technology of the guns. It also introduced many new sources, including a large number of German references, not earlier seen in scholarship.

The second, Joseph Garnier's *L'artillerie des ducs de Bourgogne*, provided an opposite focus to the study of early gunpowder weapons to that of Essenwein's. Garnier's work is nearly devoid of analysis, replacing it instead with a lengthy transcription of all of the archival records of Burgundian gunpowder artillery holdings from 1362 until 1485, a period covering the very important reigns of Valois Dukes Philip the Bold, John the Fearless, Philip the Good and Charles the

Bold. In these records can be found references not only to the conditions, size and numbers of the weapons themselves, but also to the cost and technology of these weapons, their projectiles and powder, the organization of artillery trains and the use of on-site blacksmiths and masons to provide repairs and gunstones.

Two other studies also ought to be singled out for separate consideration as they introduced the subject of early handguns, attempting to explain the origins and evolution of this more specialized but very important aspect of gunpowder weapon technology. These were M. Thierbach's monograph *Die geschichtliche Entwicklung des Handfeuerwaffen bearbeitet nach den in den deutschen Sammlungen noch vorhandenen Originalen* (Dresden 1886) and P. Sixl's long series of articles, 'Entwicklung und Gebrauch der Handfeuerwaffen', which appeared in the first four issues of the *Zeitschrift für Historische Waffenkunde* (1897-1908).⁵

The historical interest on early gunpowder weapons continued into the early twentieth century.⁶ Of great importance and influence were R. Coltman Clephan's two works. His first, *An Outline of the History and Development of Hand Firearms* (London 1906), attempted to bring up to date and to translate into English the vital points of Thierbach's and Sixl's studies. While the second, a lengthy two-part article, 'The Ordnance of the Fourteenth and Fifteenth Centuries',⁷ which appeared in 1911, attempted to do the same for the large-scale gunpowder weaponry studies written by Bonaparte and Fave, among others - part one of this work discussed numberless written sources to early gunpowder weaponry, while part two analyzed all of the known extant exemplars from the late Middle Ages. In this regard Clephan succeeded marvelously. Many of his references were new, his scholarship was concise but erudite, and his analysis was fresh. Above all, the historical questions which he asked served to renew the scholarly debates put forth by the early nineteenth-century analysts which had all too easily been shelved by so many of the late nineteenth-century writers.

Also of significance were two monographs written by Bernhard Rathgen which followed up his article on fourteenth-century Flemish artillery mentioned above, *Das Aufkommen der Pulverwaffe* (Munich 1925) and *Das Geschütz im Mittelalter* (Berlin 1928). Although the latter monograph covered the medieval catapult more than the gun, both works were comprehensive and learned. Among other things, his work on the Burgundian guns of the Hundred Years War, undoubtedly influenced by the archival work of Joseph Garnier, showed that gunpowder weapon technology was conclusively preeminent in that duchy during the late fourteenth and early fifteenth centuries.

After these works appeared in the early twentieth century, however, there seems to have been a lull in large-scale historical analysis on early gunpowder

weaponry until 1960. What replaced these were shorter works, more specialized or localized in focus.⁸ However, studies with a broader scope, like those of Bonaparte and Fave, Essenwein, Clephan and Rathgen, were not written.

Why this break in more comprehensive scholarship existed can perhaps not be known, but its existence was enough to encourage J.R. Partington, an emeritus professor of Chemistry at the University of London, to write *A History of Greek Fire and Gunpowder*, which was published in Cambridge in 1960. And while this work has been justly criticized - Partington was certainly a better chemist than he was a historian - it did mark the reopening of research into the history of early gunpowder weaponry.

Some of this was written more for a popular audience than a scholarly one, such as the three works written by retired Brigadier O.F.G. Hogg, *The Royal Arsenal* (London 1963), *English Artillery, 1326-1716* (London 1963), and *Artillery: Its Origin, Heyday and Decline* (London 1963), all of which were repetitive and pedestrian. But most were of a scholarly nature.⁹

Each of the works mentioned in the preceding note had one purpose: to investigate the invention, evolution, proliferation and technology of gunpowder weapons. Few explored the use of these weapons in military engagement and even fewer examined their impact on political, economic, technological or social history. But the above works did influence studies which focused on these issues, although in the guise of more standard military and technological histories. It is through these studies that we can recognize the effects of more than a century and a half of historical research in early gunpowder weaponry.

In chronologically wide-sweeping or general military histories, the effect of these works may not be immediately apparent. Before 1950, lengthy sections were devoted to the use of early gunpowder weapons only in Hans Delbrück's six volume *Geschichte der Kriegskunst im Rahmen des politischen Geschichte* (Berlin 1920-1932)¹⁰ and Charles Terlinden's *Histoire militaire des Belges* (Brussels 1931). However, this may be because of the very few general military surveys actually written before this late date, and not because of any neglect on the part of historians writing these studies. This assumption is in fact supported by the large number of military history surveys written after 1950 which do include discussions on the use of early gunpowder weapons in warfare.¹¹ Also, all through the twentieth century, more chronologically specific studies were published which devoted relatively large sections to an examination of the military use of early guns.¹²

Especially active are historians of late medieval and early modern navies, almost all of whom have written extensive analyses of the influence of shipboard artillery on the naval warfare of the period, and historians of late medieval and early modern fortifications, all of whom comment on the changes in fortification

construction brought about by the use of gunpowder weapons in sieges.¹³ There have also been a number of studies done on the effect of gunpowder weapons on the practice of battlefield surgery.¹⁴

Finally, interest in early European gunpowder weaponry has also encouraged research in the origin, evolution and proliferation of non-European gunpowder weapon technology. Perhaps the most impressive work in this field is by Joseph Needham, as part of his research in the history of Asian science, which culminated in the 1986 publication of the volume *Military Technology: The Gunpowder Epic* in his series *Science and Civilisation in China*.¹⁵

Early gunpowder weaponry has also become an interesting subject for the historians of technology. Certainly this is evident in the increasingly popular histories of military technology.¹⁶

This brings us to the current interest in the use and impact of early gunpowder weapons, as framed in the phrase 'The Military Revolution'. In a paper delivered at Queen's University in January 1955, Michael Roberts, then professor of History at the university, with a particular interest in early modern Swedish history, developed an engaging and highly original thesis: that the evolution and proliferation of early gunpowder weapons had in fact caused significant changes in the art of European warfare between 1560 and 1660. These changes included a 'revolution in tactics', in which lines of infantry armed with gunpowder weapons supplanted the more conventional pikemen and cavalry. These tactics required more organization and better training, producing the first 'standing army', and were found principally in the early modern Dutch and Swedish armies. They also eventually led to the development of formal military education.

The second change consisted of a 'revolution in strategy'. This meant that the better armed, professional soldiers which had been created by new training and better organization were now able to attempt more challenging strategies. Several national armies could now operate at the same time, allowing the conquests made by Gustavus Adolphus and other early modern generals.

These large armies led to the third change: an increase in the scale of warfare waged throughout Europe. More troops were needed and more conquests were made. More battles were fought and longer and more violent wars were waged.

This in turn increased the impact war had on society. The economic strain of having to support standing armies, the violence brought by large numbers of pillaging soldiers - from both enemy and friendly armies - and the rise of larger military supported states all hindered the continued prosperity of a society traditionally removed from these facets of warfare.

Printed as a pamphlet under the title *The Military Revolution, 1560-1660* by the University of Belfast in 1956,¹⁷ Roberts' thesis immediately became the object of

interest among military historians and historians of technology, most of whom applauded his efforts. Here it seemed finally that a reputable scholar had been able to synthesize the earlier studies on late medieval and early modern gunpowder weapons and to determine that a 'revolution' had in fact occurred because of their presence in Europe at that time.

For more than twenty years Roberts' thesis stood without significant criticism directed against him. But in 1976 a prominent young historian, Geoffrey Parker, whose own work on the Eighty Years War had already brought him accolades, questioned the accuracy of Roberts' technological determinism.¹⁸ Agreeing with Roberts that gunpowder weaponry had 'revolutionized' the scale of warfare in early modern Europe and that this had 'important and wide-ranging consequences' for society, he nevertheless disagreed with the earlier scholar's conclusions that tactics or strategy had been significantly affected by gunpowder weaponry, at least not in a way that always ensured decisive military success. He also saw no innovation in accepting more organization and better training, which he not only traced back to the fifteenth century but also to the sixteenth- and seventeenth-century Spanish army, an army excluded by Roberts in his analysis. Instead, Parker saw early modern strategy and tactics determined by geography and the presence or absence of modern artillery fortifications (the *trace italienne*).

Parker, in turn, also met with little criticism. Only in an article by David A. Parrott, published in 1985, were Parker's criticisms of Roberts' thesis even questioned, and this was not in support of Roberts over Parker, but rather to 'propose an alternative argument'.¹⁹ For Parrott, whose own research focused on the administration and organization of the seventeenth-century French army, 'the characteristic of the period was not revolution, but an almost complete failure to meet the challenges posed by the administration and deployment of contemporary armies'. Battles were won or lost irrespective of the tactical changes brought about by gunpowder weapons, and in fact battles became an irrelevant aspect of warfare during the period because of the failure of strategy to 'come to terms with the real determinants of warfare' during the period.

Roberts' thesis refused to die, however, and in 1988 a most curious defense of the 'Military Revolution' was published. It was most curious because it came from Geoffrey Parker. *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800* (Cambridge 1988), initially presented as a series of four lectures given at Cambridge University and dedicated to Michael Roberts, showed that Parker had become convinced, nearly a decade after his own criticism of Roberts' work, that a revolution in military tactics and strategy had indeed been effected by the innovation of gunpowder weaponry. This coupled with his continued belief in the supremacy of *trace italienne* fortifications led him to propose that not only were

the organization and education of early modern soldiers altered, the scale of warfare enlarged, and society adversely affected, but the use of gunpowder weapons also meant significant changes in supplying the armies, naval warfare, and, ultimately, the ability of Europeans to make conquests against non-European powers not blessed with such technologically destructive weapons.

Now it was Parker's book which was generally acclaimed without criticism. Most reviewers praised it with the highest accolades, and the Society for the History of Technology and the Society for Military History (formerly the American Military Institute) both awarded the book their best book honors. Some historians - like David Ralston in his *Importing the European Army: The Introduction of European Military Techniques and Institutions into the Extra-European World, 1600-1914* (Chicago 1990) and Brian M. Downing in his *The Military Revolution and Political Change in Early Modern Europe* (Princeton 1992) - have even used Parker's work as the basis of their own studies.

However, some criticism of Parker's *Military Revolution* has begun to appear. Initially this was in the form of an essay review by Bert S. Hall and Kelly DeVries which appeared in 1990, questioning Parker's chronological conclusions and technological determinism.²⁰ Later that same year a series of papers presented at a symposium at the University of Illinois by John A. Lynn, Simon Adams, William Maltby, Richard Hellie, Bruce P. Lenman, Don Higginbotham, Dennis Showalter, Hew Strachan, and Sir Michael Howard, was published under the title *Tools of War: Instruments, Ideas, and Institutions of Warfare, 1445-1871* (Urbana 1990), edited by John Lynn. Although not attacking Parker's work directly, each paper in the series challenged the concept of early modern technological determinism, thus damaging the foundation of Parker's thesis (and Roberts' before him).

Finally, in 1991, two more direct criticisms of Parker's study appeared. The first, *A Military Revolution? Military Change and European Society, 1550-1800* (Atlantic Highlands, N.J., 1991), by Jeremy Black, questioned Parker's military changes, believing that if there was a military revolution in early modern Europe it did not occur until after 1660 and resulted not from technological determinism but from the rise of absolutist states: 'Increases in armed forces encouraged other rulers who wished to play a major role in what was an aggressive competitive international system to follow suit'. The second, John A. Lynn's 'The *trace italienne* and the Growth of Armies: The French Case', argues that the construction and propagation of *trace italienne* fortifications cannot explain the increased size of the French army during the seventeenth century, nor in fact can it be seen as 'the most fundamental variable in the equation'.²¹ Instead, Lynn proposes that 'French economic and demographic development made military expansion possible' and that 'dynastic ambition and eventual diplomatic isolation forced the Bourbons to

multiply the number of their battalions'. Only after this, during the reign of Louis XIV, did fortifications begin to be influential.

This list of studies may seem exhausting, but in fact many more sources must still be researched and scrutinized, and more theses must be theorized. For the invention of gunpowder weaponry, whether or not it was a determining factor in significant late medieval and early modern military, technological, and societal changes, still marked a historical event which deserves to be studied and studied well.

Notes

1. For a discussion of these early modern writers, see: J.R. Partington, *A History of Greek Fire and Gunpowder* (Cambridge 1960) 93-95.
2. L. Lacabane in: *Bibliothèque de l'école de chartes* 2nd series, 1 (1844) 28-57.
3. R. Mallet in: *Transactions of the Royal Irish Academy* 23 (1856) 141-436.
4. A. de la Fons-Melicocq, *De l'artillerie de la ville de Lille aux XIVe, XVe et XVIe siècles* (Lille 1854); A. von Essenwein, *Quellen zur Geschichte der Feuerwaffen* (Leipzig 1872); G. Susane, *Histoire de l'artillerie française* (Paris 1874); D. Poncin, *De la science au Moyen Age. Archéologie balistique* (Antwerp 1885); Paul Henrard, 'Documents les plus anciens sur l'emploi des canons et des armes à feu dans les Pays-Bas', *Annales de la Fédération Archéologique et Historique de Belgique* 3 (1888) 218-223; Joseph Garnier, *L'artillerie des ducs de Bourgogne d'après les documents conservés aux archives de la Côte-d'Or* (Paris 1895); Joseph Hunter, 'Proofs of the Early Use of Gunpowder in the English Army', *Archaeologia* 32 (1897) 379-387; M. Jähns, *Entwicklungsgeschichte der alten Trutzwaffen (Anhang Feuerwaffen)* (Berlin 1899).
5. It should be noted that Samuel Rush Meyrick had, in 1829, attempted a study of early handguns. But his work, 'Observations upon the History of Hand Fire-arms, and their Appurtenances', *Archaeologia* 22 (1829) 59-105, devoted little space to a discussion of the origin and early evolution of hand-held gunpowder weapons, choosing instead to dwell upon their later history, which could be supported more easily by archaeological evidence.
6. H.W.L. Hime's two works, *Gunpowder and Ammunition: Their Origin and Progress* (London 1904) and *The Origin of Artillery* (London 1915), which were much more of a scholarly effort than their English predecessor, Robert Mallet; Karl Jacobs, *Beiträge zur Geschichte der Feuerwaffen am Niederrhein bis zum Jahre 1400* (Bonn 1910), perhaps the most intricate study of fourteenth-century Rhenish artillery written; Thomas F. Tout, 'Firearms in England in the Fourteenth Century', *English Historical Review* 26 (1911) 666-702; Rudolf Schneider, 'Feuer- und Fernwaffen beim päpstlichen Heer im 14. Jahrhundert', *Zeitschrift für historische Waffenkunde* 7 (1915); Bernhard Rathgen, 'Feuer- und Fernwaffen des 14. Jahrhunderts in Flandern', *Zeitschrift für historische Waffenkunde* 7 (1915-1917) 275-306, which attempted to do the same for England, the Papacy and Flanders respectively.

7. R. Coltman Clephan in: *Archaeological Journal* 68 (1911) 49-138.
8. These included: Edouard Perroy, 'L'artillerie royale la bataille de Montlher (10 juillet 1465)', *Revue Historique* 149 (1925) 187-189; Charles ffoulkes, *The Gun-founders of England* (Cambridge 1937), which included a list of 'all' English and Continental gun-founders from the fourteenth to the nineteenth centuries; Wilhelm Hassenstein's edition and analysis of *Das Feuerwerkbuch von 1420* (Munich 1941); H. Schubert, 'The First Cast-Iron Cannon Made in England', *The Journal of the Iron and Steel Institute* 146 (1942) 131P-140P; Edouard Perroy, 'L'artillerie de Louis XI dans la campagne d'Artois', *Revue du Nord* 26 (1943) 171-196, 293-315; W.H. Finlayson, 'Mons Meg', *Scottish Historical Review* 27 (1948) 124-126; Charles Roland, 'L'artillerie de la ville de Binche, 1362-1420', *Bulletin de la société royale paléontologique et archéologique de l'arrondissement judiciaire de Charleroi* 23 (1954) 17-38. As well, some authors devoted a section of their more general historical surveys of guns to the early history of the weapons - such as W.Y. Carman's chapter on 'The Development of Cannon', which introduced his *A History of Firearms from Earliest Times to 1914* (London 1955).
9. Among the most important ones were: Philippe Contamine, 'L'artillerie royale française à la veille des guerres d'Italie', *Annales de Bretagne* 71 (1964) 221-261; J.R. Hale, 'Gunpowder and the Renaissance: An Essay in the History of Ideas' in: Ch.H. Carter (ed.), *From Renaissance to Counter-Reformation: Essays in Honour of Garrett Mattingly* (London 1966) 113-144; Claude Gaier, 'The Origin of Mons Meg', *The Journal of the Arms and Armour Society* 5 (1967) 425-452; Heinrich Müller, *Deutsche Bronzegeschützrohre, 1400-1750* (Berlin 1968); François T'Sas, 'Dulle Griet. La grosse bombarde de Gand, et ses souers', *Armi Antiche* (1969) 13-57; H. Schneider, 'Schweizerische Handfeuerwaffen. Stand der Forschung', *Zeitschrift für Historische Waffenkunde* 13 (1971) 40-51; C. Bosson, 'La mis à feu et l'amélioration de la balistique dans l'arme portative', *Armi Antiche* (1971) 117-176, (1972) 79-111, (1973) 191-218; Bernard Delmaire, 'L'artillerie d'Aire au XVe siècle', *Société académique des antiquaires de la Morine* 22 (1973) 99-113; J.-F. Fino, 'L'artillerie en France à la fin du moyen âge', *Gladius* 12 (1974) 13-31; A.R. William, 'Some Firing Tests with Simulated Fifteenth-Century Handguns', *The Journal of the Arms and Armour Society* 8 (1974) 114-120; M.G.A. Vale, 'New Techniques and Old Ideals: The Impact of Artillery on War and Chivalry at the End of the Hundred Years War' in: C.T. Allmand (ed.), *War, Literature and Politics in the Late Middle Ages: Essays in Honour of G.W. Coopland* (Liverpool 1975) 57-72; H.L. Blackmore, *The Armouries of the Tower of London. I. Ordnance* (London 1975); H. Dubled, 'L'artillerie royale française à l'époque de Charles VII et au début du règne de Louis XI (1437-1469): Les frères Bureau', *Memorial de l'artillerie française* 50 (1976) 555-637; Volker Schmidtchen, *Bombarden, Befestigungen, Buchsenmeister. Von den ersten Mauerbrechen des Spätmittelalters zur Belagerungsartillerie der Renaissance* (Dusseldorf 1977); Ewart Oakeshott, 'The Developing Power of the Handgun' in: idem, *European Weapons and Armour from the Renaissance to the Industrial Revolution* (Guildford 1980); C.T. Allmand, 'L'artillerie de l'armée anglaise et son organisation à l'époque de Jeanne d'Arc' in: *Jeanne d'Arc: une époque, un rayonnement, Colloque d'histoire médiévale. Orléans - Octobre 1979* (Paris

- 1982) 73-83; S. de Hoir, 'Guns in Medieval and Tudor Ireland', *Irish Sword* 15 (1982-1983) 76-88; Philippe Contamine, 'Les industries de guerre dans la France de la Renaissance: l'exemple de l'artillerie', *Revue Historique* 271 (1984) 249-280; Michel de Lombarès, *Histoire de l'artillerie française* (Paris 1984); Dorothea Goetz, *Die Anfänge der Artillerie* (Berlin 1985); Dhira B. Mahoney, 'Malory's Great Guns', *Viator* 20 (1989) 291-310; Robert D. Smith and Ruth Rhynas Brown, *Bombards: Mons Meg and Her Sisters* (London 1989). As well, in 1986, an entire issue (vol. 26) of the *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* was devoted to a discussion of gunpowder weapons in the Late Middle Ages.
10. Translated into English as *A History of the Art of War within the Framework of Political History*, transl. Walter J. Renfroe (Westport, Conn., 1975-), of which vols. 5-6 are yet to appear. See particularly volume 4.
 11. These include: John U. Nef, *War and Human Progress: An essay on the Rise of Industrial Civilization* (New York 1950); J.F.C. Fuller, *The Decisive Battles of the Western World and their Influence upon History*, 2 vols., edited by John Terraire (London 1970), particularly volume 1; Richard A. Preston, Sidney F. Wise and Herman O. Werner (later revised by Preston, Wise and Alex Roland), *Men in Arms: A History of Warfare and its Interrelationships with Western Society* (New York 1956), Alex Roland revised the fifth edition of this work; Theodore Ropp, *War in the Modern World* (New York 19622); Michael Howard, *War in European History* (Oxford 1976); Gwynne Dyer, *War* (New York 1985); Paul Kennedy, *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000* (New York 1987); Archer Jones, *The Art of War in the Western World* (Urbana, Ill., 1987); Larry H. Addington, *The Patterns of War through the Eighteenth Century* (Bloomington 1990); Frederic J. Baumgartner, *From Spear to Flintlock* (Westport, Conn., 1991).
 12. On general medieval warfare: G. Kohler, *Die Entwicklung des Kriegswesens und der Kriegführung in der Ritterzeit von Mitte des 11. Jahrhunderts bis zu den Hussitenkriegen* (Berlin 1887); Sir Charles Oman, *A History of the Art of War in the Middle Ages*, 2 vols. (London 1924), see particularly volume 2; Ferdinand Lot, *L'art militaire et les armées au moyen âge en Europe et dans le Proche Orient*, 2 vols. (Paris 1946), see particularly volume 2; Claude Gaier, *L'industrie et le commerce des armes dans les anciennes principautés Belges du XIII^e à la fin du XV^e siècle* (Paris 1963); idem, *Art et organisation militaires dans la principauté de Liège et dans le comté de Looz au moyen âge* (Brussels 1968); H.W. Koch, *Medieval Warfare* (New York 1978); Philippe Contamine, *La guerre au moyen âge* (Paris 1980), English translation: *War in the Middle Ages*, transl. Michael Jones (London 1984); on the Hundred Years War and its participants: J. Lachauvelaye, *Guerres des Français et des Anglais du XI^e au XV^e siècle*, 2 vols. (Paris 1875); idem, 'Mémoire sur la composition des armées de Charles le Téméraire dans les deux Bourgognes d'après les documents originaux', *Mémoires de l'Académie des Sciences, Arts et Belles-Lettres de Dijon*, 3rd series, 5 (1879) 139-369; idem, 'Les armées des trois premiers ducs de Bourgogne', *Mémoires de l'Académie des Sciences, Arts et Belles-Lettres de Dijon*, 3rd series, 6 (1880) 19-335; V. Fris, 'La bataille de gave', *Bulletin de la Société d'Histoire et d'Archéologie de Gand* 18 (1910)

- 185-233; Charles Brusten, *L'armée Bourguignonne de 1465 à 1468* (Brussels 1953); Alfred H. Burne, *The Crecy War* (London 1955); idem, *The Agincourt War* (London 1956); Richard Vaughan, *Philip the Bold: The Formation of the Burgundian State* (London 1962); idem, *John the Fearless: The Growth of Burgundian Power* (London 1966); idem, *Philip the Good: The Apogee of Burgundy* (London 1970); idem, *Charles the Bold: The Last Valois Duke of Burgundy* (London 1973); Philippe Contamine, *Guerre, état et société à la fin du moyen âge: Études sur les armées des rois de France, 1337-1494* (Paris 1972); Eugene Herr, 'Armes et armures au temps des guerres de Bourgogne', in: *Grandson 1476, Centre d'histoire et de prospective militaires, série recherches de sciences comparées II* (Lausanne 1976) 170-199; Desmond Seward, *The Hundred Years War: The English in France, 1337-1453* (New York 1978); M.G.A. Vale, *War and Chivalry: Warfare and Aristocratic Culture in England, France and Burgundy at the End of the Middle Ages* (London 1981); Claude Gaier, 'Le rôle des armes à feu dans les batailles Liégeoises au XVe siècle', *Le musée d'armes* 51 (1986) 1-12, also in: *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* 26 (1986) 31-37; Monique Sommé, 'L'artillerie et la guerre de frontière dans le nord de la France de 1477 à 1482', *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* 26 (1986) 57-70; C.T. Allmand, *The Hundred Years War: England and France at War, c.1300-c.1450* (Cambridge 1988); on the Wars of the Roses: Charles Ross, *The Wars of the Roses*, (London 1976); Anthony Goodman, *The Wars of the Roses: Military Activity and English Society, 1452-97* (London 1981); on the wars of the Renaissance: Frederick L. Taylor, *The Art of War in Italy, 1494-1529* (Cambridge 1921); Michael E. Mallett, *Mercenaries and their Masters: Warfare in Renaissance Italy* (London 1974); Michael E. Mallett and Sir John R. Hale, *The Military Organization of a Renaissance State: Venice c. 1400 to 1617* (Cambridge 1984); Luciano Pezzolo, 'Armi, ideologia e politica nel cinquecento Veneto: suggestioni di una ricerca', *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* 26 (1986) 97-104; on the armies and wars of the sixteenth and seventeenth centuries: F. de Vaux de Foletier, *Galiot de Genouillac, maître de l'artillerie de France (1465-1546)* (Paris 1925); Michael Roberts, *Gustavus Adolphus: A History of Sweden*, 2 vols. (London 1953-1958); Thomas Esper, 'The Replacement of the Longbow by Firearms in the English Army', *Technology and Culture* 6 (1965) 382-393; C.G. Cruickshank, *Elizabeth's Army* (Oxford 1966); idem, *Army Royal: Henry VIII's Invasion of France, 1513* (Oxford 1969); Geoffrey Parker, *The Army of Flanders and the Spanish Road, 1567-1659* (Cambridge 1972); André Corvisier, *Armies and Societies in Europe, 1494-1789*, transl. A.T. Siddall (Bloomington 1979); Sir John R. Hale, *War and Society in Renaissance Europe, 1450-1620* (London 1985); David C. Goodman, *Power and Penury: Government, Technology and Science in Philip II's Spain* (Cambridge 1988); and on chivalry: Sir Arthur Bryant, *The Age of Chivalry* (New York 1963); Raymond Rudorff, *Knights and the Age of Chivalry* (New York 1974); Maurice Keen, *Chivalry* (New Haven 1984).
13. Studies by naval historians writing about the impact of early gunpowder weaponry include: Sir William Laird Clowes, *The Royal Navy*, 7 vols. (London 1897), see particularly volume 1; Charles de la Roncière, *Histoire de la marine française*, vol. II: *La guerre de cent ans. Révolution maritime* (Paris 1900); Frederic C. Lane, 'Naval

Architecture about 1550', *Mariner's Mirror* 20 (1934) 24-29, reprinted in: *Venice and History: The collected Papers of Frederic C. Lane* (Baltimore 1966) 163-188; idem, *Navires et constructeurs à Venise pendant la Renaissance* (Paris 1965); idem, *Venetian Ships and Shipbuilders of the Renaissance* (Baltimore 1934); L.G. Carr Laughton, 'Hull Protection', *Mariner's Mirror* 26 (1940) 55-60; idem, 'Early Tudor Ship-Guns', *Mariner's Mirror* 46 (1960) 242-285; M. Lewis, *Armada Guns: A Comparative Study of English and Spanish Armaments* (London 1961); Carlo M. Cipolla, *Guns and Sails in the Early Phase of European Expansion, 1400-1700* (London 1965); Peter Padfield, *Guns at Sea* (London 1975); John Francis Guilmartin, Jr., 'The Early Provision of Artillery Armament on Mediterranean War Galleys', *Mariner's Mirror* 59 (1973) 257-280; idem, *Gunpowder and Galleys. Changing Technology and Mediterranean Warfare at Sea in the Sixteenth Century* (Cambridge 1974); idem, 'The Cannon of the *Batavia* and the *Sacramento*: Early Modern Cannon Founding Reconsidered', *The International Journal of Nautical Archaeology and Underwater Exploration* 11 (1982) 133-144; idem, 'The Guns of the *Santissimo Sacramento*', *Technology and Culture* 24 (1983) 559-601; Sir John R. Hale, 'Men and Weapons: The Fighting Potential of Sixteenth-Century Venetian Galleys', in: B. Bond and I. Roy (ed.), *War and Society: A Yearbook of Military History* (London 1975) 1-23; Ulysses Pernambucano de Mello, 'The Shipwreck of the Galleon *Sacramento* - 1668 off Brazil', *The International Journal of Nautical Archaeology and Underwater Exploration* 8 (1979) 211-223; I.A.A. Thompson, 'Spanish Armada Guns', *Mariner's Mirror* 61 (1975) 355-371; Richard W. Ungar, *The Ship in the Medieval Economy, 600-1600* (Montreal 1980); Jeremy N. Green, 'The Armament from the *Batavia*', *The International Journal of Nautical Archaeology and Underwater Exploration* 9 (1980) 43-51; Margaret Rule, *The Mary Rose. The Excavation and Raising of Henry VIII's Flagship* (London 1985); Archibald R. Lewis and Timothy J. Runyan, *European Naval and Maritime History, 300-1500* (Bloomington 1985); C.G. Roelofsen, 'L'évolution de la flotte "Bourguignonne" aux XVe et XVIe siècles: quelques remarques sur l'introduction du canon dans la guerre maritime et son influence', *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* 26 (1986) 87-95; A.G. Jongkees, 'Armement et action d'une flotte de guerre: la contribution des comtés maritimes à l'armée générale des pays de Par-Deçà en 1477', *Publication du centre Européen d'études Bourguignonnes (XIVe-XVIe s.)* 26 (1986) 71-86; Frank Howard, 'Early Ship Guns. Part I: Built-up Breech Loaders', *Mariner's Mirror* 72 (1986) 439-453; idem, 'Early Ship guns. Part II: Swivels', *Mariner's Mirror* 73 (1987) 49-55; Colin J.M. Martin and Geoffrey Parker, *The Spanish Armada* (London 1988); John H. Pryor, *Geography, Technology, and War: Studies in the Maritime History of the Mediterranean, 649-1571* (Cambridge 1988); Kelly DeVries, 'A 1445 Reference to Shipboard Artillery', *Technology and Culture* 31 (1990) 818-829.

Indeed, so important is this discussion to naval historians that in 1988 an issue of the *International Journal of Nautical Archaeology and Underwater Exploration* was devoted to its examination, including one article, 'Towards a New Typology for Wrought Iron Ordnance', by Robert D. Smith, which sought to redefine the words used to analyze early gunpowder weapons to better suit the needs of naval researchers and underwater archaeologists. In this volume of the journal, 17 (1988), Smith's article is on

pp. 5-16, other articles include: R.A. Konstam, '16th Century Naval Tactics and Gunnery', 17-23; Joe J. Simmons, III, 'Wrought-Iron Ordnance: Revealing Discoveries from the New World', 25-34; John F. Guilmartin, Jr., 'Early Modern Naval Ordnance and European Penetration of the Caribbean: The Operational Dimension', 35-53; and Colin J.M. Martin, 'A 16th Century Siege Train: The Battery Ordnance of the 1588 Spanish Armada', 57-73. A second article, published in the same journal, 18 (1989), the following year, entitled 'A Proposed Standard in the Reporting of Historic Artillery' (191-202), written by Rudi Roth, proposed further definitional standardization.

Studies by historians of fortification changes resulting from the use of gunpowder weaponry include: E. Viollet-le-Duc, *Dictionnaire raisonné de l'architecture française du XI^e au XVI^e siècle*, 8 vols. (Paris 1875); Sidney Toy, *A History of Fortification from 3000 B.C. to A.D. 1700* (New York 1955); B.H.St.J. O'Neil, *Castles and Cannon: A Study of Early Artillery Fortifications in England* (Oxford 1960); Horst de la Croix, 'The Literature on Fortification in Renaissance Italy', *Technology and Culture* 4 (1963) 30-50; Sir John R. Hale, 'The Early Development of the Bastion: An Italian Chronology' in: idem (ed.), *Europe in the Late Middle Ages* (Evanston, Ill., 1965) 466-494; idem, *Renaissance Fortification: Art or Engineering?* (London 1977); J.-F. Fino, *Forteresses de la France médiévale* (Paris 1967); D.F. Renn, 'The Earliest Gunports in Britain?', *Archaeological Journal* 125 (1968) 301-303; J.R. Kenyon, 'Early Artillery Fortification in England and Wales', *Fort* 1 (1976) 22-25; idem, 'Artillery and the Defences of Southampton, circa 1360-1660', *Fort* 3 (1977) 8-13; idem, 'Early Gunports: A Gazetteer', *Fort* 4 (1977) 4-6; idem, 'Early Artillery Fortifications in England and Wales: A Preliminary Survey', *Archaeological Journal* 138 (1981) 205-240; idem, 'The Gunloops at Raglan Castle, Gwent' in: J.R. Kenyon and R. Avent (ed.), *Castles in Wales and the Marches. Essays in Honour of D.J. Cathcart King* (Cardiff 1987) 143-160; Judith Hook, 'Fortifications and the End of the Sienese State', *History* 62 (1977) 372-387; Christopher Duffy, *Siege Warfare: The Fortress in the Early Modern World, 1494-1660* (London 1979); Iain MacIvor, 'Artillery and Major Places of Strength in the Lothians and the East Border, 1513-1542' in: D.H. Caldwell (ed.), *Scottish Weapons and Fortifications, 1100-1800* (Edinburgh 1981) 94-152; Christopher J. Tabraham and George L. Good, 'The Artillery Fortification at Throava Castle, Galloway' in: D.H. Caldwell (ed.), *Scottish Weapons and Fortifications, 1100-1800* (Edinburgh 1981) 55-72; Colin Platt, *The Castle in Medieval England and Wales* (New York 1988); J.B. Bury, 'The Early History of the Explosive Mine', *Fort* 10 (1982) 23-30; Simon Pepper, 'The Underground Siege', *Fort* 10 (1982) 31-38; Simon Pepper and Nicholas Adams, *Firearms and Fortifications: Military Architecture and Siege Warfare in Sixteenth-Century Siena* (Chicago 1986); M.W. Thompson, *The Decline of the Castle* (Cambridge 1987); David Eltis, 'Towns and Defense in Later Medieval Germany', *Nottingham Medieval Studies* 33 (1989) 91-103.

14. These include the following works: Theodore Billroth, *Historical Studies on the Nature and Treatment of Gunshot Wounds from the Fifteenth Century to the Present Time*, transl. C.P. Rhoads (New Haven 1933); J. Trueta, *The Principles and Practice of War*

- Surgery* (London 1943); George Gask, 'Historical Sketch of the Methods of Treating Wounds in the Chest in War from A.D. 1300 to 1900' in: *Essays in the History of Medicine* (London 1950) 145-156; Allen O. Whipple, *The Story of Wound Healing and Wound Repair* (Springfield, Ill., 1963); Kelly DeVries, 'Military Surgical Practice and the Advent of Gunpowder Weaponry', *Canadian Bulletin of Medical History* 7, 131-146.
15. Volume 7 (Cambridge 1986), see also volume 5: *Chemistry and Chemical Technology*. See also his 'The Epic of Gunpowder and Firearms, Developing from Alchemy' in: *Science in Traditional China* (Cambridge, Mass., 1981) 27-56; *Gunpowder as the Fourth Power, East and West* (Hong Kong 1985); and the work done with his students, Lu Gwei-Djen and Phan Chi-Hsing, 'The Oldest Representation of a Bombard', *Technology and Culture* 29 (1988) 594-605. Other studies include the following works of Bernhard Rathgen, 'Die Pulverwaffe in Indien', *Ostasiatische Zeitschrift* 12 (1925) 11-30 and 196-217; L. Carrington Goodrich and Feng Chia-Sheng, 'The Early Development of Firearms in China', *Isis* 36 (1946) 114-123 and 250-251; D.M. Brown, 'The Impact of Firearms on Japanese Warfare, 1543-98', *The Far Eastern Quarterly* 7 (1948) 236-253; David Ayalon, *Gunpowder and Firearms in the Mamluk Kingdom: A Challenge to a Mediaeval Society* (London 1956); Sir Steven Runciman, *The Fall of Constantinople, 1453* (Cambridge 1965); A. Rahman Zaky, 'Gunpowder and Arab Firearms in the Middle Ages', *Gladius* 6 (1967) 45-58; G. White, 'Firearms in Africa: An Introduction', *Journal of African History* 12 (1971) 173-184; H.J. Fischer and V. Rowland, 'Firearms in the Central Sudan', *Journal of African History* 12 (1971) 215-239; A.C. Hess, 'Firearms and the Decline of Ibn Khaldun's Military Elite', *Archivum Ottomanicum* 4 (1972) 173-199; Djurdjica Petrovic, 'Fire-arms in the Balkans on the Eve of and after the Ottoman Conquests of the Fourteenth and Fifteenth Centuries' in: V.J. Parry and M.E. Yapp (ed.), *War, Technology and Society in the Middle East* (London 1975) 164-194; Halil Inalcik, 'The Socio-political Effects of the Diffusion of Fire-arms in the Middle East' in: V.J. Parry and M.E. Yapp (ed.), *War, Technology and Society in the Middle East* (London 1975) 195-217; I.A. Khan, 'Origin and Development of Gunpowder Technology in India, AD 1250-1500', *Indian Historical Review* 14.1 (1977) 20-29; idem, 'Early Use of Cannon and Musket in India, AD 1442-1526', *Journal of the Economic and Social History of the Orient* 24 (1981) 146-164; Vernard Foley and Keith Perry, 'In Defense of *Liber Igneum*: Arab Alchemy, Roger Bacon, and the Introduction of Gunpowder into the West', *Journal for the History of Arabic Science* 3 (1979) 200-218; R.C. Jennings, 'Firearms, Bandits and Gun-Control: Some Evidence on Ottoman Policy towards Firearms in the Possession of Reâya, from Judicial Records of Kayseri, 1600-27', *Archivum Ottomanicum* 6 (1980) 339-380.
16. Bernard and Fawn M. Brodie, *From Crossbow to H-Bomb* (Bloomington 19732); Tom Wintringham and J.N. Blashford-Snell, *Weapons and Tactics* (Harmondsworth 1973); William H. McNeil, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago 1982); Martin van Creveld, *Technology and War from 2000 B.C. to the Present* (New York 1989); Robert L. O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression* (Oxford 1989); Kelly DeVries, *Medieval Military*

- Technology* (Peterborough, Ont., 1992). The subject has also been discussed in more general histories of technology, such as: William Barclay Parsons, *Engineers and Engineering in the Renaissance* (Cambridge, Mass., 1939); Lewis Mumford, *Technics and Civilization* (New York 1934); Charles Singer et al. (ed.), *A History of Technology*, vol. III: *From the Renaissance to the Industrial Revolution, c1500-c1750* (Oxford 1957), esp. A.R. Hall, 'Military Technology', 345-376; Lynn White jr., *Medieval Technology and Social Change* (Oxford 1962); idem, 'The Act of Invention' in: *Machina ex deo: Essays in the Dynamism of Western Culture* (Cambridge, Mass., 1968) 107-131, and 'Dynamo and Virgin Reconsidered', 57-73; Maurice Daumas, *Histoire générale des techniques*, 5 vols. (Paris 1962-1979), English translation: *A History of Technology and Inventions*, transl. E.B. Hennessey, 5 vols. (New York 1968), see esp. volumes 1 and 2; Bertrand Gille, *Les ingénieurs de la Renaissance* (Paris 1964), English translation: *Engineers of the Renaissance* (Cambridge, Mass., 1966), compare: Frank D. Prager and Gustina Scaglia, *Mariano Taccola and his Book 'De Ingeneis'* (Cambridge, Mass., 1972); Arnold Pacey, *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology* (Cambridge, Mass., 1992); idem, *Technology in World Civilization* (Cambridge, Mass., 1990); Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (Oxford 1990).
17. Later reprinted in a collection of Roberts' articles: *Essays in Swedish History* (London 1967) 195-225.
 18. G. Parker, 'The "Military Revolution", 1560-1660 - a Myth?', *Journal of Modern History* 48 (1976) 195-214; later reprinted in his *Spain and the Netherlands, 1559-1659. Ten Studies* (London 1979) 85-103.
 19. D.A. Parrott, 'Strategy and Tactics in the Thirty Years War: the "Military Revolution"', *Militär-geschichtliche Mitteilungen* 38 (1985) 7-25.
 20. B.S. Hall and K. DeVries, 'Essay Review - The "Military Revolution" Revisited', *Technology and Culture* 31 (1990) 147-154.
 21. J.A. Lynn, *Journal of Military History* 55 (1991) 297-330.