



# GUNPOWDER TECHNOLOGY *in* *the* FIFTEENTH CENTURY

A Study, Edition and  
Translation of the  
*Firework Book*



Axel E. W. Müller

**Royal Armouries Research Series**

**Volume III**

**Gunpowder Technology  
in the Fifteenth Century**

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# **Gunpowder Technology in the Fifteenth Century**

**A Study, Edition and Translation  
of the *Firework Book***

Axel E. W. Müller

THE BOYDELL PRESS

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# Introduction

Gunpowder technology has often been identified as one of the key catalysts for the transition from the Middle Ages to the Early Modern Period. By 1620, the natural philosopher Francis Bacon had placed gunpowder as one of the tripartite symbols of technological advancement: 'Printing, gunpowder, and the compass. For these three have changed the appearance and state of the whole world.'<sup>1</sup> As Kay Smith put it in 2010, regarding

[...] the crucial role that gunpowder played in the development of the exploitation of energy resources from ancient times to the present. It marks the beginning of the change from animal, mechanical, or natural sources of energy [...] to the apparently unlimited power and mobility of chemical energy.<sup>2</sup>

However, when and how gunpowder technology emerged and spread to all corners of Europe in the fourteenth and fifteenth centuries is far less clear.

Gunpowder's early origins in China are well-known, but we know surprisingly little about how this technology was transferred across Eurasia, and even less about the way that early gunpowder weapons performed in practice.<sup>3</sup> This lack of understanding has had a significant effect on research into warfare in the late medieval and early modern period. Kelly DeVries and Kay Smith list a number of guns and gunners from 1326 onwards, and by the fifteenth century gunpowder artillery 'had led to significant changes on battlefields and at sieges' and 'affected every kingdom and principality'.<sup>4</sup> Surviving records of

<sup>1</sup> Francis Bacon and Joseph Devey (eds), *Novum Organum* (New York: P. F. Collier, 1902). [https://oll.libertyfund.org/title/bacon-novum-organum#Bacon\\_0415\\_198](https://oll.libertyfund.org/title/bacon-novum-organum#Bacon_0415_198) (accessed 10 August 2023), Book 1, Aphorism CXXIX.

<sup>2</sup> Kay Smith (publ. under former name of Robert Douglas Smith), *Rewriting the History of Gunpowder* (Nykøbing Falster: Middelaldercentret, 2010), 12.

<sup>3</sup> For these early origins, see Joseph Needham, *Military Technology: The Gunpowder Epic*, Part 7 of *Science and Civilisation in China*, Vol. 5, *Chemistry and Chemical Technology* (Cambridge: Cambridge University Press, 1986), and more recently, Tonio Andrade, *The Gunpowder Age: China, Military Innovation, and the Rise of the West in World History* (Princeton and Oxford: Princeton University Press, 2016).

<sup>4</sup> Kelly DeVries and Robert D. Smith, *Medieval Military Technology* (Toronto: University of Toronto Press, 2012), 138–40, and Kay Smith (publ. under former name of Robert Douglas Smith) and Kelly DeVries, *The Artillery of the Duke of Burgundy, 1363–1477* (Woodbridge: Boydell, 2005), 10–12.

master gunners are sparse from the late fourteenth century, becoming increasingly more substantial by the mid-fifteenth century, but still only amount to a patchwork of individual mentions of gunners in widely dispersed employment across Europe.<sup>5</sup> While the Tower of London recorded gunpowder production from 1346, increasing considerably between 1400 and 1410, the records say very little about purchase, storage, maintenance, and use.<sup>6</sup> In recent decades, scholars have become aware of both the gap in knowledge and the social history potential of gunpowder technology. For example, in 1996 Brenda Buchanan pointed out:

The history of gunpowder making is a comparatively neglected subject, yet this was a technology of international significance in terms of the intellectual transfer of ideas and techniques, and the practical transfer of raw materials and finished goods across continents and oceans. Unlike many industries its product supplied a diversity of markets which mirrored the cultural, social, and economic conditions in which it flourished.<sup>7</sup>

Since then, a wide range of scholars from different disciplines (military history, medieval studies, manuscript studies, sinology, economic history, history of science and technology) have contributed to the field and further demonstrated the significance of gunpowder technology to warfare, trade, intellectual exchange, culture, and society. However, they have naturally interpreted the evidence from the standpoint of their particular disciplines, often retrospectively applying modern science to medieval contexts and materials.<sup>8</sup> And,

<sup>5</sup> Most recently, Dan Spencer, *Royal and Urban Gunpowder Weapons in Late Medieval England* (Woodbridge: Boydell Press, 2019), or Knut Schulz, 'Büchsenmeister des Spätmittelalters: Migration und Ausbreitung des neuen Wissens', in *Craftsmen and Guilds in the Medieval and Early Modern Periods*, eds Eva Jullien and Michel Pauly (Stuttgart: Franz Steiner, 2016), 221–42, 230–42, or earlier, Rainer Leng, "'getruwelich dienen mit Buchsenwerk". Ein neuer Beruf im späten Mittelalter: Die Büchsenmeister', in *Strukturen der Gesellschaft im Mittelalter. Interdisziplinäre Mediävistik in Würzburg*, eds Dieter Rödel and Joachim Schneider (Wiesbaden: Reichert, 1996), 303–21.

<sup>6</sup> Thom Richardson, *The Tower Armoury in the Fourteenth Century* (Leeds: Royal Armouries, 2016), 174–90.

<sup>7</sup> Brenda J. Buchanan (ed.), *Gunpowder: The History of an International Technology* (Bath: Bath University Press, 1996), xvii.

<sup>8</sup> Notable exceptions in recent years are: Jonathan Davies, *The Medieval Cannon 1326–1494* (Oxford: Osprey Publishing, 2019), Geoff Smith, 'Saltpetre: The Soul of Gunpowder', *Journal of the Ordnance Society* 27 (2020), 5–24, and Geoff Smith, 'Sulphur: The Trigger of Gunpowder', *Journal of the Ordnance Society* 28 (2021), 115–19, Trevor Russell Smith, 'The Earliest Middle English Recipes for

until recently, there has been little about gunpowder technology in the early fifteenth century available in English. To try to understand gunpowder technology – including its introduction, use, trade, and significance – it is crucial to study a wide range of texts and records, as well as artefacts and experimental archaeology.<sup>9</sup>

While there is some information to be gleaned from fragments in local chronicles and other written evidence, as well as from isolated surviving artefacts, it is arguably through the study of military manuscripts that we can obtain the most comprehensive insight into military techniques in the fifteenth century and the emergence of this technology. Particularly valuable is the genre of technical manuscripts known as the *Firework Book* (one of the first surviving group of manuals written for gunpowder technology).<sup>10</sup> However, no sustained, comparative analysis of the *Firework Book* genre has yet been undertaken. Accordingly, this book aims to answer some of the basic questions about gunpowder and early artillery in order to create a solid foundation of good hard evidence and research for others to build on. Future research would benefit from a multidisciplinary approach integrating the results of documentary and archival research, experimental work, and test firing of actual weapons.

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Gunpowder’, *Journal of Medieval Military History* 18 (2020), 183–92, Clifford J. Rogers, ‘Gunpowder Artillery in Europe, 1326–1500: Innovation and Impact’, in *Technology, Violence, and War: Essays in Honor of Dr. John F. Guilmartin, Jr.*, eds Robert S. Ehlers Jr., Sarah K. Douglas, and Daniel P. M. Curzon, *History of Warfare* 125 (Leiden: Brill, 2019), 39–71, Clifford J. Rogers, ‘Four Misunderstood Gunpowder Recipes of the Fourteenth Century’, *Journal of Medieval Military History* 18 (2020), 173–82, and Spencer, *Royal and Urban Gunpowder Weapons*.

<sup>9</sup> Experimental archaeology is a crucial method in investigating material culture and testing research hypotheses and techniques. See issues of the online journal EXARC; Peter G. Stone and Philippe G. Planel, *The Constructed Past* (London: Routledge, 2003); the research by the HO Group: Medieval Gunpowder Research with the stated aim of investigating the composition and properties of medieval gunpowder; and recent research carried out at the United States Military Academy as published in Tessy S. Ritchie, Kathleen E. Riegner, et al., ‘Evolution of Medieval Gunpowder: Thermodynamics and Combustion Analysis’, *ACS Omega* 6:35 (2021). 22848–22856. <https://pubs.acs.org/doi/10.1021/acsomega.1c03380> (accessed 10 August 2023).

<sup>10</sup> The *Firework Book* is a genre with different versions, rather than a single book, as the 65 extant copies demonstrate considerable variation. This will be discussed in more detail in the ‘Manuscripts and Editions’ section of this Introduction, and in Chapter 1 under ‘*Urtext*, Production, and Transmission’.

It is clear that this technology was changing society, but little is known about the speed and format of the change. Gunpowder technology was transformative for every aspect of how wars were fought, because it had a substantial impact on resources, training, and construction. Some scholars have identified a ‘Military Revolution’ of the sixteenth century, in which gunpowder technology was one of the key components, but the evidence discussed in this book shows that whatever was happening was already well underway in the fourteenth and fifteenth centuries.<sup>11</sup> Whether the *Firework Book* can be viewed as a contribution to an earlier ‘Military Revolution’, or was part of a gradual change in society, will be a topic of discussion. Technological changes certainly contributed in major ways to how military interaction was conducted, and by the later fifteenth century gunpowder technology was omnipresent in Western Europe and no self-respecting local ruler could afford not to have access to gunpowder technology. There certainly was a demand for and supply of new technology such as the use of gunpowder artillery, with the consequent and overwhelming need to preserve and disseminate this knowledge, resulting in a wide range of manuals on military matters. The *Firework Book* is part of a genre emerging in the late fourteenth and early fifteenth centuries, which contains other texts related to technical military instructions such as the *Bellifortis* and the *Büchsenmeister Books*.<sup>12</sup>

All of these texts emerged at what was clearly a crucial point of development in this technology. It is less clear, however, what was the actual purpose of producing these texts.<sup>13</sup> Realistically, there are three possible explanations: a) the *Firework Book* marks the recording of a fully-fledged technology which had already been in use for decades by the early fifteenth century, well before

<sup>11</sup> For an overview on the debate on the Military Revolution, its chronology, and its conceptual debates see Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West, 1500–1800* (Cambridge: Cambridge University Press, 1988; rev. edn 2002), Clifford J. Rogers (ed.), *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe* (Oxford: Westview Press, 1995), Kelly DeVries, ‘Catapults are not Atomic Bombs: Towards a Redefinition of “Effectiveness” in Premodern Military Technology’, *War in History* 4 (1997), 454–70, and more recently Anne Curry, ‘Guns and Goddams: Was There a Military Revolution in Lancastrian Normandy 1415–50?’, *Journal of Medieval Military History* 8 (2011), 171–88, and Helmut Flachenecker, ‘Kanonen, Räderuhr und Brille: zur technischen Revolution des Spätmittelalters’, in *Überall ist Mittelalter: zur Aktualität einer vergangenen Epoche*, ed. Dorothea Klein (Würzburg: Königshausen & Neumann, 2015), 303–29.

<sup>12</sup> For more on the *Firework Book* as a genre, as well as on the *Bellifortis* and the *Büchsenmeister Books*, see Chapter 1 under ‘Firework Books as a Coherent Genre’.

<sup>13</sup> See also Chapter 2 under ‘Manuscript Evidence of Use’.

it has been assumed by modern historians to have occurred; b) it was the result of a substantial change in gunpowder manufacture and technology, which required a tool to disseminate knowledge of the change; or c) it is a textual anomaly which does not reflect actual practice at the time.

This study will show that the third explanation can be ruled out because the text does relate to operating tasks within gunpowder technology and contains well-documented ingredients, as well as recipes and instructions which work and can be recreated.<sup>14</sup> It is more likely a combination of a) and b), in that it was written at a turning point of a change in technology or technological knowledge transfer, at a time when gunpowder technology had been in use for some decades. The *Firework Book* demonstrates both a demand for this type of knowledge about gunpowder technology, and that this specialist knowledge was already well established. The texts appeared during the period when vernacular writing, including the written recording (as opposed to oral transmission) of technical knowledge, was starting to appear across Europe. This was also the time when the profession of master gunner became widespread.

## Manuscripts and Editions

In the Royal Armouries manuscript collection in Leeds there is a complex fifteenth-century vernacular text in German, catalogued as MS I.34, called the *Firework Book* (in German: 'Feuerwerkbuch'). It has not previously been edited and thus far has only been cursorily studied.

This study sets out to create a diplomatic edition and translation of I.34, the sole exemplar of a *Firework Book* in the United Kingdom and a unique example of the corpus as a whole. This work is crucial for a more complete understanding of *Firework Books*, in view of the paucity of editions of this genre. Only three modern editions in New High German of the Freiburg manuscript Ms. 362 of the *Firework Book* have been produced, together with one translation into English, based on one of these modern editions. The first modern edition, printed in 1941, was the work of a civil servant, Wilhelm Hassenstein, with limited historical and scientific knowledge but working in a military context.<sup>15</sup>

<sup>14</sup> Kay Smith (partially publ. under former name of Robert Douglas Smith), *Reports of the HO Group: Medieval Gunpowder Research, 2002–2022*, [https://ahc.leeds.ac.uk/downloads/download/35/fields\\_of\\_conflict](https://ahc.leeds.ac.uk/downloads/download/35/fields_of_conflict) or <https://www.middelalderakademiet.dk/krudt-og-kanoner> (accessed 10 August 2023).

<sup>15</sup> The author of the earliest edition and translation of a *Firework Book* in the twentieth century, Wilhelm Hassenstein, gave his profession as being in the high-ranking civil service (*Oberregierungsrat*), and stated in the dedication that his book was

The second and third editions were produced by the physicist Ferdinand Nibler (also translated into New High German) and the chemist Gerhard Kramer (who also added a partial translation into English). Both possessed scientific knowledge but lacked sufficient historical background to understand the need for accuracy in translation.<sup>16</sup> In contrast, the choice here has been to offer a translation close to the original, dealing with inconsistencies when they occur, as well as rendering the sometimes monotonous and repetitive style as closely as possible to the original. This method provides scholars with greater insight into what the text actually states, rather than what modern scholars have interpreted it to be.

All 65 surviving versions of the *Firework Book* were produced in the fifteenth and sixteenth centuries in various dialects of Early New High German (defined as the version of German used between 1350 and 1650). On the basis of the predominant vernacular adopted, they may be traced to the south-western region of present-day Bavaria. Using the didactic format of a dialogue between a master gunner and an apprentice, the *Firework Book* has deservedly been described as ‘the most frequently copied, changed, and extended book about the art of gunnery and chemistry of the period’.<sup>17</sup> However, it was frequently restructured and repackaged, with the result that no two surviving texts are identical in content.<sup>18</sup>

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presented at the 50th birthday of Reichsminister Fritz Todt (German Minister for Armaments and Ammunition, 1940–42) to honour the work carried out by German engineers and builders (Hassenstein, *Feuerwerkbuch*, inside front cover).

<sup>16</sup> Ferdinand Nibler, *Feuerwerkbuch: Anonym, 15. Jahrhundert; Synoptische Darstellung zweier Texte mit Neuhochdeutscher Übertragung* (online publication, 2005), <https://www.ruhr-uni-bochum.de/technikhist/tittmann/5%20Feuerwerkbuch.pdf> (accessed 10 August 2023). He taught electrical engineering at the German Military University in Munich, and created and maintained the website <http://www.feuerwerkbuch.de/> (defunct as of 16 February 2023, although a copy of the homepage can be found on WaybackMachine at <https://web.archive.org/web/20220618191626/http://www.feuerwerkbuch.de/> – accessed 10 August 2023). Kramer published one edition of Freiburg Ms. 362 in 1995: Gerhard W. Kramer, *Berthold Schwarz: Chemie und Waffentechnik im 15. Jahrhundert*, Abhandlungen und Berichte der Deutschen Museum N.F., 10 (München: Oldenbourg, 1995), as well as the only ‘translation’ into English in 2001: Gerhard W. Kramer and Klaus Leibnitz, *Das Feuerwerkbuch: German, circa 1400: Translation of MS 362 dated 1432 in the Library of the University of Freiburg*, Journal of the Arms & Armour Society 17.1 (London: The Arms & Armour Society, 2001).

<sup>17</sup> Kramer and Leibnitz, *Das Feuerwerkbuch*, 13. Kramer and Leibnitz’s understanding and interpretation of the *Firework Book* will be discussed in Chapter 2.

<sup>18</sup> For further discussion, see Chapter 1 under ‘Urtext, Production, and Transmission’.



An important element of the present study is the critical examination of the content of I.34, relating it to a significant subset of the other 64 surviving manuscripts of the *Firework Book* genre, thereby providing a comparative analysis of this genre and related subject areas, as well as giving a better understanding of its technical content. This study presents substantial evidence that *Firework Books* were widely popular and often reproduced, although their role and function have gradually been forgotten over time.

While Royal Armouries manuscript I.34 shares the same core content with most *Firework Books*, it also has several distinctive and unique features which make it an ideal case study. In addition to transcribing, translating, and interpreting I.34, this study aims to move beyond textuality to explain the technical content of these manuscripts and offer an interpretation of the development of early gunpowder weaponry. In contrast to most other *Firework Books*, I.34 is compiled with associated elements of text which offer a deeper insight into the knowledge of gunpowder technology and, more particularly, into the production and possible use of the *Firework Book* in the fifteenth century. I.34 contains several distinct parts of text (the second part of I.34 has long been viewed as unique) and a substantial number of images which are referred to in the manuscript text – such features are unusual for most *Firework Books*. The images vividly show the various production techniques of gunpowder explosives and their use in battle, combined with technical illustrations of mounting the equipment.<sup>19</sup> It is hoped that a detailed analysis will lead to a better understanding, not only of how the emergence of literacy contributed to the production of the *Firework Books*, but also of plausible theories as to their production, authorship, readership, reception, and other uses.

The approach does not follow the conventional type of textual study which compares multiple manuscripts in detail. A few previous attempts have been made to compare a number of manuscripts, both by the heading to each chapter and by the texts of each subheading.<sup>20</sup> In fact, Ferdinand Nibler embarked

<sup>19</sup> These illustrations allow us to appreciate better the nature and knowledge of gunpowder technicians in the period. However, while some images are included in this book, a detailed analysis of the images goes beyond the scope of this project. While they have occasionally been referred to by military historians, they have yet to be analysed by art historians and image specialists as representations of gunpowder warfare and technical manuals, or even as representations of buildings, clothing, materials, or for their use of perspective. The images have been consulted in relation to the text (at several points where the text refers to them), but it was decided that the main focus here should be limited to the presentation and interpretation of the text.

<sup>20</sup> See Ferdinand Nibler, 'Das Feuerwerkbuch: Eine verspätete Buchbesprechung etwa 600 Jahre nach dem Erscheinen des Feuerwerkbuches', *Zeitschrift für*



on this work but only partially completed it – demonstrating the complexity of the extant corpus and providing information which is partial at best, as each *Firework Book* manuscript differs from the next.<sup>21</sup> Furthermore, the considerable number of subtle differences (which increase the further one gets into the text) make this kind of study unfeasible, while the benefits would certainly be limited. Previous scholars have merely listed these variations, without comment, in the order of the key components, highlighting elements listed in one and not the other, thus providing only partial information on a text corpus.<sup>22</sup> Understanding the extent to which the manuscripts differ is only possible if all of them are compared, side by side – a daunting task given the number of extant manuscripts.

What emerges from my examination of the corpus of *Firework Book* manuscripts is a high proportion of similarities, albeit with sometimes subtle, sometimes more substantial differences. A comprehensive comparative analysis is beyond the scope of this study, and would likely be of limited value in any case. Instead, this focused analysis of one manuscript provides a thorough basis on which to explain the origins, use, circulation, and subsequent

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*Heereskunde* 67:2 (2003), 147–54, and Nibler, *Feuerwerkbuch*. Ferdinand Nibler's work is the most comprehensive attempt in that he compared both the headings in the Freiburg manuscript Ms. 362 with the Augsburg 1529 printed book (only surviving in the reprint of Hassenstein, *Feuerwerkbuch*) in detail, while also providing a comparison of chapter headings between the two texts mentioned together with Munich Clm. 30150, Dillingen Ms. XV 50, Weimar Q 342, and a further printed book by Egenolph, Strassburg, 1529, and has made a comparative study of two versions of the texts in a 'synoptic way'. However, the benefits are difficult to ascertain, with some similarities and some differences between the versions. These differences are revealed in choice of words, phrases, different placing of chapters, or more substantial changes and omissions. As he only included some selected manuscripts, his study is of limited use. Previous attempts were substantially less comprehensive, including the investigations by Max Jähns, *Geschichte der Kriegswissenschaften vornehmlich in Deutschland*, 3 vols (München and Leipzig: R. Oldenbourg, 1889–91), <http://archive.org/details/geschichtederkr00jhgoog> (accessed 10 August 2023), 382–424, and Wilhelm Hassenstein, *Das Feuerwerkbuch von 1420: 600 Jahre Deutsche Pulverwaffen und Büchsenmeisterei*, Bücher der Deutschen Technik (München: Verlag der Deutschen Technik, 1941), 14–78, 84–88, Christa Hagenmeyer, 'Kriegswissenschaftliche Texte des ausgehenden 15. Jahrhunderts', *Lewensche Bijdragen* 57 (1967), 182–95, or Franz Maria Feldhaus, *Die Technik der Antike und des Mittelalters* (Wildpark-Potsdam: Athenaion, 1931 [1971]), 362, but all of these were carried out with limited source access or discernible methodology applied.

<sup>21</sup> Nibler in his introductory comments to the synoptic, comparative analysis of four manuscripts and two early prints of the *Firework Book* (Nibler, *Feuerwerkbuch*, 3).

<sup>22</sup> See, in particular, Nibler, *Feuerwerkbuch*, or Kramer, *Das Feuerwerkbuch*.

life-story of the *Firework Book*. Taking I.34 as an exemplar for all *Firework Book* manuscripts, this study provides a textual analysis of the single manuscript and, through comparative works of secondary material, evaluates its content, role, and function within the context of technological and military development. I.34 is ideal for the purpose, as it provides the traditional *Firework Book* components, along with an additional explanatory text. Almost all manuscripts include a series of questions, often referred to as the Master Gunner's Questions. These vary in length and content, and in the number of key elements that are omitted or added. The core, however, remains the same, giving a description of the ingredients of gunpowder, and its various uses. Whether these practices were actually used, or were imagined enhancement or wishful thinking, will be discussed in Chapters 2 and 5. MS I.34 – like all other manuscripts of the *Firework Book* – has its own order of paragraphs and thematic groupings of paragraphs, as well as distinctive additions and omissions within paragraph content, accompanied by an unusual second part and provides valuable insight into the possible uses of the text.

\* \* \*

Chapter 1 discusses the complex tradition of the *Firework Book* with reference to the 65 extant manuscripts, of which I have examined 63. Also considered are how the *Firework Book* fits into the wider genre of fifteenth-century military manuals and technical writings, and how it has been studied by modern scholars. Chapter 2 provides a summary of evidence of the audience for whom the *Firework Books* were produced and what happened to individual manuscripts of the *Firework Books*. Chapter 3 gives a physical description of Royal Armouries' manuscript I.34, outlining its contents and its provenance. Chapter 4 provides editorial and translation notes, followed by a line-by-line transcription and translation of I.34. The text has to be viewed in its entirety to provide a thorough understanding of the *Firework Book* format and content, and it is essential to read it before the technology – both its terminology and its usage – can be discussed. Chapter 5 examines the key elements in the text to analyse the information that they provide and what they tell us about fifteenth-century gunpowder technology.

In summary, as the history of gunpowder technology to date has been a sort of jigsaw puzzle composed of pieces from various disciplines, the present publication aims to further our understanding of it by using I.34 as an exemplar of a *Firework Book* (albeit a unique one). Combining literary and linguistic source criticism, along with historical analysis and fieldwork, it demonstrates the role of the *Firework Book* as an essential link in the consolidation of gunpowder technology.

# 1 The *Firework Book* Tradition

This chapter provides an overview of the wider *Firework Book* tradition. It addresses whether a single genre existed or whether this term is more correctly applied to a collective group of more disparate texts. It considers the historiography of research on *Firework Books* and whether a distinction should be made between the different types of *Firework Books*. Ultimately, it explores how and where the *Firework Book* fits into the wider genre of fifteenth-century technical writings (with and without illustrations), and analyses the similarities and differences of existing manuscripts and how these have been interpreted by scholars.

## *Firework Books as a Coherent Genre*

The case needs to be made for this being a coherent tradition which requires (or is entitled to include) a clearly definable group of texts. For the purpose of this chapter, I understand a *Firework Book* to be a text written in Early New High German, consisting of a number of core elements in relation to early gunpowder artillery, including: the so-called ‘Master Gunner’s Questions’; the handling of saltpetre, sulphur, and charcoal; instructions on how to make, improve, preserve, and revitalize gunpowder; as well as other instructions related to attacks with gunpowder technology or how to defend against these. The core of the text was reproduced many times over more than a century. From 1529 onwards, it continued to be produced as printed text.<sup>1</sup> The earliest

<sup>1</sup> According to Hassenstein, the first printed edition was found as an appendix to *Flavii Gegetii Renati vier Bücher von der Ritterschaft* (Augsburg, 1529). Hall refers to ‘two unrelated first editions’: Heinrich Stainer, Augsburg, 1529, and Christian Engenolph, Strassburg, 1529, the latter published under the title *Büchsenmeisteret: von Geschoss, Büchsen, Pulver, Salpeter, und Feuerwerk*. The two printers, Heinrich Stainer (also known as Steyner or Steiner) in Augsburg, and Christian Egenolff or Engenolph, initially based in Strasbourg and later in Frankfurt, were both prolific printers with over 1450 different books recorded to have been printed on a wide range of subjects from theology, history, philosophy, natural sciences, and other medical texts, including texts by Hans Sachs, Melanchton, Paracelsus,

version probably appeared during the first years of the fifteenth century and the last well into the sixteenth. The *Firework Book* was thus so frequently restructured and repackaged that no two surviving texts are identical in content.

All surviving manuscripts of the *Firework Book* were produced in the fifteenth and sixteenth centuries in the local dialects of the south-western region of present-day Bavaria. The texts of all surviving *Firework Books*, which all show variations, were written in fifteenth-century vernacular script, almost exclusively in red and dark brown ink.

As a group such books retain a coherence and similarities to an extent much greater than, for example, cookery books or fencing manuals from the same period and region. It is striking that, in fifteenth-century Germany, the south-western region of Bavaria was at the forefront of producing vernacular manuscripts of a technical nature.<sup>2</sup> For example, Melitta Weiss Adamson and Trude Ehlert have examined the production of vernacular cookery books and their adjacent genres in fifteenth-century Germany. Both authors highlight the simplicity and low quality of the language of their original text, and the almost accidental nature of the collation of their texts, although they have omitted the important point that these ‘technical’ sources appear predominantly in Bavaria.<sup>3</sup>

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Erasmus of Rotterdam, Cicero, Petrarch, Plato, Ovid, and many others (Norbert H. Ott, ‘Steiner, Heinrich’, *Neue Deutsche Biographie* 25 (2013), 183, <https://www.deutsche-biographie.de/pnd119838451.html#ndbcontent>, and Josef Benzing, ‘Egenolff, Christian’, *Neue Deutsche Biographie* 4 (1959), 325–26, <https://www.deutsche-biographie.de/pnd122968468.html#ndbcontent> (both accessed 10 August 2023)). The most comprehensive study of the printed editions of the *Firework Book* was carried out by Klára Andresová, who identified a total of 13 printed versions of the *Firework Book* from 1529 until 1619 (Klára Andresová, ‘A Bestseller among Artillery Handbooks of the 16th Century: Printed Editions of the Late Medieval *Feuerwerkbuch*’, *International Journal of Military History and Historiography* (2022), 1–27, 1).

<sup>2</sup> The connection between the format of the *Firework Book* and fencing manuals has been highlighted by Daniel Jaquet in a so far unpublished paper, ‘Fighting Experts: Fencers, Gunners, and Arbalesters as Masters in Swiss Towns’, presented at the International Medieval Congress in Leeds in 2021.

<sup>3</sup> See, for example, Melitta Weiss Adamson, ‘Vom Arzneibuch zum Kochbuch, vom Kochbuch zum Arzneibuch: Eine diätetische Reise von der arabischen Welt und Byzanz über Italien ins spätmittelalterliche Bayern’, in *Der Koch ist der bessere Arzt: Zum Verhältnis von Diätetik und Kulinarik im Mittelalter und der Frühen Neuzeit*, eds Andrea Hofmeister-Winter et al. (Frankfurt am Main: Peter Lang, 2014), 39–62, and Melitta Weiss Adamson, “mich dunkcht ez sein knöllell”: Von den Mühen eines bayrischen Übersetzers mittelalterlicher Fachliteratur’, in *Fachtexte des Spätmittelalters und der Frühen Neuzeit: Tradition und Perspektiven der Fachprosa- und*

The title *Firework Book* (in German: ‘Feuerwerkbuch’) derives from the textual reference which seems to appear in all of the identified manuscripts, usually early in the text.<sup>4</sup> It has, however, not been used as a title at the head of the text – this was only done by librarians and archivists from the eighteenth century onwards. In 1941, the suffix ‘of 1420’ was added by Wilhelm Hassenstein in the publication of the *Feuerwerkbuch von 1420*, which provided both an edition of two copies of the *Firework Book* and an additional commentary, but he offers no discernible explanation for this choice of date.<sup>5</sup> Hassenstein’s title has been used to name this category of technical writing ever since, even though many have subsequently challenged the dating of 1420 on account of the otherwise questionable historical context in the commentary of the publication.<sup>6</sup> Other scholars have assigned it a different date of production. For example, Joseph Needham, historian of Chinese technology and science, refers to the ‘Feuerwerkbuch von 1437’.<sup>7</sup> The only thing that can be agreed is that the afterlife of the *Firework Book* had started by the 1430s, as Bert Hall notes when commenting on the dating issue:

The *Firework Book* continued to be copied, but its text seems to have stabilized after the 1430s or 1440s, and the later versions contain little that is new. When the work finally was printed in 1529, it was thoroughly obsolete.<sup>8</sup>

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*Fachsprachenforschung*, ed. Lenka Vanková (Berlin: de Gruyter, 2014), 143–54, and Trude Ehlert (ed.), *Küchenmeisterei: Edition, Übersetzung und Kommentar zweier Kochbuch-Handschriften des 15. Jahrhunderts* (Frankfurt am Main: Peter Lang, 2010), and Trude Ehlert and Rainer Leng, ‘Frühe Koch- und Pulverrezepte aus der Nürnberger Handschrift GNM 3227a (um 1389)’, in *Medizin in Geschichte, Philologie und Ethnologie. Festschrift für Gundolf Keil*, eds Dominik Groß and Monika Reininger (Würzburg: Königshausen & Neumann, 2003), 289–313.

<sup>4</sup> In the Royal Armouries manuscript I.34 it is on fol. 2r, line 1, where it is referred to as ‘*fewerwerkpuh*’.

<sup>5</sup> *Das Feuerwerkbuch von 1420*, Hassenstein, *Feuerwerkbuch*, title page.

<sup>6</sup> Bert S. Hall, *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics* (Baltimore: Johns Hopkins University Press, 1997), 71: ‘... can safely be said to stem from the period before 1420 ...’; see also Kramer, *Berthold Schwarz*, 98–99.

<sup>7</sup> Needham, *Military Technology: Gunpowder Epic*, 33, with a reference to James R. Partington, *A History of Greek Fire and Gunpowder* (Baltimore: Johns Hopkins University Press, 1960; repr. 1999), 152, who himself lists only five *Firework Books* in existence, two of which seem to be dated 1437 while one other is dated 1420.

<sup>8</sup> Hall, *Warfare in Renaissance*, 88.

Hassenstein's *Feuerwerkbuch von 1420* also provides a listing of 38 *Firework Book* manuscripts.<sup>9</sup> In recent decades there has been general consensus that Hassenstein's list was incomplete and was, moreover, based on rather dubious scholarship – as is the rest of the publication. Hassenstein even argues that the Milimete Gun illustration (Oxford, Christ Church MS 92 fol. 70v), which is said to be the first to display the characteristics of gunpowder weaponry in action, must have been a later addition to the 1326 manuscript, as the English, who were not sufficiently advanced in weapon technology (in comparison to the Germans), could not have invented gunpowder technology ('[...] sind phantastische Malereien, die nachträglich in die [...] Handschrift [...] aus den Jahren 1326 und 1327 hineingemalt worden sind, [...] und die unmögliche Vorstellung erweckt haben, daß nicht die Deutschen, sondern die schon damals im Waffenwesen rückständigen Engländer die Erfinder der Pulvergeschütze sind').<sup>10</sup> It was exactly this depiction which led to the academic case being made in the 1960s that England must have been in the forefront of technological development.<sup>11</sup>

Hassenstein was by no means the first to emphasize the 'origin myth' of the inventors of gunpowder. Early debate was strongly influenced by national interests with the aim of establishing which nation in particular had 'invented' guns and/or gunpowder and led the field in military technology. Max Jähns among others was eager to point out that the powder gun was invented in Germany. While he does acknowledge the earlier presence of gunpowder technology in China and the Arabian peninsula, he is certain that gunpowder as the driver for projectiles was a German invention by the legendary Berthold Schwarz (Niger Bertholdus) who is mentioned in almost all *Firework Books*.<sup>12</sup> Kelly DeVries describes Hassenstein's publication as 'virtually useless except for the text itself'.<sup>13</sup> Hassenstein's publication nevertheless has been regularly used in the twentieth century as a point of reference for the presence of *Firework Books* and their circulation.

Research by Rainer Leng, a medieval historian with a special interest in technical manuscripts, has been instrumental in expanding the corpus of

<sup>9</sup> Hassenstein, *Feuerwerkbuch*, 85–88.

<sup>10</sup> Hassenstein, *Feuerwerkbuch*, 83.

<sup>11</sup> Partington, *Greek Fire and Gunpowder*, 78, and Dudley Pope, *Guns* (Feltham: Spring Books, 1969), 21–23.

<sup>12</sup> Jähns, *Kriegswissenschaften*, 224–26.

<sup>13</sup> Kelly DeVries, 'Review of Gerhard W. Kramer, ed., and Klaus Leibnitz, trans. *The Firework Book: Gunpowder in Medieval Germany (Das Feuerwerkbuch, c. 1440)*', *Am-bix* 50:2 (2003), 237–38, at 237. See also Simon Werrett, who uncritically follows both Kramer and Hassenstein (Simon Werrett, *Fireworks: Pyrotechnic Arts and Sciences in European History* (Cambridge: Cambridge University Press, 2010), 27).

material available in order to show which *Firework Books* (of 1420) are extant.<sup>14</sup> Leng reuses Hassenstein's label of *Firework Book of 1420*, which was also used as an entry in the second edition of *Die deutsche Literatur des Mittelalters: Verfasserlexikon* ('German Literature of the Middle Ages: Dictionary of Authors'):

This group of manuscripts known as the *Firework Book of 1420* from the first half of the fifteenth century was first printed in 1529. [...] They transmitted personal experiences, often gained through experimentation. This resulted in a considerable number of often substantial firework books, which can be grouped together because they are almost identical, as they consisted of chapters copied almost word-for-word. [...] In total, 48 manuscripts with related content exist in German-speaking regions.<sup>15</sup>

<sup>14</sup> Particularly in Rainer Leng, *Ars belli: deutsche taktische und kriegstechnische Bilderhandschriften und Traktate im 15. und 16. Jahrhundert*, *Imagines medii aevi*, 2 vols (Wiesbaden: Reichert, 2002), and Rainer Leng, 'Feuerwerks- und Kriegsbücher', in *Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*, vol. 4/2, eds Norbert H. Ott et al. (München: C. H. Beck, 2009), 145–512, <http://www.manuscripta-mediaevalia.de/?xdbdtdn:%22hsk%200622a%22&dmode=doc#|3> (accessed 10 August 2023).

<sup>15</sup> Burghart Wachinger et al., *Die deutsche Literatur des Mittelalters: Verfasserlexikon*, 2nd edn (Berlin: de Gruyter, 1977–2008), vol. 2 (1980), cols 728–31, under the heading of '*Feuerwerkbuch von 1420*':

Das heute unter dieser Bezeichnung geführte Kompendium einschlägiger Hss. aus der ersten Hälfte des 15. Jh.s wurde erstmals i. J. 1529, ein Jahrhundert nach seiner Entstehung [...] gedruckt [...] tradierte aufgrund seiner eigenen, häufig auch experimentell gewonnenen Erfahrungen. Auf diese Weise kam es schon in der ersten Hälfte des 15. Jh.s zu einer erheblichen Zahl mitunter sehr umfangreicher Feuerwerkbücher, deren Verwandtschaft miteinander noch heute anhand der in jeder erhaltenen Hs. auftauchenden fast identischen, weil nahezu immer wieder wörtlich abgeschrieben Kapitel nachzuweisen ist. [...]

Insgesamt sind bis heute 48 dieser in zumindest einem Abschnitt inhaltlich miteinander verwandten Hss. im deutschsprachigen Raum.

The first edition was published 1933–55, but as the first volume A–F included the *Firework Book* reference, it did not include the Hassenstein reference, and the new terminology was only added in the second edition published between 1977 and 2008. Even then, the article on the '*Feuerwerkbuch von 1420*' (in vol. 2, published in 1980) varies in its definition of the entries 'Instructions on the making of gunpowder, loading of guns and firing them' ('*Anleitungen, Schießpulver zu bereiten, Büchsen zu laden und zu beschießen*' [in vol. 1, published in 1978]) and of 'Guns, armour for warfare, sieges and fireworks' ('*Pixen, Kriegsrüstung, Sturmzeug und Feuerwerk*' [in vol. 7, published in 1989]). All three entries are written by the same author, Volker Schmidtchen.



Still, no clear definition is provided of what a *Firework Book* is, or is not. Leng criticizes manuscripts he considers to be ‘loose transmissions’ (*Streuüberlieferungen*) as well as, in his opinion, ‘wrongful attributions’ (*Fehlzuschreibungen*) to the *Firework Book of 1420* tradition. Nevertheless, he produces his own attribution list of manuscripts which contain ‘substantial or larger continuous parts’ of the *Firework Book*, including a total of 58 manuscripts, with partial or full content associated with the genre of the *Firework Book*. He restricts his list to manuscripts but includes copies in sixteenth-century chancery hand, as well as other references to manuscripts believed to be missing (*‘verschollen’*) but which had been recorded at some point earlier, including one which was last recorded in private ownership.<sup>16</sup> Leng does not, however, provide a clear definition which could clarify how to include or exclude any texts related to this corpus.

The earliest version of the *Firework Book* was likely to have been written in the first few years of the fifteenth century, broadly agreeing with Hassenstein’s dating but not his fixed date, for which no evidence could be found. The *Firework Book* is distinctively different from other technical-military texts in that it deals solely with specific questions on gunpowder artillery instead of focusing on the wider aspects of gun making and on defensive or offensive tactics. Based on this group of criteria a total of 65 manuscripts can be attributed to the genre, all but one of which are in known locations and accessible to view, including fifteenth- and sixteenth-century copies, ranging from seemingly complete texts down to smaller fragments. A list of all manuscripts identified as belonging to the genre is given in the Bibliography.

Very few copies of the *Firework Book* provide dates of production or identifiable authors, and where dates or authors are provided it is hard to verify whether these are later additions. Freiburg Ms. 362 is dated in the text as having been produced in 1432.<sup>17</sup> Only one copy of the *Firework Book*, that in Dillingen, has a possible attributed author: at the end of the text, the name and date, ‘1466 Jodocus Foelki presbyter’,<sup>18</sup> have been inserted – identified as Jodocus Völki from the Vorarlberg region of Austria. A certain Jodocus Völki was documented in the 1480s as a priest in Sulz on the river Neckar.<sup>19</sup> This

<sup>16</sup> Leng, *Ars belli*, vol. 2, 441–62.

<sup>17</sup> Freiburg Ms. 362, fol. 89v, ‘Anno trecesimo 2’. This seems to be in the same hand but the ink is slightly darker in colour – although even this one is described in the Freiburg University Library catalogue entry as a copy of an earlier manuscript from around or before 1420.

<sup>18</sup> Dillingen Ms. XV 50, fol. 33r.

<sup>19</sup> See catalogue entry for Dillingen manuscript Ms. XV 50: Elisabeth Wunderle, *Die mittelalterlichen Handschriften der Studienbibliothek Dillingen* (Wiesbaden:



location seems to correlate to the manuscript's linguistic features as they have been identified as 'Alemannic with traces of Swabian dialect'.<sup>20</sup> However, the line containing the date and name appears to be written in a different coloured ink and by a different hand, and it is possible that it was added later, thus throwing doubt on the assumption that the reference could be used to date the manuscript. It is possible that Völki was an owner of the manuscript, rather than the author or copyist. The authors of most manuscripts are anonymous, sometimes described as 'very shadowy figures about whom little is known'.<sup>21</sup> Ever since the nineteenth century, there has been some speculation about the possible author of the *Firework Book*, and one long-discussed theory argues for a certain Abraham von Memmingen. Abraham was said to have been a master gunner in the early fifteenth century who was claimed to have produced a *Firework Book* for his employer, Frederick of Austria. This is based on research by Josef Würdinger, who provides no credible evidence to support this claim.<sup>22</sup> Hence, this theory has been widely dismissed in recent years.<sup>23</sup>

Most copies in existence have been rebound since production, and have often been placed together with other texts on military regimen or other technical content.<sup>24</sup> This makes any speculation about their state at the point of production difficult. They were all produced on good quality paper but with scarcely any illustrations, relegating them to somewhat low-status publications for more personal use.<sup>25</sup> This leads Kay Smith to suggest that the *Firework*

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Harrassowitz, 2006), 74–77.

- <sup>20</sup> Werner Meyer, 'Eine Abschrift des Feuerwerkbuchs. Die Hs. XV 50 der Studienbibliothek Dillingen an der Donau', *Liber Castellorum* (1981), 288–301, at 299.
- <sup>21</sup> Bert S. Hall, *The Technological Illustrations of the So-Called "Anonymous of the Hussite Wars"*: Codex Latinus Monacensis 197, Part 1 (Wiesbaden: Reichert, 1979), 5.
- <sup>22</sup> Josef Würdinger, *Kriegsgeschichte von Bayern, Franken, Pfalz und Schwaben: Band II von 1347 bis 1506* (München: Literarisch-Artistische Anstalt der Cotta'schen Buchhandlung, 1868), 397–402. See Jähns, *Kriegswissenschaften*, 392–93, S. J. von Romocki, *Geschichte der Explosivstoffe* (Hannover: Gebrüder Gänecke, 1895; repr. Hildesheim: Gerstenberg, 1976), 179, or Hassenstein, *Feuerwerkbuch*, 79–80.
- <sup>23</sup> *Verfasserlexikon*, vol. 1 (1980), cols 11–12.
- <sup>24</sup> For examples, the copies located in Dillingen, Memmingen, Darmstadt, and Strasbourg. In all of these, gaps are provided at the beginning of sections which must have been intended for a later completion (mostly made in a different colour of ink).
- <sup>25</sup> Most primary and secondary sources related to *Firework Books* are catalogued in German academic libraries under German Literature and not under History. As there is less linguistic and literary appeal compared to other texts in German at the time, they tend to be more marginalized.

*Books* could possibly be ‘private notebooks of the apprentice gunner, copied during their apprenticeship from the master’s copy with their own additions and later extensions’.<sup>26</sup> Ferdinand Nibler went one step further by suggesting that the *Firework Book* was ‘a study and reference book for a master gunner’.<sup>27</sup>

To date, there has only been one very loose ‘translation’ into English of a *Firework Book*, Freiburg Ms. 362, produced in 2001 by Gerhard Kramer and his translator, Klaus Leibnitz (appearing after Kramer’s death). Kramer and Leibnitz make some intriguing claims in the introductory paragraphs to the effect that the Freiburg *Firework Book* was ‘written by chemists (or alchemists) for the use of master gunners’. They continue:

It was written in German Gothic script, which is notably difficult to read. Its content is technical and arcane, its vocabulary archaic and recondite, its language – Middle High German – familiar only to scholars. The advice it contains, at least in part, is obscure and enigmatic, it’s [sic!] pre-scientific concepts unfamiliar and abstruse. It could be deciphered only by a scholar who was a linguist, an historian and a chemist. Taken as a whole, however, this manuscript is an eminently sound and practical manual.<sup>28</sup>

This statement includes a range of suppositions, contradictions, and factual errors. The claim that the *Firework Book* was written by a chemist or alchemist is unsubstantiated in that they fail to provide a definition of what they (or a fifteenth-century expert audience) understand a chemist or alchemist to be.<sup>29</sup> They seem to contradict themselves by describing the text as ‘technical and arcane, its vocabulary archaic and recondite’, but also ‘sound and practical’.<sup>30</sup> In fact, the vocabulary, while technical, is relatively straightforward. The language of the Freiburg *Firework Book* – as for all other *Firework Books* in existence

<sup>26</sup> Smith, *Rewriting Gunpowder History*, 95.

<sup>27</sup> ‘Lehr- und Handbuch für den Büchsenmeister’ (Nibler, *Feuerwerkbuch*, 3).

<sup>28</sup> Kramer and Leibnitz, *Das Feuerwerkbuch*, 20.

<sup>29</sup> Many scholars have tried to address the roles of alchemist and chemist in late medieval society. See Leah DeVun, *Prophecy, Alchemy, and the End of Time: John of Rupeccissa in the Late Middle Ages* (New York: Columbia University Press, 2009), P. G. Maxwell-Stuart, *The Chemical Choir: A History of Alchemy* (London: Continuum, 2008), or Michela Pereira, ‘Alchemy and the Use of Vernacular Languages in the Late Middle Ages’, *Speculum* 74:2 (1999), 336–56. However, the scholars’ main concern seems to be the role of alchemy as pseudo-science and its relation to religion. In the end, the title ‘alchemist’ or ‘chemist’ becomes a loose collective term for anyone who is more or less engaged in activities related to alchemy and associated issues.

<sup>30</sup> Kramer and Leibnitz, *Das Feuerwerkbuch*, 20.

– is not ‘archaic’ Middle High German (as Kramer and Leibnitz suggest) but Early New High German, written in the regional dialect of the respective author. Most fifteenth-century copies of the *Firework Books* – including the Freiburg *Firework Book* – are written in cursive, clear bastarda.<sup>31</sup> Therefore, we can see that Kramer and Leibnitz’s evaluation, as evidenced in the above quote, betrays a lack of understanding of late medieval and early modern language, science, concepts, and terminology. Moreover, they undervalue the *Firework Book’s* use of the core content and invaluable rhetorical technique of question and answer, providing the reader with a familiar didactic format, similar to that found in early medical texts or later in manuals on mining, but also in scholastic texts.<sup>32</sup> Kramer and Leibnitz are correct, however, when they observe that a full understanding of the text requires the multidisciplinary skills of a chemist, historian, and linguist.

Up to now there have been only occasional references in scholarly publications in English to the *Firework Book* and its position within the wider genre of technical treatises on aspects of master gunners’ instructions and manuals.<sup>33</sup> German academic scholarship, on the other hand, has attempted to identify several, different categories of firework and war books, of which the *Firework Book* tradition is only one.<sup>34</sup> An early reference to the *Firework Book* genre was provided by the nineteenth-century historian Max Jähns in 1889–91,<sup>35</sup>

<sup>31</sup> See Joachim Kirchner, *Germanistische Handschriftenpraxis* (München: Beck, 1950), 22–23. Kramer and Leibnitz refer to it as ‘German Gothic Script’ (Kramer and Leibnitz, *Das Feuerwerkbuch*, 20). It is difficult to get to the bottom of what Kramer and Leibnitz may have interpreted as Gothic Script. It is most likely that they confused the bastarda script (sometimes called Gothic) with the language presented.

<sup>32</sup> Ferdinand Nibler describes the *Firework Book of 1420* as one of the oldest, if not the oldest, German-language text with technical content (*deutschsprachige[s] Buch mit technischem Inhalt* – Nibler, *Feuerwerkbuch Buchbesprechung*, 147). It is a very bold claim, but difficult to substantiate – not only because a definition would be required for what constitutes a book, what he means by ‘technical content’ or even what he regards as ‘German-language’.

<sup>33</sup> Notable exceptions include DeVries and Smith, *Military Technology*, 152, Smith, *Rewriting Gunpowder History*, 95–100, Hall, *Warfare in Renaissance*, 71, or even earlier, Partington, *Greek Fire and Gunpowder*, 144 and 155, and Needham, *Military Technology: Gunpowder Epic*, 267.

<sup>34</sup> Leng, *Ars belli*, vol. 1, 4–23, and Leng, ‘Feuerwerks- und Kriegsbücher’, 145–53.

<sup>35</sup> Jähns was one of the most prominent military historians in nineteenth-century Germany. After a long military career he became Professor of the History of Military Art (*Kriegskunst*) at the Military Academy (*Kriegsakademie*) in Berlin from 1872 to 1886. His 865-page, 3-volume *Geschichte der Kriegswissenschaften* (1889–91) provides an overview of military history from Antiquity to the end of

who includes it in his section on technical works (*Fachwissenschaftliche Werke*) and produces an unsubstantiated explanation on the incoherent order of the instructions – describing them as ‘untidy’. He suggests that the individual instructions were on separate pieces of paper, only collated with greater or less attention by the redacting editors.<sup>36</sup> Jähns even comments in detail about the one copy known to be in existence in French. Following the prevalent stance of German nationalism at the time, he argues that this must be a later copy, and represents an acknowledgment of the dominance of German gunpowder artillery in the fifteenth and sixteenth centuries across Europe.<sup>37</sup> However, Jähns fails to provide evidence for his arguments, falling back on general statements.<sup>38</sup>

Research into these technical texts in the nineteenth century was often driven by the antiquarian curiosity of military practitioners who wished to understand better the origins of their own discipline. Their motives and methodologies were multifaceted and produced mixed results. Max Jähns, Bernard Rathgen, and many other military historians of the period were retired officers who engaged in research into the history of artillery. Their research, in the course of collating a large number of sources and establishing early categorizations, has been described as containing substantial misinterpretations resulting from insufficient critical distance to sources.<sup>39</sup> Between the 1890s

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the sixteenth century, predominantly in Germany. This text, still referred to today, has been viewed as one of the cornerstones of German military historical studies.

<sup>36</sup> ‘Diese Unordnung, welche sämtliche Codices anhaftet, findet sich nicht überall in der selben Reihenfolge, und so darf man vermuten, daß ursprünglich einzeln auf Zettel geschrieben waren, die von Redaktoren mit größerer oder geringerer Einsicht in das Original oder in eine auch schon anderweitig verdorbene Kopie eingeschaltet worden sind’ (Jähns, *Kriegswissenschaften*, 394).

<sup>37</sup> His work contains statements such as ‘how no other peoples in the then Europe can demonstrate’ (*‘wie sonst kein Volk des damaligen Europas auszuweisen hat’*, Jähns, *Kriegswissenschaften*, 382), the ‘esteem which German gunpowder artillery possessed even in the fifteenth century’ (*‘die Achtung, in welcher die deutsche Büchsenmeisterei schon im 15. Jahrhundert stand’*, Jähns, *Kriegswissenschaften*, 408), or, referring to the translation into French, as a ‘simple translation of the old German Firework Book’ (*‘einfache Übersetzung des alten deutschen Feuerwerkbuches’*, Jähns, *Kriegswissenschaften*, 408).

<sup>38</sup> Jähns, *Kriegswissenschaften*, 408.

<sup>39</sup> Volker Schmidtchen, *Kriegswesen in späten Mittelalter: Technik, Taktik, Theorie* (Weinheim: VCH, 1990), 5, and Rainer Leng, *Anleitung Schiesspulver zu bereiten, Büchsen zu laden und zu beschiessen: eine kriegstechnische Bilderhandschrift im cgm 600 der Bayerischen Staatsbibliothek München*, *Imagines Medii Aevi* 5 (Wiesbaden: Reichert, 2000), 10.

and 1960s, Marcelin Berthelot, Theodor Beck, and Bertrand Gille highlighted the master gunner and gun maker traditions as one of the contributory elements in the development of the discipline of engineering. Friedrich Klemm, too, recognized the role of fifteenth-century gunnery manuals which mark the early beginnings of technical writings.<sup>40</sup> Franz Maria Feldhaus proposed the first typology in 1931 (revised in 1954)<sup>41</sup> while ignoring illustrations and the technical aspects of the content of the texts. In North America, the earliest main contribution to the subject was made by Lynn White, as part of the wider quest to revive research into medieval technology as a fundamental part of social history.<sup>42</sup> Since the 1960s this has changed, with scholars across Europe and North America publishing on aspects of military technology, their description and depiction in the fifteenth and sixteenth centuries. However, the main effort would appear to be focused on the illustrations with far less emphasis on the text available.<sup>43</sup>

Over a period of more than 30 years, the military historian Volker Schmidtchen developed a system of sub-categorization of medieval publications on military technology. It was he who first clearly subdivided the genre into five distinct categories: 1) literary sources (chronicles, annals, and other reports of events); 2) manuscripts which exclusively or partially depict and describe military technology; 3) manuals, regulations, statutes, and instructional writings; 4) account books, rolls, inventories, books of feuds (*Fehdebücher*), and other registers of events (*actae*); and 5) technical sources (arms and equipment). Even Schmidtchen admits, however, that this categorization

<sup>40</sup> See Marcelin Berthelot, 'Pour l'histoire des arts mécaniques et de l'artillerie vers la fin du moyen âge', *Annales de chimie et de physique*, ser. 6, 24 (1891), 433–521, Theodor Beck, *Beiträge zur Geschichte des Maschinenbaus* (Berlin: Julius Springer, 1899), 270–92, Bertrand Gille, 'Études sur les manuscrits d'ingénieurs du XVe siècle', *Techniques et civilisations* 5 (1956), 77–86, at 79–81, or Friedrich Klemm, *Die Geschichte des technischen Schrifttums. Form und Funktion des gedruckten technischen Buchs vom ausgehenden 15. bis zum beginnenden 19. Jahrhundert* (München: Diss. Masch, 1948).

<sup>41</sup> See Feldhaus, *Technik der Antike und des Mittelalters*, 324–27, as well as Franz Maria Feldhaus, *Die Maschine im Leben der Völker. Ein Überblick von der Urzeit bis zur Renaissance* (Basel and Stuttgart: Birkhäuser, 1954), 229–53.

<sup>42</sup> See Lynn White Jr, *Medieval Technology and Social Change* (London: Oxford University Press, 1962), 96–101. See also Robert Fox (ed.), *Technological Change: Methods and Themes in the History of Technology*, Studies in the History of Science, Technology & Medicine 1 (Amsterdam: Harwood Academic, 1996), 11–15.

<sup>43</sup> One laudable exception was Bert Hall, who singled out the *Bellifortis* and the *Firework Book* as by far the most prominent genres produced in Germany in the fifteenth century (Hall, *Illustrations ... Hussite Wars*, ch. 2).

has its limitations and cannot be applied across all records. Each of his categories is a loose collection of different sources and formats. Nor is it helpful that many texts are untitled or are anonymous, which, in turn, leads to subjective, often artificial labelling at their respective libraries or archives.<sup>44</sup> Schmidtchen locates the *Firework Book* genre within his category 2, as manuscripts which depict and describe military technology.

The *Firework Book* genre is thus seen as one of the subgroups within the group of firework and war book manuscripts related to warfare technology in the German vernacular – with its main focus on the development and technologies of explosives and improved smithing and woodcraft technologies which supported those developments – emerging in the fifteenth century in vernacular cultures, and especially in German manuscripts.<sup>45</sup> The tradition appears not to have spread in the fifteenth century into Italian, French (with possibly one exception), or Spanish, although there is one indication of a version in Hebrew.<sup>46</sup> Illustrated military manuscripts were produced only in small numbers in Italy in the fifteenth and sixteenth centuries. The high level of decoration, and the use of expensive ink and materials, as well as the absence of wear and tear, suggest that they were probably used as gifts and collector's items for display rather than being intended for use as manuals in a workshop.<sup>47</sup>

<sup>44</sup> Schmidtchen, *Kriegswesen*, 22–23.

<sup>45</sup> As defined by the *Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*, see Leng, 'Feuerwerks- und Kriegsbücher', 145–512.

<sup>46</sup> What has survived is a sixteenth-century copy of the *Livre du secret de l'art de artillerie et cannonerie* in French. It is not possible to establish whether this text had an older original in French or is a sixteenth-century French translation of a text from a different language (Paris, Bibliothèque nationale de France, Ms. Latin 4653, <https://archivesetmanuscrits.bnf.fr/ark:/12148/cc63506g> (accessed 10 August 2023)). The reference on the manuscript in Hebrew comes from Partington, *Greek Fire and Gunpowder*, 179 n. 45, where the author refers to M. Ginsburger, 'Les Juifs et l'art militaire au Moyen-Âge', *Revue des Études Juives* 88 (1929), 156–66. However, when consulting the article referred to, all Ginsburger mentions is that there is meant to be a Hebrew manuscript in Munich which Ginsburger argues to be based on content from the *Firework Book*. Rather than thinking it was a translation of a German text, he believes that it is an original by a Jewish author. No reference nor justification for this assumption has been provided (Ginsburger, 'Les Juifs et l'art militaire', 157–58). The suggested manuscript could not be traced.

<sup>47</sup> Marcus Popplow, 'Militärtechnische Bildkataloge des Spätmittelalters', in *Krieg im Mittelalter*, ed. Hans-Henning Kortüm (Berlin: Akademie, 2001), 251–68, at 262. One of the most outstanding authors was Mariano Taccola (1381–1453/58), some of whose works survive from 1430–50. See *Mariano Taccola, Liber Tertius de Ingeñeis ac edifiitiis non usitatis*, ed. J. H. Beck (Milano: Edizioni il Polifilo, 1969),



The later Middle Ages saw what Lynn White called ‘the emergence of a conscious and generalized lust for natural energy and its application to human purposes’.<sup>48</sup> This concept was further developed by Bert Hall into the emergence of literature dealing with technology and machinery in response to this new ‘consciousness of a power technology’.<sup>49</sup> Starting with Villard de Honnecourt (whose notebook dates from c. 1235), a growing number of similarly intended writings, including Guido da Vigevano’s *Texaurus regis Francie acquisitionis terre sancte* (c. 1335), depicted military technological devices for the crusades. Gradually these types of writing increased in quantity but remained largely limited to the geographical area that today includes southern Germany, Austria, and northern Italy. There are no known manuscripts of this kind in the Low Countries, Scandinavia, Iberia, or the British Isles.<sup>50</sup>

### The *Bellifortis* and the *Büchsenmeister Book*

Most of the manuscripts of this genre in German were produced in the first few decades of the fifteenth century at a time when other genres of vernacular writing, such as treatises on technical aspects of field medicine, wound healing, and apothecary practice, were beginning to emerge.<sup>51</sup> Other elements in this group are texts on military technology for use at court, called the *Bellifortis*, which survives in a number of manuscripts with the first version believed to have been written between 1402 and 1405, and manuscripts related to the *Büchsenmeister Book* (literally meaning ‘Master Gunner Book’), with the earliest surviving manuscript dated to 1411.<sup>52</sup> This means that chronologically the

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Mariano Taccola, *De ingeneis*, eds Frank D. Prager and Ulrich Montag (Cambridge, MA: MIT Press, 1971), and Mariano Taccola, *De rebus militaribus (De machinis, 1449)*, ed. Eberhard Knobloch (Baden-Baden: Koener, 1984). For an analysis of the manuscripts in historical context see Paolo Galluzzi, *Prima di Leonardo. Cultura delle machine a Siena nel Rinascimento* (Milano: Mondadori Electa, 1991).

<sup>48</sup> White, *Medieval Technology*, 129.

<sup>49</sup> Hall, *Illustrations ... Hussite Wars*, 8.

<sup>50</sup> Hall, *Illustrations ... Hussite Wars*, 9. There is one already-mentioned possible French translation.

<sup>51</sup> Melanie Panse, *Hans von Gersdorff: ‘Feldbuch der Wundarznei’. Produktion, Präsentation und Rezeption von Wissen*, Trierer Beiträge zu den historischen Kulturwissenschaften 7 (Wiesbaden: Reichert, 2012), 204–7.

<sup>52</sup> For a comprehensive study of the *Bellifortis* see Leng, *Ars belli*, vol. 1, 109–49, Udo Friedrich, ‘Herrscherpflichten und Kriegskunst. Zum intendierten Gebrauch früher ‘Bellifortis’-Handschriften’, in *Der Codex im Gebrauch. Akten des Internationalen Kolloquiums 11.–13. Juni 1992*, eds Christel Meier et al. (München: Wilhelm

*Firework Book* can be placed after the production of the *Bellifortis*, and possibly around the same time or just before the earliest version of the *Büchsenmeister Book*. This leads me to speculate that the earliest *Firework Book* would have existed in the early years of the fifteenth century, and may have influenced the *Büchsenmeister Book* which contains elements of the *Firework Book*. Apart from some specific mentions of the *Bellifortis* by Partington and Singer, and works on the Chinese origins by Needham, little research has been done on the relationship of these treatises and their shared roles in the history of the development of gunpowder technology.<sup>53</sup> As Leng observes, the main focus has been on the debate about corning – the change from individual loose powder of a floury consistency to more potent corned powder.<sup>54</sup>

The *Bellifortis* has generally been described as the first of the genre of illustrated manuscripts with technical military content in the later Middle Ages.<sup>55</sup> However, most extant *Bellifortis* manuscripts contain considerable

Fink, 1996), 197–210, and Lynn White Jr, 'Kyeser's *Bellifortis*: The First Technological Treatise of the Fifteenth Century', *Technology and Culture* 10 (1969), 436–41. The earliest *Büchsenmeister Books* are Vienna, Österreichische Nationalbibliothek, Cod. 3069, and Munich, Bayerische Staatsbibliothek, Cgm. 356. See Leng, *Ars belli*, vol. 2, 334–36, and 198–201, and Leng, *Anleitung Schiesspulver*, 12–22.

<sup>53</sup> Partington, *Greek Fire and Gunpowder*, 149–50, *A History of Technology*, ed. Charles Singer (Oxford: Clarendon Press, 1954–84), 653–56, and Needham, *Military Technology: Gunpowder Epic*, 342–65.

<sup>54</sup> Leng, *Ars belli*, vol. 1, 37. Corned powder or corning is a development in the production of gunpowder which involves adding water or alcohol to the ground powder and drying it so that the powder turns lumpy, which in turn improves combustion and consistency. When and how corned powder developed is a subject discussed by experts in the 1990s and beyond. There is scientific evidence that at some point in the fifteenth century gunners started using corned gunpowder, which was more powerful in its kinetic properties. This corned powder is much more advanced technologically from the earlier version of *Knollenpulver* mentioned in the *Firework Book* and discussed in Chapter 5. For the discussion on corned powder and corning see Kelly DeVries, 'Gunpowder and Early Gunpowder Weapons', in Buchanan, *Gunpowder: History of Technology*, 121–36, Bert S. Hall, 'The Didactic and the Elegant: Some Thoughts on Scientific and Technological Illustrations in the Middle Ages and Renaissance', in *Picturing Knowledge: Historical and Philosophical Problems concerning the Use of Art in Science*, ed. Brian Baigrie (Toronto: University of Toronto Press, 1996), 3–39, Hall, *Warfare in Renaissance*, here especially 68–87, and Gerhard W. Kramer, 'Das Feuerwerkbuch: Its Importance in the Early History of Black Powder', in Buchanan, *Gunpowder: History of Technology*, 45–56, but also much earlier Romocki, *Geschichte der Explosivstoffe*.

<sup>55</sup> Leng, *Ars belli*, vol. 1, 7. This is, however, not correct, as the fourteenth-century Guido da Vigevano's *Texaurus regis Francie acquisitionis terre sancte* (c. 1335) already contains military illustrations.



material from the *Firework Book* and vice versa.<sup>56</sup> While changes occurred during the fifteenth century,<sup>57</sup> the core body of both manuscript groups can be relatively clearly defined.<sup>58</sup> According to Leng, 47 manuscripts of the *Bellifortis* are in existence, while a further 58 manuscripts are assumed to belong to the *Firework Book of 1420* genre.<sup>59</sup> It was clear that the *Bellifortis* cost much more to produce than a *Firework Book*: on high-quality paper, but written predominantly in Latin, and – most importantly – dominated by colourful (and expensive) illustrations. Conceptually, the *Bellifortis* seems much more interested in praising the military equipment depicted, usually in Latin verse, instead of explaining its actual use.<sup>60</sup> Thus, as argued by Theresia Berg and Udo Friedrich, the *Bellifortis*'s assumed readership is much more the untrained

<sup>56</sup> Leng, *Ars belli*, vol. 1, 199, 205–6.

<sup>57</sup> Leng, *Anleitung Schiesspulver*, 17–18.

<sup>58</sup> Leng, *Ars belli*, vol. 1, 19.

<sup>59</sup> Leng, *Ars belli*, vol. 1, 21, and vol. 2, 442–62. In total, Leng identifies some 100 texts produced in fifteenth-century Germany in relation to military technology and tactics, even with the exclusion of fencing and crossbow manuals, with a further 170 in the sixteenth century. However, he freely admits that this is a flawed attempt. In Leng, 'Feuerwerks- und Kriegsbücher', he provides a structure of 'manuals for fire-works and war (*Feuerwerks- und Kriegsbücher*)' as part of the 'Catalogue of German language illustrated manuscripts of the Middle Ages (*Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*)'. He provides as subcategories 1) anonymous master gunner books, 1400–1450 (*Büchsenmeisterbücher der ersten Hälfte des 15. Jahrhunderts*); 2) The *Firework Book of 1420* (*Feuerwerkbuch von 1420*); 3) illustrated manuscripts of military technology for a courtly audience (*Bilderhandschriften zur Kriegstechnik für höfische Adressaten*); 4) anonymous and other master gunner books, 1450–1500 (*Anonyme und sonstige Büchsenmeisterbücher aus der zweiten Hälfte des 15. Jahrhunderts*); 5) other and anonymous war books, sixteenth century (*Sonstige und anonyme Kriegsbücher des 16. Jahrhunderts*); and 6) Arsenal inventories (*Illustrierte Zeughausinventare*); and a further 14 categories with named authors including Johannes Bengedans, Johannes Formschneider, Franz Helm, Konrad Kyeser, Martin Merz, and Philipp Mönch – with a grand total of 206 manuscripts considered. It is not entirely clear how he made editorial decisions to include or exclude certain manuscripts, which may not include illustrations.

<sup>60</sup> Similar to the *Firework Book of 1420*, the *Bellifortis* exists in a number of known copies. According to Graf zu Waldburg Wolfegg, 35 manuscripts are in existence, with their provenance known only from the early nineteenth century onwards. All of these manuscripts were high-quality productions, using multi-coloured illustrations on high-end paper. Christoph Graf zu Waldburg Wolfegg, 'Der Münchner "Bellifortis" und sein Autor', *Patrimonia* 137 (2000), 26–27. Bertrand Gille defines a German School of technological thought, and a movement which can be subdivided into 'The primitives', Konrad Keyser, and the manuscripts of the Hussite War – in order of sophistication. He provides a comprehensive list of *Bellifortis*

non-expert instead of the artisan and practitioner readership of the *Firework Books* or the *Büchsenmeister Books*.<sup>61</sup>

As with the *Firework Book*, little is known about the *Bellifortis*: the name of its author, Konrad Kyesser, emerges in only two manuscript references.<sup>62</sup> Direct indications for the use of a *Bellifortis* cannot be established and the interest of a potential user can only be glimpsed from the list of dedications.<sup>63</sup> However, both the *Firework Book* and the *Bellifortis* have frequently been copied and their copies reveal alterations and amendments, together with additions.

The differences between the *Firework Book* and the *Bellifortis* are neatly summed up by Hall: 'The practical, prosaic, unillustrated Feuerwerkbuch and the fanciful, wide-ranging, lavishly illustrated *Bellifortis* together constitute the two main poles of the fifteenth-century Germanic tradition'.<sup>64</sup> Arguably, the most noticeable difference between the *Bellifortis* and the *Firework Book* is the predominant language used. The *Bellifortis* was mainly written in Latin interspersed with occasional German terms, while the *Firework Book* was composed in vernacular German, thus making the *Firework Book* the earliest textbook for specialists on military matters in any vernacular language.<sup>65</sup> This could possibly indicate the difference between the *Bellifortis* and the *Firework Book* with regard to their intended audience, reception, and use. It seems to be the common perception that there was a more scholarly, alchemical, and clerical tradition of texts of a technical nature which were produced in Latin – something which continued through the sixteenth and seventeenth centuries

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copies which has been amended and enhanced by Leng, *Ars belli* (Bertrand Gille, *The Renaissance Engineer* (London: Lund Humphries, 1966), 55–77).

<sup>61</sup> Theresia Berg and Udo Friedrich, 'Wissenstradierung in spätmittelalterlichen Schriften zur Kriegskunst: Der "Bellifortis" des Konrad Kyesser und das anonyme "Feuerwerkbuch"', in *Wissen für den Hof. Der spätmittelalterliche Verschriftlichungsprozess am Beispiel Heidelberg im 15. Jahrhundert*, ed. Jan-Dirk Müller (München: Wilhelm Fink, 1994), 170.

<sup>62</sup> Friedrich, 'Herrscherpflichten und Kriegskunst', 198.

<sup>63</sup> Friedrich mentions one manuscript containing a list of Kyesser's dedications to previous employers, Sigismund of Hungary, Wenzel of Bohemia, and Franz of Carrara, while another contains a number of coats-of-arms, and a third specifies an *ex libris* from the Margrave Ernst Friedrich von Baden-Durlach. This, the author concludes, is an indication of presence among the political ruling classes (Friedrich, 'Herrscherpflichten und Kriegskunst', 200–1).

<sup>64</sup> Hall, *Illustrations ... Hussite Wars*, 20.

<sup>65</sup> Berg and Friedrich, 'Wissenstradierung', 215, and *Verfasserlexikon*, vol. 2 (1980), cols 730–32, where the author goes a step further and describes the *Firework Book of 1420* as the first book of technical content in German vernacular.

– while texts in vernacular languages were more practically oriented and created for a more immediate use.<sup>66</sup> The stated reason in the *Firework Book* as to why it was necessary to write down complex details was because there were ‘so many things of which each good master gunner [and/or gun master] ought to be capable and which could not all be remembered well by a master and kept in his mind’.<sup>67</sup> This indicates that it was intended as an *aide memoire*, to be used frequently, as and when needed.<sup>68</sup> This, however, is an oversimplification about what the *Firework Book* is, as will be evidenced in subsequent chapters.

Compared to the *Bellifortis*, the *Firework Book* and the *Büchsenmeister Book* are much more clearly aimed at the practitioners themselves. They are functional and instructive texts, lacking jokes or innuendos. Instead, they focus, in a very matter-of-fact way, on disseminating information on the construction and use of guns and the production and use of gunpowder. These books have moved away from courtly entertainment to a practice-oriented role for the subject expert.<sup>69</sup> However, similarly to earlier comparison with the *Bellifortis*, the earliest versions of the *Büchsenmeister Book* place the main emphasis on the illustrations, with the textual references providing additional explanations, making the text of secondary importance to the illustrations. Earlier versions of the *Büchsenmeister Book* contain neither detailed recipes nor the detailed follow-through of the *Firework Book*, something that later changed, according to Leng.<sup>70</sup>

A key distinguishing feature of the core *Firework Book* – at first glance – is that it is unlike other associated texts such as the *Bellifortis* and the *Büchsenmeister Books* in that it hardly ever contains illustrations.<sup>71</sup> It is mainly restricted to the transmission of technical knowledge related to gunpowder and its components which does not require visual explanation. Leng moves one step further in his introduction to the *Firework Book* content by explaining that ‘the reason was that the *Firework Book*’s limitation to transmitting chemical

<sup>66</sup> See Berg and Friedrich, ‘Wissenstradierung’, 174–76, or Panse, *Feldbuch der Wunddarzney*, 11–16.

<sup>67</sup> See Chapter 3, fol. 33r.

<sup>68</sup> For evidence of actual use see Chapter 2.

<sup>69</sup> Leng, *Ars belli*, vol. 1, 109–49.

<sup>70</sup> Leng, *Ars belli*, vol. 1, 150–97.

<sup>71</sup> There are a few exceptions, such as the front page of Heidelberg Universitätsbibliothek, Cod. Pal. germ. 502, which contains an illustrated first page capital with a gun; or basic illustrations as marginalia in Vienna Cod. 3064 (not always classified as a *Firework Book* of 1420, but with some elements of it – see Leng, *Anleitung Schiesspulver*, 17–18) or Munich Cgm. 399 (see Leng, *Ars belli*, vol. 2, 454).

knowledge on the production of gunpowder and its key components meant that the *Firework Book* did not require a visual transmission'.<sup>72</sup>

The fifteenth century sees the emergence of a range of technical texts. As Hall indicates, two schools of military-related writings rapidly emerge, with the Italian texts taking an all-encompassing approach, combining all aspects of military matters in one single text, while the German texts focus almost exclusively on technical matters. In the mid-fifteenth century, a treatise, *Ingenieurkunst- und Wunderbuch* ('*Book of the Art of Engineering and Miracles*') appears which contains a compilation of various instructive texts largely based on the *Bellifortis*.<sup>73</sup> Around the same time there emerged a group of manuscripts attributed to one Johann Formschneider, a master gunner or gun maker (*Büchsenmeister*) from Nuremberg. While only fragments of Formschneider's treatise survive, they indicate a wide ranging and detailed interest in military machines with the intention of improving some of Kyeser's writings as well as the *Firework Book*.<sup>74</sup> Modern scholarship has shown that these manuscripts were collected by local princes and rulers, in order to accumulate knowledge in their courtly libraries – with less of a sense as to whether they were actually used.<sup>75</sup> Thus, they provided access to a new technology with hitherto unknown effects.<sup>76</sup> Both of these statements lack supporting evidence and can only be seen as one possible interpretation of their reasons for production and usage.

One outstanding example is the *War Book* (*Kriegsbuch*) by Johannes Bensedans, surviving in three copies, which contains in parts a *Büchsenmeister Book* (literally translated as the 'master gunner' or 'gun master' book). We know from surviving letters, which have been dated to c. 1450–67, that the author Bensedans applied to the then High Master of the Teutonic Order for the

<sup>72</sup> 'Die Beschränkung auf die Vermittlung chemischen Wissens um die Herstellung von Pulverbestandteilen und Büchsenpulver erforderte keine visuelle Umsetzung' (Leng, *Ars belli*, vol. 1, 198).

<sup>73</sup> Also called the 'Skanderbeg manuscript' after the Albanian nobleman George Kastrioti Skanderbeg (d. 1468), who was said to have owned it. See the anonymous *Ingenieurkunst- und Wunderbuch*, Weimar, Stiftung Weimarer Klassik / Anna-Amalia-Bibliothek, fol. 328 (unpublished).

<sup>74</sup> Hall, *Illustrations ... Hussite Wars*, 23.

<sup>75</sup> Ralf G. Päsler, 'Sachliteratur (Artillerie-, Fecht-, und Ringbücher)', in *Handbuch Höfe und Residenzen im spätmittelalterlichen Reich*, vol. 15.III: *Hof und Schrift*, eds Werner Paravicini et al. (Ostfildern: Thorbecke, 2005), 573–84, at 579.

<sup>76</sup> Päsler, 'Sachliteratur', 574.

position of master gunner.<sup>77</sup> While no records show whether Bengedans was actually employed by the Order, he is listed as a participant on a diplomatic mission on their behalf.<sup>78</sup> He lists his wide-ranging skills, such as purifying saltpetre, the production of fire arrows of different types, the casting of cannons, and manufacture of other military technical devices.<sup>79</sup> In contrast to the *Firework Book* tradition, Bengedans emphasizes his own skills in the improving and ennoblement of precious metals.<sup>80</sup> The 'War Book' clearly shows that Bengedans felt the need to portray himself as multi-skilled in technical and scientific endeavours, even if most of his writing is far from original but derived from multiple other sources. Bengedans's writings, an example of the new category of reference books for military technology which emerged in the second half of the fifteenth century, are viewed as an ideal introduction to the art of artillery, a practical manual for apprentices and specialists alike.<sup>81</sup> The *Büchsenmeister Books* describe the establishment of the role and title of 'master gunner', and his official key functions. Most of the *Büchsenmeister Books* are attributed to a named author, and include a wide range of illustrations, usually with only small amounts of text written predominantly in German vernacular. It is clear that the *Büchsenmeister Books* relied heavily on elements of the *Firework Book* but, with the introduction of illustrations, it was produced for a different audience and a different use.<sup>82</sup>

Thus, the *Büchsenmeister Book* texts served a range of different purposes: as *aides memoire* for new techniques of hitherto abstract knowledge and processes which were perceived to be too complex for an individual to remember;<sup>83</sup> and

<sup>77</sup> *Kriegskunst und Kanonen: Das Büchsenmeister- und Kriegsbuch des Johannes Bengedans*, eds Hans Bloen and Rikke Agnete Olsen (Aarhus: Aarhus Universitetsforlag, 2006), vol. 2, 62.

<sup>78</sup> Bloen and Olsen, *Benedans*, vol. 1, 15.

<sup>79</sup> Bloen and Olsen, *Benedans*, vol. 2, 81.

<sup>80</sup> Bloen and Olsen, *Benedans*, vol. 2, 66.

<sup>81</sup> Bloen and Olsen, *Benedans*, vol. 1, 17.

<sup>82</sup> Leng puts the *Firework Book* together with earlier and later *Büchsenmeister Books* into one single category, stating that the manuscript Munich Cgm. 600 likely preceded the production of the *Firework Book*, while later named versions are described as a continuum (Leng, *Ars belli*, 150–266).

<sup>83</sup> The reasons for this have been explained differently by scholars, from the argument that 'new technology required accurate knowledge of abstract processes' (Päsler) to the fact that they 'have nothing to do with mechanics or ballistics as a science, but instead seem to have served as a sort of cookbook for the gunner' (Hall). See Bert S. Hall, "'Der Meister sol auch kennen schreiben und lesen': Writings about Technology ca. 1400–ca. 1600 A.D. and their Cultural Implications', in *Early Technologies*, ed.

they also turned – as was highly explicit in the case of Bengedans – into a work portfolio, a reference work for future employers.

## Sixteenth-Century Market for Science and Technology Books

In the sixteenth century, printers in Germany were the leading producers of a wide range of ground-breaking publications in the fields of both science and technology: Copernicus in astronomy, Leonard Fuchs in botany, Hieronymus Brunschwig in pharmacology, Vesalius in anatomy, as well as Agricola's *De Re Metallica*, first printed in Basel in 1556.<sup>84</sup> There clearly appears to have been a market for publications of this kind. It is important to point out that these publications were driven by humanists, and were exclusively written in Latin. Alongside these Latin texts, vernacular publications in Early New High German began to become more frequent, their origins being traced to early sixteenth-century text versions such as *Eyn wohlgeordnet und nützlich büchlein, wie man bergwerk suchen und finden soll* ('A well-structured and useful book on how to seek and find mines'), commonly called *Bergbüchlein*, by Ulrich Rülein von Calw, a humanist, medical researcher, and mathematician.<sup>85</sup>

Chronologically, the *Buch von den probierten Künsten* by Franz Helm, printed in 1535, is often seen as the culmination of the *Büchsenmeister Book* tradition.<sup>86</sup> This book sums up all core aspects of gunpowder technology, from powder production to firing, and includes many elements of the *Firework Book*, such as the 12 Master Gunner's Questions, which have been updated to sixteenth-century requirements and understanding of the technology. By then, the profession of master gunner had become more specialized, while the

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Denise Schmandt-Besserat (Los Angeles: Undena Publications, 1979), 47–58, at 52–54, or Päsler, 'Sachliteratur', 578–79.

<sup>84</sup> David E. Connolly, 'Ulrich Rülein von Kalbe's *Bergbüchlein* in the Context of Sixteenth-Century German Mining/Metallurgical Literature', in *De Re Metallica: The Uses of Metal in the Middle Ages*, eds Robert O. Bork et al. (Farnham: Ashgate, 2005), 347 – in an article on sixteenth-century mining literature and Ulrich Rülein von Kalbe's *Bergbüchlein* (first printed around 1500 in Saxony).

<sup>85</sup> Available electronically at the Staats- und Landesbibliothek Dresden, <https://digital.slub-dresden.de/werkansicht/dlf/12328/1/> (accessed 10 August 2023).

<sup>86</sup> Edited by Leng with critical introduction (Leng, *Franz Helm*, 3–135). Andresová's assertion that 'the late medieval *Feuerwerkbuch* [...] was commonly issued under the name of the *Büchsenmeisterei* during the 16th century' is an oversimplification as no comprehensive standardization occurred (Andresová, 'Artillery Handbooks of the 16th Century', 23).



manufacture of cannons and the ingredients required for firing them (gunpowder, wadding, plugs, projectile, wedges, etc.) was delegated to others.<sup>87</sup>

The emergence of these texts went hand-in-hand with the development of other reference books, and could be seen as a move away from the specialist user to a more domestic audience, with texts such as the *Medieval Housebook* which include collections of drawings and texts. *Das mittelalterliche Hausbuch* (c. 1480) is attributed to the so-called 'Master of the Amsterdam Cabinet' and is often assumed to be one of the inspirations for the works of Dürer.<sup>88</sup> This *Hausbuch* includes a range of pyrotechnical recipes which, it has been argued, are drawn from the *Firework Book*, as well as incorporating astrological constellations and gardens of delights, together with military and domestic machines.<sup>89</sup> One of the many derivatives of this *Hausbuch* is the 'War Book' (*Kriegsbuch*), written in 1496 by Master Gunner Philipp Mönch (born in 1457) and illustrated as '*büch der stryt vnd buchßen*' (which can be translated as 'book of conflict and guns'), possibly made for Philip the Upright, Elector Palatine of the Rhine. A copy of this text is found in Heidelberg as Cod. Pal. germ. 126.<sup>90</sup>

## Urtext, Production, and Transmission

Hassenstein had already noted in 1941 that the main focus of the *Firework Book of 1420* is on people, including the attribution of what qualities do (and do not) make a good master gunner, thus arguing that the *Firework Book* differs from modern technical treatises, in that the technology comes second

<sup>87</sup> 'Wie bei einem schnell immer komplexer werdenden Handwerk zu erwarten, tritt ab der zweiten Hälfte des 15. Jahrhunderts eine immer deutlicher werdende Spezialisierung ein. [...] ab 1460 folgen ganze Dynastien von berühmten Büchsengeießern, während die Büchsenmeister die Feuerwaffen nur noch transportieren, warten und bedienen' (Leng, 'getruwelich dienen', 320–21). It was only in the sixteenth century that the use of fireworks for pleasure and entertainment was recorded (see Rainer Leng, 'Feuerwerk zu Ernst und Schimpf. Die spielerische Anwendung der Pyrotechnik im Lustfeuerwerk', in *Homo faber ludens. Geschichten zu Wechselbeziehungen von Technik und Spiel*, eds Stefan Poser and Karin Zachmann (Frankfurt am Main: Peter Lang, 2003), 85–111).

<sup>88</sup> Christoph Graf zu Waldburg Wolfegg, *Venus and Mars: World of the Medieval Housebook* (London: Prestel, 1998), 8–9.

<sup>89</sup> Hall, *Illustrations ... Hussite Wars*, 15.

<sup>90</sup> Available online at <https://digi.ub.uni-heidelberg.de/diglit/cpg126> (accessed 10 August 2023).