



University of HUDDERSFIELD

University of Huddersfield Repository

Müller, Axel

The Firework Book: An edition, translation, and analysis of Royal Armouries Ms. I.34 as an example of tradition and change in fifteenth-century gunpowder technology

Original Citation

Müller, Axel (2019) The Firework Book: An edition, translation, and analysis of Royal Armouries Ms. I.34 as an example of tradition and change in fifteenth-century gunpowder technology. Doctoral thesis, University of Huddersfield.

This version is available at <http://eprints.hud.ac.uk/id/eprint/35024/>

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.

<http://eprints.hud.ac.uk/>

The *Firework Book*: An edition, translation, and analysis of Royal Armouries Ms. I.34 as an example of tradition and change in fifteenth-century gunpowder technology

Axel E. W. Müller

A thesis submitted to the University of Huddersfield
in partial fulfilment of the requirements for
the degree of Doctor of Philosophy

May 2019

Copyright statement

- i. The author of this thesis (including any appendices and/or schedules to this thesis) owns any copyright in it (the "Copyright") and s/he has given The University of Huddersfield the right to use such Copyright for any administrative, promotional, educational and/or teaching purposes.
- ii. Copies of this thesis, either in full or in extracts, may be made only in accordance with the regulations of the University Library. Details of these regulations may be obtained from the Librarian. This page must form part of any such copies made.
- iii. The ownership of any patents, designs, trade marks and any and all other intellectual property rights except for the Copyright (the "Intellectual Property Rights") and any reproductions of copyright works, for example graphs and tables ("Reproductions"), which may be described in this thesis, may not be owned by the author and may be owned by third parties. Such Intellectual Property Rights and Reproductions cannot and must not be made available for use without the prior written permission of the owner(s) of the relevant Intellectual Property Rights and/or Reproductions.

Abstract

In the Royal Armouries collection is a manuscript which comprises a text in Early New High German, known as RA I.34. It has never been published in its entirety, and has never been transcribed or translated. It forms part of a corpus of *Firework Books* which were produced from the early fifteenth century onwards. In total, 65 fragments of the *Firework Book* could be traced, and each text has different content and components while retaining core elements of text common to all. The *Firework Book* is a significant example of the development of fifteenth-century gunpowder technology and makes a core contribution to arguments surrounding the so-called 'Military Revolution'. RA I.34 displays common core elements of the *Firework Book* tradition, but it is also distinctive in a number of different ways. Unlike most copies of the *Firework Book* RA I.34 is still in what appears to be its original format and binding, with text written by two distinctly different hands with regional variations in the language. It also contains a section with illustrations.

This thesis provides an edition and translation into English of RA I.34, an analysis of its content, and a comparison to other *Firework Book* manuscripts, and their historiography. Chapter 1 provides a description of the *Firework Book* tradition and its historiography. Chapter 2 provides a description of the physical attributes, the content and the provenance of RA I.34. Chapter 3 comprises an edition of the manuscript and a translation from Early New High German into English. Chapter 4 offers a close analysis of the content of the text of RA I.34 while chapter 5 explores the use and the ownership of the *Firework Book*.

This thesis positions the *Firework Book* at a crucial stage in the development of gunpowder artillery, thus offering an unparalleled insight into fifteenth-century gunpowder technology, and its position in the change of military technology at the end of the Middle Ages.

Contents

Abstract	3
Contents	5
Acknowledgements	6
Introduction	8
Chapter 1: The <i>Firework Book</i> tradition	16
Chapter 2: The Leeds <i>Firework Book</i> Manuscript RA I.34	37
Chapter 3: The text	56
Chapter 4: Analysis of the text	186
Chapter 5: The use and the ownership of the <i>Firework Book</i>	223
Conclusion	242
Bibliography	244

Word count: 113,813

Acknowledgements

It is always a challenge to mention everyone who has been involved in a project conceived and developed over so many years and I am certain (though it is not for the want of trying) that I may well have overlooked one or more of those many people who have provided support and advice throughout the process of this thesis.

First of all my thanks go to my two supervisors Richard Morris and Tim Thornton. I can thoroughly recommend that everyone should have two supervisors whose vast bases of knowledge have offered an unceasing source of advice and guidance combined with a huge amount of patience. Any oversights in the final thesis were not caused by any lack of support, but rather through the revelation of my own limitations.

The work has relied on many friends, family, colleagues, and fellow researchers along the way – far too many to mention individually –, and I am extremely grateful for all their help, support, and encouragement.

Particular thanks and gratitude go to:

Kay Smith and Ruth Rhynas Brown, both formerly at the Royal Armouries, for far too many helpful interventions to list individually – always inquisitive and supportive, always ready to listen and counter the most wacky ideas – and for feeding me through this journey of discovery. These thanks can also be extended to all the other members of the *HO Group: Medieval Gunpowder Research* and everybody at the Middelaldercentret in Nykøbing Falster.

Steven A. Walton, Michigan Tech University, for talking me through the original idea, for constant inspiration, support and for follow-through invaluable discussions on many occasions.

John Tailby, formerly of the German Department at the University of Leeds, for introducing me to the pleasures of Early New High German and for providing such a wide range of insights into the world of fifteenth-century vernacular literacy.

Everybody at the *Frühneuhochdeutsches Wörterbuch (FWB)*, especially its editors Oskar Reichmann and Anja Lobenstein-Reichmann, for allowing me wide-ranging access to the

FWB as well as much unpublished material, while simultaneously allowing me to see into their own linguists' brains.

The Royal Armouries and all their staff for enabling this research on one of their many treasures. In particular, Peter Smithurst, Curator Emeritus, for his invaluable advice on historical gunpowder production in the early modern period and beyond, and Stuart Ivinsen, the Librarian, for providing access to manuscript I.34 often long beyond the official opening hours.

Everybody in the Institute for Medieval Studies and the School of History at the University of Leeds, both staff and student, for facilitating this research, for providing me with a platform on which to engage with so many medievalists and for highlighting the joy and fascination that research into the Middle Ages can bring. In particular, thanks to my colleagues Iona McCleery and Emilia Jamroziak for guidance and advice on academic directions and context.

Everybody at the University of Huddersfield, especially those involved in the Arms&Armour Group, and in particular Glenn Foard for discussing this project at an early stage.

All the librarians and archivists across the globe who act as custodians of the treasures of the past, all of whom when consulted have been immensely helpful to the solitary researcher who enquires about their holdings in – what to them must have appeared to be at best – a niche subject.

My friends Brenda Bolton and Christine Meek for commenting on drafts of the text, and for preventing me from committing the worst crimes against the English language. Needless to say, some have managed to sneak through – and the fault for that is entirely my own.

My family and friends for being there for me throughout. Having lost both parents over the process of this dissertation highlighted to me that having family and friends are such an integral part of my life – something I would not want to be without.

Last but by no means least, my eternal thanks are to Iona, my long-suffering partner, who has helped me through this long and gruelling process, with positive support and encouragement and without whom none of this would ever have gone beyond the initial 'sort of a good idea'.

Introduction

In the Royal Armouries manuscript collection in Leeds there is a relatively short yet complex fifteenth-century vernacular text in German, catalogued as MS I.34, called the *Firework Book*. It is part of a tradition of instructional treatises on the range of gunpowder technology, and it remains unedited and thus far has only been cursorily studied.

This dissertation 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. It will critically examine the content of I.34, relate it to a significant subset of the other 64 surviving manuscripts of the *Firework Book* genre, provide a comparative analysis of the genre of *Firework Books* and related subject areas as a whole, and give better understanding of its technical content. This thesis presents substantial evidence that *Firework Books* were widely popular and often reproduced, but that their role and function were gradually forgotten over time. It also provides an analysis of sources showing how the *Firework Book* might have been used, by whom it was written, for whom, and what happened to the *Firework Books* after they were written.

Background

All 65 surviving copies of the *Firework Book* were produced in the fifteenth and sixteenth centuries in various dialects of Early New High German. On the grounds of the predominant vernacular adopted, they may be traced back to the south-western region of present-day Bavaria. The *Firework Book* marks a crucial stage in the development of gunpowder weaponry in European history, marking the transition from orally transmitted knowledge to written instructions and knowledge retention. 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’.¹ The core of the text was reproduced many times over more than a century. The earliest version probably appeared during the first quarter of

¹ Gerhard W. Kramer and Klaus Leibnitz (2001), *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, 13. Kramer’s understanding and interpretation of the *Firework Book* will be discussed in chapter 5.

the fifteenth century and the last well into the sixteenth. The *Firework Book* was thus so frequently restructured and repackaged that no two texts are identical in content. As a group, however, such books retain a coherence and similarities to an extent much greater than, for example, cookery recipe books 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.²

Apart from fragments in local chronicles and in other written evidence, as well as in existing isolated artefacts, it is through the study of military manuscripts such as the *Firework Book* that we can arguably obtain the most comprehensive insight into military techniques in the fifteenth century and the emergence of gunpowder artillery. The so-called Military Revolution of the sixteenth century, in which gunpowder artillery was one of the key components, was already well on its way in the fourteenth and fifteenth centuries – if we accept that it happened at all.³ Military technology was changing, but little is known about the speed of change, and this thesis will provide some indication about the question of its pace. There clearly was a demand for and supply of new technology such as the use of gunpowder artillery. The *Firework Book* belongs to a genre which contains other kinds of

² The two most prominent researchers in the field of vernacular cookery books in fifteenth-century Germany are Melitta Weiss Adamson and Trude Ehlert who both looked at cookery books, their production, but also their adjacent genres. See, for example, Melitta Weiss Adamson (2014), 'Vom Arzneibuch zum Kochbuch, vom Kochbuch zum Arzneibuch: Eine diätetische Reise von der arabischen Welt und Byzanz über Italien ins spätmittelalterliche Bayern', in Andrea Hofmeister-Winter, Helmut Krug, and Karin Kranich eds., *Der Koch ist der bessere Arzt: Zum Verhältnis von Diätetik und Kulinarik im Mittelalter und der Frühen Neuzeit*, Frankfurt am Main: Peter Lang, 39-62, and Melitta Weiss Adamson (2014), "'mich dunkcht ez sein knölllell": Von den Mühlen eines bayrischen Übersetzers mittelalterlicher Fachliteratur', in Lenka Vanková ed., *Fachtexte des Spätmittelalters und der Frühen Neuzeit: Tradition und Perspektiven der Fachprosa- und Fachsprachenforschung*, Berlin: De Gruyter, 143-54, or Trude Ehlert ed. (2010), *Küchenmeisterei: Edition, Übersetzung und Kommentar zweier Kochbuch-Handschriften des 15. Jahrhunderts*, Frankfurt am Main: Peter Lang, and Trude Ehlert and Rainer Leng (2003), 'Frühe Koch- und Pulverrezepte aus der Nürnberger Handschrift GNM 3227a (um 1389)', in Dominik Groß and Monika Reiningger eds., *Medizin in Geschichte, Philologie und Ethnologie. Festschrift für Gundolf Keil*, Würzburg: Königshausen & Neumann. Both authors highlight the low linguistic value of their original text, and the almost accidental nature of the collation of their texts. Neither author, however, seems to comment on the fact that these sources also appear predominantly in Bavaria.

³ For an overview on the debate on the Military Revolution, its chronology, and whether it happened at all see Geoffrey Parker (1988 – revised edition 2002). *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800*, Cambridge: Cambridge University Press, Clifford J. Rogers ed. (1995), *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe*, Oxford: Westview Press, and more recently Anne Curry (2011), 'Guns and goddams: was there a military revolution in Lancastrian Normandy 1415-50?', *Journal of Medieval Military History* 8, 171-88, and Helmut Flachenecker (2015), 'Kanonen, Räderuhr und Brille: Zur technischen Revolution des Spätmittelalters', in Dorothea Klein ed., *Überall ist Mittelalter: Zur Aktualität einer vergangenen Epoche*, Würzburg: Königshausen & Neumann, 303-29.

texts related to technical military instructions such as the earlier *Bellifortis* and the later *Büchsenmeister* Books.⁴ The *Firework Book* demonstrates both a demand for this type of knowledge, and that this specialist knowledge was already fairly well established. Whether this can be viewed as a contribution to the Military Revolution, or was more part of a gradual change in society, will be discussed in chapter 5. However, gunpowder technology was transformative for every aspect of how wars were fought, bringing with it a close interrelation to finance, training, and construction. 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.⁵

It is less clear, however, what role the *Firework Book* played in this sequence of developments, and what the actual purpose of producing such books was. Realistically, there are three possible options as to why they were produced: a) the *Firework Book* marks the writing down of a fully-fledged technology which had already been in use for decades by the early fifteenth century, well before 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 thesis will show that the third option can be ruled out because the text does relate to operating tasks within gunpowder technology and contains recipes and instructions which work and could be recreated.⁶ It is more likely a combination of options a) and b) in that it was written down at a tipping point of a change in technology or technological knowledge transfer, at a time when gunpowder technology had been in use for some decades. The texts appeared at a time when vernacular writing, and the recording of technical knowledge were starting to emerge.

⁴ See chapter 1 for a discussion of the genre.

⁵ Kay Smith (2010) (published under former name of Robert Douglas Smith), *Rewriting the History of Gunpowder*, Nykøbing Falster: Middelaldercentret, 12.

⁶ Kay Smith (2002-2016) (partially published under former name of Robert Douglas Smith), *Reports of the HO Group: Medieval Gunpowder Research*, https://ahc.leeds.ac.uk/downloads/download/35/fields_of_conflict – accessed 8 February 2019.

Although the *Firework Book* has long been known to scholars of military literature, no sustained, comparative analysis of the genre has as yet been undertaken. In order to understand the content of the *Firework Book* it needs to be studied in an interdisciplinary fashion: its historical context, language, technological content – all of these together offer a unique body of knowledge which could not be understood from the standpoint of one discipline alone.

Little is known about gunpowder technology in the early fifteenth century. Most writings on the subject come from experts from different disciplines who interpret what evidence they examine from their particular standpoints, and often retrospectively applied. To try to understand gunpowder technology it is crucial to study a wide range of texts and records, as well as artefacts and experimental archaeology.⁷

Texts such as the *Firework Book* are the most comprehensive, sizeable building block of evidence available to clarify the practitioner's knowledge of gunpowder. By 1620, Francis Bacon placed gunpowder as 'one of the tri-partite symbols of technological advancement, along with the printing press and mariner's compass'.⁸ However, in the early fifteenth century the process through which gunpowder was becoming a crucial component of technological advancement was well underway, but its details were still obscure. Nevertheless, gunpowder technology had become one of the key components of the transition from the Middle Ages to later periods. Thus gunpowder technology, the *Firework Book*, and this thesis help to understand this transition from the medieval and early modern periods.

Aims

Royal Armouries I.34 shares the same core content with most *Firework Books*, but also has several distinctive and unique features which make it an ideal case study. This dissertation sets out to transcribe, translate, and interpret I.34; it also aims to move beyond textuality to explain the technical content of these manuscripts and offer an interpretation of the

⁷ 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 (2003), *The Constructed Past*, London: Routledge, and in relation to gunpowder the HO Group's research.

⁸ Haileigh Elouise Robertson (2015), *'Imitable Thunder': The Role of Gunpowder in Seventeenth-Century Experimental Science*, PhD Dissertation University of York, unpublished, 21.

development of early gunpowder weaponry. In contrast to most other *Firework Books*, I.34 is compiled with associated elements of text which provide a unique insight into the production and possible use of the Firework Book in the fifteenth century. My goal is not merely to understand the single underlying text but to place this text in the context of other variations and elaborations of the tradition. It is expected 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 to produce plausible theories as to their production, authorship, readership, reception, and other use.

The thesis does not pursue the conventional type of textual study which compares manuscript with manuscript in detail. A few previous attempts have been made to compare a number of manuscripts, both by the heading to each chapter as well as by the texts of each subheading.⁹ In fact, the physicist and engineer Ferdinand Nibler embarked on this work but only partially completed it – his efforts serving only to highlight that this endeavour demonstrates the complexity of the available corpus and provides information which is partial at best, as each *Firework Book* manuscript differs from the next.¹⁰ Furthermore, the number of manuscripts in existence and the more or less subtle differences between them make this kind of study unfeasible, while the benefits of doing so would certainly be somewhat limited. These comparisons have not added much to the understanding of the texts, but instead have emphasized their complexities. They do not

⁹ See Ferdinand Nibler (2003), 'Das Feuerwerkbuch: Eine verspätete Buchbesprechung etwa 600 Jahre nach dem Erscheinen des Feuerwerkbuches', *Zeitschrift für Heereskunde* 67/2, 147-54, and Ferdinand Nibler (2005), *Feuerwerkbuch : Anonym, 15. Jahrhundert; Synoptische Darstellung zweier Texte mit Neuhochdeutscher Übertragung* [s. n.], [S. l.], Online <http://www.feuerwerkbuch.homepage.t-online.de/> – accessed 22 February 2018. Ferdinand Nibler's work is the most comprehensive attempt where he compared both the headings in four manuscripts and two printed editions, and 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. 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 (1889-91), *Geschichte der Kriegswissenschaften vornehmlich in Deutschland*. 3 vols. München and Leipzig: R. Oldenbourg <http://archive.org/details/geschichtederkr00jhgoog> – accessed 22 March 2018, 382-424, and Wilhelm Hassenstein (1941), *Das Feuerwerkbuch von 1420: 600 Jahre Deutsche Pulverwaffen und Büchsenmeisterei*, Bücher der deutschen Technik. München: Verlag der Deutschen Technik GmbH, 14-78, 84-8, Christa Hagenmeyer (1967), 'Kriegswissenschaftliche Texte des ausgehenden 15. Jahrhunderts', *Leuvense Bijdragen* 57, 182-95, or Franz Maria Feldhaus (1931), *Die Technik der Antike und des Mittelalters*, Widpark-Potsdam: Athenaion (reprint 1971), 362, but all of these were carried out with limited source access or discernible methodology applied.

¹⁰ Nibler in his introductory comments to the synoptic, comparative analysis of up to five manuscripts of the *Firework Book* (Nibler (2005), 3).

comment on but purely list these differences, and in the order of the key components, highlight elements listed in one and not in the other, thus providing partial information on a text corpus which on its own is of limited benefit. Understanding to which extent the manuscripts differ is only possible if all of them are compared, side by side. It is clear already that no one manuscript is identical to another, and that differences increase the further one gets into the text.

What emerges from viewing nearly all *Firework Book* manuscripts is a high proportion of similarities, albeit with sometimes subtle, sometimes more substantial differences. A comprehensive comparative analysis would need to be on a larger scale than the scope of this thesis allows. Instead, a focussed analysis of one manuscript such as I.34 provides a comprehensive basis to explain what the *Firework Book* was produced for, how it was used, and what happened to it in subsequent centuries.

I.34 provides a deeper insight into the knowledge of gunpowder technology at the time, in that it 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 show vividly the various production techniques of gunpowder explosives and their use in battle, combined with technical illustrations of mounting the equipment. These illustrations allow us to appreciate better the nature and the knowledge of gunpowder technicians in the period. However, the detailed analysis of the images goes beyond the scope of this dissertation. 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.¹¹ The images have been consulted in relation to the text (at several points

¹¹ See, for example, Rainer Leng (2000), *Anleitung Schiesspulver zu bereiten, Büchsen zu laden und zu beschiessen: eine kriegstechnische Bilderhandschrift im cgm 600 der Bayerischen Staatsbibliothek München*, Imagines Medii Aevi, Bd. 5, Wiesbaden: Reichert, Rainer Leng (2001), *Franz Helm und sein 'Buch von den probierten Künsten': ein handschriftlich verbreitetes Büchsenmeisterbuch in der Zeit des frühen Buchdrucks*, Wiesbaden: Reichert, or Volker Schmidtchen (1977), *Bombarden, Befestigungen, Büchsenmeister: Von den ersten Mauerbrechern des Spätmittelalters zur Belagerungsartillerie der Renaissance – eine Studie zur Entwicklung der Militärtechnik*, Düsseldorf: Droste, and Volker Schmidtchen (1990), *Kriegswesen in späten Mittelalter. Technik, Taktik, Theorie*, Weinheim: VCH. The only analysis to date of the images in I.34 has been carried out by Sarah Barter Bailey (1996), 'The Royal Armouries "Firework Book"', in Brenda Buchanan, *Gunpowder: The History of an International Technology*, Bath: Bath University Press, 57-86. More details about the images can be found in chapter 2.

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.

The thesis sets out to take I.34 as an exemplar for all *Firework Book* manuscripts and through textual analysis of the single manuscript as well as through comparative works of secondary material to evaluate its content, role, and function within the context of technological and military development. I.34 is ideal for such a study as it provides both the traditional *Firework Book* components (albeit sometimes in an order that differs from the majority of other *Firework Books*), as well as an additional explanatory text. This might indicate that I.34 is a substantially later or more comprehensive copy, or that it was the work of an author who felt that the ‘improved’ order was more practical. If the latter, however, it would appear strange that the author chose to address the more esoteric or ‘flashy’ subject areas first – for these are not the most practical ones to apply, and require a substantial amount of prior knowledge which follows only later in the document.

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. For example, 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 4 and 5.

Thesis structure

Chapter 1 discusses the complex history of the *Firework Book* with reference to the 65 extant manuscripts, of which I have seen 63. Also considered is how the *Firework Book* fits into the wider genre of fifteenth-century technical writings, and how it has been studied by modern scholars. Chapter 2 gives a physical description of Royal Armouries’ manuscript I.34 and outlines what it contains and its provenance. Chapter 3 provides editorial and translation notes, followed by a line by line transcription and translation of I.34. The decision was made to place the edition and translation in the centre of this thesis. The text has to be viewed in its entirety to provide an overview of the *Firework Book* format and

content, and it is essential for it to have been read before the technology, both its terminology and its usage, is discussed. In chapter 4, the key elements in the text are examined to analyse the information that they provide and what they tell us about fifteenth-century gunpowder technology. Finally, chapter 5 suggests for whom the *Firework Books* were produced and what happened to them after they were produced.

The recent historiography of the *Firework Book* is sparse: only three modern editions have been produced in New High German together with one translation, based on one of the modern editions, into English. The first edition, printed in 1941, was the work of a civil servant with limited historical and scientific knowledge but working in a military context.¹² The more recent edition and translations (from Early New High German to New High German and into English) were produced by a physicist and a chemist, respectively, who possessed scientific knowledge but lacked sufficient historical comprehension and failed to understand the need for accuracy in translation.¹³ The choice in this thesis has been to make a translation close to the original, dealing with inconsistencies when they occur, and also rendering the sometimes monotonous and repetitive style as close as possible to the original. This method provides scholars with an insight into what the text states, rather than what modern scholars have interpreted it to be.

In summary, *Firework Books* have hitherto been spasmodically studied piecemeal by experts in only some of the fields that are necessary for the task. This dissertation, therefore, aims to remedy previous neglect. It brings together literary and linguistic source criticism with historical analysis and fieldwork to ascertain the role of the *Firework Book* as an essential link in the consolidation of gunpowder technology. By using I.34 as exemplar of a *Firework Book*, albeit a unique one, it becomes a key tool for modern understanding of the development of gunpowder.

¹² The author of the earliest edition and translation of a *Firework Book* in the twentieth century, Wilhelm Hassenstein, states his profession as a senior civil service rank (*Oberregierungsrat*), and states in the dedication that this book was presented at the 50th birthday of Reichsminister Fritz Todt (German Minister for Armaments and Ammunition, 1940-1942) to honour the work carried out by Germany engineers and builders (Hassenstein (1941), inside front cover).

¹³ The most prolific scholars working on interpreting the *Firework Book* in the last thirty years are the physicist Ferdinand Nibler, who taught electrical engineering at the German Military University in Munich, and who created and maintained the website <http://www.feuerwerkbuch.de/>, and the chemist Gerhard Kramer who published one edition of Freiburg Ms. 362 in 1995, as well as the only 'translation' into English in 2001.

Chapter 1: The *Firework Book* tradition

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

The title *Firework Book* derives from the textual reference which seems to appear in all of the identified manuscripts, usually early on in the text.¹ In 1941, the suffix 'of 1420' was added by Wilhelm Hassenstein in the publication of the *Feuerwerkbuch von 1420*, but he offers no discernible explanation for this choice of date.² Hassenstein's title has been used to name a category of technical writing ever since, even though many have since challenged the dating of 1420 on account of the otherwise questionable historical context in the commentary of the publication.³ Other scholars have applied a different attribution to the assumed date of production. For example, Joseph Needham, pioneering historian of Chinese technology and science, refers to the 'Feuerwerkbuch von 1437'.⁴ The medievalist and historian of technology Bert Hall refers to 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, by then representing the state of things before but not during the transformation.⁵

¹ In the Royal Armouries manuscript I.34 it is on fol. 2 r, line 1, where it is referred to as '*fewrwerkpûch*'.

² *Das Feuerwerkbuch von 1420*, Hassenstein (1941).

³ Bert S. Hall (1997), *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics*, Baltimore MD: Johns Hopkins University Press, 71: '...can safely be said to stem from the period before 1420...'; see also Gerhard W. Kramer (1995), *Berthold Schwarz: Chemie und Waffentechnik im 15. Jahrhundert*. *Abhandlungen und Berichte der Deutschen Museum N.F.*, Bd. 10, München: Oldenbourg, 98-9.

⁴ Joseph Needham (1986), *Military Technology: The Gunpowder Epic (Science and Civilisation in China 5, 7)*, Cambridge: Cambridge University Press, 33, with a reference to James R. Partington (1960 [1999]), *A History of Greek Fire and Gunpowder*, Baltimore: Johns Hopkins University Press, 78, and Dudley Pope (1969), *Guns*. Feltham: Spring Books, 152, who lists five *Firework Books* in existence, two of which seem to be dated 1437 while one other is dated 1420.

⁵ Hall (1997), 88.

Hassenstein's *Feuerwerkbuch von 1420* also provides a listing of 38 *Firework Book* manuscripts in existence.⁶ There is general consensus that Hassenstein's list is incomplete and based on dubious scholarship – as is the rest of the publication. Military historian Kelly DeVries describes Hassenstein's publication as 'virtually useless except for the text itself'.⁷ Hassenstein's publication is nevertheless regularly used as a point of reference for the presence of *Firework Books* and their circulation in the twentieth century.⁸ Recent research by Rainer Leng, a medieval historian with special interest in technical manuscripts, has been instrumental in expanding the corpus of material available in order to show which *Firework Books (of 1420)* exist.⁹ Leng reuses Hassenstein's label of *Firework Book of 1420*, which was also used as one of the lexicon's lemma in the second edition of the *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-

⁶ Hassenstein (1941), 85-8.

⁷ Kelly DeVries (2003), 'Review of Gerhard W. Kramer, ed., and Klaus Leibnitz, trans. *The Firework Book: Gunpowder in Medieval Germany (Das Feuerwerkbuch, c. 1440)*', *Ambix* 50.2 (2003), 237-8, 237. See also Simon Werrett who uncritically follows both Kramer and Hassenstein (Simon Werrett (2010), *Fireworks: Pyrotechnic Arts and Sciences in European History*, Cambridge: Cambridge University Press, 27).

⁸ Hassenstein even argues that the Milimete Gun illustration, 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', Hassenstein (1941), 83). 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. (Partington (1960 [1999]), 78, and Pope (1969), 21-3). Hassenstein was by no means the first to emphasise the 'origin myth' of the inventors of gunpowder. Early debate was strongly influenced by national interests with the aim to establish 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). (Jähns (1889-91), 224-6).

⁹ Particularly in Rainer Leng (2002), *Ars belli: deutsche taktische und kriegstechnische Bilderhandschriften und Traktate im 15. und 16. Jahrhundert*, *Imagines medii aevi*, 2 vols, Wiesbaden: Reichert, and Rainer Leng (2009), 'Feuerwerks- und Kriegsbücher', in Norbert H. Ott, Ulrike Bodemann, and Gisela Fischer-Heetfeld eds., *Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*, Vol. 4/2, München: C. H. Beck, 145-512. <http://www.manuscripta-mediaevalia.de/?xdbcidn:%22hsk%200622a%22&dmode=doc#|3> – accessed 3 February 2017.

word. [...] In total, 48 manuscripts with related content exist in German-speaking regions.¹⁰

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 'wrongful attributions' (*Fehlzuschreibungen*), which, in his opinion, were wrongly attributed as part of 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 and other copies which are assumed to be missing ('*verschollen*') but were recorded at some point earlier, including one which was last recorded in private ownership.¹¹ Leng does not, however, provide a clear definition which could clarify how to include or exclude any texts related to this corpus.

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, my working definition is to regard a *Firework Book* as a text written in Early New High German, consisting of a number of core elements in relation to early gunpowder artillery, from 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

¹⁰ Burghart Wachinger et al (1977-2008), *Die deutsche Literatur des Mittelalters: Verfasserlexikon, 2nd edition*, Berlin: Walter de Gruyter, vol. 2 (1980), columns 728-731, 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 1933-1955, but as the first volume A-F included the *Firework Book* reference, it has not included 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 volume 2, published in 1980) varies in its definition of the lemmata 'Instructions on the making of gunpowder, loading of guns and firing them' ('*Anleitungen, Schießpulver zu bereiten, Büchsen zu laden und zu beschießen*' [in volume 1, published in 1978]) and of 'Guns, armour for warfare, sieges and fireworks' ('*Pixen, Kriegsrüstung, Sturmzeug und Feuerwerk*' [in volume 7, published in 1989]). All three entries are written by the same author, Volker Schmidtchen.

¹¹ Leng (2002), vol. 2, 441-62.

instructions related to attacks with gunpowder technology or how to defend against these. In my opinion, the earliest version of the *Firework Book* was likely to have been written in the first quarter 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 to other technical-military texts in that it deals solely with specific questions on gunpowder artillery instead of focussing 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 are in known locations and accessible to view, including fifteenth- and sixteenth-century copies, from both 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 publication or identifiable authors. The Freiburg manuscript Ms. 362 is dated in the text as having been produced in 1432.¹² Only one copy of the *Firework Book*, that in Dillingen, has an attributed author: at the end of the Dillingen text, the name and date, '1466 Jodocus Foelki presbyter',¹³ has 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.¹⁴ This location seems to correlate to the manuscript's linguistic features as they have been attributed to be 'Alemannic with traces of Swabian dialect'.¹⁵ However, the line containing the date and name appear 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, not the author or copyist. The authors of most manuscripts are anonymous, or 'very shadowy figures about whom little is known'.¹⁶ There has been some speculation about the possible author of the

¹² Freiburg Ms. 362, fol. 89 v, 'Anno trecesimo 2'. This seems to be in the same hand but the ink is slightly darker in colour.

¹³ Dillingen Ms. XV 50, fol. 33 r.

¹⁴ See catalogue entry for Dillingen manuscript Ms. XV 50 (Elisabeth Wunderle (2006), *Die mittelalterlichen Handschriften der Studienbibliothek Dillingen*, Wiesbaden: Harrassowitz, 74-7).

¹⁵ Werner Meyer (1981), 'Eine Abschrift des Feuerwerkbuchs. Die Hs. XV 50 der Studienbibliothek Dillingen an der Donau', *Liber Castellorum* (1981), 288-301, 299.

¹⁶ Hall (1979b), 5.

Firework Book, and one long-discussed theory argues for a certain Abraham von Memmingen.¹⁷ However, this theory has been widely dismissed in recent years.¹⁸

Most copies in existence have been rebound since production, and have often been placed together with other texts of military regimen or of other technical content.¹⁹ 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 rather lower-status publications for more personal use.²⁰ This leads Kay Smith to suggest that the *Firework 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'.²¹ Ferdinand Nibler went one step further by suggesting that the *Firework Book* was 'a study and reference book for a master gunner'.²²

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.²³ German academic scholarship, on the other hand, has attempted to identify categories of firework and war books, of which the *Firework Book* tradition is one.²⁴ An early reference to the *Firework Book* genre was provided by the

¹⁷ 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 the research by Josef Würdinger, which lacked evidence to back up this claim (Josef Würdinger (1868), *Kriegsgeschichte von Bayern, Franken, Pfalz und Schwaben: Band II von 1347 bis 1506*, München: Literarisch-Artistische Anstalt der Cotta'schen Buchhandlung, 397-402). See Jähns (1889-91), 392-3, Romocki (1895), 179, or Hassenstein (1941), 79-80.

¹⁸ *Verfasserlexikon*, vol. 1 (1980), column 11-2.

¹⁹ For examples, the copies located in Dillingen, Memmingen, Darmstadt, or 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 different colour ink).

²⁰ 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.

²¹ Smith (2010), 95.

²² 'Lehr- und Handbuch für den Büchsenmeister' (Nibler (2005), 3).

²³ Notable exceptions include Kelly DeVries and Robert D. Smith (2012), *Medieval Military Technology 2nd Edition*. Toronto: University of Toronto Press, 152, Smith (2010), 95-100, Hall (1997), 71, or even earlier, Partington (1960 [1999]), 144 and 155, and Needham (1986), 267.

²⁴ Leng (2002), vol. 1, 4-23, and Rainer Leng (2009), 'Feuerwerks- und Kriegsbücher', in Norbert H. Ott, Ulrike Bodemann, and Gisela Fischer-Heetfeld eds., *Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*. Vol. 4/2, München: C. H. Beck, 145-512. <http://www.manuscripta-mediaevalia.de/?xdbdtdn:%22hsk%200622a%22&dmode=doc#|3> – accessed 3 February 2017, 145-53.

nineteenth-century historian Max Jähns in 1889-91.²⁵ Jähns includes the *Firework Book* 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 more or less attention by the redacting editors.²⁶ 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.²⁷ However, Jähns fails to provide evidence for his arguments, and reverts to making general statements.²⁸

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 in artillery history. 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’.²⁹ Between the 1890s 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

²⁵ Jähns is one of the most prominent military historians in nineteenth-century Germany. After a long military career he became Professor for the History of Military Art (*Kriegskunst*) at the Military Academy (*Kriegsakademie*) in Berlin from 1872-86. His 865-page, three-volume *Geschichte der Kriegswissenschaften* (1889-91) provides an overview of military history from Antiquity to the end of the sixteenth century, predominantly in Germany. This text, still referred to nowadays, has been viewed as one of the cornerstones of German military historical studies.

²⁶ ‘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 (1889-91), 394).

²⁷ 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 (1889-91), 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 (1889-91), 408), or, referring to the translation into French, as ‘simple translation of the old German *Firework Book*’ (*‘einfache Übersetzung des alten deutschen Feuerwerkbuches’*, Jähns (1889-91), 408). Discussed in some detail by Leng (2002), vol. 1, 27-31.

²⁸ Jähns (1889-91), 408.

²⁹ Schmidtchen (1990), 5, and Leng (2000), 10.

Klemm, too, recognized the role of fifteenth-century gunnery manuals which mark the early beginnings of technical writings.³⁰ Franz Maria Feldhaus proposed the first typology in 1931 (revised in 1954)³¹ 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.³² 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. One laudable exception was Bert Hall who singled out the *Bellifortis* and the *Firework Book* as by far the most prominent produced in Germany in the fifteenth century.³³

Over a period of more than thirty 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 register of events (*'actae'*); and 5. Technical sources (arms and equipment). Even Schmidtchen admits, however, that this categorisation 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.³⁴ Schmidtchen

³⁰ See Marcelin Berthelot (1891), 'Pour l'histoire des arts mécaniques et de l'artillerie vers la fin du moyen âge', *Annales de chimie et de physique*, Series 6, Volume 24, 433-521, Theodor Beck (1899), *Beiträge zur Geschichte des Maschinenbaus*, Berlin: Julius Springer, 270-92, Bertrand Gille (1956), 'Etudes sur les manuscrits d'ingénieurs du XVe siècle', *Techniques et civilisations* 5, 77-86, 79-81, or Friedrich Klemm (1948), *Die Geschichte des technischen Schrifttums. Form und Funktion des gedruckten technischen Buchs vom ausgehenden 15. bis zum beginnenden 19. Jahrhundert*, München: Diss. Masch.

³¹ See Feldhaus (1931), 324-7, as well as Franz Maria Feldhaus (1954), *Die Maschine im Leben der Völker. Ein Überblick von der Urzeit bis zur Renaissance*, Basel, Stuttgart: Birkhäuser, 229-53.

³² See Lynn White (1962), *Medieval Technology and Social Change*, London: Oxford University Press, 96-101. See also Robert Fox ed. (1996), *Technological Change. Methods and Themes in the History of Technology (Studies in the History of Science, Technology & Medicine 1)*, Amsterdam: Harwood Academic, 11-5.

³³ See Bert S. Hall (1979), *The Technological illustrations of the So-Called "Anonymous of the Hussite Wars": Codex Latinus Monacensis 197, Part 1*, Wiesbaden: Reichert, chapter 2.

³⁴ Schmidtchen (1990), 22-3.

locates the *Firework Book* genre within his category 2, 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 in German vernacular,³⁵ related to warfare technology – 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. 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.³⁶ Illustrated military manuscripts were produced only in small numbers in Italy in the fifteenth and sixteenth centuries. Those actually produced were clearly intended for collecting, as gifts, and for display and less for practical use.³⁷ One of the most outstanding authors was Mariano Taccola (1381-1453/58), some of whose works survive from 1430-50.³⁸

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’.³⁹ This was developed by Bert Hall into the emergence of literature dealing with technology and machinery in response to this new ‘consciousness of a power technology’.⁴⁰ 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

³⁵ As defined by the *Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*, see Leng (2009), 145-512.

³⁶ The reference provided comes from Partington (1960 [1999]), 179n45, where the author refers to M. Ginsburger (1929), ‘Les Juifs et l’art militaire au Moyen-Âge’, *Revue des Études Juives* 88, 156-66. However, when consulting the article referred to, all Ginsburger mentions is that there is meant to be a Hebrew manuscript based 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. However, no reference nor justification for this assumption has been provided (Ginsburger (1929), 157-8). The suggested manuscript could not be traced.

³⁷ Marcus Popplow (2001), ‘Militärtechnische Bildkataloge des Spätmittelalters’, in Hans-Henning Kortüm ed., *Krieg im Mittelalter*, Berlin: Akademie, 251-68, 262.

³⁸ See J. H. Beck ed. (1969), *Mariano Taccola, Liber Tertius de Ingeneis ac edifiitiis non usitatis*. Milano: Edizioni il Polifilo, Frank D. Prager and Ulrich Montag eds. (1971), *Mariano Taccola, De ingeneis*, Gustina Scaglia, Cambridge, MA: MIT Press, and Eberhard Knobloch ed. (1984), *Mariano Taccola, De rebus militaribus (De machinis, 1449)*, Baden-Baden: Koener. For an analysis of the manuscripts in historical context see Paolo Galluzzi (1991), *Prima di Leonardo. Cultura delle machine a Siena nel Rinascimento*, Milano: Mondadori Electa.

³⁹ White (1962), 129.

⁴⁰ Hall (1979b), 8.

types of writings increased in quantity but remained largely limited to the geographical areas in what 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.⁴¹

The manuscripts in German were produced at a time in the first few decades of the fifteenth century at a time when other genres of vernacular writings, such as treatises on technical aspects of field medicine, wound healing, and apothecary practice were beginning to emerge.⁴² Other elements in this group are the *Büchsenmeister* Book (the first surviving copies have been dated to be from the mid-fifteenth century) and manuscripts on military technology for use at court, such as the *Bellifortis*, written between 1402 and 1405.⁴³ This means that chronologically the *Firework Book* can be placed after the production of the *Bellifortis*, but before the production of the *Büchsenmeister* Book.

The *Bellifortis* has generally been described as the first of the genre of illustrated manuscripts with technical military content in the later Middle Ages.⁴⁴ However, most extant *Bellifortis* manuscripts contain considerable material from the *Firework Book* and vice versa.⁴⁵ While changes occurred during the fifteenth century,⁴⁶ the core body of both manuscript groups can be relatively clearly defined.⁴⁷ 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.⁴⁸ It was clear that the *Bellifortis* cost much more to produce

⁴¹ Hall (1979b), 9. There is one already mentioned French translation.

⁴² Melanie Panse (2012), *Hans von Gersdorff: ‚Feldbuch der Wundarznei‘. Produktion, Präsentation und Rezeption von Wissen (Trierer Beiträge zu den historischen Kulturwissenschaften 7)*, Wiesbaden: Reichert, 204-7.

⁴³ Written in Latin, it has a wide range of illustrations. For a comprehensive study of the *Bellifortis* see Leng (2002), vol. 1, 109-149, Udo Friedrich (1996), 'Herrscherpflichten und Kriegskunst. Zum intendierten Gebrauch früher 'Bellifortis'-Handschriften', in Christel Meier, Dagmar Hüpper, and Hagen Keller eds., *Der Codex im Gebrauch. Akten des Internationalen Kolloquiums 11.-13. Juni 1992*, München: Wilhelm Fink, 197-210, and Lynn White (1969), 'Kyeser's *Bellifortis*: The First Technological Treatise of the Fifteenth Century', *Technology and Culture* 10, 436-41.

⁴⁴ Leng (2002), 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 (see below).

⁴⁵ Leng (2002), vol. 1, 199, 205-6.

⁴⁶ Leng (2000), 17-8.

⁴⁷ Leng (2002), vol. 1, 19.

⁴⁸ Leng (2002), vol. 1, 21, and Leng (2002), 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 (2009), he provides a structure of 'manuals for fireworks and war (*Feuerwerks- und Kriegsbücher*)' as part of the 'Catalogue of German language illustrated manuscripts of the Middle Ages

than a *Firework Book*: on high-quality paper, but written predominantly in Latin, and – most importantly – dominated by colourful (and expensive) illustrations.⁴⁹

As with the *Firework Book*, little is known about the *Bellifortis*: the name of its author, Konrad Kyeser, only emerges in two manuscript references.⁵⁰ 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.⁵¹ However, both the *Firework Book* and the *Bellifortis* have frequently been copied (while unfortunately not being found together in the same manuscript) 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’.⁵² Arguably, the most noticeable difference between the *Bellifortis* and the *Firework Book* is the predominant language used. The *Bellifortis* is 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

(*Katalog der deutschsprachigen illustrierten Handschriften des Mittelalters*)’. He provides as subcategory 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.

⁴⁹ 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 only known from the early nineteenth century onwards. All of these manuscripts were high-quality productions, using multi-coloured illustrations, and high-end paper. Christoph Graf zu Waldburg Wolfegg (2000), ‘Der Münchner „Bellifortis“ und sein Autor’, *Patrimonia* 137, München: KulturStiftung der Länder und Bayrische Staatsbibliothek, 21-60, 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* copies which has been amended and enhanced by Leng (2002). (Bertrand Gille (1966), *The Renaissance Engineer*, London: Lund Humphries, 55-77).

⁵⁰ Friedrich (1996), 198.

⁵¹ Friedrich mentions one manuscript containing a list of Kyeser’s dedications to previous employees, 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 (1996), 200-1).

⁵² Hall (1979b), 20.

military matters in any vernacular language.⁵³ This could possibly indicate the difference between the *Bellifortis* and the *Firework Book* with regard to their reception, use, and their intended audience. 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 – while texts in vernacular languages were more practically orientated and created for a more immediate use.⁵⁴ 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’.⁵⁵ This indicates that it was intended as an *aide memoire*, to be used frequently, as and when needed.⁵⁶ This is an oversimplification about what the *Firework Book* is, as will be evidenced in subsequent chapters. If that indeed was the case, then that would place the *Firework Book* into a very different category.

The *Verfasserlexikon* states that the oldest existing manuscript of the *Firework Book of 1420* is the Freiburg manuscript Ms. 362, which was dated by the scribe to 1432 – although even this one is described in the catalogue entry as a copy of an earlier manuscript from around or before 1420.⁵⁷ As pointed out earlier, no evidence is provided for this.⁵⁸ While all *Firework Books* reveal distinctive differences in their contents, they possess a core of more similar components than compilations such as recipe books. The content of each *Firework Book* varies but consists of the key elements which will be discussed for I.34 in chapter 2.⁵⁹ 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 these treatises and their

⁵³ Theresia Berg and Udo Friedrich (1994), ‘Wissenstradierung in spätmittelalterlichen Schriften zur Kriegskunst: Der ‘Bellifortis’ des Konrad Kyesser und das anonyme ‘Feuerwerkbuch’’, in Jan-Dirk Müller ed., *Wissen für den Hof. Der spätmittelalterliche Verschriftlichungsprozess am Beispiel Heidelberg im 15. Jahrhundert*, München: Wilhelm Fink, 169-232, 215, and *Verfasserlexikon*, vol. 2 (1980), column 730-2, where the author goes a step further and described the *Firework Book of 1420* as the first book of technical content in German vernacular.

⁵⁴ See Berg/Friedrich (1994), 174-6, or Panse (2012), 11-6.

⁵⁵ See chapter 3, fol. 33 r.

⁵⁶ For evidence of actual use see chapter 5.

⁵⁷ Now held in Freiburg University Library.

⁵⁸ *Verfasserlexikon*, vol. 2 (1980), column 730-2.

⁵⁹ For a tabulatory listing of all surviving *Firework Books* see the bibliography.

relationship to the history of chemistry.⁶⁰ As Leng observes, there has been little discussion of the chemistry with the main focus on the debate about corning – the change from individual loose powder to more explosive corned powder.⁶¹

A key distinguishing feature of the core *Firework Book* is – at first glance – that it is unlike other associated texts such as the *Bellifortis* in that it hardly ever contains illustrations.⁶² It is mainly restricted to the transmission of technical knowledge related to gunpowder and its components which do 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 transmit chemical knowledge on the production of gunpowder and its key components meant that the *Firework Book* did not require a visual transmission’.⁶³ The texts of all *Firework Books* were written in fifteenth-century vernacular script, almost exclusively in red and dark brown coloured ink.

Many *Firework Books* appear to be unfinished, and each copy starts with more similarities to the others, and then diverges substantially. A number of attempts have been made to compare various manuscripts and the diversity and increasing diversification of each copy makes what initially appeared to be a simple task increasingly ever more complicated.⁶⁴ There is a clearly defined pattern and format, something which must have been familiar to a wider audience beyond the author.

⁶⁰ Partington (1960 [1999]), 149-50, Charles Singer ed. (1954-84), *A History of Technology*, Oxford: Clarendon Press, 653-6, and Needham (1986), 342-65.

⁶¹ Leng (2002), vol. 1, 37. For the discussion on corned powder and corning see Kelly DeVries (1996), ‘Gunpowder and Early Gunpowder Weapons’, in Buchanan (1996), 121-36; Bert S. Hall (1996), ‘The Didactic and the Elegant: Some Thoughts on Scientific and Technological Illustrations in the Middle Ages and Renaissance’, in Brian Baigrie ed., *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science*, Toronto: University of Toronto Press, 3-39; Hall (1997), here especially 68-87; and Gerhard W. Kramer (1996), ‘Das Feuerwerkbuch: Its Importance in the Early History of Black Powder’, in Buchanan (1996), 45-56; but also much earlier S. J. von Romocki (1895 [1983]), *Geschichte der Explosivstoffe*, Hannover: Gebrüder Gänecke [Hildesheim: Gerstenberg].

⁶² 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 [2000], 17-8) or Munich Cgm. 399 (see Leng (2002), vol. 2, 454).

⁶³ ‘Die Beschränkung auf die Vermittlung chemischen Wissens um die Herstellung von Pulverbestandteilen und Büchsenpulver erforderte keine visuelle Umsetzung’ (Leng (2002), vol 1, 198).

⁶⁴ See Nibler (2005) who set out to compare the Freiburg manuscript Ms. 362 with the Augsburg 1529 printed book (only surviving in the reprint of Hassenstein (1941)) 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.

Hassenstein in 1941 already noted 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 twentieth-century technical treatises, in that the technology comes second – after the human factor.⁶⁵ This observation, while underlined with colourful language, arguably best describes the focus of the *Firework Book* and gives an insight into its intended use.

What exactly was the use of *Firework Books* – whether at the time of production of the *urtext*, at time of copying, at time of printing, at time of reading or using – may never be fully clarified. The differing nature of each text suggests that any possible use included a degree of oral transmission. There are various stages which could explain the production of the *Firework Book*:

- a. The author of the *urtext*: the person who first conceived the idea to produce a book of this kind, and then went on to commission it. What we can surmise about the author is that he had an in-depth knowledge of the practical aspects of gunpowder production and use. It is possible that the text was dictated to a scribe and that large parts of the content of the *Firework Book* and its components were retained in oral memory.⁶⁶
- b. The copyist(s) and printers, medieval and post-medieval: it is clear that in some instances the copies were not necessarily produced by those who knew or understood what they were copying. Seemingly little concern was shown about any possible consequences should the text be copied inaccurately. All the manuscripts I have viewed contain some scribal errors, transmission mistakes, and other forms of miscommunication or misleading information – the question is why this was so. Was the scribe not taking sufficient interest in transcribing the text correctly, or did he perhaps not understand the need for accuracy of transmission, or might he possibly have lacked the technical knowledge or relevant understanding of what he was writing down or copying? All viewed manuscripts reveal a number of incidents where there are clear contradictions in header and text, others where the text is incomplete (e.g. two lines are missing).

⁶⁵ Hassenstein (1941), 95.

⁶⁶ See also chapter 5.

The fact that many *Firework Books* differ in the order of the recipes and instructions, however, suggests that – at some level – there was both an understanding of the subject matter, and a desire to improve it.

- c. The possible users: one stage further removed from the production of the text was the user: a master gunner, his less well trained apprentices, or even some local authorities or rulers. The *Firework Books* differ from the earlier *Bellifortis* or the later *Büchsenmeister* Book texts as most of them lack illustrations and would thus be of little use to anyone with a low level of literacy. However, the formulaic nature of most sections, the uses of rubrication and headers make the reading of them substantially easier for a less fluent reader to move relatively quickly into the relevant sections of the text.

There has been some speculation about the origins of the *Firework Book* and whether one text (an *urtext*) which is earlier than any others might be established. All *Firework Books* in existence appear to be copies of an *urtext*, or a teaching tradition – which in this case has not survived. The strong similarities, yet almost predictable differences in words and configuration of the text seem to indicate a detailed knowledge of the texts' components, and the ability of the author to distinguish between 'core texts or phrases that must not be changed' and 'interchangeable elements' which could be treated with more flexibility. Hence the preamble 'Any prince, earl, lord, knight, squire, or town who frequently fear that they may be besieged by their enemies...' remains as it is in all copies of the text, barring a few vowel shifts resulting from regional variations and occasional additions of consonants based on the specific author's spelling preferences.⁶⁷ One common view among modern scholars is that the Freiburg Ms. 362 may be a copy of the earliest *Firework Book*.⁶⁸ Kramer stated this with some vehemence but without necessarily providing any evidence for the claim. This has led other scholars, such as Schmidtchen, Tittmann, and Leng, to suspect that Kramer's preference for Freiburg resulted from the fact that he and the Freiburg manuscript

⁶⁷ 'Welch furst grauff her[r] ritter knecht oder stet besorgent vor iren feinden beligert vnd benot werden...' (Leeds, Royal Armouries, I.34, fol. 1 r).

⁶⁸ Kramer (1995), 95, and Nibler (2005), 3, who both argue that it is the oldest in existence while Leng (2009), 179, argues that Munich Cgm. 4902, dating from 1429, and Heidelberg, Cod. Pal. Germ 787, dating from 1430 (although the manuscript itself is only a sixteenth-century copy) are older.

shared that city as their place of origin, their home town.⁶⁹ Leng, in fact, argues that the surviving Freiburg manuscript was produced later than copies of the *Firework Books* located in Heidelberg or Munich.⁷⁰ It seems most likely that the *urtext* no longer exists, and that the earliest manuscripts in Heidelberg, Munich, and Freiburg are part of the first generation of disseminated *Firework Books*. However, this connects closely to the question about whether the origin of the *Firework Book* can be connected to its intended use. This will be discussed in more detail in chapter 5.

Many *Firework Book* copies contain a number of scribal errors. Vienna Cod. 2952 is a particularly noteworthy example with a larger than usual number of scribal copying errors – many of them were corrected at (or shortly after) time of production. There is the repeated presence of the term ‘rat’ which has been interpreted as a misspelling of ‘rot’ (‘red’ – the vowel shift would not normally happen in this direction) but was present in the majority of surviving manuscripts.⁷¹ This may provide some indication of how the surviving copies of the *Firework Book* have been produced. It suggests that they were copied by non-subject experts whose task it was to copy but not to comprehend the content. There is also the possibility of an oral transmission of this knowledge to be presented or dictated to a scribe, which would explain the change of order of the elements, yet the inclusion of almost all of the key elements.

Schmidtchen speculates that the *Firework Book* was unusually late in being printed, which in his understanding was as the result of its ‘semi-secret nature’.⁷² The survival of over 60 manuscripts or fragments does suggest, however, that there were a substantial number of

⁶⁹ Schmidtchen (1990), 29, Leng (2002), vol. 1, 38-9 and 205-10, and Wilfried Tittmann (2002), ‘Das unaufhaltsame Ende von Berthold Schwarz. Anmerkungen zu Gerhard W. Kramer: ‘Das Pyr Autómaton – die selbstentzündlichen Feuer des Mittelalters’, Online publication <http://www.ruhr-uni-bochum.de/technikhist/tittmann/2%20Ende.pdf> – accessed 25 February 2015, 1.

⁷⁰ Leng (2002), vol. 1, 206 (mainly footnote 880).

⁷¹ See also Royal Armouries, I.34, fol. 6 r, line 14.

⁷² *Verfasserlexikon*, vol. 2 (1980), column 730, ‘*Firework Book of 1420*’:

Each Master Gunner/Gun maker aimed to keep the special knowledge of the art of firework a secret if at all possible. This is why the manuscripts were only exchanged among friendly ‘colleagues’, or were only passed on to successors who were closely related to the master.

(Jeder Büchsenmeister [...] war bemüht, die [...] besonderen Kenntnisse der Feuerwerkunst nach Möglichkeit geheim zu halten. So wurden die hsl. Aufzeichnungen allenfalls unter befreundeten ‘Kollegen’ ausgetauscht oder an den meist in engem verwandtschaftlichen Verhältnis zum Meister stehenden Nachfolger weitergegeben.)

Unfortunately, the author provides no reference or support for this statement on usage.

Firework Books in existence which were copied and kept (and, possibly read). Many include ‘manuscripts with complete or partial depicted and described art of war’ and ‘war manuals, statutes, and instructive texts’.⁷³

Often a *Firework Book* text seemingly stops at random, is incomplete, has frequently been rebound after its original production, or is found together with other texts. In the case of I.34 only part 1 can be identified as part of the core *Firework Book* corpus while part 2 seems to produce an amendment to part 1, and the nature of the blank part 3 may indicate that space was being left for further content. This will be discussed further in chapter 5.

To date, there has only been one ‘translation’ into English of a *Firework Book*, Freiburg Ms. 362, produced in 2001 by Gerhard Kramer and his translator, Klaus Leibnitz – in fact, this appeared posthumously as Kramer died shortly before publication. It is a very loose translation of the manuscript and makes some intriguing claims in the introductory paragraphs in that the Freiburg *Firework Book* was ‘written by chemists (or alchemists) for the use of master gunners’. Kramer continues:

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.⁷⁴

This statement includes a wide range of suppositions, contradictions, and factual errors. Kramer claims that the *Firework Book* was written by a chemist or alchemist. However, he fails to provide a definition of what he (or a fifteenth-century expert audience) understands a chemist or alchemist to be.⁷⁵ He describes the text as ‘technical and arcane, its vocabulary archaic and recondite’ but yet as ‘sound and practical’.⁷⁶ In fact, the vocabulary is relatively

⁷³ ‘*Handschriften mit ausschließlic oder teilweise abgebildeter und beschriebener Kriegstechnik*’ and ‘*Kriegsordnungen, Statuten und Lehrschriften*’ (Schmidtchen (1990), 22).

⁷⁴ Kramer (2001), 20.

⁷⁵ Many scholars have tried to address the roles of an alchemist and a chemist in late medieval society. See Leah DeVun (2009), *Prophecy, Alchemy, and the End of Time: John of Rupecissa in the Late Middle Ages*, New York: Columbia University Press, P. G. Maxwell-Stuart (2008), *The Chemical Choir: A History of Alchemy*, London: Continuum, or Michela Pereira (1999), ‘Alchemy and the Use of Vernacular Languages in the Late Middle Ages’, *Speculum*, 336-56. However, the scholars’ main concern seems to be about 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.

⁷⁶ Kramer (2001), 20.

straightforward while technical. The language of the Freiburg *Firework Book* – as it is for all other *Firework Books* in existence – is not Middle High German 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.⁷⁷ Kramer's description betrays a lack of understanding of late medieval and early modern language, science, concepts, and terminology. He undervalues 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 manuals on mining, but also in scholastic texts.⁷⁸ Kramer is correct, however, when he observes that the full understanding of the text requires multidisciplinary skills of a chemist, historian, and linguist.

The fifteenth century sees the emergence of a range of technical texts. As Hall references, 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*.⁷⁹ 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 survive of Formschneider's treatise, 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*.⁸⁰ Modern scholarship has shown that these manuscripts were collected by local princes and rulers, in order to accumulate knowledge in

⁷⁷ See Joachim Kirchner (1950), *Germanistische Handschriftenpraxis*, München: Beck, 22-3. Kramer refers to it as 'German Gothic Script' (Kramer (2001), 20). It is difficult to get to the bottom of what Kramer may have interpreted as Gothic Script. It is most likely that he confused the bastarda script (sometimes called Gothic) with the language presented.

⁷⁸ 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 (2003), 147). It is a very bold claim, but hard 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'.

⁷⁹ Also called 'Skanderbeg manuscript' after the Albanian nobleman George Kastrioti Skanderbeg (d. 1468) who was said to have owned the manuscript. See the anonymous *Ingenieurkunst- und Wunderbuch*, Weimar, Stiftung Weimarer Klassik / Anna-Amalia-Bibliothek, fol. 328 (unpublished).

⁸⁰ Hall (1979b), 23.

their courtly libraries – with less of a sense as to whether they were actually used.⁸¹ Thus, they provided access to a new technology with hitherto unknown effects.⁸² 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 Bengedans which contains in parts a *Büchsenmeister* Book, surviving in three copies. We know that the author Bengedans applied three times to the then High Master of the Teutonic Order (as stated in his surviving letters which have been dated to be from c. 1451-1467)⁸³ for the position of master gunner. While no records show whether Bengedans was actually employed by the Teutonic Order, he is listed as a participant on a diplomatic mission on behalf of the Order.⁸⁴ 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.⁸⁵ In contrast to the *Firework Book* tradition, Bengedans emphasizes his own skills in the improving and ennoblement of precious metals.⁸⁶ 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 collated from multiple other sources. Bengedans’ writings are viewed as an ideal introduction to the art of artillery, a practical manual for apprentices and specialists alike.⁸⁷ Bengedans’s text is one of the exponents of the new category of reference books for military technology which emerged in the second half of the fifteenth century: the *Büchsenmeister* Book (literally translated as the ‘master gunner’ or ‘gun master’ book). This describes 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, but are predominantly written in German. It is clear that the *Büchsenmeister* Book relied heavily on

⁸¹ Ralf G. Päsler (2005), ‘Sachliteratur (Artillerie-, Fecht-, und Ringbücher)’, in Werner Paravicini, Jan Hirschbiegel, and Jörg Wettlaufer eds., *Handbuch Höfe und Residenzen im spätmittelalterlichen Reich*, vol. 15.III: *Hof und Schrift*, Ostfildern: Thorbecke, 573-84, 579.

⁸² Päsler (2005), 574.

⁸³ Hans Blosen and Rikke Agnete Olsen eds. (2006), *Kriegskunst und Kanonen: Das Büchsenmeister- und Kriegsbuch des Johannes Bengedans*, Aarhus: Aarhus Universitetsforlag, vol. II, 62.

⁸⁴ Bengedans (2006), vol. I, 15.

⁸⁵ Bengedans (2006), vol. II, 81.

⁸⁶ Bengedans (2006), vol. II, 66.

⁸⁷ Bengedans (2006), vol. I, 17.

elements of the *Firework Book* but, with the introduction of illustrations, it was produced for a different audience and a different use.⁸⁸

The *Büchsenmeister* Book text served a range of different purposes: they could serve as *aide memoire* for new techniques of hitherto abstract knowledge and processes which were perceived to be too complex for an individual to remember.⁸⁹ In addition to being a register of techniques and methods, they also turned – as was highly explicit in the case of Bengedans – into a work portfolio, a reference work for future employers.

In the early sixteenth century, printers in Germany were the leading producers of a wide range of ground-breaking printed 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 1556.⁹⁰ There clearly appears to have been a market for publications of this kind, it is important to point out that these publications 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 the *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.⁹¹

⁸⁸ Leng puts the *Firework Book* together with earlier and later *Büchsenmeister* Books into one single category, stating that the manuscript Munich Cgm. 600, was likely to have preceded the production of the *Firework Book*, while later named versions are described as a continuum (Leng (2002), 150-266).

⁸⁹ 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 (1979), '*Der Meister soll auch kennen schreiben und lesen*': Writings about Technology ca. 1400-ca. 1600 A.D. and their Cultural Implications', in Denise Schmandt-Besserat ed., *Early Technologies* 3, Los Angeles: Undena Publications, 47-58, 52-4, or Päsler (2005), 578-9.

⁹⁰ David E. Connolly (2005), 'Background, Summary, and Aftermath of the 1548 Mining Law for the Schlackenwalden Tin Mines, Bohemia', in Robert O. Bork et al eds., *De Re Metallica: The Uses of Metal in the Middle Ages*, Farnham: Ashgate, 347 – in an article on sixteenth-century mining literature and Ulrich Rülein von Kalbe's *Bergbüchlein* (first printed around 1500 in Saxony).

⁹¹ Electronically available at the Staats- und Landesbibliothek Dresden, <https://digital.slub-dresden.de/werkansicht/dlf/12328/1/> – accessed 9 April 2019.

Chronologically, often seen as the culmination of the *Büchsenmeister Book* tradition is the *Buch von den probierten Künsten* by Franz Helm which was printed in 1535.⁹² This book sums up all core aspects of gunpowder technology, from powder production to firing, and it includes many elements of the *Firework Book*, such as the twelve 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 manufacture of cannons and the ingredients was delegated to others.⁹³

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 Hausbuch* 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.⁹⁴ 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.⁹⁵ 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*', possibly for Philip the Upright, Elector Palatine of the Rhine. A copy of this text is found in Heidelberg as Cod. Pal. germ. 126.⁹⁶

The *Firework Book* fits into an emerging tradition of technical writings and reference books which started to emerge in the fifteenth century. Its peculiar style raises questions about

⁹² Edited by Leng with critical introduction (Leng (2001), 3-135).

⁹³ '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 Büchsengeißern, während die Büchsenmeister die Feuerwaffen nur noch transportieren, warten und bedienen' (Rainer Leng (1996), '*getruwelich dienen mit Buchsenwerk. Ein neuer Beruf im späten Mittelalter: Die Büchsenmeister*', in Dieter Rödel and Joachim Schneider eds., *Strukturen der Gesellschaft im Mittelalter. Interdisziplinäre Mediävistik in Würzburg*, Wiesbaden: Reichert, 302-21, 320-1). It was only in the sixteenth century that there was recorded use of fireworks for pleasure and entertainment (see Rainer Leng (2003), '*Feuerwerk zu Ernst und Schimpf. Die spielerische Anwendung der Pyrotechnik im Lustfeuerwerk*', in Stefan Poser and Karin Zachmann eds., *Homo faber ludens. Geschichten zu Wechselbeziehungen von Technik und Spiel*, Frankfurt am Main: Peter Lang, 85-111).

⁹⁴ Christoph Graf zu Waldburg Wolfegg (1998), *Venus and Mars: World of the Medieval Housebook*, London: Prestel, 8-9.

⁹⁵ Hall (1979b), 15.

⁹⁶ Electronically available at <https://digi.ub.uni-heidelberg.de/diglit/cpg126> – accessed 9 April 2019.

usage, ownership, and purpose for production. Any attempt to define the *Firework Book* is imperfect and open to interpretation. No definitive definition can easily be produced and it probably helps to keep an open mind to allow for the inclusion of additional fragmentary texts into the tradition. As what is left is often broken up and rebound it will always be a working definition as to what it was originally intended to be. The manuscripts in existence attributed as part of the *Firework Book* tradition are varied and differ from copy to copy. What is not clear is whether the surviving copies were purely made by scribes who were interested in copying texts as accurately as possible, or whether they were copies made by new master gunners who were keen to showcase their knowledge, and to adapt it to the circumstances of their day. Or even, whether there was a stage of an oral transmission or a dictation of an orally represented knowledge by someone to a scribe. Yet, all of them contain distinctive joint features and core elements which are surprisingly unchanged over what is a substantial time period of some hundred years. Some of these issues will be returned to in chapter 5.

Chapter 2: The Leeds *Firework Book* Manuscript RA I.34

This chapter discusses the physical characteristics and the content structure of Royal Armouries MS I.34, in order to place it among other manuscripts of this genre. However, the content itself will be discussed in chapter 4. A more comparative analysis of the ownership of this and other *Firework Books*, and their possible use, will appear in chapter 5. It is clear that I.34 is a highly distinct manuscript but serves as an ideal platform to explore some of the issues shared by the others in terms of content.

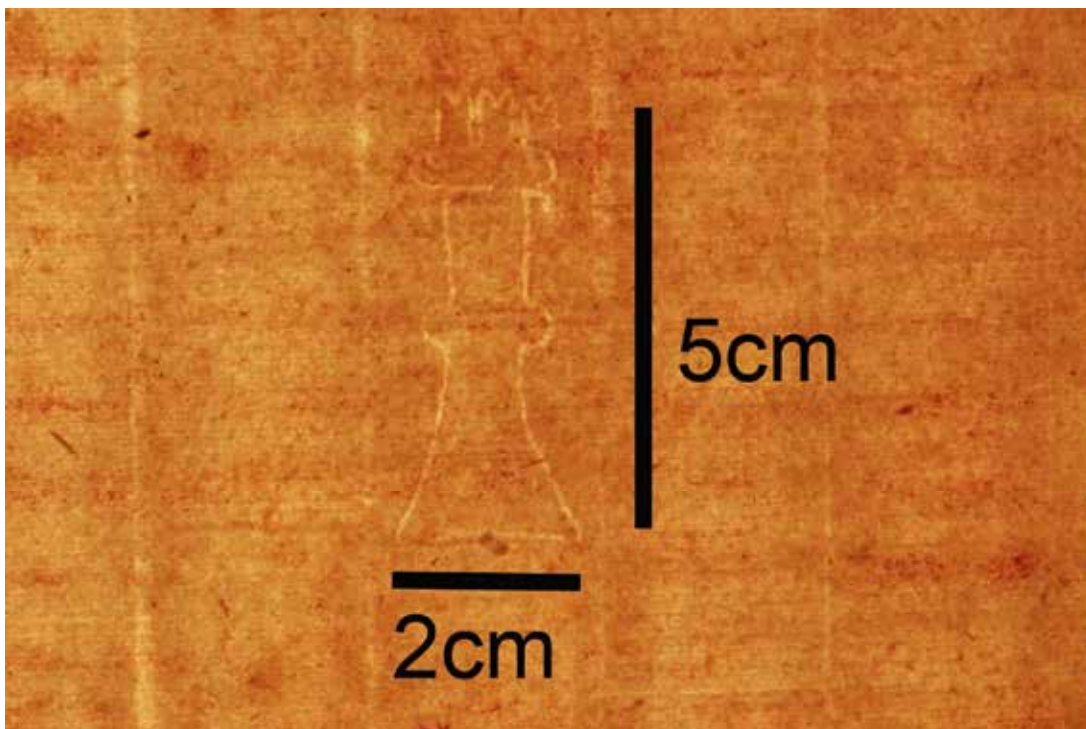
I.34 is described in the Armouries' catalogue as a "*Firework Book*", an illuminated manuscript showing the manufacture and use of gunpowder'.¹ The catalogue gives the date as 'mid-fifteenth century', and suggests that the geographic range is 'South German'. The entry is limited to four pages, in which the content of the text is scarcely mentioned. Instead, the main focus of the catalogue entry is on individual descriptions of the illustrations.

¹Royal Armouries catalogue entry, record 2465:

<u>Reference Code:</u>	RAR.00345; I.34
<u>Title:</u>	<i>Firework Book</i> (South German, mid-15 th century)
<u>Title:</u>	Illuminated manuscript showing the manufacture and use of gunpowder
<u>Dates:</u>	mid-15 th century
<u>Extend/Media:</u>	Manuscript
<u>Archival History:</u>	In the Library of Feldzeugmeister von Hauslab in Vienna when Demmin published drawings copied from it in 1869 (<i>Guide des Amateur d'Armes</i>) and when Essenwein published figures from it in 1877 (<i>Quellen zur Geschichte der Feuerwaffen</i>)
<u>Acquisition:</u>	Bought from E. Weil and presented to the Armouries by the National Art Collections Fund for £550. Acquired 1950.
[...]	
<u>Phys. Character:</u>	11.9 inches x 8.5 inches (300mm x 220 mm)
[...]	
<u>Phys. Character:</u>	4 leaves, which should have been numbered lxxxvij, lxxxviii, cvj and cxlj were torn out after the foliation was inserted
<u>Phys. Character:</u>	fflxjv. – lxxxijv. Blank. All leaves are pricked and ruled as if it had been intended to show an illustration opposite a page of text throughout
<u>Phys. Character:</u>	fflxxxiiijv. – cxiiij illustrated atlas of military stratagems and devices, some showing firemaster in action, none captioned
<u>Phys. Character:</u>	ff.cxiiijv. – cxliijv. Blank. Some water damage to last few pages
<u>Phys. Character:</u>	Limp parchment binding, reinforced down the back, with two decorated studs, possibly for a loop fastening, inserted
<u>Phys. Character:</u>	Centres of each gathering reinforced with narrow strip of re-used parchment
<u>Phys. Character:</u>	Pencilled notes in German, on contents and comparanda, and bookplate, Ex Libris Liechtensteinianis, inside front cover [...]

In 1996, Sarah Barter Bailey, the then librarian of the Royal Armouries, produced the first scholarly article to address I.34 directly but – similar to the catalogue entry which is also accredited to her – she devoted only five pages to the text, concentrating mainly on its physical characteristics, with the main focus of her article focussing on a description of how she interprets the illustrations, dismissing the text as a ‘version of the standard Firework Book text’.²

In total, the manuscript contains 140 folios, in twelve gatherings, each of six sheets folded in half, numbered straight through at the top of each page from fol. i to fol. cxliii, the front flyleaf being un-numbered. Barter Bailey believes that ‘4 leaves, which should have been numbered lxxxvij, lxxxviii, cvj and cxlj were torn out after the foliation was inserted’, as described in the catalogue. The paper has two different water marks in a total of twelve gatherings.³



Royal Armouries, I.34, fol. 83 in gathering 7 (picture provided by Royal Armouries library).

² Sarah Barter Bailey (1996), ‘The Royal Armouries “Firework Book”’, in Buchanan (1996), 57-86, 57.

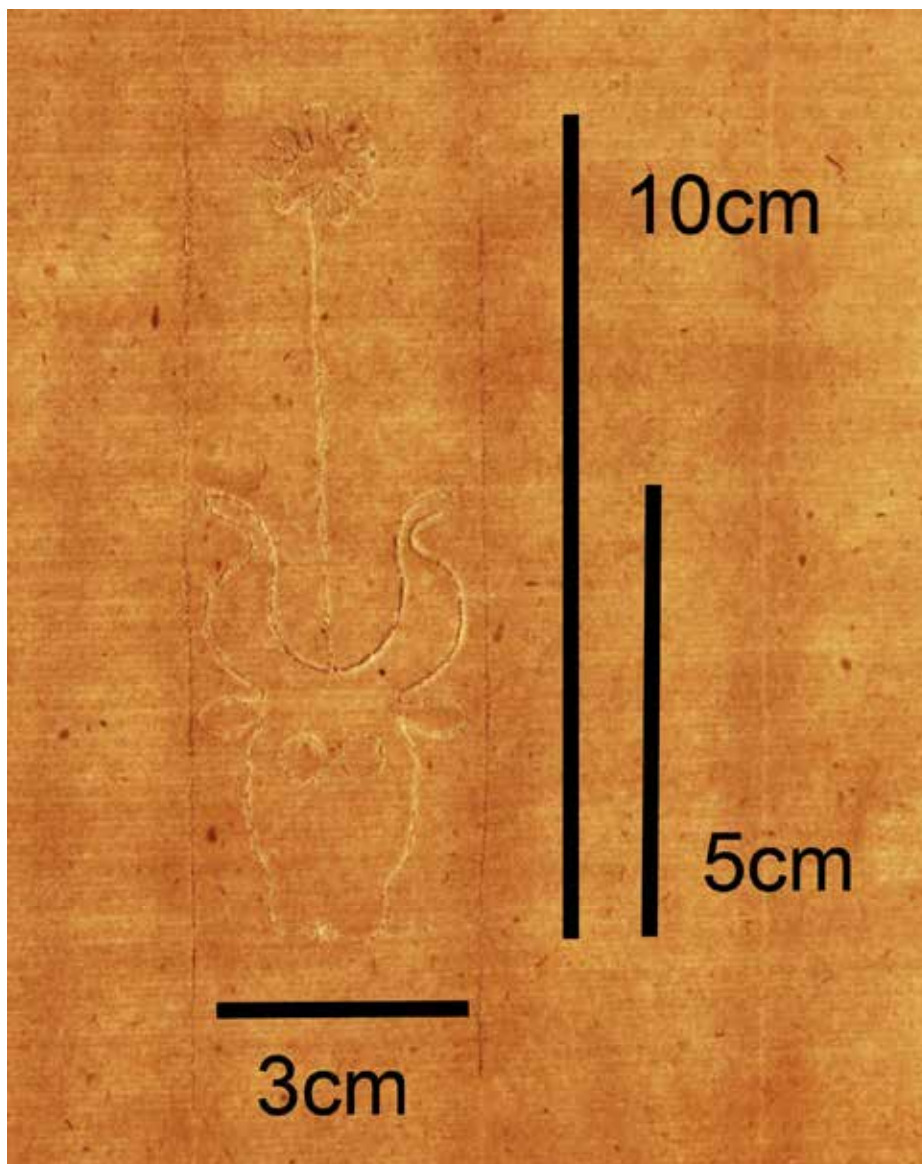
³ Royal Armouries catalogue entry, record 2465:

Phys. Character: Water marks: Gatherings 1-7 and 12: a triple-crenellated tower. ? Piccard II 207.

Gatherings 8-11: Ox head with flower between its horns. ? Piccard XII 486. 1 sheet (5/12 of gathering 7) has a mark of a Greek cross patee [sic]. ? Piccard XI 314 [...]

The catalogue also mentions a third mark, described as a ‘Greek cross patee’, but this mark could be found neither by the current librarian nor by myself.

Gatherings 1-7 and 12 contain a triple-crenelated tower which is two centimetres wide and five centimetres high. Barter Bailey compares the watermark to PICCARD II 207.⁴ This is a relatively commonly used watermark with a wide range of subcategories. Based on the Watermark Classification System (*Wasserzeichen-Informationssystem*), the nearest likely match was II 311, and the *Wasserzeichen-Informationssystem* records a total of 546 paper examples in existence, with the bulk dated to be from c. 1438 to 1480. The earliest dated example is from c. 1301, and the latest is from 1573.⁵



Royal Armouries, I.34, fol. 117 in gathering 11 (picture provided by Royal Armouries library).

⁴ Barter Bailey (1996), 57.

⁵ [https://www.wasserzeichen-online.de/cron_distribution2.php?class=006001002001001001002001002&filter1=Realien++Bauwerke++Turm+\(mit+Zinnen\)+/ein+Turm,+frei+/ohne+Anbau+/ohne+Fenster+/mit+Wulst+/ohne+Beizeichen+/mit+Binnenzeichnung%](https://www.wasserzeichen-online.de/cron_distribution2.php?class=006001002001001001002001002&filter1=Realien++Bauwerke++Turm+(mit+Zinnen)+/ein+Turm,+frei+/ohne+Anbau+/ohne+Fenster+/mit+Wulst+/ohne+Beizeichen+/mit+Binnenzeichnung%20) – accessed 24 March 2018.

Gathering 8-11 contain a watermark of an ox head with eyes, with a flower on a single stem, containing eight petals, above its head. Barter Bailey suggests a closeness to PICCARD XII 486.⁶ This was even more commonly used in the later Middle Ages, and as a result of its wide ranging use the subcategories are yet more varied. The most likely match lists in the *Wasserzeichen-Informationssystem* a total of 62 examples, with the bulk from c. 1444 to 1453. The earliest dated example is from c. 1439, and the latest is from 1472.⁷

Both watermarks have been associated with paper mills all over Germany and Austria from the fourteenth to the sixteenth centuries and it has been impossible to find more detailed attributions. It is quite likely that that the paper of I.34 was produced from c. 1430-1450 onwards, following Theodor Gerardy's suggestion that most paper produced during this period would usually have been expected to be used within three or four years after production.⁸

I.34 is bound in leather from the skin of an unspecified animal and appears not to have been rebound in recent times, making the cover possibly of the same age as the manuscript itself. However, this is not verifiable without further scientific analysis which is beyond the scope of this thesis. While it is not possible to establish for certain that the I.34 copy was originally bound as one single volume, it must be assumed that it was indeed bound like this at some point in the fifteenth century. This could have been the time at which the second part of text was written and the illustrations were added, as the continuous numbering and the page referencing would only have been possible if it already formed one single volume. This may also explain the reason for the two separate watermarks from slightly different time periods.

Returning to the manuscript itself, it consists of four distinct parts: two parts of text, one parts left blank, and lastly, the illustrations. As Barter Bailey notes, the first part of the text

⁶ Barter Bailey (1996), 57.

⁷ https://www.wasserzeichen-online.de/cron_distribution2.php?class=002007002002001005001&filter1=Fauna+Ochsenkopf+frei,+mit+Oberzeichen+mit+einkonturiger+Stange+Blume+ohne+weiteres+Beizeichen+acht+Blät%tenblätt er+mit+Augen% – accessed 24 March 2018.

⁸ See Theodor Gerardy (1964), *Datieren mit Hilfe von Wasserzeichen, beispielhaft dargestellt an der Gesamtproduktion der Schaumburgischen Papiermühle Arensberg von 1604-1650 (Schaumburger Studies, Band 4)*, Bückeberg: No publisher listed, 64-71, and Theodor Gerardy (1980), 'Die Beschreibung des in Manuskripten und Drucken vorkommenden Papiers', *Codicologia* 5, 37-51, 38.

(fol. 1 r – 51 r) is ‘a version of the classic German *Firework Book* text’.⁹ The second part of the text (fol. 52 r – 61 r) is written in a different hand, and is that part which directly engages with the illustrations (fol. 84 v – 114 r). It is notable that between the second part of the text and the illustrations there is a further part of the book which is currently blank (fol. 61 v – f 84 r) but pricked and ruled, ready to be written on. The implication is that I.34 was left incomplete but there is no indication of what the intended content may have been. The only other manuscript of the *Firework Book* tradition where this occurs is New York, Spencer Collection, Ms. 104.

The presence of these four distinct parts in one manuscript, however, provides an important indication as to why the *Firework Book* was made and what its initial purpose was. One of the core questions which this dissertation addresses is for whom the *Firework Book* was written and what its purpose was. What caused it to be written and how can the existence of a considerable number of copies be explained? And indeed, who were the users (readers, owners, and re-writers) and recipients of the *Firework Books*?¹⁰

The text cannot be attributed to any particular author, and there is no textual reference to the identity of either author or scribe. The two distinct parts of the text are written in clear *bastarda*,¹¹ in brown ink, in a single column on pricked paper. The rubrics and header texts are written in red ink, seemingly by the same hand and at the same time. The text is written in c. 300 mm x 220 mm in both parts with an average of 22-23 rows per folio in part 1, and 30-31 rows per folio in part 2. Initials – mostly at the beginning of new sections of text – are listed in red, sometimes not inserted, and at others traced in brown ink to allow for later additions which did not always occur. While the text parts contain no illustrations, some section headings are decorated with a mild flourish, seemingly by the same scribe who produced the text.

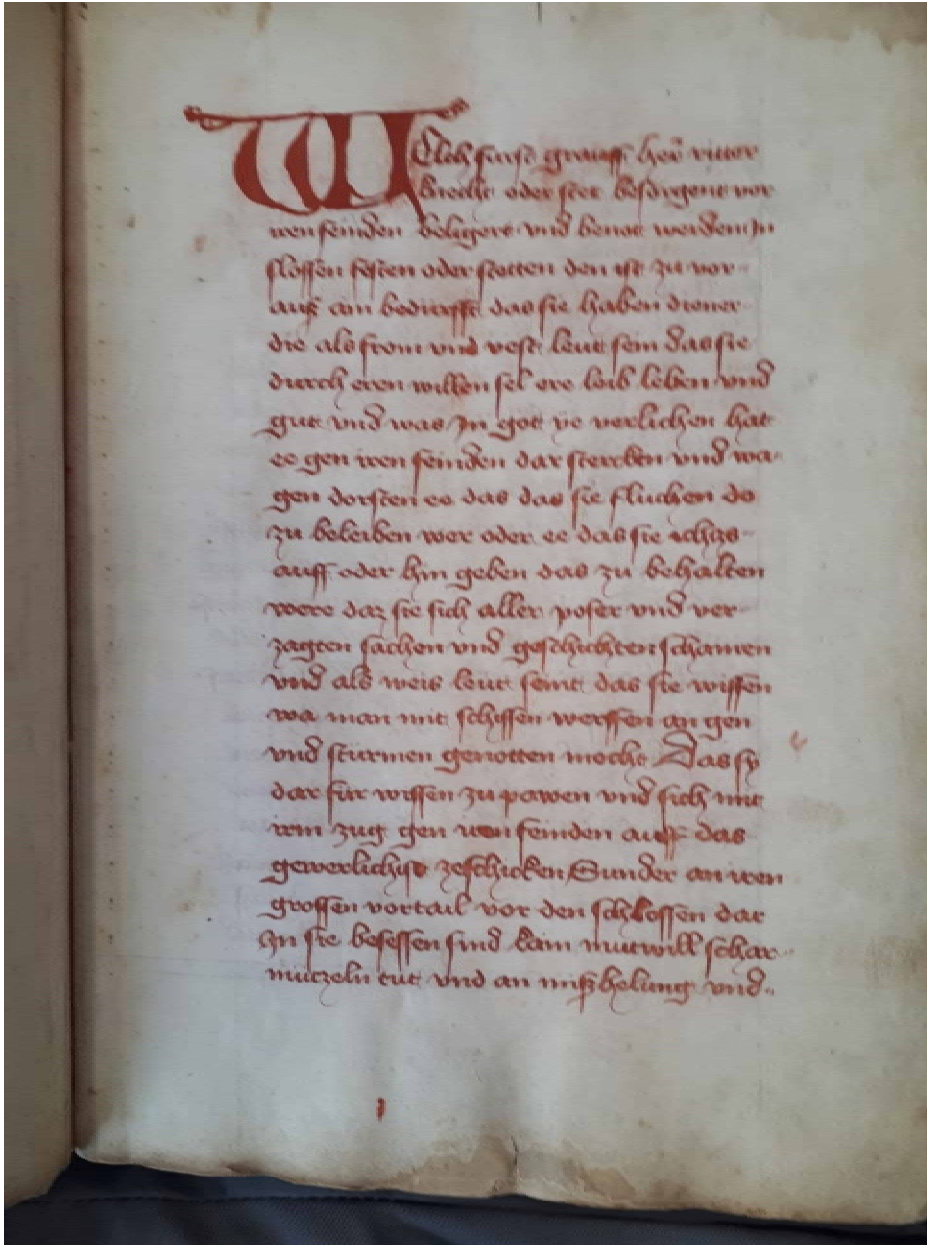
A clear distinction can be made between the two hands in the text, not only in the hand writing but also in the language used. With regional variations clearly distinguishable between parts 1 and 2, both texts were written in Early New High German. Early New High German is defined as the version of German used between 1350 and 1650. The *Early New*

⁹ Barter Bailey (1996), 57.

¹⁰ See chapter 5 for exploring this question further.

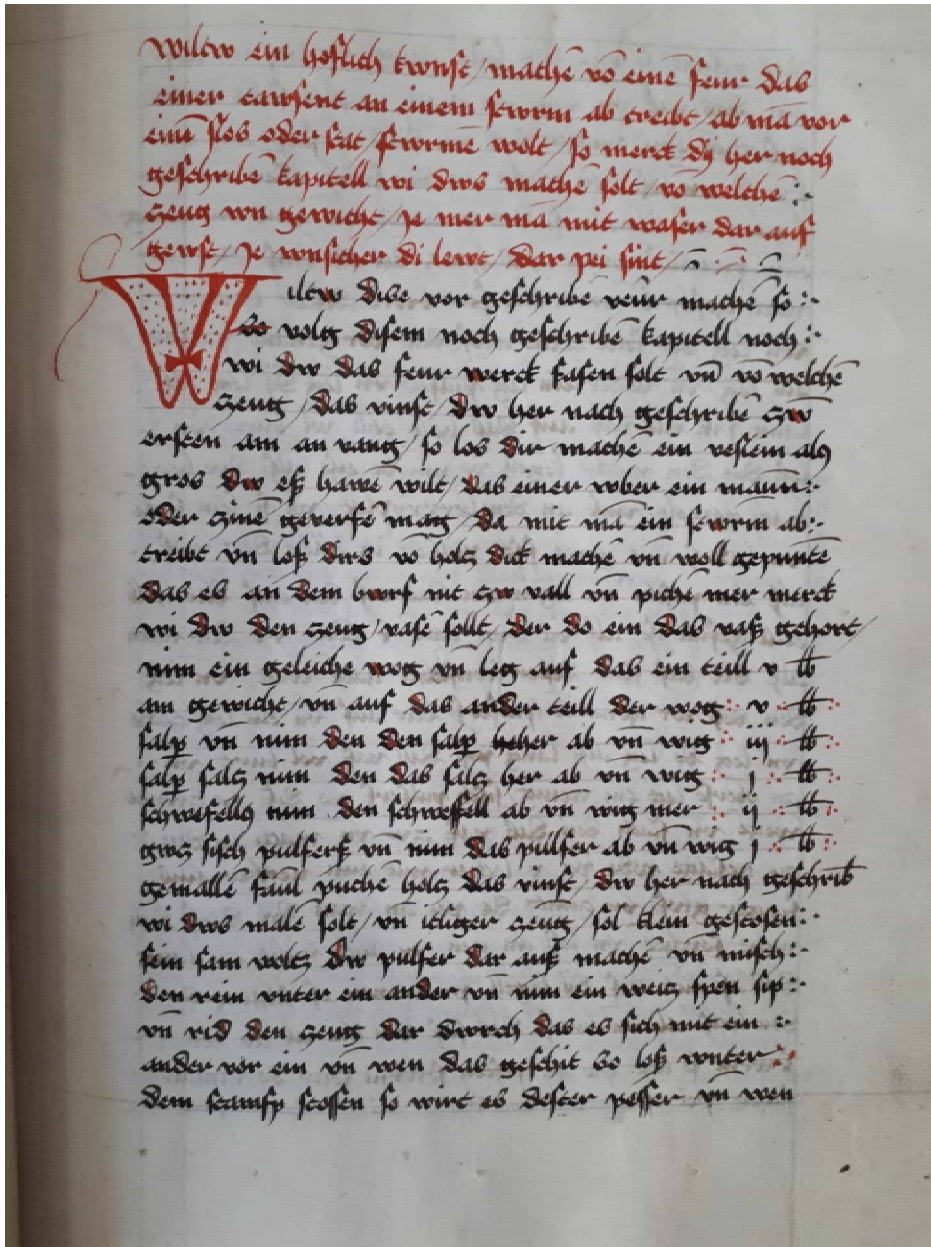
¹¹ Kirchner (1950), 22-3.

High German Dictionary (Frühneuhochdeutsches Wörterbuch) defines it as ‘a period in German history, which not only precedes the modern period in chronological terms, but also provides the historical, social, economic, and spiritual foundations for culture up to the present’.¹²



Royal Armouries, I.34, fol. 1 r – preamble in part 1 (author, courtesy of the Royal Armouries).

¹² ‘Eine Epoche der deutschen Geschichte, die der Neuzeit nicht nur im rein zeitlichen Sinne vorausgeht, sondern in der auch *historische, soziale, ökonomische und geistige Grundlagen* der neuzeitlichen bis hin zur gegenwärtigen Kultur gelegt wurden.’ (*Frühneuhochdeutsches Wörterbuch Online*, Introduction, <https://adw-goe.de/forschung/forschungsprojekte-akademienprogramm/fruehneuhochdeutsches-woerterbuch/woerterbuch/>).



Royal Armouries, I.34, fol. 53 r, first folio of part 2 (author, courtesy of the Royal Armouries).

Part 1 of the text in I.34 has been attributed as being part of the core *Firework Book* genre as described in chapter 1. At fol. 1 v and 2 r the text even provides the name for this 'book which is called the *Firework Book*' ('*pûch das do haist das fewr werkpûch*'). This part can be subdivided in seven different subgroups:

1. A preamble – containing general instructions that any ruler who is required to defend their property against enemy attack ought to employ a master gunner within his staff.
2. Twelve Master Gunner's Questions – listing the core principles of gunpowder artillery which should be known to any good master gunner.

3. Recipes and instructions related to all aspects of gunpowder, its constituent parts, and their uses. All of these instructions are not repetitions, but often variant versions of some core recipes with slight variations.

- Boiling saltpetre
- Making different types of gunpowder: long-range, 'good'
- Bringing back spoiled powder, and how to separate the core constituents from gunpowder
- Making fireballs, frightening shots
- Growing saltpetre on walls
- Instructions on which ingredients make gunpowder strong
- Boiling and purifying saltpetre
- Making different types of gunpowder: 'masterful', even better
- Properly purifying saltpetre
- Recognizing adulterated and the most potent saltpetre
- Making right-fitting stone for a gun
- Identifying right type of charcoal
- Mixing good and less good saltpetre together
- Right weights of mixing together gunpowder, and benefits of grinding it
- How to load a gun
- How to make gun plugs
- Separating salt from saltpetre, making the 'best' saltpetre, purifying saltpetre from walls, what to do if things appear to go wrong, turning raw saltpetre into purified saltpetre
- Preparing sulphur and which one is best
- Making best charcoal

4. A section on the 'inventor'/'discoverer' of gunpowder – Niger Bertholdus.¹³ This section is interpolated half-way into the discussions of ingredients at fol. 20 r.

¹³ Much has been written about the role and function of Niger Bertholdus (or, Berthold Schwarz) as the discoverer (NB: not the inventor) of gunpowder. Frequently, as in the early sixteenth century he is described as a 'great expert of the secret art of alchemy' (e.g. Turmair/Aventinus 1522/33 – <http://stabikat.de/DB=1/XMLPRS=N/PPN?PPN=336894708>, 5, 516, 22). Little evidence is available as to whether or not Schwarz existed; however, almost all *Firework Books* include a reference to Schwarz. The argument could be made that Schwarz may be the placeholder for someone else could be seen in the Kassel

5. The section on the use of the ingredients:
 - Making gunpowder
 - i. Good ordinary powder
 - ii. The best powder that ‘cannot be spoiled’
 - iii. Bringing back powder that ‘has been spoiled’
 - iv. Bringing saltpetre, sulphur, charcoal together into gunpowder
 - v. Separating the three ingredients from each other
 - vi. An instruction on the nature of saltpetre
 - vii. Making salpratica and purifying salammoniac
 - Instruction how to fire at night and how to use gunpowder in a siege situation, including how to make wall-breaching powder, and how to shoot down a tower
 - Making powder which ‘burns when it gets wet’
 - Making coloured powder
 - Making fire arrows
 - Making powder which makes the shot louder
 - Instructions about the gun dimension and where to position it
 - Instructions on breaking a gun
 - Instructions on loading and firing a gun safely
6. A section on the attributes, moral qualities, skills, and attitudes of a good master gunner. This section is interspersed into the general section on ingredients.¹⁴
7. Continuation of the section on the use of the ingredients
 - Making good tinder
 - Making good ‘ball powder’
 - Making ‘hidden fire’ and ‘fire which can lit quickly’

manuscript 4^o Ms. math. 14, where Schwarz (claimed to be a Franciscan) was replaced by Albertus Magnus (a Dominican). For further reference on this see chapter 4. For a more detailed summary on the legend of Niger Berthold/Schwarz see Partington (1960 [1999]), 91-143, Wilfried Tittmann (1983), ‘Der Mythos vom „Schwarzen Berthold“’, *Waffen- und Kostümkunde* 25, 17-30, 17-30, Franz Maria Feldhaus (1906-8), ‘Was wissen wir von Berthold Schwarz?’, *Zeitschrift für Historische Waffenkunde* 4, 65-9, 113-8, Hans Jürgen Rieckenberg (1956), ‘Berthold, der Erfinder des Schießpulvers. Eine Studie zu seiner Lebensgeschichte’, *Archiv für Kulturgeschichte* 36, 316-22, Kramer (1995), 18-32, and Kramer (2001), 76-7.

¹⁴ In other versions of the *Firework Book* the sections on the ‘discoverer’ and the master gunner attributes often, but not always, follow the Master Gunner’s Questions.

- Instructions on buying saltpetre
- Making oil of sulphur, '*oleum compilatum distillatum*'
- Bringing back spoiled powder
- Purifying saltpetre
- Firing special types of shots, such as rods, hailstorm, hedgehog
- Firing quickly and accurately
- Firing a gun where water ended up in powder
- Firing different types of powder and shots such as the use of more than one plug
- Setting fire to waterlogged poles
- Firing accurately and from siege towers
- Making fire arrows
- Setting fire to water, and the use of oil of sulphur and Greek fire
- Checking that saltpetre is of good enough quality, how to test it, and how to bring make it better
- Making gunpowder for fire arrows, and other purposes
- Turning gunpowder into *Knollenpulver* ('lump powder')¹⁵
- Making fire arrows for varying purposes
- Emptying a gun
- Firing a glowing ball
- Making tinder
- Hardening an iron tip into a 'house arrow'

Part 1 ends with the phrase '*Et sic est finis*' (fol. 51 r) near the bottom of the page, a clear indication that there was an intended end of a seemingly canonical text.

Part 2 follows directly on from part 1 on the next folio without any specific introduction or explanation. Compared to part 1, it is far shorter and it starts with a rhetorical question which is repeated throughout part 2: 'If you want to make a 'courtly art' of' (*'wiltw ein hoflich kwnst mache'*, fol. 52 r). This part deals with:

¹⁵ See discussion on *Knollenpulver* in chapter 4.

- Making an incendiary device for large-scale attacks, longer-ranging, more severe, to smoke out a castle – using a barrel or a wheel hub
- Making a shot which cannot be extinguished and ‘kills a hundred men’
- Making ‘secret firework’
- Making fire arrows, in four different colours with different attributes
- Making ‘hard water’: how, and for what purpose
- Making and use of ‘burnt oil’ or *olium petroleum*
- Instructions on cooling down a gun

Part 2 ends with ‘This way, you see to take all the precautions that no harm is done to the gun’ (*‘so scheust dw an alle sorg das der pusche[n] kein schade[n] prengt’*, fol. 61 r) at the end of the instructions on how to cool down a gun. The text finishes half-way down a page, and it can be assumed that more text was intended to be added at a later stage.

According to informal conversations with curators at the Royal Armouries, it has long been assumed that this part was a unique comment on the earlier instructions in part 1. In the course of the research for this thesis, at least one other version of this section of text has been located as part of the manuscript which contains the *Strasbourg Firework Book*. However, the Strasbourg version copies the I.34 text including references to the illustration page numbers without providing any associated illustrations.¹⁶ This suggests that part 2 of I.34 is not unique as previously thought. The likelihood is that I.34 is the older version, copied in full in the Strasbourg manuscript. Nevertheless, it might still be that part 2 was made decades after part 1 of I.34 had been produced.

Barter Bailey believes that the recipes were written down when remembered, ‘as if the compiler was adding to the collection or improving it as he compiled it, without taking the trouble to go back and eliminate duplication’. However, she admits that the hand ‘is a regular copyist’s hand not that of a man making a series of scribbled personal notes’.¹⁷ Barter Bailey highlights that a level of the contradiction existed between the apparent content of the text and the format of its presentation. It puzzled her that there seemed to have been repetitions, and less of a structure. As the analysis in chapter 4 will show, there is

¹⁶ Strasbourg Ms. 2259, fols. 30 r – 36 v.

¹⁷ Barter Bailey (1996), 58.

less repetition than previously assumed, and a clearly discernible structure. At the same time, there are scribal errors and differences to other *Firework Books* which – I would argue – give a much clearer indication what the text was produced for.

Any Early New High German text contains both regionally specific terminology and highly localized spelling with no orthographical standardization in place, and this text is no difference.¹⁸ The two parts of text show the difference in spelling and use of terminology. For instance, the two parts show a frequent change of vowels in similar words such as a shift from ‘a’ to ‘e’ such as in ‘*gemaincklick*’ (part 1, fol. 10 r) or ‘*gemain*’ (part 1, fol. 39 r) vs. ‘*gemein*’ (part 2, fol. 60 r). Similarly, the shift from ‘*lassen*’ (part 1) vs. ‘*loß*’ (part 2) are a shift from an ‘a’ to an ‘o’. These vowel shifts are one of the key indicators of regional variations.

The core three ingredients of gunpowder are spelled in a distinctively different way in the text: ‘*salpetter*’ (part 1) vs. ‘*salp*’ (in part 2 – almost always abbreviated except for fol. 59 v where it is spelled out as ‘*salpeter*’) – indicating a possibly increased familiarisation with the ingredient mentioned. Differences can be found in the use of sulphur and charcoal, too: ‘*swebel*’ (part 1) vs. ‘*schwefell*’ (part 2), and ‘*koln*’ (part 1) vs. ‘*kolle*’ (part 2).

The use of different terms can be both a semantic shift between the times of production of the two texts, or related to different use: for example, ‘*puchsen pulfer*’ (part 1: fols. 1 v, 8 r and v, 13 r, 14 r, 19 r, 21 r, 22 r, 25 v, 29 v, 30 r, 41 v, 46 v, 47 r, and 48 r) compared to ‘*sisch pulfer*’ or ‘*schiß pulfer*’ (part 2: fols. 52 r and v, 53 v, and 54 r). Both have been translated as *gunpowder*, but the term *puchsen pulfer* refers to ‘*powder from the gun*’ while ‘*sisch pulfer*’ refers to ‘*powder which can be fired*’.

Many other differences in the spelling can be noted such as ‘*fewr werk*’ or ‘*fewr*’ (part 1) compared to ‘*feur werck*’ or ‘*veur*’ (part 2); ‘*wiltu*’ (part 1) compared to ‘*wiltw*’ (part 2), to name a few.

¹⁸ Early New High German has been identified as following Middle High German (where a substantial vowel shift occurred) to be the earliest version of what later became New High German (Thorsten Roelcke (1998), ‘Die Periodisierung der deutschen Sprachgeschichte’, in Werner Besch, Anne Betten, and Oskar Reichmann eds., *Sprachgeschichte*, 2.1 (2nd ed.), Berlin/New York: Walter De Gruyter, 798-815, 804-6).

In part 2 we also find an increased number of abbreviations, where hardly any end-*n* has been written out (see fol. 52 r, abbreviations are extended with text in square brackets). This may indicate someone who writes more frequently, or writes for personal notes, rather than producing something that was primarily intended to be read by others. Also, the phrase '*los dir machen*' (e.g. fol. 52 r) appears, which can be translated as 'have made for yourself'. This does not occur in part 1, and may indicate that the second author was much less hands-on, and more accustomed to instruct others to produce items for him. This may be an indication of the possible changed status of the author and/or scribe.¹⁹

Following fol. 61 v, a total of 22 folios are left blank. Fols. 84 r – 114 r contain all the illustrations, all without any accompanying text. These illustrations are described in detail in the catalogue entry of the Royal Armouries. There is a distinctive difference between these illustrations and many other related manuscripts in the fifteenth century.²⁰ Most illustrations in manuscripts ascribed to the *Bellifortis* or *Büchsenmeister* Book genre tend to be a combination of text and image, and the text is often provided to explain the image in some detail. The text in part 1 makes no reference to the illustrations. In part 2, there are a number of references to the illustrations at the end of the manuscript as well as to other parts of the text. At least some of the page numbers will have been added at a later stage, seemingly by the same scribe but with different ink (or at a different time), as some numbers appear to be taking up more space than allocated and run into the subsequent text (fol. 54 r) while others leave more space than required (also fol. 54 r). On other occasions, the numbers are not on the same line as the rest of the text (for example, fol. 55 v).

In particular, fol. 52 v refers to 'sheet 95'; fol. 54 r refers to 'sheet 79'; fol. 55 v refers to 'sheet 95' and 'sheet 96'; fol. 57 r lists 'sheet 90' and later to 'sheet 90 or 95' (the additional 'v' or 5 is in superscript); fol. 60 r there is a reference to a drawing on 'sheet 90'. On fol. 53 v, there is a reference to another sheet, but the actual number has not been completed. The fact that there is a gap in the text implies that it must either have been forgotten by the

¹⁹ Further linguistic analysis may be advisable. A project headed by Klaus Wolff at the University of Augsburg aims to locate the geographical origins of the scribe but the results are still forthcoming.

²⁰ See, for example, the manuscript Munich Cgm. 600, entitled: *Anleitung Schießpulver zu bereiten. Büchsen zu laden und zu beschießen*, contains images throughout with captions in German vernacular or Latin or a mixture of both. See chapter 1 for further explanation on the distinction of the genres.

scribe or was intended to be completed at a later stage. On fol. 56 r the text refers to 'sheet 60 or 90' (additional 'xxx' or 30 crossed out) with once again some more space left behind the numbers. On fol. 57 v the text refers to another section 'written on sheet 55'. Fol. 53 r refers to 'sheet 55' which is another section of text with some relevance to the recipe described. Fol. 53 r refers to 'sheet 53' with plenty of space still left in the text. This may imply a change of heart by the scribe. The text clearly refers to 'as you can see on sheet 53' which is not the way that the earlier reference is mentioned (here the author states 'as you can see described at').

The illustrations (some samples provided on pages 52-55) offer a glimpse of the activities carried out by a master gunner – a clearly identifiable figure drawn in almost every illustration as a figure of authority. They can largely be subdivided into three parts: activities in the field (fols. 84 r – 86 r, 90 r – 91 r, and 106 v), activities in the workshop (fols. 85 v, 86 v – 89 v), and the remainder of technical drawings. However, as all the illustrations are without captions they are open to interpretation as to what is intended in the depiction. For example, they show some of the insides of the incendiary devices, but do not necessarily provide a comprehensive picture, which has led scholars such as Barter Bailey to explain the illustrations by their own speculative assumptions, such as 'apparently intended to' and 'what are probably'.²¹

Considerations of authorship and production context are covered in chapters 1 and 5; the ownership history of the manuscript can only be traced so far. Starting from its acquisition in 1950 and working backwards chronologically, I.34 was purchased by the Royal Armouries from the art dealer E. Weil, who, in turn, had acquired it from the Prince of Liechtenstein – the manuscript still contains a book plate '*Ex libris Lichtensteinianis*'. Hassenstein lists it as a copy belonging to the Feldzeugmeister, Ritter von Hauslab-Liechtenstein.²² This probably refers to the same manuscript cited by Max Jähns in 1889-91, 'a precious very old manuscript from the library of Hauslab-Liechtenstein (Rossau near Vienna), which has added to it a pyrotechnical book of recipes and an exquisitely illustrated atlas'.²³ Before this, in 1877, some illustrations of the I.34 manuscript pages, then also belonging to the library of

²¹ Barter Bailey (1996), 79 and 80.

²² Hassenstein (1941), 87.

²³ 'köstliche, sehr alte Handschrift der bibliothek Hauslab-Liechtenstein (Roßau zu Wien), welcher ein pyrotechnisches Rezeptbuch und ein vorzüglicher Bildatlas angehängt sind' (Jähns (1889-91), 393).

the Hauslab family, had been published by Essenwein.²⁴ Even earlier in 1868, possibly the same manuscript was listed as the property of Franz Ritter von Hauslab (1798-1883), a polymath who spent his life as soldier, engineer, and cartographer.²⁵ But where he had acquired it from could not be established. It seems that this might be the same manuscript, but that it is impossible to prove. Before this date, no further trace of ownership has been found and this is consistent with the ownership of other known copies of the *Firework Book* as discussed in chapter 5.

To conclude, any single manuscript is a complex object and has its own history and provenance. It can contain text, paratext, marginalia, images, annotations, signs of wear and tear, and binding. It was owned over the years, amended, changed, often cut and rebound. The fact that I.34's provenance cannot be pinned down to earlier than the nineteenth century does not mean that it cannot be studied. Its study necessitates bringing together a blend of palaeographical, diplomatic, historiographical, linguistic, technical, and archaeological analysis. As the cultural historian Peter Miller says in relation to the study of objects, what is necessary is 'a scientist's knowledge of materials, a practitioner's knowledge of techniques, and a historian's knowledge of context'.²⁶ This range of knowledge also applies to the study of this manuscript. This chapter has described the physical attributions of I.34, its format and history, and provided a summary of its content structure. The following chapter will provide a transcription and translation.

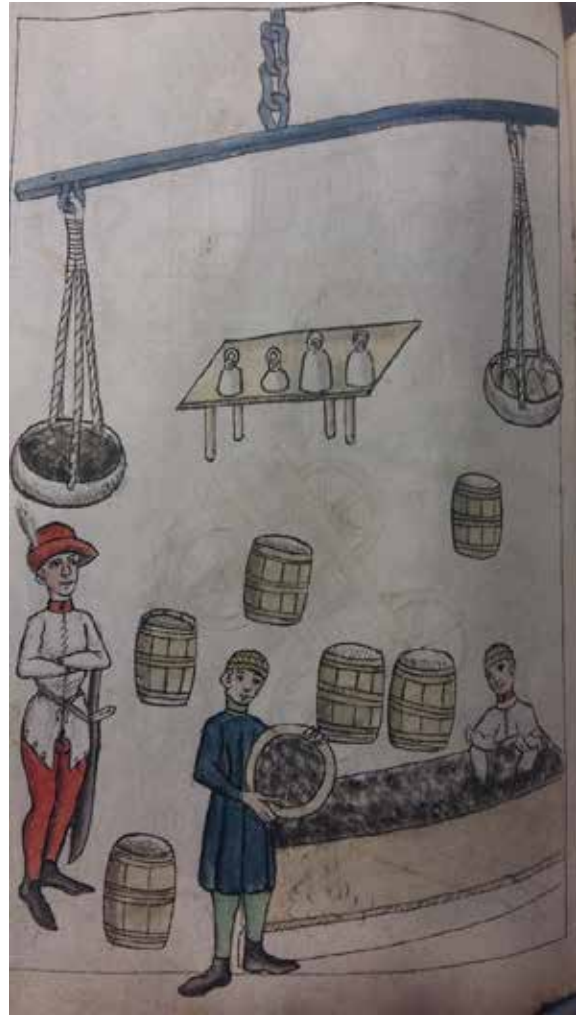
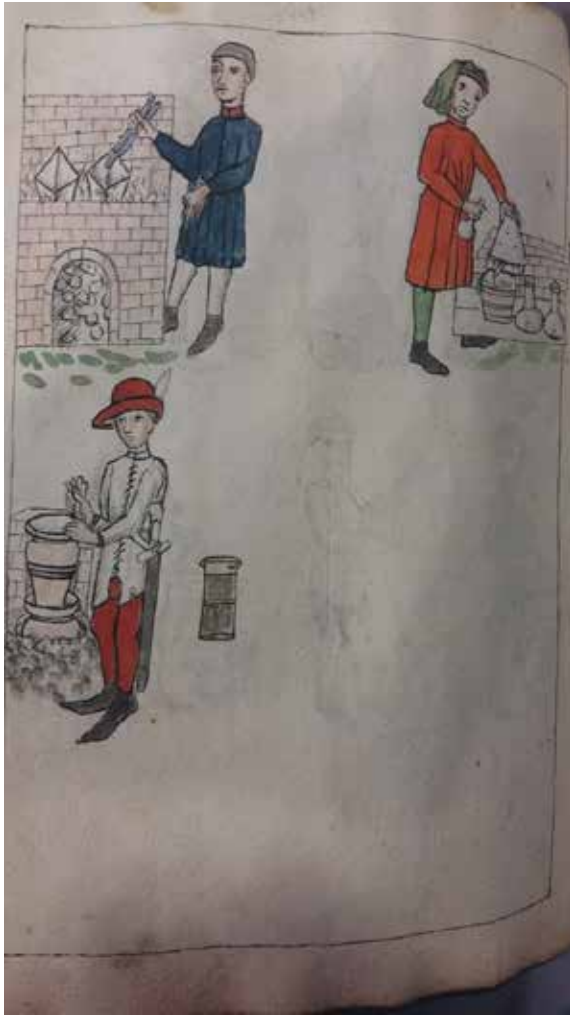
²⁴ August von Essenwein (1877 [1969]), *Quellen zur Geschichte der Feuerwaffen*, 2 vols., Leipzig/Graz: Akademische Druck- und Verlagsanstalt, 111 and B. 1. – dated by Essenwein c. 1430-1440.

²⁵ Karl Schneider (1868), 'Zusammenstellung und Inhalts-Angabe der artilleristischen Schriften und Werke in der Bibliothek Seiner Exzellenz des Herrn Feldzeugmeisters Ritter v. Hauslab', *Mittheilungen über Gegenstände der Artillerie- und Kriegs-Wissenschaften*. Hg. vom K. K. Artillerie-Committé, Wien: Braumüller, 123-211, 126.

²⁶ Peter Miller (2017), *History and Its Objects: Antiquarianism and Material Culture since 1500*, Ithaca and London: Cornell University Press, 16.



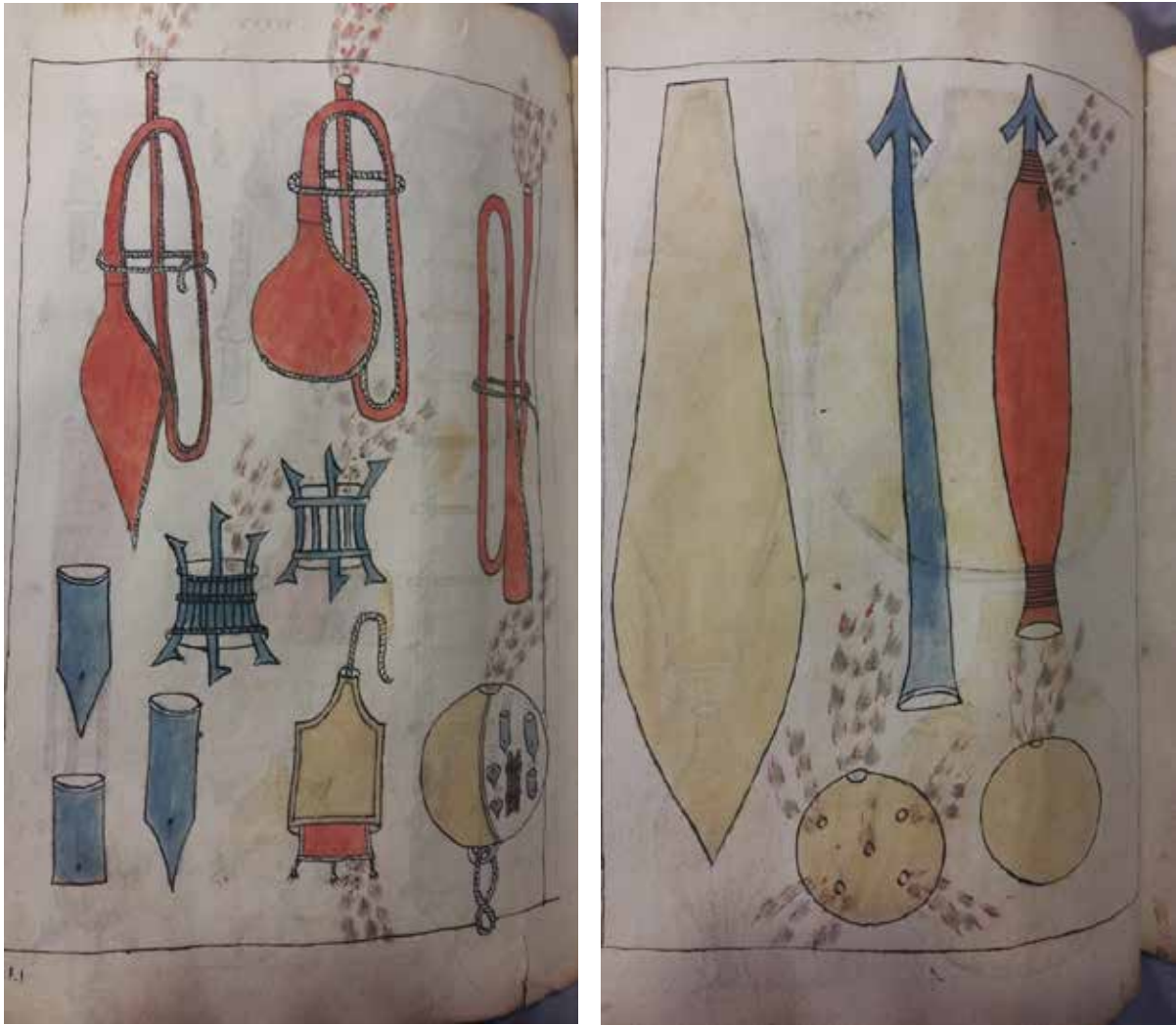
Royal Armouries, I.34, fols. 90 v and r – in the field (author, courtesy of the Royal Armouries).



Royal Armouries, I.34, fols. 89 v and 86 v – in the workshop (author, courtesy of the Royal Armouries).



Royal Armouries, I.34, fols. 85 v and 87 r – in the workshop (author, courtesy of the Royal Armouries).



Royal Armouries, I.34, fols. 94 v and 95 v – incendiary devices (author, courtesy of the Royal Armouries).

Chapter 3: The text – editorial principles and translation notes

This chapter provides the text and a translation into English of I.34. It is integral to the understanding of the *Firework Book* tradition and I.34's position in it, that the edition and translation is placed in the centre of this thesis. Only after providing a complete translation is it possible to analyse the content of the *Firework Book* in detail. Before the edition and translation it is important to set out my key editorial principles.

Transcription

In transcribing and translating the *Firework Book* I have tried to replicate the text as it appears in the manuscript. Since no facsimile of the original exists, I have reproduced the text in diplomatic transcription. The guiding principle of the transcription is to remain faithful to the original, with the intention of providing all the core elements of the original manuscript.

The transcription aims to make the German text as accessible as possible for a reader who is familiar with modern New High German. However, the spelling of the words is taken as in the manuscript and has not been harmonized to enable scholars to observe any linguistically specific features.

The decision was made to retain the page layout of the manuscript text line by line, with any words that were carried over the line allowed to remain. Hyphenation has been included where it has been provided in the manuscript.

When obvious scribal errors occur, they are marked in the transcription. Scribal errors, such as word or line repetitions have been included, as have crossings out.

By way of convention, the following rules are observed throughout: vowels *v* and *j* are retained and have not been converted to *u* and *i*, resulting to e.g. '*vnd*' and not '*und*'.

The two colours of the manuscript text are represented in bold for red, and non-bold for the brown. Enlarged initials are reproduced in larger font, but standardized – which is not the case in the manuscript.



Royal Armouries, I.34, fols. 6 r, 14 r, 42 v and 57 r – initials in parts 1 and 2 (author, courtesy of the Royal Armouries).

Going beyond the diplomatic edition, abbreviations are expanded, added in the text in italics and placed in square brackets.

Diacritic marks have been reproduced, often indicating a lengthening of a vowel, but only when it is clear that they are actual characters and not a scribal oversight as a slip of the pen.

In the interest of ease of reading for a modern audience the following editorial alterations have been carried out:

- Where capitalization exists it remains as it appears.
- Paragraph spacing has been provided only where indicated in the original.

However, no punctuation has been added unless provided in the text.

Translation

For the English translation I have attempted throughout to translate the prose into a form of English that should be comprehensible to a reader of modern English who has not undergone a specific technical training.

The translation follows the original text as closely as possible, and especially aims to reflect the often monotonous and repetitive sentence structure. This follows the translation theory approach of translating largely '*word for word*' where possible, and only when necessary choosing a '*sense for sense*' approach as discussed by the translation theorist Susan Bassnett.¹ For instance, one of the most often used words '*vnd*' is repeated more often than would be usual in an English text. Additions which were deemed necessary for clarification are added in italics and placed in square brackets. In passages where the meaning is unclear

¹ Susan Bassnett (2002), *Translation Studies*, 3rd Edition, London: Routledge, 51-7.

an attempt at explanation has been provided in the translation, referenced in an explanatory footnote.

The translation is intended to be as close to the original as possible, to allow for cross-referencing to the original Early New High German. This results in a very literal translation, and even the sentence structure is only rearranged when required to reflect English grammatical conventions, with the intention to reproduce the ‘author’s text’ as much as possible, while producing a ‘relevant translation’ as defined by Jacques Derrida.²

Modern punctuation and capitalization have been added to ease the reader’s task.

Presentation

The transcription and translation are placed side by side to allow for cross-referring and cross-reading where required. However, line numberings have been added to the left of the original text. Any superscripts and textual addition in the original have been added as full lines of text. As part 2 of the text is written in smaller font in the manuscript, the margins have been decreased in order to keep both text and translation on one page – as in part 1.

² Vincent Gillespie and Anne Hudson eds. (2013), *Probable Truth: Editing Medieval Texts from Britain in the Twenty-First Century*, Brepols: Turnhout, 7. A great amount of scholarship has been produced on the theory and practice of translating medieval texts into modern languages, and making them accessible to a modern reader. Most influential in the theoretical framework on translation in recent decades has been the work of Jacques Derrida, and the subsequent translation is indebted to the framework provided by Derrida (see, among others, Jacques Derrida and Lawrence Venuti trans. (2001), ‘What is a “Relevant” Translation’, *Critical Inquiry*, Vol. 27, No. 2, 174-200).

Chapter 3: Edition and translation Royal Armouries I.34 – part 1

fol. 1 r

Welch furst grauff her[r] ritter

1 knecht oder stet besorgent vor
iren feinden beligert vnd benot werden in
5 slossen festen oder stetten den ist zu vor=
auß ain bedürfft das sie haben diener
die als from vnd vest leut sein das sie
durch eren willen sel ere leib leben vnd
gut vnd was in gott ye verlichen hat
ee gen iren feinden dar stercken vnd wa=
10 gen dorsten ee das das sie fluchen do
zu beleiben wer oder ee das sie ichiz=
auff oder hin geben das zu behalten
were daz si sich aller poser und ver=
zagten sachen vnd geschichten schamen
15 vnd als weis leüt seint das sie wissen
wa man mit schissen werffen an gen

fol. 1 r

Any prince, earl, lord, knight,
squire, or town who frequently fear that they may
be besieged by their enemies and threatened in their
castles, strongholds, or towns,
they need in advance to have servants
who are reliable¹ and competent people and who
as a matter of honour will commit their souls, lives, bodies, and property
and all that God has given them
against their enemies.² And
they [*should*] dare to be bold³ rather than running away,
to hold their ground rather than
giving up everything⁴ that they should keep
where they should be ashamed of all bad and
disheartened matters and events.
And are wise enough people to know
when one can start firing

¹ 'from vnd vest' – often translated as 'pious', generally used without religious connotations (Baufeld, 96). The religious connotation was introduced with Martin Luther's writing and cannot be applied retrospectively. The definition used here is related to '*rechtschaffend, ordentlich*' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/bederblich.h1.4adj_1513870571).

² No reference could be traced for '*dar stercken*'; it is possible that this is a scribal error, and that it should be '*dar strecken*' in the sense of 'sacrifice' ('*hingeben, opfern*') or simply '*darreichen*' ('present') (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/darstrecken.s.3v_1513372249).

³ '*wagen dorsten*' – both words mean to 'dare' or to 'risk' or simply to 'start' (*Frühneuhochdeutsches Wörterbuch Online*, Def. 15, http://fwb-online.de/go/bestehen.s.3v_1513302171), from Middle High German '*türen*'.

⁴ '*ichiz*' or '*ichts*' or '*icht*' – positive form of 'nothing' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/icht.s.2n_1518601445).

vnd stürmen genotten mocht Das sy
 dar für wissen zu pawen vnd sich mit
 irm zug gen iren feinden auff das
 gewerlichst zeschicken Sunder an iren
 grossen vortail vor den schlossen dar
 an sie besseren sind kain mutwill schar=
 mützeln tut vnd and mißhelung vnd

20

and exactly where to start besieging.⁵ They
 therefore should know how to build⁶ and how to handle
 their equipment⁷ most skilfully against
 their enemy. Especially to their
 great advantage in front of a castle,
 they should not engage in a deliberate skirmish
 or other misconduct and

fol. 1 v

1 zwaiung in guter freuntschaft vnder ein
 ander beleiben an den sachen nach der weiß
 esten rat vnder in handelIn vnd welch
 5 furst grauff her[r] ritter oder knecht oder
 stet haben solich from weiß diener vnd
 vest die mugen sich ir wol trosten Doch
 bedurffen si beÿ in zu haben leut di ar=
 baitten binden vnd mugen als schmid zim=
 merleut schüster milner pfister vnd an=
 10 der arbayter Besunder gut puchsen maist[er]
 vnd schutzen do mit si sich behelffen müge[n]
 vnd wen[n] das ist das man von guten püchse[n]
 maistern guten trost nÿmt so ist ein yedlich
 fürst her[r] ritter oder knecht vnd stet bedurf=

fol. 1 v

break a good friendship between two [*people*].
 [*They should*] live with each other in a manner which
 makes use of the best counsel. And any
 prince, earl, lord, knight, squire, or
 town that has such competent, wise, steadfast,
 and bold servants can rest assured. Nevertheless
 they need to have people who are competent workers
 and who can work as a smith, carpenter,
 shoemaker, miller, baker, or other
 workers. Especially [*they need*] good master gunners
 and gunners on whom they can depend.
 When it is the case that good master
 gunners are relied on, then each and every
 prince, lord, knight, or squire, and town

⁵ 'genotten' or 'genöten' – 'to urge, force' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/gen%C3%B6t.s.4adj_1514015990). This sentence is not clear in the original, but has been left as a literal translation. It appears more a written version of a spoken commentary, an often repeated formula in almost all *Firework Books*, and its meaning is 'ought to hold on to all equipment and personnel instead of surrendering which is bad and disheartening behaviour they should be ashamed of. They should be wise enough to know when to fire and when to attack.'

⁶ This is likely to refer to defensive structures, and the role of the master gunner to defend them – in some copies of the *Firework Books* there is an added word or two to highlight this, Dillingen Ms. XV 50, fol. 1 r, 'bössywerck vmd brust wer' (meaning 'bulwarks and gabions'), and in Weimar Manuscript Q 342, fol. 55 r, 'für Anläufe, Stürme, Einwerfen' ('for attacks, advances, and assaults').

⁷ 'zug' or 'zeug' – collective term for 'things', here 'equipment' or 'train' – not yet captured by *Frühneuhochdeutsches Wörterbuch*.

15

en das puchsen maister gut maister sind
 vnd alle die ol vnd pulfer wol beraiten
 können vnd vi auch andre stuck die nützlich
 vnd gut sind zu dem puchsen pulfer zu
 fewrpfählen zu fewr kugeln die man wirft
 zu fewr kugeln die man auß der puchsen
 schewst vnd zu andern fewr wercken vnd
 sachen die in disem puch das do haist

fol. 2 r

das fewr werkpuch her nach geschriben
 sten vnd dar vmb das der stuck so vil sind
 die ein yedlicher guter puchsen maister
 können sol vnd das sie alle ain maister
 nit wol bedencken noch in seinem sinne
 behalten mag Dar umb so stet her=
 nach geschriben alle die stuck vnd kunst
 die ein yedlicher guter puchsen maister
 können sol vnd wie ainer ain yedlich
 stuck von an gang piß an das end auß

fol. 2 r

the firework book which stands written as follows.
 And as there are so many things of
 which each good master gunner⁹
 should be capable of and which could not all
 be well remembered by a master and kept
 in his mind; therefore there are written below
 all the items and methods¹⁰
 that every good master gunner
 should know and how he can make each
 item from beginning to end,

⁸ 'stuck' – could mean anything and everything from 'piece' to 'part', 'element', 'item', or at times simply 'things'.

⁹ This could also mean 'gun master' – the word order is debatable. *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/b%C3%BCchsenmeister.s.0m_1513302890. There is a distinct difference to the role of 'Büchschmied' – the smith in charge of the manufacture of a gun (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/b%C3%BCchschmied.s.0m_1513341043).

¹⁰ 'kunst' is a very broad term with many different applicable uses. The *Frühneuhochdeutsches Wörterbuch*, vol. 8, col. 1830, provides two possibly suitable definitions for 'kunst':

- a) Definition 3: 'knowledge, expertise, insight; also specialist knowledge, training' ('Wissen, Kenntnis, Kunde, Einsicht [...] auch 'Gelehrsamkeit, Fachkenntnis'), or
- b) Definition 4: 'Science; especially, the rules and regulations that are the foundation of art of science, theory, methodology' ('Wissenschaft; speziell: die einer Kunst oder Wissenschaft zugrundeliegenden Regeln, Theorie, Methode')

'Method' was deemed the closest approximation in English in this context. The term 'kunst' is similar to the English use of the term 'art' which similarly underwent a large shift in meanings over the centuries. See chapter 4 for a more detailed discussion.

10

gericht vnd gut bereiten vnd können sol
do mit er dan[n] mit der andern leut hiff
die peÿ im sein ein yedlich schloß vest vnd
stat behalten mug vnd von der kunst
die zu der buchsen gehort geschehen
zweiff frag So beschicht auch über yed=
lich frag besunder ein gut vnder rich=
tung vnd lere Die erst frag

15

Die erst frag ist ob daz fewr den stein
auß der puchsen treib oder der dunst
der von dem fewr get Zu sprechen etlich
das fewr hab die kraft den stain zetreiben.

20

fol. 2 v

1 Ich sprich aber das der dunst hab die kraft
Exemplum ein peispil Zin[d]e ein pfunt guts
pulfers vnd thu es in ein sennig weinfaß

and can prepare them well and should be able to do them,
in order that with the help of other people
he can hold any castle, stronghold,¹¹ or
town. Regarding the ‘art’
which belongs to the gun there
twelve questions arise.¹² Therefore concerning each
question good¹³ information and instructions
are provided. The first question

The first question is whether the fire drives the stone¹⁴
out of the gun or the vapour¹⁵
which comes from the fire. Many [people] agree
that it is the fire that has the power to propel the stone.

fol. 2 v

I say: the vapour has the power
Exemplum, for example:¹⁶ set alight a pound of good
[gun]powder and put it into a solid¹⁷ wine barrel

¹¹ There is a subtle difference between ‘schloß’ and ‘vest’: it is used as a rhetorical repetition here, ‘vest’ relates to any fortified structure big or small.

¹² ‘geschehen’ is a verb with multiple meanings such as ‘to happen’ or ‘to occur’. Here the translation of ‘arise’ was chosen to reflect the causality.

¹³ The author often uses terms such as ‘gut’, ‘recht’ or ‘wol’, as well as comparatives such as ‘pöß’ or ‘pößler’, or superlatives such as ‘pester’. All of these are subjective, emotive terms which could be translated at times into a more technical language of ‘accurate’ or ‘reliable’. However, for the sake of this translation it has been decided to override the sense of the emotive and subject terms and translate it often with a more imprecise ‘good’.

¹⁴ ‘Projectile’, ‘round shot’, ‘stone ball’.

¹⁵ The literal translation here would be ‘pressure’.

¹⁶ The author repeats the same words – first in Latin, then in German. The *Frühneuhochdeutsches Wörterbuch* lists under definition 3 ‘Beispiel, Verhaltensweise, die anderen zum Vorbild oder (seltener) zur Abschreckung dient; Vorbild, Muster, Lehre’ a range of examples where ‘beispiel’ is used in conjunction with ‘exempel’ or ‘lere/leer/lern’ (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/beispiel.s.2n_1543441567). For more discussion on the subject see chapter 4.

¹⁷ ‘sennig’ – in Freiburg Ms. 362, this term is listed as ‘sämig’ – which in turn is interpreted by Kramer as a measurement ‘one saum in volume [about 150 litres]’ (Kramer (2001), 22 – no reference provided), Nibler states that ‘a clear definition is not possible. Hassenstein’s interpretation, on page 43, of it being thick-walled has to be disputed. Kramer uses a measure of c. 150 litres. Most likely is that this relates to a barrel of c. 30–40 litres in size.’ (*Eindeutige Erklärung nicht möglich. Hassenstein S. 43*)

5 vnd vermach es wol das kein dunst do von
komen müg den[n] zu dem widloch do du es
an zindest vnd so du es anzindest so ist daz
pulfer zehant verprunnen vnd pricht der
dunst das vaß

10 **D**ie ander frag ob salpeter oder swebel
die kraft hab den stein zu treiben sprich
ich sie baide dan[n] wann das pulfer anzün=
det wirt in der buchs so ist der swebel
also hitzig vnd der salpeter als kalt das
die kelt die hitz nicht geleiden mag noch
die hitze die keltin wan[n] kelt vnd hitz sein
zwey wider wertige dinck also mag ir yed=
weders das ander nicht geleiden vnd ist
doch ains an das ander nicht nutz zu dem
pulfer zu prauchen

20 **D**ie dritt frag ob ~~eb~~ lutzel pulfer beld
ein puchs prech oder weiter schieß

and close it well afterwards so that no vapour
should escape apart from through the touch hole¹⁸ where you
light it. And when you light it the
powder burns immediately¹⁹ and the vapour
breaks²⁰ the barrel [*apart*].

The second²¹ question [*is*] whether saltpetre or sulphur
has the power to expel the stone. I say:
it is both for when the powder is lit
in the gun the sulphur is so
hot and the saltpetre is so cold that
the cold cannot bear the heat nor the
heat the cold,²² for cold and hot are
two opposing parts²³ which do not tolerate
each other, yet
one without the other [*is*] not useful to
be used for powder.

The third question [*is*] whether a little more powder is likely to²⁴
break a gun or [*it*] fires further

(*sämig=dickflüssig=>dickwandig*) ist zu widersprechen. Kramer. S. 154, führt 'sämig' auf 'Saum', ein altes Hohlmaß von ca. 150 l zurück. Am verständlichsten scheint die Rückführung auf die Traglast eines 'Saum'-Tieres – also ein mittelgroßes, von z. B. einem Maultier tragbares Faß mit etwa 30-40 l Fassungsvermögen.' (Nibler (2005), 49)). All of the above assumptions to 'sennig' are unevicenced and no trace of provenance for this theory could be established. Hence, the more general translation.

¹⁸ 'widloch' – 'touch hole'.

¹⁹ 'zehant' – literally 'at hand', 'to hand' – here translated as 'immediately' (Baufeld (1996), 261).

²⁰ 'pricht' means 'break', but presumably implies 'bursting'.

²¹ 'ander' literally means 'other', but as Early New High German does not use the cardinal number 'second', all reference works refer to this as a possible translation.

²² This is a reference to the medieval concept of 'qualities' which – coming from Greek natural philosophy – was a concept widely accepted and commented on in the fifteenth century in Europe as a natural philosophical core principle. It subdivided nature into four qualities 'hot', 'cold', 'dry', 'wet' – deriving from the four elements 'fire', 'earth', 'air', and 'water'. These were seen as the core building stones in nature. (*Frühneuhochdeutsches Wörterbuch*, vol. 8, 510-11). See chapter 4 for more details.

²³ Similar to the term 'stuck' – as explained above – this could mean anything and everything from 'piece' to 'part' or 'element' or just 'thing'.

²⁴ 'beld' – 'soon', 'quickly', or more likely here 'is likely to'.

als ob man die buchsen silt piß an den
klotzen Da sprich ich wen[n] man die puchsen

fol. 3 r

1 fult piß an den klotzen so mag das fewr
vnd der dunst nicht weitten gehaben den
schuß zu verbringen piß das daz fewr ain
tail hindersich auf print vnd das pulfer
5 den klotz auf schlecht Ist aber die puchs
den drittail piß an den vierden geladen So
mag das pulfer gemaintlich ains mals
prin[n]en vnd mag der dunst sein kraft ver=
pringen vnd schust weiter vnd pricht die
10 puchs vil ee den von dan[n] der si fult mittin
gestossem pulfer piß an den klotz

Die vierd frag ob ein linder klotz von
lindem holz den stein paß treib oder
von hertem holz als aichein vnd buchein
15 als vil maister priessen vnd ob die selben
klotz kurz oder lanck düer oder grünen sein

if one fills the gun right up to
the plug.²⁵ To that I say: if one fills the gun

fol. 3 r

right up to the plug, then the fire
and the vapour do not have the width²⁶ to
carry the shot until the fire has partially²⁷
burned down backwards²⁸ and the powder
has reached the plug. But if the gun
is filled by one third to one quarter, then
the powder can burn all at once.²⁹
And the vapour can use its strength
and fires further and breaks³⁰ the
gun much more readily than if the powder
[is] compressed and [comes] right up to the plug.

The fourth question [is] whether a lime³¹ plug [made]
out of lime wood drives the stone better, or, whether
[one made] out of hard wood such as oak or beech [does],
as recommended³² by many masters. And whether
the said plug should be short or longer, dryer or

²⁵ 'klotz' – can be any piece of wood for multiple uses (see definition 1 in *Frühneuhochdeutsches Wörterbuch*, vol. 8, 1147).

²⁶ Presumably here in a less literal sense, to have 'space' or 'room'.

²⁷ 'ain tail' – here 'partially'.

²⁸ 'hindersich' – here 'backwards' (Götze (1967), 122).

²⁹ 'gemein' – means 'common' (*Frühneuhochdeutsches Wörterbuch*, vol. 6, 828).

³⁰ This section is not clear in the original. The text implies that it would be better to load the chamber only partially, but at the same time it implies that there is a higher risk of the gun to explode or break into pieces. It is a positive and negative consequence in one sentence used indiscriminately. One explanation for this could be that it is a 'higher-risk' strategy with likely better (or possibly much worse) results.

³¹ 'linder' – could mean both 'lime', as the type of tree, and the general description of the softness. Therefore, it could also mean 'soft' but here (to compare the wood with oak and beech) it seems more likely to be lime.

³² 'priessen' or 'preisen' – ambiguous term which could be translated as 'need', 'recommend' or 'praise'.

süllen Sprich ich die herten kloz sein nit
 gut wann dar vmb sie sein zeherte vn[d]
 lassen sich nicht treiben piß auff sein
 stat vnd behebt den dunst vil paß dan[n]
 die herten klotzen Item der klotz sol
 nit lenger sein dan[n] er brait seÿ die peste[n]
 düren klotz die man gehaben mag die

20

fol. 3 v

1 mach von dürm erlen holz Aber die pesten
 grünen klotz die macht man auß grünem
 erlen holz Aber die pesten grünen klotz
 macht man auß pirckeim holz als pald
 5 es von dem stain gehawen wirt so mach
 sie als do vor stat.

Die funfft frag ob der stain ver gang

so er hort ligt Sprich ich ye herter
 der stain ligt ÿe herter er get also das er
 gar wol verschopt seÿ daß der dunst do
 von nit gen mug So wirt der dunst starck
 vnd schewst weit vnd hert

10

greener. I say: hard plugs are not
 good as they are too hard and
 they cannot be driven [right] up to its
 place. And [the softer plugs] retain the vapour much better than
 the harder plug [would]. Thus, the plug should not
 be longer than it is broad. The best
 dry³³ plugs one can have [are those that]

fol. 3 v

one can make from dry alder wood, but the best
 green plugs are made out of green
 alder wood. But the best green plugs
 are made out of birch wood as soon as
 it has been cut from the trunk³⁴ and do this
 as stated previously.³⁵

The fifth question [is] whether the stone goes further

if it lies hard.³⁶ I say: the tighter³⁷
 the stone lies the more ferociously³⁸ it goes. It has to fit
 very tightly³⁹ so that the vapour cannot
 escape. This way, the vapour becomes strong
 and it [the gun] fires far and hard.

³³ 'düren' – can mean both 'dry' and 'thin'. At this point, 'dry' seems more likely in this context.

³⁴ 'stain' or 'stam[m]' – likely to be a scribal error in the original, as in this context it is more likely to mean 'stam' – 'trunk', and not 'stain' – 'stone'.

³⁵ The author uses conflicting and repetitive statements, by stating first the 'best wood' is 'alder' followed by stating later the 'best wood' is 'birch'. In both cases, the author uses the superlative. It is possible that there may be a question of availability or 'even better use' but the German original does not provide an indication for that.

³⁶ Presumably meaning 'tighter' or 'better fitting'.

³⁷ 'herter' – comparative of 'hart' – literal meaning 'hard' but also associated to a field of connotations such as 'firm', 'solid', 'heavy', 'strong', 'fierce' or – as here – 'tight'.

³⁸ While the literal translation is chosen, the meaning here is likely to relate to 'further'.

³⁹ 'verschoppen' – here used in the meaning of 'block'.

Die sechst frag ob ^{die} pissen do man den stein
 mit verpisset von lindeim oder von
 herthem holtz sull sein sprich ich welcher
 stain gerecht in die puchsen gehort vnd
 er nit mer weitin het dan[n] er bedarff
 vnd er getrang lugen muß so solt du in
 verpissen mit dünnern herten ppissern von
 aichem holtz Ist aber der stein etwas zu
 klein das er nit also getragt ligt so solt
 du in verpissen mit dunnen pissen

15

20

Die sibend frag ob die selben pissen dick

fol. 4 r

oder dün[n] sein sullen von dünem holtz sprich
 ich das die selben pissen dick oder dün[n]e
 sullen sein von dunnen holz Aber wenn
 du den stein do mit verpisset so solt du in
 pissen mit aim schrot eÿsen an dem stain
 ab haw[e]n also das die pissen nit fur den
 stain gangen

5

The sixth question [*is*] whether the wedges⁴⁰ which one uses
 to wedge in the stone should be [*made*] out of soft⁴¹ wood or
 hard wood. I say: [*make sure*] the
 stone fits properly in the gun and
 it [*the stone*] has not got more girth than it needs
 and that it has to fit tightly. Then⁴² you have to
 wedge it in with thin hard wedges of
 oak wood. But if the stone is a little too
 small so that it does not fit tightly, then you should
 wedge it in with thin wedges.⁴³

The seventh question [*is*] whether the same wedges

fol. 4 r

should be thick or thin when [*they are made*] out of fir wood. I say:
 That wedges shall be thick or thin
 [*when they are made*] out of fir wood.⁴⁴ But if
 you do wedge in the stone with this [*wood*], then make
 sure you cut it off with a small piece of iron⁴⁵ at the stone
 so that the wedges do not
 go beyond⁴⁶ the stone.

⁴⁰ 'pissen' – see *Frühneuhochdeutsches Wörterbuch*, vol. 4, 482: in the sense of 'a piece' ('*Brocken, Stückchen*') or more specifically (Götze (1967), 34) '*bisse*' – '*Keil*' – 'wedge'.

⁴¹ 'lirne' – here 'soft'.

⁴² In the meaning of 'in that case'.

⁴³ The last two sentences are contradictions. It has to be either one or the other, and both cannot be right. This must be down to a scribal error.

⁴⁴ The 'answer' to this question seems to be a contradiction. It could be read that the author expresses preferences that one would be better than the other, but in the end it does not make that much difference.

⁴⁵ See Christa Baufeld (1996), *Kleines frühneuhochdeutsches Wörterbuch. Lexik aus Dichtung und Fachliteratur des Frühneuhochdeutschen*, Tübingen: Max Niemeyer:

'schrot' – 'a small, cut-off piece' ('*abgeschnittenes Stück*').

⁴⁶ '*fur*' in the meaning of 'in front of' or 'ahead' ('*vor*').

Die achtend frag war mit man den
stain verschoppen sull das der dunst
do von gen mug Sprich ich nym wachs
vnd wechse ein tuch do mit vnd tu es ein=
fach zu aim sail vnd schopp das mit eim
guten schoppeysen zwischen dem stain vnd
die puchsen auf die pissen so vert es ver.

10

Die newnd frag ob ain puchs weiter
schieß von zweyerleÿ pulfer dan[n] von
ainerleÿ wan[n] du die puchsen ladest vnd
verschuessen wilt So lug das du habst
zwayerleÿ puluer vnd tu das gut pul=
fer an den poden vnd das pöß dar auff
so scheußt du weiter wan[n] mit ainem wan[n]
das tut die widerwertikeyt baid[er] pulf[er]

15

20

Die zehend frag ob der stain den klotze[n]

fol. 4 v

1 an rüeren sol oder nit Sprich ich der stein
sol hert an dem klotzen ligen Du solt den
klotzen nemen vnd solt in mit ainem tuch
bewinden vnd solt den klotz vnter augen
5 prennen das tail das gegen dem stain
gehört vmb das daz er hört werd vnd
lad den stain hört dar an vnd verpiß

The eighth question [is] with what one
should block the stone so that the vapour
can escape.⁴⁷ I say: take wax
and wax a piece of cloth with it and make it simply
into a rope and stuff it, with a
good ramrod, between the stone and
the gun around the wedge, then it will go far.

The ninth question [is] whether a gun fires
further with two types of powder than with
one type. When you load a gun and
want to fire it make sure that you have
two types of powder and put the good
powder at the bottom and the inferior on top:
then you fire further than with one [type of powder], as this
is done by the opposing characteristics of the two powders.

The tenth question [is] whether the stone should touch

fol. 4 v

the plug or not. I say: the stone
should be hard against the plug. You should
take the plug and should wrap it in a piece of cloth
and should – while watching carefully⁴⁸ – burn that part
of the plug that belongs next to the stone
so that it becomes hard. And
load the stone tightly against it and push

⁴⁷ This may be viewed as a contradiction as before the author insists on making sure that the vapour cannot escape. However, in order to enable a projectile to be propelled there needs to be one direction in which the vapour can escape.

⁴⁸ 'unter Augen' – meaning 'carefully, not leaving it out of one's sight'.

vnd verschopp den wol das in der dunst
gemeinlich treiben muß

¹⁰ Die aylft frag ob das pulfer posser sey
zu tun in die puchsen knollen pulfer
oder gestossen pulfer Sprich ich das knol=
len pulfer zwey pfunt mer tun dan ge
stossen pulfer dreÿ pfunt gethon mochten
¹⁵ Aber du solt das knollen pulfer bereiten
vnd machen als in disem puch hernach
geschriben stet

Die zwelfft frag wie scharzer stain
ein pfunt pulfer mit seiner kraft
gewerffen müg vnd was sein recht
²⁰ trag sey Sprich ich ain puchs sey groß
oder klein so sol alweg ein pfunt pulfers
ain newn pfundigen stain treiben ist

fol. 5 r
¹ auch des stains mynder so vil get auch

and wedge it thoroughly so that the vapour must
force it out as usual.⁴⁹

The eleventh question [*is*] whether the powder is better
to put in the gun if it is *Knollenpulver*⁵⁰
or ground powder.⁵¹ I say: two pounds of
Knollenpulver can do more than
three pounds of compressed powder could do.
But you should prepare the *Knollenpulver*
and make it as it is written in this book
below.

The twelfth question [*is*] how black⁵² stone
can propel one pound of powder with
its force and what its right weight might be.
I say: a gun may be large
or small and always one pound of powder
should propel a nine pound stone [*ball*].

fol. 5 r
If the stone [*ball*] is smaller, then powder will be reduced

⁴⁹ 'germainlich' – as in 'commonly', implying that this is the case unless something unexpected happens.

⁵⁰ Or, 'lumped powder'. As *Knollenpulver* and corning have a major influence in the development of gunpowder it was decided to leave this in the original. See chapter 4 for a detailed discussion on *Knollenpulver*.

⁵¹ There is little indication about the status of the powder. The original refers to the fact that the powder was ground, but not that it is still in powder format. A

comparative format is required to distinguish it from the *Knollenpulver*. Other *Firework Books* refer to this powder as 'geräden' ('powder pushed through a sieve' – Freiburg Ms. 362), 'gereden' (possibly 'ground by a wheel' – Dresden Ms. App. 463 or Heidelberg, Cod. Pal. germ. 585 or 502) while others, such as Heidelberg, Cod. Pal. germ. 122, also have 'gestossen'.

⁵² 'scharzer' – possibly scribal error, as a misspelling. A missing 'w' would make it 'schwarz' – 'black', but from the context it is more likely that this relates to the weight of the stone. Other *Firework Books* such as Dresden Ms. App. 463 or Freiburg Ms. 362, refer to it as 'swerer' (fol. 13 r) or 'schwärer' (fol. 74 v) – 'heavy'.

des pulfers ab **Hernach stet geschri=**
ben wie man salpetter sieden sol

Wiltu salpetter sieden so nym starcke
laug als hie nach geschriben ist
vnd tu den salpetter dar ain vnd laß den
als lang sieden als man visch seut vnd
geuß in dan[n] ab in ein schon beckin vnd
laß in kald werden und schut die laug
wider ab dem salpetter wider in das keslin
vnd laß das sieden piß der halbtail oder
der viertail ain seüt vnd laß das dann
kalt werden vnd schut es dan[n] aber ab
vnd der[r] dar nach den salpetter vast wol
ee du in mischest also solt du guten salpet=
ter leutern der von zwirunt oder dreystunt
geleutert ist worden **Aber wie man**
salpetter sieden sol

Wiltu salpeter leutern einen zentner
minder oder mer so nym lauter=
wasser oder wein vnd tu den salpetter
dar ain also das der salpetter nit weiß
werd vnd daß das wasser ploß ainen

fol. 5 v
finger fur den salpeter auf gang vnd tu in

as well.⁵³ **After this is written**
how one should boil saltpetre.

If you want to boil saltpetre take strong
lye as is described later
and place the saltpetre therein and let it
boil for as long as one poaches fish. And
then drain it into a decent basin and
let it cool down and remove the lye
and replace the saltpetre in the small pot
and let it boil until half or
a quarter has been boiled off. And let it
cool down and pour it off again
and take the saltpetre and dry it well⁵⁴
before you mix it. In this way you can purify good
saltpetre which has [*already*] been purified twice or
three times. **But how one**
should boil saltpetre.

If you want to purify a hundredweight,
more or less, then take clear
water⁵⁵ or wine and add the saltpetre to it
so that the saltpetre does not turn white
and that the water comes to only one

fol. 5 v
finger above the saltpetre. And put it

⁵³ Likely to mean that the smaller the ball, the less powder will be required to propel it. It is not clear from the original whether there is an assumption that the size of both reduces in the same proportions.

⁵⁴ 'vast' – 'strong' (Alfred Götze (1967). *Frühneuhochdeutsches Glossar. 7th edition.* Berlin: De Gruyter, 73: 'stark').

⁵⁵ 'lauter' could mean 'clean, only', or solely 'not diluted with foreign substances, clear' ('lauteres wasser').

über ein fewr vnd so er anfach zu sieden so
 tu zu ainem zentner ain lb salarmoniack
 vnd sechs lot spengrün oder als vil gute[n]
 galizen vnd seud in in der leng als do vor
 geschriben ist vnd geuß das dan[n] ab vnd
 laß den salpetter gesten vnd tu dann das
 wasser wider über das fewr vnd seud das
 dann aber also lang als vor ainen halben
 tail ein vnd tu aber ain pfunt salarmo=
 niack her in vnd so es gesüed als vor stet
 so schut es dan[n] ab vnd laß es gesten erst
 haft du den aller pessten salpetter den ye=
 mant gehalten mag besunder so laß mijn
 dem geschür wol ertrucknen vnd wen[n] du
 in also geleütert hast so schait er sich **Wie**
man das weit schüessent pulfer macht

over a fire and when it starts to boil
 add to the hundredweight one pound of salammoniac⁵⁶
 and six lots⁵⁷ of verdigris⁵⁸ and just as much [*i.e. the same quantity*] of
 stone of Galicia⁵⁹ and boil it for as long as has been⁶⁰
 stated above and pour it off. And
 let the saltpetre rest and place
 the water over the fire again and boil
 it down as long until [*it reduces to*] one half of
 it, and add a pound of salammoniac
 to it. When it has been reduced as before
 pour it out and let it rest.
 This way you have the best saltpetre that
 anyone could find. If you let
 the bowl dry well, and when you have
 thus purified, it it will separate.⁶¹ **How**
to make long-range firing powder.

Wiltu das aller pest pulfer machen
 zu ainem weitten schuß so nym[m] iii
 pfunt salpeters ain pfunt grauß swebels
 zwen vierdung kolin ain halb saitit arse=
 nicu[m] albu[m] vnd stoß das ein klein zusammen=

If you want to make the best powder of all
 to fire a long distance, take three
 pounds of saltpetre, one pound of grey sulphur,
 two quarters of charcoal, and half a settit⁶² of *arsenicum*
*album*⁶³ and grind them up together.

⁵⁶ Salammoniac appears in a number of places in this and other *Firework Books*. There has been some speculation about what it actually relates to and what chemical reaction it would incur. According to Kramer and Nibler this refers to 'ammonium chloride, NH₄Cl' (Kramer (2001), 31, and Nibler (2005), 52).

⁵⁷ One 'lot' equals half an ounce. Imperial measures: 1 pound = 16 ounces = 32 lot; i.e. three ounces.

⁵⁸ According to Kramer (2001), 31: 'basic Cu⁺⁺ acetate', or 'Copper(II) acetate', also referred to as 'cupric acetate'.

⁵⁹ According to Kramer (2001), 31: 'zinc sulphate, ZnSO₄' – according to Nibler (2005), 12: 'most commonly iron or zinc sulphate'.

⁶⁰ Scribal error – duplication of 'in' – or not – could be 'ihh in' = 'it in'.

⁶¹ There are a number of stages of processes to happen here. The crucial one is the precipitation. For more details see chapter 4.

⁶² 1 settit = 1/4 lot = 4 grams (see fol. 10 r, or Kramer (2001), 40; and also Nibler (2005), 20, footnote 132).

⁶³ According to Kramer (2001), 40, 'arsenic oxide, AS₂O₃', according to Nibler (2005) it is 'AS₄O₆' – but the rationale for either is not explained.

vnd nÿme ain quertlein gutzs gepranzs=

fol. 6 r

1 weins vnd ein settet campfer vnd laß es wider ain ander sieden vnd wenn es kalt werd so schut es vnder das pulfer vnd stoß das ab vnd laß es wol trucken so haustu das weit schiessent pulfer so man es fin= den mag **Aber wie man gut pulfer machen sol**

Wiltu das aller sterckst pulfer mach en das nyemant gemachen kan so nÿm[m] drew pfunt salpetters ains pfunt grauß swebels zwen[n] vierdung kolin als vor vnd misch das vnter ain ander vnd tu das in ein glesslin vnd laß das den[n] sten vnd nÿm[m] rat salarmoniack album vnd vnd pulfer vnd tu das vnder ain ander vnd das in ein gleslin uber ein gefug fewr vnd rwr das vnder ain ander ein halbestu[n]d vnd nÿm[m] starcken gepranten wein vnd= schut des ein aÿr schal vol vnder das pul=

Take a quart⁶⁴ of good brandy

fol. 6 r

and a settit of camphor⁶⁵ and bring it to boil so that it reduces. And when it has cooled down pour it into the powder [*mixed earlier*] and grind it together and let it dry well. This way you have the powder with the longest range you can find.⁶⁶ **But how you make good powder.**

If you want to make the strongest powder of all that no one [e/se] can make, then take three pounds of saltpetre, one pound of grey sulphur, two quarters of charcoal as before and mix it together. And put it into a small glass and let it rest. Take red⁶⁷ *arsenicum album*⁶⁸ and⁶⁹ the powder [*mixed earlier*] and mix them together. And put it into a little glass vessel over a tepid fire and stir it together for half an hour. Take strong brandy and add an egg shell full of it to the

⁶⁴ The author uses a diminutive of 'quart' which could be used as term of endearment or a sign for brandy to be viewed as precious.

⁶⁵ According to Kramer (2001), 40: 'C₁₀H₁₆O'.

⁶⁶ The challenge with this statement is how this could possibly be verified. The range depends on a variety of different factors, and adding additional ingredients to the basic mixture of gunpowder is unlikely to make much difference.

⁶⁷ According to Nibler (2005), 55, footnote 114). Cim. 30150 (Nibler (2005), 55, footnote 114).

⁶⁸ This is described by Kramer (2001), 40, as 'white salammoniack [NH₄Cl]'. However, no evidence is provided for this assumption.

⁶⁹ Likely scribal error, 'vnd' repeated.

20 pulfer in das gleslin vnd rwr es vnter
ein ander piß das pulfer wider trucken
werd vnd misch das den[n] vnter ain ander
vnd stoß das vil wol vnd lad den drittait

fol. 6 v

1 der puchsen do mit **Wie man verdorben
pulfer wider pringt**

Ist ain pulfer verdorben von alter vnd
ist der salpetter dennoch dar in gut
5 so nym[m] das pulfer vnd seud das mit wein
vnd rwr das vast piß das es sich vor dick=
en nit wöl lassen rwren vnd tu dan[n] dar
zu frisch kolin als vil du sein bedarfft vnd
tu das dan[n] in ein guten hare[n]sack vnd=
henck den sack dan[n] in ein haise stuben=
10 piß das das pulfer wol ertrucken **Wie ma[n] poße von ain
ander schaidet vnd wider**

pringt

Wiltu pöß pulfer von ain an=
der schaiden vnd wider pringen
vnd ist auch das gewißest so nym[m] das=
15 pulfer vnd tu das in ain zwilchein sack

powder⁷⁰ in the little glass and stir it together
until the powder dries up again.
And mix it together
and grind it all well and load a third [*of it*]

fol. 6 v

into a gun. **How you bring back powder
that has been spoiled.**

When powder has been spoiled because of age and the
saltpetre in it nevertheless is still good,
then take the powder and boil it with wine
and stir strongly until it has thickened
to the point when it cannot be stirred anymore. And add
as much fresh charcoal as necessary
and put it into a good hairy sack⁷¹ and
hang the sack in a heated room
until the powder has dried well. **How you
separate [*the components of*] bad [*powder*] from one
another and how you bring it [*the powder*] back.**

If you want to separate bad powder
from other [*not bad powder*] and want to bring it back,
then this is the most certain [*way*]. Take the
powder and put it in a cotton cloth bag.⁷²

⁷⁰ Likely scribal error, 'pul' written twice.

⁷¹ A 'hairy sack', according to the definition provided in the *Frühneuhochdeutsches Wörterbuch*, relates to a 'bag made out of course, simple material, and possibly animal hair' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/h%C3%A4ren.h2.4adj_1544513501).

⁷² 'zwilchin' – could be cotton or linen, but more likely to be linen in the fifteenth century; the main purpose is that it is rather thick and strong compared to 'barchant' – see below; in Götze (1967), 240: 'of minor quality' ('aus geringen Stoff').

vnd tu wein in ein kesel vnd seud das dar dar uber gang vnd henck den sack mit dem pulfer dar ain so get der salpeter in den wein vnd beleibt der swebel in dem sack vnd schut den[n] den wein ab so er kalt werd vnd nym[m] den salpetter auß vnd seud den wein anders vnd tu salarmoniack

20

fol. 7 r

1 dar zu so schait es sich **Wie man gut fewr= kugeln die man auß der puchsen scheust gerecht vnd gut beraitten vnd dar zu= machen sol das man die auß der puchse[n] schießen mug**

5

Wiltu gar gut fewr kugeln machen die man auß der puchsen schust so so nym[m] buchsen pulfer als vil du wilt= vnd knit das mit gebrantem wein vnd= mach ainen taig dar auß der sinwell sey= als ain kugel vnd nym[m] dreÿ heslein steb vnd die stoß düch die kugeln vnd solt die kugeln über ziechen mit barchat vnd den[n] in swebel swein[n]en vnd aber uber ziechen mit taig der mit halb salpetter vnd halb swebel gemischt sey vnd uber zeuch das

15

And put wine in a pot and bring it to boil⁷³ and hang in it the bag with the powder so that the saltpetre goes into the wine and the sulphur remains in the sack. Then drain the wine and allow it to cool down. Take the saltpetre out of the wine and boil the wine once more and add salarmoniac⁷⁴

fol. 7 r

so that it subdivides itself. **How you make good fireballs which can be shot from a gun well and properly and how you shoot them out of a gun.**

If you want to make good fire balls which can be fired from a gun, take as much gunpowder as you want and mix it with brandy and make it into paste as round as a ball. Take three sticks of hazel wood and push them through the ball. Wrap the ball in fustian cloth⁷⁵ and then soak it in sulphur. And wrap the paste again [*around the ball*] which is a mixture of half saltpetre and half sulphur and cover it once again

⁷³ 'Seud das dar uber gang' – while technically the boiling of water is absolute, how to boil water in practice has a range of different levels, and is not always clear to explain. As in present-day general context, people may refer to 'strongly boiling', 'slightly boiling', or 'simmering' which is mirrored in the *Firework Book* text. The author frequently describes it as 'boiling over' or 'boiling hard'.

⁷⁴ Kramer (2001), 39: 'NH₄Cl'.

⁷⁵ 'barchant' or 'barchent' – variety of heavy cloth made out of cotton (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/barchent.s.0m_1543669452).

aber mit dacken vnd zu dem jungsten mal
 über zeuch sie mit ludern die zwilchein
 sein vnd mit eysnem trat trewtz weiß=
 dar über vnd den[n] so sweine[n] die kugeln in
 halb swebel vnd halb hartz vnd wenn
 sie bereit sein so var mit ainem negwerlein
 treiwtz weiß ~~et~~ durch die kugeln vnd

20

fol. 7 v

1 wen[n] du schiessen wilt so por ein lochlein
 durch den clotz vnd geleich die lochlein ge=
 gen ain ander sechen vnd nÿm[m] dan[n] ain=
 kleins rütlein vnd stoß es durch die kugeln
 5 vnd durch den klotz ein das pulfer das du
 verschiessen wilt das es ein ander geleich
 zu sag vnd zund dan[n] die buchs an **wie**
man ain schreckenden schuß ~~tt~~ schuessen
vnd machen sol das der stain über hun=
dert spring tut wan[n] er von der puchse[n]

10

vert

Wiltu ainen schreckenden

schuß tun oder schiessen so nÿm[m]
 schrentz pappir vnd leim die auff ander

with cloth. And, for the final time, wrap it
 with cloth [*made*] out of coarse material.
 And wrap iron wire in a mesh around it
 and submerge the ball in
 half sulphur and half resin and when
 they are ready drive a drill⁷⁶
 through the ball. And

fol. 7 v

when you want to fire it drill a hole
 through the plug and align the holes
 with each other [*ball and plug*]. Take a
 little rod⁷⁷ and push it through the ball
 and through the plug that you
 want to fire so that they appear to be
 the same [*piece*].⁷⁸ And then set light to the gun. **How**
you fire a frightening shot
and how you make a stone bounce
over a hundred [*times*] when it comes out of the
gun.

If you want to make a frightening

shot and fire it, take
 shredded paper⁷⁹ and glue it together

⁷⁶ 'negber' or 'nebegër' – drill (*Mittelhochdeutsches Wörterbuch* von Beneke, Müller, Zarnke). See also Nibler (2005): 'nägbertil' => 'nägborlin' => 'Nägbor' = 'Bohrer' – 'drill', Schmeller I, 1733. The modern expression would be 'Nagelbohrer' (see footnote 130, Nibler (2005)).

⁷⁷ This could act as a fuse.

⁷⁸ Meaning 'appearing to be as one piece'.

⁷⁹ Nibler (2005): 'schrentz bapyr' = 'schrentz papyr' => 'Schrenzdeckel: Pappendeckel aus zusammengeleimtem Fließpapier', Johann Andreas Schmeller ed. (1872-1877 [2008]), *Bayerisches Wörterbuch. Vols 1&2*, München: Oldenbourg, <http://publikationen.badw.de/de/022964277.pdf> and <http://publikationen.badw.de/de/022964287.pdf>, II, 609, and Baufeld (1996), 211.

so that it is as big as the plug is meant to be.⁸⁰ And do not drive the plug flush on top of the powder or also not into the barrel of the gun. And load the stone [ball] in front of the plug and wedge in the stone [ball]. [Make sure that you] remove any wedges which are on top of the stone. And plug the stone tight with hardened cloth and point the gun level⁸¹ and light it so that it presses against the stone. It will bounce over a hundred [times]⁸² and the gun shall be thick⁸³ at the front⁸⁴ and

fol. 8 r

it [the plug] should be hammered in properly and should not go in flush against the stone.

How you grow saltpetre so that it grows much better than when it grows on the walls.

If you want to cause the saltpetre to grow better than on the walls, then have made for yourself⁸⁵ a tube as large as you would like which is full of little holes. And take

als groß der clotz sein sol vnd schlach den clotzen nit auff das pulfer vnd auch nit gar in das ror der puchsen vnd lad den stain für den klotzen vnd verpiß den stain die selben pissen schlach ab auff dem stain vnd verschopp denn den stain mit gehörte[m] tüch vnd richt die puchsen in geleich geleich gewicht vnd zund sie an so last d[n] stain vnd tut über hundert spring vnd die buchs sol vorn an dich sein vnd wol

fol. 8 r

ein geschlagen vnd sol nit für den stain gen

Wie man salpetter ziehen sol dz er gar vil posser wechst den[n] er an den mauren tut

Wiltu machen das der salpetter pößer wechst den[n] an den muren so hailß dir machen ein rören als groß du wilt die vol cleiner lochlein seÿ vnd nym[m] wein

⁸⁰ Here the meaning is likely to refer to the size being of the same size as the plug.

⁸¹ Presumably scribal error, repetition of 'gleich'.

⁸² Hundred – no measurement given, is it likely to be a distance or the number of bounces.

⁸³ Presumed to be 'dick' – 'thick' – not clear from context. Likely to be a scribal error.

⁸⁴ 'dich' or 'dicht' – 'close to you' or 'in front' (*Frühneuhochdeutsches Wörterbuch*, vol. 5, 588).

⁸⁵ The use of terms in the original comes across as a strong emphasis to say 'have made for yourself' or 'have yourself made', rather than only 'have made'. See chapter 4 for discussion.

10 staine ain pfunt vnd ain pfunt saltz oder
 gleich als des weinsteins vnd kalck dreÿ=
 stund als vil vnd ains mans harm der
 wein trinckt vnd mach ain dick muß do
 mit vnd tu es in die rören vnd vnd laß
 es dreÿ tag an der sun[n]en sten vnd geuß
 an dem vierden tag herwider auß vnd
 henck die rören in ainen koler so wechst
 guter salpetter her auß **Welch specie**
puchsen pulfer schnell vnd starck macht

15 **Lebendiger swebel vnd gutes käcksilber**
 mach gewicht gemessen so dan[n] dar
 zu gehort sind baide vast gut zu dem
 pulfer zu weittreibenden schiessen von der
 puchsen **Wie man salpetter gerecht**

fol. 8 v

1 **sieden vnd leutern sol**

Wiltu salpetter sieden vnd gerecht

a pound of cream of tartar⁸⁶ and a pound of salt or
 the same as the cream of tartar⁸⁷ and three
 times the amount of chalk and the urine of a man
 who drinks wine. Make a thick paste with these
 and put it in the tube and⁸⁸ let
 it stand in the sun for three days.
 On the fourth day pour⁸⁹ the contents out
 and hang the tube in a cellar and good
 saltpetre will grow out of it. **Which ingredients make**
gunpowder fast and strong.

Native sulphur⁹⁰ and good mercury,
 weighed accordingly⁹¹ in appropriate parts,⁹² they belong to
 [*the powder*] both put together, [*and*] added to the
 powder so that the gun fires
 a long distance. **How you boil saltpetre properly**

fol. 8 v

and purify it.

If you want to boil saltpetre and purify it

⁸⁶ According to *Dictionary of Chemical Technology*, 'Weinstein' or 'Weinsaures Kalium' is the equivalent to Potassium Bitartrate, potassium hydrogen tartrate, or $\text{KHC}_4\text{H}_4\text{O}_6$ – a by-product of winemaking. During fermentation it crystallizes in wine casks, and may appear in wine in bottles.

⁸⁷ Possible scribal error; Freiburg Ms. 362 lists only ½ pound of salt – the reference here is a duplication and does not make sense.

⁸⁸ Presumably scribal error, repetition of 'vnd', not translated.

⁸⁹ The original German 'geuß' indicates a decanting action of a liquid, but at this stage the paste would be quite hard and impossible to pour, and the term could simply mean 'empty out'. For purpose of accuracy, the original German intention has been retained.

⁹⁰ 'Lebendiger Schwefel' has also been described as 'Jungfernschwefel' or 'natürlicher Schwefel' ('virgin sulphur' or 'native sulphur'). – *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

⁹¹ Presumably a scribal error. 'mach' could mean a verb 'make'. It is more likely from the context to be 'nach'.

⁹² Presumably meaning 'in equal parts'.

leutern so nym[m] lebendigen kalck
vnd tu den in regen wasser oder in schon
wasser vnd laß in sten dreÿ tag so wirt
ein laug do von die laug nÿm[m] lauter=
vnd schon vnd tu den wilden salpetter
dar ain der vor nit gestossen vnd geleu=
tert ist vnd seud in piß das das viertail
des wassers einsied vnd spreng den[n] ein
wenig des wassers auff die gelauenden
koln get ein ploß fewr do von so hat es
sein genug vnd geuß den[n] das wasser ab
in ein hiltzeins vaß vnd laß es kalt wer=
den so vinst du guten gerechten salpetter
an dem grunde **Wie man gar ein mai=
sterlich nutz gut starck vnd schnel puch=
sen pulfer machen sull**

5

10

15

Wiltu gut puchsen pulfer machen
das do nutz gut schnel vnd starck
wirt so nym[m] dar zu ein pfunt gutzs sweb=
els vnd ain viertail ains pfundes gutzs
lindeins kolns von lindem oder von den[n]em

20

fol. 9 r
holze dan an este seÿ gewessen vnd wellest
du des pulfers mer machen so wig die=
vorgenanten specie nach gewicht vnd r[ü]r

1

Properly, then take quicklime⁹³
and add it to rain water or other pure
water and let it rest for three days, then
it turns to lye.⁹⁴ Take the lye, which is proper
and pure, and add the raw⁹⁵ saltpetre
which has not previously been crushed or purified to the lye
and boil the mixture until a quarter of
the water has boiled away. Then sprinkle a
small amount of the water on to some glowing
charcoal. If a blue flame appears, then it has
had enough. Pour the water off
into a wooden barrel and let it cool down
and you will find good and proper saltpetre
at the bottom. **How you make
masterful, strong, and fast gun
powder.**

If you want to make good gunpowder
that can be useful, good, fast, and strong,
then take a pound of good sulphur
and a quarter of a pound of good
lime wood charcoal of a lime tree or from thin
fol. 9 r
wood which used to have branches. And if you want to
make more of the powder then weigh up the
aforementioned ingredients as per their weight and mix

⁹³ Calcium oxide, CaO – literally ‘living limestone’.

⁹⁴ Likely to turn into Ca(OH)₂ – calcium hydroxide, Kramer (2001), 31.

⁹⁵ Or ‘wild’ – in the sense of unpurified or ‘as it can be found in nature’.

5 nit dar in aber du tust ein werck das nichtz
 verfact vnd merck vast wol ain halber
 zentner pulfers zeucht dreyßig pfunt=
 swebels vnd dreyzehenthalb pfunt kols=
 vnd dreÿ pfunt spengrüen vnd ein vier=
 tail ains pfundes salarmoniack vnd so
 10 vil ains mals man des pulfers mache[n]
 wil denn als vor geschriben stet so vil
 muß man auch der vor genanten specie
 yedlichs nach seinem gerechten gewicht
 mer nyemen **Wie man noch ain posser
 puchsen pulfer machen sol**

15 **W**iltu ain gut puchsen pulfer mach=
 en das noch pesser vnd stercker
 wirt den[n] von dem das do vor geschriben
 20 stet so solt du nyemem dar zu als vor
 bescheiden ist vnd gehort dar zu vnd=
 dar in zu nyemen ein gut weiß pulfer
 das solt du also machen als hie nach=
 geschriben stett Zin[n] des gepranten

fol. 9 v

1 campfer der do ist weiß ain tail vnd gebra[n]=
 ten salarmoniack das do auch weiß ist vnd

nothing in it,⁹⁶ as you make a product that does not
 disappear.⁹⁷ And make sure that a good half
 hundredweight of powder is made up⁹⁸ with thirty pounds of
 sulphur, and thirteen and a half pounds of charcoal,
 and three pounds of verdigris, and a quarter
 of a pound of salammoniac. As
 often as you want to make more of this powder,
 as is stated above, you must again take
 the same quantity of the above ingredients
 each in its correct
 proportions.⁹⁹ **How you make an even better
 gunpowder.**

If you want to make a good gunpowder
 that becomes better and stronger
 than that stated above
 then take as before all the ingredients
 proportionally and put them together
 and take the ingredients and turn it
 into good white powder as is written
 below. Take one part of burnt

fol. 9 v

campfor which is white and eight parts
 of burnt salammoniac which is also white

⁹⁶ Likely to mean that nothing should be added to the mixture.

⁹⁷ 'verfachen' – with the meaning of 'ephemeral' or 'evaporate'. The negative used implies that it is powder which is good to be used for a long time without significant loss in quality.

⁹⁸ From 'zeugen' – 'to make, or to bear', but more likely here meant figuratively as 'made up'.

⁹⁹ This section is a reminder about the nature of this role. The author makes sure to remind the reader that trying out different recipes is not advisable.

leuchtet als die prawnen stain so die swert
 socken haben acht tail vnd tu der zweyer
 specie von sublimato vnd mercurio dar
 zu vnd tu das zu samen in ein morser
 vnd stoß das als vast dir mügst vntz es
 ein pulfer werd vnd piß das es weiß
 wirt vnd ist die aller pest lere die man
 in ganzer alchamie vinden mag vnd tu
 gar wenig von dem pulfer in das daz do
 gemacht ist von salpetter swebel vnd
 koln nach dem als dich die wag lert
 am achten tail ains lotes ist genug in
 ein pfunt der vor genanten pulfer sal=
 petter swebels vnd kolns

5

10

15

Gauner ist gar kestenlich in der appo=
 tecken geprentter salarmoniack ist
 weiß vnd leich vnd vint man es in der
 appotecken salarmoniack der nit geprent
 ist der ist an der gestalt als lanter zuck=

20

and which glows as the brown stone¹⁰⁰
 that is used in sword scabbards.¹⁰¹ Add two
 types of *sublimato*¹⁰² and mercury
 and place it into a mortar
 and grind it together as much as possible until it
 become a powder and turns white.¹⁰³
 This is the best recipe¹⁰⁴ that can be found in
 all of alchemy. Add a little bit of the powder
 to the one you made of
 saltpetre, sulphur, and
 charcoal as the scales teach you.
 One eighth of a lot¹⁰⁵ is enough for
 a pound of the afore mentioned powder of saltpetre,
 sulphur, and charcoal.

Camphor¹⁰⁶ is very pricey in the apothecary.
 Burnt salammoniac is white and
 light and can be found in the
 apothecary. Unburnt salammoniac
 has a structure like purified sugar

¹⁰⁰ Nibler believes this to be a 'sword polishing stone' ('*Terminus technicus der Schwertfeger*'), literally a 'brown stone' ('*brauner Stein, [...] der leuchtet*'), citing as reference points Weimar *Firework Book 'prawn stein'* and the Memmingen text as '*brun stain*', discrediting at the same time Hassenstein's argument that this may refer to a 'stone from a well' ('*Brunnenstein*'), as the term in the two different surviving prints is '*Prunnenstein*'. (Nibler (2005), footnote 116). I translated this as 'brown stone' as the actual meaning is unclear.

¹⁰¹ This connection between a brown stone and scabbard may reinforce Nibler's suggestion of a possible connection between brown stone and a sword polisher.

¹⁰² HgCl₂ – mercury chloride (Kramer (2001), 43).

¹⁰³ This is a very unlikely recipe. Charcoal has the tendency to turn any mixture black.

¹⁰⁴ Or 'instruction'.

¹⁰⁵ ¹/₃₀ or ¹/₃₂ of a pound', or according to *Frühneuhochdeutsches Wörterbuch*, vol. 9.1, 1408, '1 lot usually is equivalent to ½ ounce, ¹/₁₄ of a mark, or ¹/₃₂ of a pound of weight' ('*1 Lot entsprach in der Regel einer halben Unze, einem Viertel einer Mark, einem Zweihunddreißigstel eines Gewichtpfundes*').

¹⁰⁶ Other *Firework Books* refer to this as '*gauncy*', '*gani*', '*saucy*', '*aney*', '*sane*' – but it was decided to refer to this here as 'camphor' (*Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/kampfer.h2.0m_1513374772).

er vnd vint man es in der appotecken

fol. 10 r

¹ **A**triment ist swertzlot vnd vint ma[n] es in der appotecken vitriolum romanu[m] ist nit kopper vnd vint man es inder appo= teken sublimata mercurius ist zu teutsch geret als vil als kecksilber weisser sweb= el hat ainen vnder schaid es ist vntr dem weissen einer pösser dan[n] der ander Merck vol eben arsenicu[m] spricht zu teutsch opperment vnd ist nit kopper in der appo= tecken zaspaniam spricht zu teutsch spen= grünen vnd vint man es gar gmaincklick Item wa man in disem pûch vnd in diser geschrift vint das wert setit das bedeüt nit anders den[n] ein viertail eins lotzs eins yëtlichen gewichtzs **Wie man sal= petter der vor auß geleutert ist vnd= doch nit genug geleutert ist auff sein rechte stat gerecht vnd wol zu gutem**

¹⁰

¹⁵

and can be found in the apothecary.

fol. 10 r

Atramentum¹⁰⁷ is deep black and can be found in the apothecary. *Vitriolum romanum* is not precious and can be found in the apothecary. *Sublimata mercurius* which in German means as much as mercury.¹⁰⁸ White sulphur is different from other [*sulphurs*], it is among the white [*sulphurs*] better than others. Note carefully as well that *arsenicum* is called in German orpiment and it is not expensive. *Aspanium*,¹⁰⁹ or in German verdigris, and can be found commonly in an apothecary. Note that when this book and this text refers to the measurement ‘settit’ then this means nothing else but a quarter of a lot of any common weight. **How you turn saltpetre which has previously been purified, but not enough, into its right and proper state, and how you purify it**

¹⁰⁷ *Atrimentum*, or *Atramentum*, atrament, or atriment: a black liquid, often used for dyeing leather or in painting. See also reference to ‘atramentous’ and its definition of ‘black as ink’. Partington refers to it as ‘ink’ (Partington [1960 [1999]], 155). It is ‘black liquid, mixture or solution of CuSO₄ and iron sulfate’. Its use was for medication and as dyeing ink (‘*schwarze Flüssigkeit; [...] Gemisch aus CuSO₄ und Eisensulfat bzw. deren Hydraten [...] die in Wasser gelöst diese dunkel färben [...] Verwendung als Heilmittel, Schusterschärze (zum Färben des Leders), Tinte, Frühneuhochdeutsches Wörterbuch Online, http://fwb-online.de/go/atrament.s.2n_1543646551).*

¹⁰⁸ Earlier in the text, fol. 9 v, these were described a two different components.

¹⁰⁹ In German, the origin of verdigris is not from Greece (‘from the Middle English *vertegres*, from the Old French *verte grez*, an alteration of *vert-de-Grèce* (‘green of Greece’) – *Oxford English Dictionary Online* ‘verdigris’, but from Spain (from Middle Latin *viride Hispanum*) and this could be a generic form for ‘somethings from Spain’. Checked in *Frühneuhochdeutsches Wörterbuch*, no reference found.

salpetter leuttern sol

Wiltu salpetter sieden vnd leuttern
der vor auch ainst geleutert ist
so nym[m] salpetter als vil du sein gehaben
magst vnd tu den in ein güten kessell

20

fol. 10 v

vnd leg in eben vnd nym[m]e denn ein holzlein
vnd miß den salpetter wie vil do sein sey
vnd laß vor do sein erzaichet and dem holz=
lein do stupff ein lochlein vnd wer das
zaichen drei[e]r finger prait über sich auff
vnd stupff aber ein löchlein vnd nym[m] [m]
vast guten essich vnd tu als vil dar ein
piß das der essich ge an das ober lochlein
vnd tu dan[n] den kessel uber ein ~~g~~ gefüg
fewr vnd so es anfach lawen so fewm=
den fewm oben herab gar wol vnd so
so erwallen wol so nym[m] [m] galizen stain
oder augstein vnd leg sein ein sturk dar
ein vnd laßes wol wallen das der wal
sich si ergang vnd rwre es von angeng
sitlich vnd so der salpetter über ~~w~~ al aller
ding zergangen sey so nym dan[n] den kessel
ab vnd stöl in an ein haimliche stat
do es kalt sey vnd do nyemant wandel

15

into proper saltpetre.

If you want to boil and purify saltpetre
which has been purified before [*but not enough*]
then take as much saltpetre as you have of it
and put it into a good pot
fol. 10 v
and spread it out and take a wooden stick
and measure the saltpetre how much it is.
Make a hole on the stick¹¹⁰ where [*the saltpetre*] comes to
and then mark another one
three finger wide above the first,
and make another hole. And take
very good vinegar and add enough for
the vinegar to reach the upper hole
and place the pot on top of a suitable
fire and when it starts to boil then take off
the top¹¹¹ from the top. And
when it starts to boil more strongly take some acetate
or white vitriol¹¹² and add a piece of it
to the mix and let it boil strongly until the boiling
comes to an end. And stir steadily from the beginning.
And when the saltpetre has dissolved
take the pot off the fire
and place it in an undisturbed place
where it is cool and where no one passes

¹¹⁰ Likely meaning to make a mark to measure the amount of liquid.

¹¹¹ Likely to be impurities which have risen to the top in the form of froth.

¹¹² Scribal error, repetition of 'so'. White vitriol is the historical name for zinc sulphate ZnSO₄.

- 20 zu hab dar vin das dir nichts dar ein
val vnd hut dich dar vor das dir
nichts dar ein kom dan[n] das oben geschri=
ben stet vnd so er ein klein weil uber=
fol. 11 r
- 1 schlecht so geuß in ab in ein sauber ge=
schir vnd laß in kalt werden vnd so der
essich erkalt vnd der salpetter so nym[m] den[n]
den kessel vnd geuß den kalten essich=
5 lauter vnd schon oben ab so hast du ein
guten geschaiden lautern salpetter vnd
laß den salpetter in dem kessel vnd tu in
zu ainem warmen offen vnd kere in=
das er wol erseich vnd ertrucken vnd=
10 nym[m] dan[n] den selben trucken salpetter vn[d]
leg in zu ainem offen auf ein lader
laderlachen vnd laß in wol dur werden
ÿe durzer er wirt ÿepesser er wirt vn[d]
nym[m] in vnd wirck do mit als do vor ge=
15 schriben stet ein bewerung des salpet=
ters nym[m] den rwrstab oder des zergang=
ens salpeters auß dem kessel vnd spreng
das auff die gelawenden koln gibt es
gut frisch zwitzred gaust vnd in et=
- so that nothing falls into the mixture.
And be careful that nothing
enters the mixture other than what is stated
above. And when it [*the vinegar*] has boiled¹¹³ for a little while
fol. 11 r
then pour it off into a clean bowl
and let it cool down. When the vinegar cools down
and [*with it*] the saltpetre, take the
pot and pour the cold vinegar
pure and good off at the top. And you have
good separated and purified saltpetre. And
leave the saltpetre in the pot and place it
in a warm oven and turn it over
so that it drains and dries. And take
the same dry saltpetre and place it
in an oven on a
leather¹¹⁴ cloth and let it dry out properly –
the drier it gets the better it will become. And
take it and work it as it has been written
before. Measuring of the saltpetre:
with a whisk or [*some other tool*] take some of the dissolved
saltpetre out of the pot and sprinkle
it on glowing charcoal. If the charcoal gives off
a good, lively, repeated sizzle¹¹⁵ and if the fire

¹¹³ Literal translated 'beaten over', meaning that it boiled heavily with liquid spilling over the edge. Checked in *Frühneuhochdeutsches Wörterbuch*, no reference found.

¹¹⁴ '*lader*' written twice, once crossed out. Presumably scribal error.

¹¹⁵ '*zwitzred*' – 'twice', or, 'more than once'. '*gausen*' (Jacob and Wilhelm Grimm (1971). *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online*. 16 vols. Leipzig: Hirzel. 1854-1961. http://woerterbuchnetz.de/cgi-bin/WBNetz/wbgui_py?sigle=DWB, Band 4,1,1, column 1588 – accessed 23 March 2018) – 'sizzle' ('*aufzischen*'). The translation is leaning towards the figurative image of the action implied.

licher maß plawes fewr so ist der sal=
petter fein vnd gut.

Aber den abgossen salpettern schonen
essich solst du ton in ein schonen

fol. 11 v

1 kessel uber ein gefug fewr vnd den selben
lassen sieden das der halb tail einseut=
vnd nÿm[m] in denn ab dem fewr vnd tu do
mit geleich als mit dem vorigen den[n] allein
5 so er gestet so macht du wol den lautern
essich ab gießen vnd in behalten oder auß
schütten

Ein lere soltu wissen ÿe dicker

vnd ÿe mer du den salpetter leuterst
ÿe minder dir des salpetters wirt vnd swint
10 vast aber er wirt wertber wer im also tut
der aller konnst vnd pest salpetter den ÿe=
mant finden noch gehalten mag vnd wirck=
est do mit fast in andern specieba v[o]n pulfer

Item wan[n] das ist die kaufleut gewon=

15 lichen vast in allen sachen damit sie=
vmb gen vortail suchen wa sie mugen
vnd do mit ir kaufmanschatz dick ge=
ringert vnd geswecht wirt also das

burns in a blue flame then the saltpetre
is fine and good.

But you should place the removed saltpetre
and the good vinegar in a good

fol. 11 v

pot on top of a gentle fire. Let the mixture
boil so that it is reduced by half
then take it off the fire and do the same
as the one before. When it appears on its own¹¹⁶
then you can pour off the purified
vinegar and keep it or pour it
away

One point you should know:

the thicker and more often you purify the saltpetre
the less the saltpetre becomes and disappears
almost completely. But it also becomes more precious
when you have turned it into the most audacious and best saltpetre
anyone can find and it will react well
with almost all types¹¹⁷ of powder.

Note that the merchants normally,
in almost all matters they are dealing with,
seek their advantage when ever they want to
so that their trading capital¹¹⁸ does not shrink in size
but grows. Then, when the

¹¹⁶ Meaning that the saltpetre has crystallized. See Smith (2002-2016), mainly 2013 and 2014 reports, for images on how saltpetre crystallizes.

¹¹⁷ Not clear about 'speciba' – it seems to refer to varieties or types, but neither seems to be an ideal translation.

¹¹⁸ 'kaufmanschatz' can relate to a wide range of items from 'trading goods' to the overall business. See http://fwb-online.de/go/kaufmanschaz.s.0m_1544289397.

die leut die vmb sie kauffen wen[n]en sie
haben guten kauff gethan so werden
sie oft betrogen vnd besunder an dem
dem salpetter dar vmb stet hernach

20

people who buy from them think they
have made a good purchase, that then they have
often been cheated and especially in¹¹⁹
saltpetre. This is why

fol. 12 r

1 geschriben stet wa pÿ man in erkennen
sol gerechten guten salpetter fein ver=
misch mit saltz oder mit aland so vint
man auch in disem pûch gar äygentlich
5 beschriben wie man saltz vnd aland vn[d]
alle vnsauberkeit von dem salpetter
schaiden vnd leuttern sol

fol. 12 r

there is written below how one can recognise when
good and proper saltpetre has been carefully
mixed with salt or with alum. This is why you can find
very accurately described in this book
how you can separate salt and alum and
all impurities from saltpetre
and how you can purify it.

Ein besunder kunst ist zu salpetter zu
kauffen der nit auff sein stat geleu=
10 tert ist noch geschaiden vnd als
er erst von venedig komen ist Merck
wol man vint salpetter der gemengt
ist mit aland der ist in dem mund we=
der zu pitter noch zu suß kenst du den
15 aland wol von dem salpetter schaiden
so mach du wol das kauffen aber sein
wirt lutzel vnd must in doch tewr kauf=
fen vnd verfacht der aland noch des
saltz geleich nicht Es ist wol den kra=
20 mern die den salpetter verkauffen wan[n]
sein wirt vil an dem gewicht aber=

It is a special 'art'¹²⁰ to buy saltpetre in a state
which has not been purified up to scratch
nor has been separated and has just come
like this from Venice. Note carefully
that you can find saltpetre which is mixed
together with alum and which tastes neither
too bitter nor too sweet when put into your mouth –
if you can separate the alum from the saltpetre
then you may well buy it. But there will
be little of it and you have to buy it dearly.
The alum does not evaporate nor the
salt in the same quantity. It suits the traders who
sell the saltpetre when
it has a lot of weight but little

¹¹⁹ Possible scribal error, repetition of 'dem' in original – not translated.

¹²⁰ 'kunst' has been translated as 'art'. In both languages, these terms have multiple meanings. This will be discussed further in chapter 4.

lutzel an der schaidung vnd leutrung

fol. 12 v

1 man vint auch salpetter der nit gemein
gut ist wan[n] das er ein wenig geseubert
vnd geleutret ist geleich als er new von
dem perg oder stain komen ist vnd der
5 selb zerkennen ist in dem mund gar vast
pitter vnd enpfinst du weder saltz noch
aland dar in den solt du kauffen wann
er lauter seÿ ÿe leuter ÿe pesser wan[n] der
lauter schait sich gern vnd vast wol vn[d]
10 wirt posser zeug dar auß dan[n] auß dem
vorigen man vint salpetter vnd sol in
suchen bey prucken der augstain oden=
sunst in stainen gehawen vnd lochern
der perg alban feuchten muren die vnder
weiln ertucken vnd uber lang etwen
naß werden **Welch salpetter aller kref=
15 tigst ist**

Du solt wissent sein mit rechter war
heit das der salpetter der wilt ist
nit als vil kraft vnd macht hat als der
20 salpetter der do wechst in den heusern vn[d]
in den kelrn an den mawrn die vnder

[*substance*] when separated and purified.

fol. 12 v

You will also find saltpetre, which is usually not
good, when it is [*only*] a little cleaned and
purified similar to when it comes fresh¹²¹
from the mountains or the stone [*quarry*]. And
you can spot it when it is very bitter in your mouth
and you taste neither salt nor
alum in it. You should buy it if
it is purified. The more purified the better as the
more purified [*saltpetre*] can be divided [*from the alum*] easily and quickly
and it turns into better material¹²² than
the previous [*kind*]. You can find saltpetre and should look for
it in quarries, [*where there is*] agate stone,¹²³ or in
stone quarries and holes
in meadows, on damp walls which sometimes
dry out and which over prolonged periods
turn damp again. **Which saltpetre is the most
potent.**

You should be informed with the real
truth that the saltpetre which is raw does
not have as much power and force as the
saltpetre that grows in houses and
in the cellars on the walls which at

¹²¹ 'New' in the meaning of 'fresh' or 'unpurified'.

¹²² 'Zeug' is a general term which could be translated into '*matériel*', an armoury in German is often described as '*Zeughaus*', a place where the material for arms and armours is being kept. However, in this context it is more generically used as 'stuff' or 'substance'.

¹²³ In *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/achat.s.0m_1514384844: 'Semi-precious gem achat' ('*Halbedelstein Achat*').

fol. 13 r

weilen ertrucknen vnd uber etwen lang
wider naß werden vnd wa du haimsche[n]
wol vnd rech leuterst so tut sein ein pfunt
so vil mit seiner kraft vnd küenheit als
des wilden salpetters drey lb tun mochten
**Wie man in ein yedlich puchsen sie seÿ
clein oder groß die stain hawen sol
das sie gerecht werden**

fol. 13 r

times are dry and over a time
become wet again. And when you purify [*saltpetre*] from the home
well and good, then one pound
has as much power and audacity¹²⁴ as
three pounds of raw saltpetre can have.
**How you make the stone for each gun
whether it is small or big
so that they are right.**

Man sol allweg die weit der puchsen
inwendig peÿ dem clotz meßen vnd
denn die form des stains dar nach ziehen
mit einem gewissen zirckel vnd als man den
stain haut so sol man in hawen das der
zering vmb uber all der form geleich zu
ste **Welch specie das kol sterckt das es
nicht verdürbt**

You should always measure the width of the gun
on the inside next to the plug and
then draw the form of the stone accordingly
with a reliable compass. And when you strike the
stone then you should carve it in such a way that
it has the same form all around.¹²⁵

**Which kind of charcoal is the strongest and which
does not deteriorate.**

Du solt wissen das atriment sterckt die
koln das sie nit verderben wan[n] das
geschicht vast vnd vil das daz kol an
ein puchsen pulfer verdürbt do peÿ atri=
ment nit ist het man atriment dar zu
getan das es nit verdorben wer dar vmd

You should know that atrament strengthens
charcoal so that it does not go off. For it
happens quickly and often that the charcoal in
gunpowder goes off when it has no atrament,
[*but*] not when one has added atrament
so that it does not go off which thereby

fol. 13 v

fol. 13 v

¹²⁴ The use of both of these terms '*kraft*' and '*küenheit*' suggests the personification of saltpetre, giving it personal agency. See also fol. 15 r.

¹²⁵ This is likely to mean that the stone is intended to be perfectly round so that it fits tightly into the gun.

1 so sterckt es das kol **Wie man salpetter**
der vor ain mal geleuert ist in dem
andern siedern leutern sol das es sich schon
reingt vnd schait von allem dem das
5 nit zu gehort vnd das nit faulen kan
noch mag wan[n] das es lauter gerechter
vnd guter salpetter wirt war zu du
in brauchen wilt

Nym colina alis alumen iaspanicum
10 vitriolum romanu[m] vnd salcomnime
vnd leg es in dem andern siedern des sal=
peters vnd das ist vast nutz vnd ist das
alle pest zu dem schaiden des pulfers vnd
das bewere ich also sa commune das zeucht
15 zu im vnd tailt sein geleich als salem sil=
uestru[m] alumen zeucht zu im vnd tailt
sein geleich als alumen den man in den
salpetter legt so man in mert iaspariu[m]
vnd vitrolun romanu[m] auf haufent ein=

strengthens the charcoal. **How you purify saltpetre**
which has been purified earlier, which is mixed together
with some other [ingredients], so that it is already
clean and divides itself from everything
which does not belong to it. And it cannot and does not
want to turn mouldy. Then it becomes properly purified
and good saltpetre which you will
need.

Take *colina alis*,¹²⁶ Spanish alum,¹²⁷
Roman vitriol,¹²⁸ and common salt,¹²⁹
and mix them together with the saltpetre, and let it
boil. Then it becomes very useful and is
the best of all for separating powder – and
I can vouch for that. Take the mixture [you put] together
and divided in equal parts. And [add] *salem*
*silvestrum*¹³⁰ as alum is attracted to it and remove it from the powder
in the same way as with alum which one adds to
saltpetre so that one gets more. Jasper
and Roman vitriol bulk up

¹²⁶ Not clear what this refers to. One explanation could be that it is a form of '*culinalis*' (meaning: boiled or purified). In Freiburg Ms. 362, fol. 78 r this is listed as '*comla*' (likely to be an abbreviation), translated by Nibler as '*comula*' (no explanation provided). Kramer's translation lists this as '*comla* (unidentified)' (Kramer (2001), 32).

¹²⁷ In other Firework Book versions, such as Freiburg Ms. 362, fol. 78 r, or St Gallen VadSig Ms. 396, fol. 14 v, this is called *alumen Yspanicum* which is interchangeable with *Alumen hispanium*; or *Alumen hispanium* (fol. 34 r) or *Alumen gispanium* (fol. 27 v, Kunstbuch des Wolfgang Sedelius I, Munich Cgm. 4117, which in turn has been identified as soda or CO₂-water according to Thomas Brachert (2010), *Nachträge und Corrigenda zum "Lexikon historischer Maltechniken. Quellen – Handwerk – Technologie – Alchemie, München 2001"*, Hildesheim: Hornemann Institut).

¹²⁸ Copper (II) sulfate, CuSO₄.

¹²⁹ This section in the Freiburg Ms. 362 is listed on fol. 78 r: '*Nym comla vl alume[n] yspanicum bittriuolum romoniu[m] vnd sal comonie*', which Kramer translates as 'Take *comla* [unidentified] or *alumen yspanium* [Spanish alum, a natural product], *vitriolum romanum* [Roman potash alum], and *sal commune* [rock salt, NaCl]' (Kramer (2001), 32). This section is only one of two where the rhetorical repetition of '*Wiltu...*' is omitted and instead starts directly with '*Nym...*'. These two sections (see fol. 37 r) are the longest listings of ingredients.

¹³⁰ Origin of term not clear. Could be related to a fir tree ('*Pinus Silvestris*') – in Freiburg Ms. 362, fol 78 r, it is '*sal silvestris*'.

20 yetlichs species oder materÿ vnd von den
vorgenanten specien muß es sein wurcken
lauf vnd tailung han vnd weiß in recht[er]

fol. 14 r

1 warhait das duzs nicht felt **Wer gerecht
vnd gut puchsen pulfer machen wil
der volgt disem nach geschriben capit=
tel nach wan[n] das weist vnd lert gar
5 verschaidentlich gewiß vnd gewar wie
man die specie dar auß man das pul=
fer machen sol nach gerechttem gewicht
ÿedlich nyemen vnd mischen sol das sein
weder zu vil noch zu wenig ist vnd
10 das das ein gut nutz pulfer dar auß
werden sol wan[n] es geschicht oft vnd
vil das pulfer unnutz werden wann
man der stuck ains so dargehort zu we=
nig oder oder zu vil nympt dar vmb
15 merk eben**

Es ist aber ein gewiß ler auff puchsen
pulfer recht vnd gut zu machen
du solt machen ain gewiß gut wag vnd
leg auf ÿedweder tail der wag guten ge=
20 leutterten salpetter als vil du den[n] ÿe wölst
das der salpetter gegen ein ander geleich=
weg vnd nym[m] dan[n] ein tail salpetter ab

any ingredient or material. And from the
said elements it has to trigger
an action and a separation. And I know the real

fol. 14 r

truth¹³¹ which will not fail you. **Anyone who wants
to make good and proper gunpowder
should follow this chapter written below
as it teaches and instructs
in many ways truly and honestly how
you mix the ingredients out of which you can make
powder each time taking
the right weight. And [you] shall mix it
neither too much nor too little and
a good useful powder can come of
it as it happens so often and
frequently that powder becomes useless when
you take too little or too
much of one ingredient. Therefore take good
note.**

These are precise instructions on making gun
powder right and properly.
You should make a good and accurate pair of scales.
Place on either side of the scales as much good
purified saltpetre as you would like
so that the saltpetre at each side weighs
the same. Then take one part

¹³¹ Or, 'for certain'.

fol. 14 v

1 der wag vnd leg den selben tail hin vnd
gegen dem beliben salpetter leg auf die wag
ein geleichter wag oder gewicht so vil gutzs
frisch swebels vnd wan[n] das geschickt so=
5 leg den salpetter hin vnd nym[m] dan[n] paiden
tail des swebels vnd tail in in geleicht ge=
wicht vnd wen[n] das geschicht ✗ so leg ein
tail des swebels hin vnd laß den[n] andern
tail beleiben vnd wen[n] das also geschechen
10 ist dem beliben tail des swebels leg zu an
gleichem gewicht so vil dan[n] ab oder lin=
des kols das nit est gehabt hat vnd nit
mit wasser geschlecht sey vnd wan[n] das
also geschechen ist so leg den tail des kols
hin vnd den beliben swebel tail gegen ein
15 ander in geleich gewicht wan[n] das ge=
schicht so nym[m] ain tail des swebels in ge=
leich gewicht so vil des obgeschriben
kols so das geschechen ist so nym[m] dan[n] dar
20 nach all ob geschriben tail den salpetter
den swebel vnd das kol vnd misch sie all
vnter ain ander so du yin[d]er pest kast vnd

fol. 15 r

1 magst vnd so es also gemischt sey so stoß
es vast wol ye mer du es stost vnd ye klein[er]
das pulfer wirt ye küener vnd schneller
das pulfer vnd laut dester heller wan[n] es
5 an gezunt wirt vnd der[r] das pulfer wol

fol. 14 v

of the saltpetre off the scales and put it aside. And
place on the [opposite] side of the scale to the saltpetre
an equal quantity or weight of good,
fresh sulphur. When that is done,
put the saltpetre aside and take both
parts of the sulphur and split it into equal
weights. When that is done, then put one
part of the sulphur aside [from the scales] and leave the other
part in place. When that is done,
put the remaining part of sulphur to the
same weight, and take it off. Take lime wood
charcoal which did not have branches and which
has not been made bad with water. When that
is done, put a part of the charcoal
to the remaining part of sulphur to
the same weight. When that is
done, take another part of sulphur of the same
weight as the above described
charcoal. When that is done, then take the
saltpetre, sulphur, and charcoal
described above and mix them all
together as much as you can and are

fol. 15 r

able to. When it is mixed together then grind
it well, the more you grind and the finer
the powder becomes, the bolder and faster
the powder and the louder and brighter [it becomes] when it
is set alight. Dry the powder well

in ainem guten peckin in einer warmen
 stuben vnd sunder hüt dich vor fewr vnd
 tu es dem offen nit zu nach wan[n] es ein=
 pfacht von hitz geleich als von fewr vnd
 also hastu ein gewiß gewicht wie man
 zeug sol auß wegen vnd nach aber an
 zu wegen andern gezeug vnd tu geleich
 als vor merck dise ler eben wan[n] sie ist
 die gewist lere so sie in diser kunst uber
 all ist wan[n] welchs zeugs ¶ mer ist denn
 sein sein sol nach diser lere so hastu ain
 werck gantzlich vmb sunt gethan vnd
 dar zu den zeug ellentlich verdebt vnd
 wer dise vor geschribne ler verstet dem
 ist sein genug **Wie sich der zeug schuck**
von dem stossen

Wan[n] du den

zeugt stöst so wirt er vnder ain=

fol. 15 v

1 ander verwandelt vnd wirt ein weing
 feucht des solt du nicht achten wan[n] es ge=
 nug gestossen sey so nym[m] es auß vnd der[r]
 es wol so werden groß knollen vnd hebt

in a good basin in a heated
 room. Be aware of fire and
 do not place it too closely to the stove as it may catch fire
 through heat as well as the flame. And
 in this way you have an exact weight when you have
 weighed the material, and after weighing other
 material and do the same [*as before*].¹³²
 Note carefully these instructions as they are
 the exact instructions as this an 'art' which exists
 everywhere. For if there is more material than
 there should be following these instructions, then you have made
 this work a complete waste of time as
 the material will be spoiled miserably.¹³³
 He who understands the above instructions will
 know all he needs to. **How the material changes**¹³⁴
when grinding it.

When you then

grind the material it will be

fol. 15 v

mixed up and it will become a little
 damp which should not concern you. When you
 have ground it enough, then take it out [*of the mortar*] and let it
 dry out well. Large lumps¹³⁵ will form and the ingredients

¹³² This could also imply that it means: 'when you are told to use a specific weight of something, it matters, and makes a difference'.

¹³³ The whole section sounds like 'weigh it properly, or it won't work', 'precision is crucial'.

¹³⁴ 'schuck' is a challenging term to translate. It implies that the grinding action causes a change in the material, but the origin of 'schuck' is not clear. In other manuscripts it is referred to as 'changed' ('schicket', Freiburg Ms. 362, fol. 81 r, or Heidelberg, Cod. Pal. germ. 122, fol. 14 r).

¹³⁵ 'knollen' generally refers to 'lumps'. However, in the development of gunpowder *Knollenpulver* has a major relevance. See chapter 4 for overview on the *Knollenpulver* debate.

5 sich der zeug an einander die knollen laß
beleben wan[n] der zeug vil mynder an den
knollen den[n] ob er klein gestossen wer **Wie**
man ein yedlich puchs sie seÿ groß oder
klein laden sol mit dem puluer klotze[n]
vnd stain nach rechter mensur das es
der puchsen nicht zu ring noch zu swer
ist

15 **N**ach diser lere soltu yetlich
buchsen sie seÿ groß oder klein das
vor der puchsen messen wie lang
es in wendig seÿ piß an den poden vnd
tail dan[n] das selb meß in funff geleich
tail ain tail sol der klotz sein so er in die=
puchsen wirt geschlagen der ander tail
sol man sten vnd der drittail hinder
sich hinein sullen geladen sein mit gute[m]
pulfer vnd dißeler treibt gewiß schuß
von der puchsen **Wie man puchsen clotz**

1 fol. 16 r
machen sol

5 **W**iltu klotz machen so nym[m] gutz
dürs albriß holz vnd mach sie
dar auß vnd mach sie da vornen kleiner
denn hinden vmb das du ein clotz wölst
in die puchsen schlachen das er ye getrang=

stick together. Keep the lumps
together. The material with fewer lumps is less good when
the lumps are ground down.¹³⁶ **How**
you should load any gun, whether it is big
or small, with powder, plug,
and stone and in the right measure, so that
it is neither too light nor too heavy for the
gun.

According to these instructions you should measure each
gun whether it is big or small. Measure its
length inside the gun
right to the bottom.
Divide this measurement into five equal
parts. One of these parts should be the [*length of the*] plug
as you have to drive it into the gun, another part
should be the stone and the third part behind
should be filled with good
powder. This drives a shot properly
from the gun. **How you make gun**

fol. 16 r
plugs.

If you want to make plugs then take good
dry white poplar wood and make them [*i.e. plugs*]
out of it. Make them smaller at the front
than at the back, so that the plug can be
driven into the gun, and that it [*the plug*] can be as tightly

¹³⁶ This could mean that it is beneficial to the quality of the powder if there are fewer (or if they are ground down) the powder is less efficient.

er hin ein ge vnd schlach den clotz gar=
mit ainander ein vnd vnd laß nichtz
auß wendig dem ror so lait sich der stain
recht in die puchsen fur den clotz **Wie**
man saltz von salpetter schaiden sö

10

Wiltu saltz von salpetter schaiden
vnd tun so nym[m] den salpetter
vnd wirff in in ain kalzwasser also
das das wasser nun ploß über den sal=
petter ye ab du solt den salpetter vor mes=
sen mit ainen holz ee du das wasser dar
ein tust so zerget das saltz vnd beleibt
der salpetter in der kelt wan[n] der salpetter
mag indem kalten wasser mit zergen er
gestet wol in denn kelt in vnd geuß wasser
ab vnd laß den salpetter wol erseichen

20

fol. 16 v
vnd tu in an die sunne[n] das er wol truck=
en werd so verget sich der salpetter wol
für gut **Aber gar ein gut kunst wie**
**man wie man das saltz von dem sal=
petter schaid vnd im helffen sü** das
der salpetter vesch vnd gut wirt

1

5

inside [*the barre*] as possible and that you can drive the plug thoroughly
inside [*the barre*]. Do not let it stick out of
the barrel so that the stone lies
right on the plug in the gun.¹³⁷ **How**
you should separate salt from saltpetre.

If you want to separate salt from saltpetre,
and do it [*wel*], then take the saltpetre
and throw it into cold water so that
the water just covers the
saltpetre. Measure the saltpetre
with a wooden stick before you add the
water. Then the salt dissolves, and the
saltpetre remains in the pot as the saltpetre
prefers the cold water and it will appear as
crystals.¹³⁸ Pour off the water
and let the saltpetre settle and form.¹³⁹

fol. 16 v

Place it in the sun so that it dries
well. This way the saltpetre becomes
good. **But this is a special method to
separate the salt from the saltpetre
and how you help with making
the saltpetre fresh and good.**

¹³⁷ There is a difference between the gun, the barrel, and the powder chamber. The barrel is perceived to be the part of the gun where the ball or stone is kept, while the powder chamber is the narrower section at the end of the gun. For more details see chapter 4.

¹³⁸ The original implies a level of creation (*'gestehn'*) which incorporates the understanding of some active input rather a mere appearance.

¹³⁹ Kramer and Nibler refer to Freiburg Ms. 362, fol. 77 r, where it says 'vinegar or wine' are to be added to the mixture to separate the two (Kramer (2001), 30, and Nibler (2005), 11). The above listed text does not mention any additional ingredients other than water.

Wiltu aber salpetter vesch vnd gut machen das er starck werd so tu den salpetter in ein kesel vnd tu so vil weins oder essichs dar zu das er aber ploß über den salpetter gang vnd misch in vnter ein ander vnd stoß ein rütten dar ein vnd miß den wein oder den essich vn[d] zeichen das geleiche halb vnd seud das auch halbs ein vntz an das zeichen der rütten vnd wen[n] du es also seudst so geuß den[n] wein oder essich ab vnd seich das sauber ab so vinstu den salpetter an dem pot=den in dem kessel der salpetter gestet in dem waser den solt du nyeme[n] vnd in wol derren and der sun[n]en so hastu guten salpetter **Wie man wein essich oder laug**

fol. 17 r

nennet dar nach als salpetter dar in geleutert worden ist

Du solt wissen als pald du den salpette[er] tust in wein oder in essich oder in laug oder in wasser als pald das geschicht so haissen das die maister dan[n] dar nach salpetter wasser vnd stost man pulfer do mit ab wan[n] es krefftigt das pulfer

¹⁴⁰ i.e. 'the liquid is reduced by half'.

¹⁴¹ 'abstossen' in the sense of 'smooth', to remove impurities ('abhobeln', 'Unebenheiten bereinigen'). *Frühneuhochdeutsches Wörterbuch Online*, def. 14, http://fwb-online.de/go/abstossen.s.3vu_1544459265.

If you want to make saltpetre fresh and good so that it becomes strong then put the saltpetre in a pot and add enough wine or vinegar to just cover all the saltpetre and mix it together. Push a stick [*into the saltpetre*] and mix with the wine or the vinegar and make a mark of half the quantity [*on the stick*]. Boil it down by half,¹⁴⁰ until you reach the mark on the stick. And when it has boiled, then pour the wine or vinegar off. Drain it tidily and you will find the saltpetre at the bottom of the pot. Saltpetre forms in the water, and you should take it and dry it well in the sun, and you have good saltpetre. **What you call wine vinegar or lye**

fol. 17 r

after saltpetre has been purified in it.

You should know that as soon as you put the saltpetre into wine or vinegar or lye or in water, when this is done, then this is called by the masters afterwards saltpetre water. And if one uses this to purify¹⁴¹ the powder than that the powder is stronger

mer den[n] der wein oder essich **Wie man
den aller pösten salpetter machen sol
vnd saltz vnd aland aller gewist do
do von schaiden**

10

Aalso soltu den aller posten salpetter
machen vnd den alant vnd das saltz
do von schaiden nÿm[m] zway pfunt vnge=
loschens kalcks vnd ain pfunt salpamiu[m]
ain pfunt galizen stains zway pfunt
saltz vnd mach her auß ein laug von
wein oder von essich vnd laß die laug
drey tag sten das sie lauter werd vnd
dar nach tu den salpetten in ain kessel
so vil du wilt vnd tu diser laug dar zu

15

20

fol. 17 v

so vil das die laug ploß uber den kessel ge
vnd misch das als vor geschriben ist vnd
seud das geleich halbs ein vnd geuß es
dan[n] ab so vinstu alant vnd saltz vnd alle
vnrainikeit an dem poden in dem kessel vnd
laß das salpetter wasser das so vor ein=
laug ist gewesen kalt werden so gestet der
salpetter als essich die do gefroren sein vnd
wenn er also gestat so schut die laug her=

1

5

than the wine or vinegar. **How you
make the best of all saltpetres
and [how to make sure that] salt and alum will certainly
be separated from it.**

This¹⁴² is how you should make the best saltpetre of all
and [how to] make sure that the alum and salt
separate from it. Take two pounds of
quicklime and one pound of *salpamiu*,¹⁴³
one pound of cupric acetate, [and] two pounds of
salt. Turn this into a lye of
wine or of vinegar and let the lye
stand for three days so that it turns into purified [*saltpetre*].¹⁴⁴
After that put the saltpetre in a pot,
as much as you want, and add to this enough lye

fol. 17 v

so that the lye reaches [*the rim of*] the pot.
And mix it as is stated earlier and
boil it down by half. Then pour it
out and you will find alum and salt and all
impurities at the bottom of the pot.
Let the saltpetre water which was the lye
cool down and saltpetre will form
as if the vinegar was frozen. And
when that happens, pour out the lye

¹⁴² Presumably scribal error, repetition of 'a' – an indication that the rubrics were added at a later stage, and that sometimes the scribe of the text adds the first letter in error.

¹⁴³ Not clear what this refers to. In Freiburg Ms. 362 this refers to as '*ispantium*' (fol. 77 r), translated by Nibler and Kramer as 'verdigris' (Nibler (2005), 11, and Kramer (2001), 30). Left in the original, as this assumption could not be verified.

¹⁴⁴ Precipitation process as described above.

10 ab vnd trucken den salpetter wol an der sun=
nen so hastu den aller pesten salpetter den
yemant gehalten mag man gibt des selben
salpeters der also geleutret vnd gereinigt
wirt ein pfunt vmb ein guldein so gut
15 wirt er vnd so vil get sein ab aber ain lb
des selben salpeters tut mer den sunst funff
pfunt so man in zu zeug berait **Wie man
salpetter leuttern sol den man erst ab
den mauren nympt das er gut wirt**

20 **W**iltu newn salpetter leuttern als
er erst ab den mairen genuemen
ist so nym[m] salpetter als vil du sein gehabe[n]

fol. 18 r
1 macht vnd leg es in ein keltin vnd schut ein
haisß wasser oder wein ist possen den[n] wasser
oder essich vnd rwr es vntr ain ander mit
ainem stecken vnd laß es kalt werden vnd
5 dar nach geuß das wasser durch ein dick
tuch das es lauter sey vnd tu es aber uber
ein fewr vnd laß es sieden in der maß als
man visch sey vnd seuch es dan[n] aber durch
ein dinß düch vnd laß es kalt werden so ge=
10 stet der salpetter zu zapfen vnd schut den
wein oder den essich oder das wasser ab vnd
laßden salpetter wol trucken werden so wirt

and dry the saltpetre well in the sun.
This way you have the best saltpetre which
anyone may have. For a pound of this same
saltpetre which has been purified and cleaned, you pay¹⁴⁵
a guilder which is how much
it is worth. It is so good that one pound
of the same saltpetre does more than five
pounds of any other kind when you make it into powder.¹⁴⁶ **How you
purify saltpetre which has just been taken off
walls so that it turns good.**

If you want to purify fresh saltpetre when
it has just been taken off the walls,
take the quantity of saltpetre you have

fol. 18 r
and put it in a basin and pour into it
hot water or wine, which is better than water,
or vinegar and stir it. And mix it well together
with a stick and let it cool down. And
afterwards pour off the water through a thick
cloth so that it becomes purified. And put it over
a fire again and let it boil in the same way as you
poach fish. And then pour it out through
a thin cloth and let it cool down and thus the
saltpetre will start to crystalize. And pour off the
wine, or the vinegar, or the water and
let the saltpetre dry out. This is good, but not

¹⁴⁵ The original uses the term 'give', suggesting an exchange economy, but in this context 'pay' seems more suitable.

¹⁴⁶ Meaning that 'it is five times more powerful than ordinary stuff'.

er gut aber als man den vorigen leuttert
der ist pösser **Ob der salpetter nach dem
sieden nit gesten wil wa mit man in
dan zu pringt das er gestet**

15

Es kompt vil vnd dick dar zu das der
salpetter nach dem sieden nit gesten=
wil vnd das geschicht nun ob man vil wei[n]s
oder essich oder wasser dar an tut das nit
in rechter maß ist als vor beschaiden ist
wiltu machen das er geste so nÿm[m] eins

20

fol. 18 v

1 manß haren der wein getrunken hat vnd ÿe
elter der harm ist so er ÿe posser ist vnd leg
saltz dar ein vnd seud den salpetter als vor
so gestet er wol vnd wirt lauter vnd schön
5 **Wie man den wilden salpetter der do hert
zepft ist reinigen vnd leuttern sol**

Wiltu das salpetter der wild ist auß
den pergen vnd der do hert zepft
ist so lauter vein vnd gut machen als ob
er nit zepft wer so nÿm[m] sein als vil du
sein gehaben magst vnd gib in zu malen
in ain müll vnd wan[n] es klein gemalen sey
so nÿm[m] in vnd tu in in ein kessel vnd geuß
dar an als dich diß pûch vor gelert hat

10

as good as that purified by the previous method
which is better. **When, after boiling, no saltpetre
appears and how you can
make it to appear.**

It happens often and regularly that
no saltpetre appears¹⁴⁷ after boiling
and that happens when you have added [too] much wine
or vinegar or water to the saltpetre which is not
in the right quantity as is described before.
If you want to make it appear then take

fol. 18 v

the urine of a man who has drunk wine, and the
older the urine is the better, and place
the salt in it and boil the saltpetre as previously
and it will become pure and good.¹⁴⁸
**How you turn raw saltpetre which crystalized hard¹⁴⁹
so that it is clean and purified.**

If you want to make saltpetre, which is raw from
the mountains and which crystalized hard,
to be very pure and made well as if
it was in icicle form. Take however much you want
and put it to grind
in a mill. And when it is finely ground
then take it and put it into a pot and pour
over it what this book has taught you previously

¹⁴⁷ The German original implies a level of choice such as 'choosing to appear' or 'deciding to appear'.

¹⁴⁸ What is important is that a large amount of urea is produced which is required for the saltpetre process.

¹⁴⁹ The original uses the term 'zapfen' which is related to icicles or pine cones, but for clarity it helps to give it the description of 'crystals'.

15 vnd rwr es vmb vnd laß es dreÿ tag.sten
dar nach tun in über ein fewr vnd seud
die zweÿtail ein vnd geuß das übrig
durch ein tûch vnd was in dem tûch beleibt
das seud denn in starckem essich piß das
das halbtail ein geseut vnd geuß dann
aber ab vnd laß daz gesten das es kalt
werd vnd geuß das wasser dan[n] do von

fol. 19 r

1 so hastu dan[n] schonen salpetter zapfen die
laß trucken werden **Wie man den swebel
beraiten sol daz er zu dem puchsenpulver
vnd zu allem fewr werck nutzlicher
krefziger vnd hitziger wirt dan[n] vor**

5 **W**iltu guten swebel machen so nym[m]
weisen swebel auß der kram vnd
zerlaß den in ein irdischen geschir[r] das es
zergang vnd nym[m] zu ainem pfunt sweb=
els ein lot quecksilbers das mit swebel ge=
tet seÿ vnd rwr das vnter den swebel vnd
dar nach geuß den swebel in guten gepran=
ten wein so wirt er so vil dester trückner
vnd dester hutziger **Welch swebel der
posser swel ist**

15

and stir it and let it rest for three days.
Then place it over a fire, boil it so
that it is reduced by two parts¹⁵⁰ and pour the remainder
through a cloth. And what remains in the cloth –
that should be boiled with strong vinegar so that
half of it is boiled away. Pour it off
and let it rest so that it cools
down and pour the water off it

fol. 19 r

and you have nice saltpetre crystals which
can be dried. **How you prepare sulphur
so that it can be used for gunpowder
and for all fireworks which is more useful,
stronger, and hotter than before.**

If you want to make good sulphur then take
white sulphur¹⁵¹ from the store and
dissolve it in an earthenware dish until
it has dissolved. Add to a pound of sulphur
one lot of mercury which is saturated
with sulphur and stir it into the sulphur.
Then pour the sulphur into good brandy
and it will become much dryer
and even hotter. **Which sulphur is
the best sulphur.**

¹⁵⁰ Presumably reducing it so that a third is left.

¹⁵¹ It is not entirely clear what is referred to here. Super sublimated sulphur is also called 'white sulphur of Das', or 'ω-Sulphur', which is an allotrope of sulphur, but that is a post-medieval commercial product. While the colour of sulphur is mainly yellow, when exposed to oxygen and moisture it takes on a pale yellow, grey, or white colour at the surface. The use of the colour here may indicate a lower quality of sulphur.

Lebendiger swebel ist der aller pest sweb=
 el wan[n] er ist stark vnd gut vnd
 schnell zu fewr vnd braucht man sein nit
 als vil vntr pulfer als vntr swebel als
 du mich wol hie nach horen wirst **Wie**
man den aller pesten kol machen sol den
ÿemant machen kan

20

fol. 19 v

Wiltu die aller pesten koln machen
 die ÿemant gemachen kan oder
 mag so nÿm[m] weiß denne holz oder albren
 oder lindes holz das frisch seÿ vnd mach
 dar auß scheiter vnd der[r] sie in einem bach=
 offen vnd verpren[n] sie gar wol zu eyteln
 koln vnd beware das daz die die scheiter kein
 ast haben vnd nym[m] die koln also frisch
 vnd tu sie in ein becklin vnd lesch die mit
 dem gepranten wein ab vnd stürtz alweg
 em peck über das ander so du die koln leschst
 das dich der flamme nit verpren **Wie ma[n]**
zu zunder pulfer das aller pöst kol mach=
en sol das ÿemant gehalten mag

1

5

10

Das aller pest kol das ÿemant gehabe[n]
 mag zu zunder pulfer wer das mache[n]
 wil der sol nÿemen ein verschlossen tischlach
 das gar wol vnd schon gewaschen seÿ an

15

Native sulphur is the best sulphur
 for it is strong and good and
 burns quickly. You need not add
 as much to the powder as with [ordinary] sulphur
 as you will hear from me later. **How**
to make the best charcoal anyone can
make.

fol. 19 v

If you want to make the best charcoal
 anyone could or would like to make,
 then take white fir wood or poplar
 or lime wood which is fresh. And break it up
 into kindling and dry it in an oven
 and burn it into proper
 charcoal. Be careful that the kindling wood is free of
 branch holes. Take the fresh charcoal
 and place it into a basin and extinguish it
 with brandy. Always place one bowl
 over the other to ensure that when you extinguish the charcoal
 that the flame does not burn you. **How you**
make the best charcoal for priming powder
that anyone has ever made.

The best charcoal that anyone may have
 for use as tinder powder. Anyone who wants to make
 this should take a closed¹⁵² tablecloth
 that is in good condition and has been washed

¹⁵² The literal translation is 'closed', but it could imply 'clean' or 'unused' or 'folded', could also be 'starched' or 'tightly woven', or even 'without holes'.

alles stercken vnd sauber ertruckent sey vnd
verpren[n] das zu pulfer in ainem irdischen
haffen vnd lesch es mit nichte[n] du solt dem
haffen setzen in einen haissen offen oder in

with starch and has been dried cleanly.
And burn this into powder in an earthenware
bowl and do not extinguish it with nothing. And place the
bowl in a hot oven or in

fol. 20 r

in ein groß fewr das das tischlach dar in
verprin[n]en müg Du solt auch den haffen
wol bedecken das der dunst nit do von müg
das kol ist über als kol **Hernach stet ge=**

fol. 20 r

a large enough fireplace to burn a table cloth
in it. You should also cover the bowl
well so that the fumes cannot escape.
This is better charcoal than other charcoal. **Below is**

schriben wie ein maister hieß Niger
Bercholda vnd ist gewessen nigrematica
vnd ein alchimist zum ersten die kunst
vnd auß buchsen zu schiessen vnd wie
er das fand

written how a master named Niger
Bertholdus who was a necromancer
and an alchemist discovered first the method
to fire guns and how
he found¹⁵³ it.

Die kunst hat fun=

den ein maister hieß niger bertholda
vnd ist gewessen ain nigermaticus vnd
ist auch mit grosser alchamie vmb gange[n]
sunder als die selben maister mit grossen
kunstlichen hoflichen Sachen vmb gen mit
gold mit silber vnd mit den siben materÿ
also das die selben maister silber vnd gold

The method was found by
a master called Niger Bertholdus¹⁵⁴
who was a necromancer and who
also handled major alchemy¹⁵⁵
such as the same masters who
deal with the big, artful, and courtly matters,
with gold, with silver, and with the seven materials,
such as the same masters who were able to separate

¹⁵³ There is a question about the use of the term 'finden'. 'Finden' may imply an incidental nature of discovery rather than an organized structured approach – which is the same in most other western European languages.

¹⁵⁴ In the *Frühneuhochdeutsches Wörterbuch* in the entry on 'alchemy' reference made to alchemy's main focus as 'the quest to create gold out of unpurified materials, often with negative connotations' (*Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/alchimei.s.1f_1519026099). In this context, there is no sense of negative connotation, but instead a seeming level of admiration in the praise of Niger Bertholdus.

¹⁵⁵ The author seem to make a point by using 'major' ('gross') as if that provides for a particular kind. It is not clear whether this relates to an actual definition or knowledge or any reader, or whether it is merely used as a rhetorical device. Term not included in *Frühneuhochdeutsches Wörterbuch*, as all Latin terms were excluded.

von dem andern geschmeid schaiden kün=
nen vnd von kunstlichen varben so sie
mache[n]

Also wolt der selb maister

²⁰ bertholt ain varb preenne[n] zu der sel=
ben varb gehort salpetter swebel vnd
pleÿ vnd ol vnd wen[n] er die stuck in ein

fol. 20 v

¹ kupfre dinck pracht vnd er den hafén wol
vermacht als man auch tun muß so brach
der hafén zu gar vil stucken er macht auch
groß gantz kupffer heffen vnd verschlug
die mit einem grossen eÿsnein nagel vnd
wen[n] der dunst dar von nicht kom[m]e mocht

so pracher vnd tetten die stuck grossen scha=

den also tet der vor genant maister berch=
tholt das pleÿ vnd ole do von vnd legt

¹⁰ kol dar zu vnd hieß ain puchs giessen vnd

versucht ob man stain do mit gewerffen

mocht wan[n] es im vor mals türen zer

worffen het also vand er dise kunst vnd

pessert sie etwas Er nam da zu salpet[ter]

vnd swebel geleich vnd kol etwas mÿnder

vnd also ist die selb kunst seid so wol ge

naw gesucht vnd funden worden das sÿ

silver and gold from the other metals
and who could make such artful
colours.

And when the same master

Berthold[us] wanted to burn a colour – the same
colour which belongs to saltpetre, sulphur, and
lead, and oil –¹⁵⁶ he placed the ingredients in a

fol. 20 v

copper pot and sealed the pot,

as you have to, and the pot

broke into many pieces. Then he made a

large copper pot, sealing it shut

with a big iron nail. And

when the steam could not escape,

it broke and the broken pieces [*of the copper pot*] caused great

damage. So, the said Master Berthold[us]

took away the lead and oil and added

charcoal. And he ordered a gun to be cast, and

tried out whether one could throw a

stone with it [*the gun*] to demolish towers [*as it has done*] before.

In this way, he discovered this method and

improved it a little.¹⁵⁷ He took saltpetre

and sulphur in equal parts and a little less charcoal

and this is the same method that has been

researched and found to be

¹⁵⁶ This has been interpreted in other *Firework Book* editions as using the ingredients to make gold. However, this cannot be ascertained from the context. See Kramer (2001), 25, or Nibler (2005), 6.

¹⁵⁷ This is a curious downplaying of the role of Bertholt when the author seems to diminish the achievement to a rather modest scale of improvement.

an puchsen vnd an pulfer vast gepesert
ist worden als ir an disem puch wol ver=
stet **Wie man ein gemein gut pulfer
machen sol von dreÿen stucken**

20

Wiltu machen ein gemein gut pulfer

fol. 21 r
machen von dreien stucken so nym[m] zewey
pfu[n]t salpeter ain pfunt swebel dreÿ vier=
ling kohn vnd stoß die mit gutem wein
ab vnd der[r] es wol an der sunne[n] so wirt
es ein gemein pulver **Item is disem nach
geschriben capittel stet geschriben wie
man das aller pöst puchsen pulfer mach=
en sol das nyemant mag gemachen vnd
das es nit verdirbt**

1

5

Wiltu das aller pest pulfer machen
das nyemant gemachen mag
oder kan so nym[m] drithalb zentner salpeter
ein zentner swebel vnd stoß das vnter ein
ander vnd wig es den[n] auß mit einer rech=
ten wag vnd nym[m] alweg den achtail kols
vnd den dreÿßigsten tail salarmonic den
selben tail salarmonic silitageris vnd

10

15

better for guns and vastly better for powder
as you can understand well from this book.
**How you make ordinary, good powder
with three components.**

If you want to make ordinary, good powder

fol. 21 r
from three ingredients, then take two
pounds of saltpetre, one pound of sulphur, three
quarts of charcoal and grind them together with good wine.
Dry it out in the sun, and this will
become ordinary powder. **Here in this
following chapter is written how
you can make the best powder of all
that anyone has ever made and
that does not get spoiled.**¹⁵⁸

If you want to make the best powder of all
that anyone has ever made
or can make: then take three halves of a *zentner*¹⁵⁹ of saltpetre,
one *zentner* of sulphur and grind them together
and weigh on proper scales
and take off one eighth [of a *zentner*] of the charcoal
and one thirtieth part of salammoniac and the
same part of salammoniac *silitageris*.¹⁶⁰

¹⁵⁸ In the meaning of 'deteriorate'.

¹⁵⁹ 'Drithalb' = 1.5 *Zentner* (just as in 'anderthalb' being 1½) (*Frühneuhocheutsches Wörterbuch*, vol. 5, 1471-2, 1 *Zentner* = 100 pounds). An alternative reading could be 'a third of a *Zentner*' which would make the saltpetre content too small for the powder to be functioning.

¹⁶⁰ According to Kramer (2001), 37: 'Chaucer's *Yeoman's Tale* refers to this as 'bole Armeniac' which he claims can be translated to 'Armenian potter's clay'. Alternatively, it could simply be a measurement or container of a certain size'.

misch vnd stoß das vnder ein ander vnd
 nym[m] ye zu dreißig pfunt zeugs als vor
 vnd drew lot demerturis sublimato vnd
 ein lot camper vnd funff lot arsenicu[m]
 vnd tu salpetter wasser dar zu ein wenig

20

fol. 21 v

1 vnd nit zu vil das do von dem salpetter kompt
 vnd stoß das da mit ab du solt der stuck
 keins rwren du solt das pulfer in kohn las=
 sen vnd solt das gar wol derringen ist das=
 du den salpetter wol leuterst vnd die an=
 dern stuck auch gut sein so verdirbt diß
 pulfer nym[m]er mer **Wie man vordorben
 pulfer wider pringit**

5

Es geschicht vil vnd dick das pulfer

von alter poß wirt vnd der kol zu
 feuch wirt oder das der salpetter nit
 wol geleutert ist vnd das das pulfer ver=
 dirbt dem solt du also wider helffen
 du solt nyemen guten gepranten wein vnd
 solt in dar in siedem salpetrica vnd sal=
 petter geleich vnd solt das pulfer also
 mit haissem wein beschütten vnd solt
 das darnach stossen gar wol vnd solt

10

15

Mix and grind it together and
 take thirty pounds of each as before
 and three lots of *demerturis sublimato*,¹⁶¹ and
 one lot of camphor, and five lots of *arsenicum*.
 And [*then*] add a little bit of saltpetre water,

fol. 21 v

but not too much of that which comes from the saltpetre,
 and then grind it. You should not stir any of
 the ingredients. You should leave the powder in the charcoal
 and you should make sure that it is very dry. Then you have
 purified the saltpetre properly and the other
 ingredients are also good so that this powder
 will never go off. **How you bring
 back powder that has been spoiled.**

It happens often and frequently that powder
 turns bad from age and that the charcoal becomes too
 damp or that the saltpetre has not
 been purified properly. If powder has been
 spoiled then you can bring it back in this way:
 you should take a good brandy and
 boil it [*the brandy*] in salpetrica and saltpetre
 in equal measures. Then pour
 hot brandy¹⁶² over the powder. You should
 then grind it very well and should

¹⁶¹ Kramer (2001), 37, refers to this as 'mercury sublimate' (in Freiburg Ms. 362 this is listed as 'Mercurio sublimato' [fol. 80 v]), mirroring Mercury(I) chloride (Hg₂Cl₂) mentioned in other sources.

¹⁶² Including the dissolved saltpetre and salpetrica.

20 nÿeme[n] in dein hefen vnd solt die fullen
wol gestossen vnd solt die hefen wol ver=
machen vnd solt die setzen in ain pack=
offen der nit zu haiß seÿ vnd so das pul=

fol. 22 r
1 fer in dem hafem wol trucken worden seÿ
so nym[m] es den[n] herauß vnd stoß das ein=
wenig vnd nit zu vil so kumpt das pul=
fer aller ding wider zu im selber vnd
5 wirt posser pulfer wan[n] es vor ÿe gewe=
sen ist **Item in disem nach geschriben**
capittel vinstu gar ein gut ler vnd=
gewiß wie du die drew stuck des sal=
petters swebel vnd kolns wen[n] se ge=
stossen vnd zu einem puchsen pulfer vn=
der ein ander gemischt sein wider von
ein ander schait vnd das du yedlichs
stuck besunden von dem andern nympt
als ee sie zu ainem puchsen pulfer ge=
15 **mischt waren**

Wiltu puchsen pulfer von ain an=
der schaiden also das du den sal=
petter also weißen hast als vor vnd den
swebel den andern weg vnd das kol den
ritten weg vnd des yedlichs als frisch
20 seÿ als es vor ist gewesen so nym[m] pul=
fer als vil du wilt vnd tu das in ein

then place it into bowls and fill¹⁶³ them
well ground. Close the top of the
bowl, and place it in a baking oven
which is not too hot. When the powder

fol. 22 r
has dried out in the bowl,
take it out of the oven and grind it further
but not too much. This way the powder
will regain all its properties as before and
it will turn into better powder than what it was
before. **Here in the following chapter**
you will find good instructions and
knowledge of how you handle the three ingredients
saltpetre, sulphur, and charcoal, when they are ground
and mixed together into gun
powder. How you can separate them from
each other, and how each
ingredient can be used separate from the other
as before they were mixed together into
gunpowder.

If you want to separate [*the ingredients of*] gunpowder from each
other so that you have saltpetre that
is white as before, and
sulphur goes a different way, and the charcoal the
third way, and each of them is just as fresh
as it was before: then take the quantity of powder
you want and put it in

¹⁶³ Possible scribal error, could be 'sullen'. The most likely intended meaning here would be 'should have'.

- fol. 22 v
- 1 haissen essich der siedent sey also das der
essich ain drittail über das pulfer ge vnd
laß das ein weil sten vnd fewrn den[n] den
kol ab mit einem rechein der zwischen
5 einem gebelingspannen ist vnd schut deis[en]
essich dar nach in einen zwilichen sack so
get der essich dar in so der salpetter zerga[n]g=
en ist durch den sack vnd beleibt der sweb=
el in dem sack wan[n] der swebel mag in kaÿ=
10 nem wasser zergan als der salpetter tut
der swebel mag auch nicht verderben
vnd dar nach so der sack wol erseicht so
er wöll den essich vnd seud in in der maß
als man visch seut vnd laß den essich dar
15 nach kalt werden vnd laß in gesten vnd
seüch das wasser dan[n] ab so vinstu den sal=
petter in zapffens weiß den swebel soltu
wol erwaschen auß wasser so wirt er als
lauter als vor Aber das pöst schaidwasser
20 in den essich so du in anders erwöllen wolst
so tu dar ein ein pfunt salparticu[m] vnd ain
pfunt galizenstains **Es geschieht oft vnd**
- fol. 23 r
- 1 **vil das pulfer unnutz wirt vnd doch
von alter wegen nit werdorben ist
vnd newr der geprech ist der dreier stuck**
- fol. 22 v
- hot vinegar which is at boiling point. Make sure that the
vinegar covers the powder by a third part and
let it rest for a while. Burn off¹⁶⁴ the
charcoal with a cloth which is stretched
over a frame, and then pour this vinegar
into a cloth bag so
that the vinegar as well as the saltpetre
goes through the bag, but the sulphur
remains in the cloth bag as sulphur does not
like to dissolve in water, unlike saltpetre.
Sulphur also does not go off.
After all the liquid has gone through the bag,
take the vinegar, and boil it in the same way
as you boil fish. And let the vinegar
cool down and let it rest. Pour off
the water and you will find white
saltpetre crystals. The sulphur you should
wash out of the water and it will be more
purified than before. But the best of all separating water
you can have in the vinegar is
when you add a pound of salparticum and a
pound of white vitriol. **It happens often**
- fol. 23 r
- and frequently that powder becomes useless, not
because it has not been spoiled due to its age, but
rather because one of the three ingredients in the mixture –**

¹⁶⁴ The broader translation would be 'take off', but it is important that the text insists on the burning – not clear how that could be achieved.

ain salpetter swebel vnd kol zu vil peÿ
den andern zwayen stucken ist wie vnd wa
peÿ man wissen mag welcher stuck zu vil
peÿ dem andern ist des wirst du in disem
nach geschriben capittel aigentlich vnder
weist so stet auch sunst in disem pûch
geschriben wie man solch pulfer pössern
vnd wider pringen süll

Ob dir ein pulfer vnder dein hant
kompt des zu vil salpeters swebels
oder kols hat yeder sechs stuck vnder den
dreyen stucken zu vil wer wilt du wissen
welchs stucke zu vil do ist pren[n] des pul=
fers als groß als ein nuß auf ainem ge=
latten stain warn Aber ist des kols zu vil
so beleiben die koln also roch vnd als ein
ruß mit grosser unsaubrikeit Aber ist des
swebels zu vil so print der swebel alweg
lancksam dar nach so das pulfer verprint

fol. 23 v
es sey denn das der swebel nit wol gestossen
sey

**Was natur der salpetter hat vnd
welcher der pöst ist**

salpetre, sulphur, and charcoal – there can be too much of one
compared to the other two ingredients – as and when
one knows which ingredient is too much
compared to the others. You will find in this
chapter following instructions
how it is written elsewhere in this book
how such powder can be made better
and can be brought back.

Should a powder come into your hands
that has too much saltpetre, sulphur,
or charcoal: six parts of each of the
three ingredients are too much.¹⁶⁵ If you want to know
which ingredient you have too much of, then burn
a quantity of the powder as big as a nut on a
smooth stone. If the charcoal is too much,
then the charcoal will remain and it will burn
with soot and a lot of impurities. If the sulphur
is too much, then the sulphur will burn
more slowly than the rest of the powder burns

fol. 23 v
unless the sulphur has not been ground down
properly.

**What the nature of saltpetre is and which one
is the best.**

¹⁶⁵ This seems to imply that gunpowder is not of usable quality if one of the three ingredients makes up more than sixty percent of the overall mixture. This is in direct contradiction of the ratios suggested throughout, where saltpetre makes up between fifty-one and seventy-two percent. This sentence is not repeated in most *Firework Books*, e.g. Bucharest Ms. Varia II, 374, Dresden Ms. App. 463, Freiburg Ms. 362, Heidelberg, Cod. Pal. Germ 787, Munich Cgm. 4902, or Strasbourg Ms. 2259, but it is identical in Darmstadt Ms. 1074 fol. 20 r. See also discussion in chapter 4.

5 **Salpetter** der ist von natur kalt vnd
 trucken in quartu gradu das ist an dem
 wierden genant der salpetter wechst auch
 in dreÿ weg er wechst auch an dem per=
 gen er wechst an dem feld an herten staine[n]
 als aland als hert vnd als weiß vnd
 10 schat im kein regen Der dritt salpetter
 wescht gern an den mawren vnd in den
 kelern die do feucht sein der selb ist auch
 der pest Du solt wissen das salpetter in
 saltz ist vnd peist vast vnd haist nach
 15 latein stain saltz vnd wenn er geleuttret
 wirt so haist er nit mer salpetter er haist
 salniter wan[n] er wirt als kalt vnd als
 trucken von dem sieden wa in hitz begreiff
 do mag er nit beleiben von der grossen
 20 keltin wegen die er an im hat der sweb=
 el ist von natur haiß vnd trucken vnd
 empfacht geren das fewr so mag dann

[bottom margin right] der salpetter

fol. 24 r

1 der salpetter nit peÿ der hitz beleiben al=
 so ist es auch vmb das quecksilber vnd
 vmb etlich stuck mer die kein fewr gelei=
 den mugen sunder soltu dich alweg hüe=
 5 ten vor dem frischen weisen salpetter **Wie**

Salpêtre is by nature cold and
 dry in 'quartu gradu', that is in the
 fourth degree: saltpetre also grows
 in three different ways, it grows in the mountains,
 it grows in the fields, on hard stone,
 as alum hard, or as white and
 no rain spoils it. The third saltpetre
 grows on walls and in
 cellars which are damp, and that one
 is the best one. You should know that saltpetre is
 in salt, and is very corrosive. It is called
 in Latin 'rock salt'. When it is purified,
 it is no longer called saltpetre but is called
 salniter. When it turns cold and dry
 after boiling, when it catches the heat, then it does
 not like to remain so on account of the great
 coldness which it possesses. Sulphur
 is by nature hot and dry and
 catches fire easily. But

the saltpetre¹⁶⁶

fol. 24 r

the saltpetre does not like to be near the heat
 which is why mercury
 and other ingredients also do not cope
 well with fire. But you should always be
 careful about fresh white saltpetre. **How**

¹⁶⁶ This note is made at the bottom of the page, most likely as a binding notation as it is at the end of one gathering.

man machen sull ein gut salpratica de[n]
man spricht salpratica do mit man alle
pulver schaut vnd schnell es sey pulver
von schiessen zu fewrkugeln zu fewr pfeiln
oder zu andern fewrwercken zu prauchen

10

Wiltu machen ein gut salpratica de[n]
man spricht salpertia vnd leüter
in das salniter dar auß werd vnd [^{wen[n]}] du das
salniter dreistund geleutert hast so tu es in
einen kesel vnd schut gepranten wein dar
zu das der wein dreier finger hoch über
den salpetter auf ge vnd tu zu ainem pfunt
salniter vier lot salarmoniak vnd ein lot
kämpfer vnd seud das ~~vnd~~ vnd wenn das
ein viertail ein gesotten sey so tu es dann
ein clein weil ab dem fewr vnd schut den
wein in ein newn haffen der irdisch sey vnd

20

fol. 24 v
henck den salpertia an ein sail in ein kalten
keler vnd laß in dreÿ wocken dar in hange[n]
oder sechs wochen so wirt er grob vnd
lancknutz vnd wechst das post dar durch
vnd das zartest vnd dar nach so du in dar
gehenckst so ge an dem newnden tag dar
vnd wasch den haffen auß wendig mit
einem haffen vast in ein schon beckin
vnd behalte das wol wan[n] das ist das

to make good *salpratica* which
is called *salpratica* with which all
powder is made and which can be used in powder
to shoot fire balls, fire arrows
or to make other fireworks.

If you want to make good *salpratica* which
is called *salpertia*¹⁶⁷ and which can be purified
into *salnitre*. If you purify
salnitre for three hours, then you put it into
a pot and add brandy to it so
that the wine is the width of three fingers above
the saltpetre. Add to one pound of
salnitre, four lots of salammoniac, and one lot of
camphor. Boil it until
one fourth of the liquid has boiled down. Take
it off the fire for a short while and pour the
wine into a new earthenware bowl.

fol. 24 v

Hang the *salpertia* on a rope in a cold
cellar and let it hang there for three weeks
or for six weeks. It will become coarse and
will keep for a long time and it will grow the best
and the softest. And after you let it hang
on the ninth day you can go to it and
wash out the bowl with another
good strong bowl in a suitable basin.
And keep what you get as it is at its best and it is

¹⁶⁷ See Partington (1960 [1999]), 155, and Needham (1986), 353.

10 pöst vnd das sterckst stuck das yemant
gehaben kan vnd tut man sein vnder
dreyßig pfunt ein lot doch ye wie man
sein dar ein tut ye pessers alweg wirt
vnd gibt man sein ein pfunt vmb dreyß
15 ig pfunt haller

**Wie man guten salpette[er]
an den mawrn ziechen vnd ab nyeme[n] sol**

20 **W**iltu guten salpette ziechen an den
mawren so schut salpette wasser
do salpette in gesoten sey in ein feucht=
mawr in ein keler oder do salpette gern
wechst die mawr gewint salpette genug
vnd dar nach so du in ab nyempfst so spreng

fol. 25 r
1 alweg das wasser mit einem wedel an
die mawr das die mawr do von naß werd
so wechst es gern

**Wie man salarmoniacu[m]
leuttern vnd bereiten sol**

5 **S**alarmoniacu[m] sol man also leuttern
sol nym[m] salarmonato als vil du
wilt vnd leg in in ein saubern kesel
vnd tu guten wein dar zu ye zu einem

the strongest that anyone
can have. If you add one lot of this
into thirty pounds, it will be good; but the more you add to it,
the better it will get.
And for one pound you will get thirty
pounds haller.¹⁶⁸

**How you develop good saltpetre
on the walls and how you take it off [the walls].**

If you want to develop good saltpetre
on the walls, then pour saltpetre water
in which saltpetre had rested onto a damp
wall in a cellar or where saltpetre likes
to grow. The wall will gain enough saltpetre.
And after you take off the saltpetre sprinkle

fol. 25 r
some more water on to the wall
with a brush so that the wall is wet
and it will grow nicely.

**How you purify salammoniac
and how you prepare it.**

Salammoniac can be purified like this: you
should take *sal ammonato*¹⁶⁹ as much as you
want and place it in a clean pot.
Add good wine to it, for each

¹⁶⁸ A 'haller' is a silver coin minted in the Swabian city of Hall, and is worth half a penny. Not clear what the meaning of this equation is – other than this produced very high-quality material.

¹⁶⁹ There are a number of different spellings of this ingredient. However, it is likely to refer to salammoniac. Kramer (2001), 49, believes it is 'raw salammoniac' or NH₄Cl. In other *Firework Books*, e.g. Freiburg Ms. 362, fol. 85 r, Dillingen Ms. XV 50, fol. 22 v, this is listed as 'salarmoniac' (see also 1529 Egenolph print, 34).

pfunt salarmoni[?]tu[m] ain maß gutz weins
 vnd seud das drittail ein vnd tu den[n] den
 wein her auß vnd laß in kalt werden
 so schut den wein den[n] ab dem salarmo=
 niak vnd laß in trucken werden so ist er
 bereit man gibt unberaiten salarmo=
 nak ein pfu[n]t vmb sechzehen schilling
 haller vnd der wol bereit ist ein pfunt
 vmb ein guldein **Her nach stet geschri=**
ben ein gar gut hefflich stuck wie man
ein maister nachtzs schiessen sol vnd wis=
sen mag wa er hin geschossen hat

10

Ein gar hofflich gut kunst die
 hernach geschriben stet als du gern

20

fol. 25 v
 wölst wissen wa hin du zu nachtzs scheüst
 so nym[m] zechen pfunt hartz ein pfunt vnst=
 lit vnd zerlaß das in einem kessel vnd
 tunck den stein dar ein vnd nym[m] ein pald

1

pound of salammoniac add a measure of good wine.
 Boil it down by a third, and pour off
 the wine and let it cool down.
 Pour the wine off the salammoniac
 and let it dry, and it is purified.
 Unpurified salammoniac costs
 sixteen shillings and a haller per pound
 and if it is prepared well it will be worth
 a guilder for one pound.¹⁷⁰ **Below is written**
a very 'courtly' advice¹⁷¹ **how**
a master can fire at night and how he can know
how to aim his fire.

A¹⁷² very good, 'courtly' method which
 is described below:

fol. 25 v
 if you would like to know how you fire at night
 then take ten pounds of resin, one pound of cheap tallow,¹⁷³
 and melt it in a pot. Dip
 the stone into it and take

¹⁷⁰ One guilder equals 24 shillings. One shilling equals 12 pennies. This section is copied in many other *Firework Books*, e.g. Freiburg Ms. 362, fol. 85 r, Dillingen Ms. XV 50, fol. 22 v, New York Spencer Collection Ms. 104, fol. 37 v, and Heidelberg, Cod. Pal. germ. 122, fol. 22 v. In all of these sections the value stated stays the same without adjustment for inflation, even in a copy in the case of the Dillingen manuscript or in the sixteenth century, which have been dated to be from the 1460s or 1529 respectively.

¹⁷¹ 'hefflich' or 'hofflich' has been translated as 'courtly' throughout. This does not mean it refers to a courtier or people actually based at, or employed by a court. Rather, it refers to a skill or knowledge which could be put to good service in a courtly context. It clearly has an aspirational connotation, and is mentioned at three different occasions in part 1. See chapter 4 for a discussion on this.

¹⁷² Scribal error in original. Repetition of 'e'.

¹⁷³ In Nibler 'Unschlitt', or 'vns{t}lit' = 'inßlat' => 'Unschlitt' (Nibler (2005), 54, footnote 137); in Kramer 'Cheap tallow' – no reference provided (Kramer (2001), 49). The *Frühneuhochdeutsches Wörterbuch Online* refers to it as 'unstit' in the entry on candles (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/kerze.s.1f_1514210227). Defined as the lowest quality of butchered animal product.

- 5 dar auß vnd wirf in in ein puchsen pul=
fer das verhangt vnd verwigt sich in
das hartz vnd die puchsen dar nach mit
ladest vnd den stain mit guten laudern
verschoppen vnd scheuß wan[n] du wilt so
10 sichst du den stain prin[n]en du darfft den
stain nit an zinden wan[n] er get selber
prinnent von der puchsen wan[n] du die
puchsen an zint hast **Es ist zu wissen**
15 **wan[n] das ist das man frome fürsten herre[n]**
ritter knecht vnd stet oft vil vnd zu ma[n]ge[n]
mal als gar versampt bezogen vnd beli=
gert sind worden Also das sie sich dar
vor nit gewist haben zu hüeten vnd auch
20 **solch leut peÿ in nit hetten noch die zu**
in pringen mochten durch der kunst
weishait rat vnd hilfß das sie iren fein=
den wider sten vnd sich ir auff enthalten
- fol. 26 r
- 1 **mochten vnd wan[n] auch laider oft schein=**
berlichen ist das den[n] manig from fürst
ritter vnd knecht vnd stet oft swerlich
engolten haben vnd des zu verdorbenlich
5 **ein schaden komen ist vnd der wirdig**
adel der dem hailigen römischen reich
zu sterck vnd dienst geordnet vnd von
got selber gewirdigt ist dar durch et=
wen[n] geschmecht vnd getruckt worden
- fol. 26 r
- Unfortunately, it is also often the case that these**
have often not been compensated well by the prince,
knight, squire, or town, which is
why – as a result – they have
come to dreadful harm. The worthy
nobility who are there to strengthen
the Holy Roman Empire and considered to
be worthy by God himself have been
shamed and defeated.

¹⁷⁴ This helps the gunners to provide some sense of direction, distance, and perspective – something that is still done in modern artillery.

10

ist dar vmb so rat ich allen fürsten
 herren rittern vnd knechten vnd stetten
 die do stet vnd vesten haben in ganzen
 trewen das sie sich bewaren vnd fursech=
 en mit köst vnd gezeug den sie alweg
 haben in iren vesten vnd schlossen salpett[er]
 vnd swebel vnd ander specie die zu puch=
 sen pulfer vnd fewrwercken gehören als
 in disem puch dar vor vnd hie nach ge=
 schriben stet vnd sunder das sie haben
 solch holz in gutem haw gehawen vnd
 an ein trucken stat gelert das du nach
 diß püchs lere nutz vnd gut seÿ vnder

15

Therefore, I advise all princes,
 lords, knights, squires, and towns
 which have towns or castles in all
 honesty that they should preserve and seek
 out such food and supplies at all times
 in their castles and strongholds: saltpetre
 and sulphur and other ingredients required
 belonging to gunpowder and fire works as
 are described in this book beforehand
 and later. Especially that they have
 such wood well chopped and in a
 dry store so that it can be used for
 these gun instructions and that it is good

20

fol. 26 v

das pulfer zu den clozen hinder den stain
 vnd zu den puchsen do mit man die stain
 verpiset vnd e-ist das ist dar vmb zu tun
 ob yemant durch urstumpft bezoge[n] vnd
 beligert wurd da er doch peÿ hett do
 mit er sich seiner feint erwerben mocht
 dan[n] der also beligert wirt seÿ vnd sein
 feind das veld getrawen in zu haben so
 fachen sie mangerleÿ an do mit sie in
 wollen gewinnen vnd dar vmb stet in
 disem nachgeschriben capittel ob ein furst
 herr ritter oder knecht oder stet sein vein=
 de so nachtet hi zu gerüst hetten das

1

5

10

fol. 26 v

within the powder, on the plug, behind the stone,
 and in the guns which are used
 to fire the stone. That is so that
 anyone who has been attacked through *urstumpft*¹⁷⁵ and
 besieged, he has with him someone
 who can defend him against an enemy
 when he is also under siege and when his
 enemy is in the field, then to have such [*knowledge/person*]
 try various things so that they
 want to win and therefore there is written later
 in this chapter whether a prince,
 lord, knight, or squire or town have
 made preparations against their enemy so that

¹⁷⁵ No meaningful translation for this term could be found. It could be that it relates to 'guile', 'sheer power', or even 'core' (from the etymological sources of 'ur'='origin' and 'stumpf' = 'trunk'), or something more generic such as 'craft'.

15 sie im an die mawr komen weren mit
latzen oder schürme[n] vnd layttern an
stussen zu schürme[n] wolten wie ein yed=
licher furst her[r] ritter oder knecht oder
stet in schloß vest oder stet sturmhals
wol behalten vnd iren veinden wider
stun mügen

20

E[e] vor dir ligt es seÿ in einer vesten
oder in einer stat vnd man an die

fol. 27 r

1 mawr komen wer mit gutten schürme[n]
oder mit lazen vnd man an die mawr
mit leütern stöst oder pricht vnd du e sein
in wendig nit wissend pist wa man auß
5 wendig an stöst oder pricht so nÿm[m] einen
würffel vnge in wendig zu der mawr
vnd leg in in die mawr ye auff den ne
sten stein vnd wa der wurffel auff springt
do prich gegen in durch die mawr auß
10 Nim[m] aber vor hin dreißig pfut hartz
dreÿßig pfunt salpetters swebels vnd
kohn alles wol gestossen in das ze[r]lassen
hartz vnd mach pallen dar auß als
groß als die öpfel vnd zünd sie an vn[d]
15 wirff sie zu in die außwendig in der mawr
sein so prinne[n] die paln vnd gewinnen

they can come to the walls with
cats and screens and ladders with the
intention to take it, [just] as any
prince, lord, knight, or squire or
town in a castle, stronghold, or town can withstand
their enemy and they hold their
position.

When he [*the enemy*] is in front of you, whether you are in a castle
or a town and when he has come

fol. 27 r

to the walls with good screens
or with cats,¹⁷⁶ and he hits the walls
with ladders and breaches them while you
are inside without knowing what is happening
outside and whether it breaches [*the walls*], then
take a single die within the walls
and put it on the wall. On the nearest
stone the die falls onto
there will the wall break down.
Prepare before then thirty pounds of resin,
thirty pounds of saltpetre, sulphur, and
charcoal all well ground and mixed with
the resin. Make this into balls the size
of apples and set them alight
and throw them beyond the wall.
The balls will burn and give off such a lot

¹⁷⁶ A cat was a wooden structure, a form of siege tower, which was used to protect an attacker at a siege from enemy attack. Possible images of this kind of cat can be found in I.34 illustrations at fols. 91 r and v.

also grossen dunst vnd rauch vnd print
 auch also ser das dir dein feind keinen
 schaden tun mügen piß du aber die
 puchsen geledest vnd also mag sich ein
 yedlicher wol erweren vor katzen vnd
 schürmen vnd sein schloß vest vnd stat

20

fol. 27 v

1 oder stürm hab behalten. Merck wol eben
 vnd bewar dich mit köst vnd zeug vnd
 fromme[n] leuten denn manig vest sein ver=
 lorn worden vnd die leut dar in gefange[n]
 5 dar vmd das sie sieh sich mit virstechen
 hetten mit kost vnd zeug vnd auch des
 halb nit haben mochten piß man sie entret=
 tet oder ir feind mit guten taidingen do
 von gewest hetten **Item in disem hernach**
geschriben capittel stet geschriben wie
man ein tureren nyder schiessen sol vnd
wie man in beschiessen sol das man
in mit wenig schüssen als wol nider
scheust als mit vil schussen

10

15 **W**iltu einen turen nider schiessen
 auff ainen hauffen so lug das
 du habst ein guten quaderaten vnd

of steam and smoke and they will burn
 so much that no enemy can cause
 you any harm until you have loaded your
 gun. That is how anyone can
 protect themselves against cats and
 screens and their castle, stronghold, or town

fol. 27 v

can withstand such an attack. Note carefully
 to prepare your food and supplies and
 that many reliable people lost strong castles
 and the people inside were captured
 only because they have miscalculated
 food and supplies and they could not
 keep hold of them until they could fight off the siege
 or their enemy was turned away by good
 deeds.¹⁷⁷ **Here in this chapter**
written below there is written how
you can shoot down a tower and
how you should shoot at it so
that you can bring it down with a few shots
rather than with many.

If you want to reduce¹⁷⁸ a tower
 to rubble, then see that
 you have a good quadrant and

¹⁷⁷ Disputed in various forms. Nibler calls it 'Tading' or 'Taiding' = 'Gerichtsverhandlung, Richterspruch', Schmeller (2008), I, 585. Göttingen 2° Cod. Ms. philos. 64, fol. 132 r, 'tadingen' = 'deeds'. *Frühneuhochdeutsches Wörterbuch Online* refers to it as 'dispute', 'decision', or 'achieve' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/teidingen.s.3v_1513765010).

¹⁷⁸ The literal translation of the original is 'shoot down'.

ein rechte mensur vnd auch ein gute
 puchs vnd das du sie ladest mit sweb=
 el puchsen clotzen die pi[e]chein sein vnd
 die stain die du schiessen wilt solt du
 pinden mit guten eÿsneÿn reÿffen die

20

good measuring skills¹⁷⁹ as well as a good
 gun. You should load the gun with sulphur
 gun plugs which are covered in pitch and
 the stone you want to fire should be
 tied with good iron rings which

fol. 28 r

1 crewrweiß uber ein ander gange[n] vnd
 lug das du ein gerechte mensur habst
 zwaier man hoch an dem turen von dem
 5 ertreich vnd alle die schuß die du tust die
 du all neben einander ab vnd scheuß nit
 hocher noch nider[er] so erschelt er vnd er=
 wegt sich der turen vnd velt behend ni=
 der den[n] ob du sunst zwayhundert schuß
 dar an test **Item wenn das ist das man=
 ges man[n]es feind sich fur sein stat vest
 oder stet legen vnd sünst mangan feind
 hat die auff setz haben wie sie im ein
 schloß abgewinnen mochten es seÿ
 mit an lauffen des morgens als man
 15 frw auff schleulst reit oder get des
 nachtes mit steigen Dar vmb stet
 hernach geschriben in disem capittel
 wie ein man ein fewrwerck mach vn[d]
 auß werffen sull do mit er sich wol**

fol. 28 r

are placed in a crossways fashion over one another. And
 make sure that you have the right measurement
 of the height of two men at the tower from the
 ground upwards and that all shots you fire
 should be able to land next to each other and neither
 higher or lower, then the tower will be hit,
 will move, and will fall down as quickly
 as if you had otherwise fired two hundred shots
 at it. **Here when you have the
 enemy with many a man who is laying in siege to one's
 town, castle, or stronghold.¹⁸⁰ And any kind of enemy
 that can besiege you, and who can capture
 your castle, be it
 at the beginning of the morning
 as you ride early to the castle, or be
 it at night with ladders. Therefore there is written
 in the following chapter
 how a man can make a firework and
 use it, with which he can cause a**

¹⁷⁹ Can have a variety of meanings, most likely a generic term for 'measure', referring to the ability for the measurer to take care (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/geometer.s.0m_1514540582).

¹⁸⁰ Unclearly about '*stat, vest vnd stet*' in original – appears to be a rhetorical expression, but includes the same stem of 'town' twice. The text also switches the subject from 'you' to 'he' and back again, making it unclear whether the fireworks are part of the offensive or defensive.

20

versechen mag doch wenn er das
fewerck auß geworffen hat vnd
hin nach sich uber auß weschen wil

fol. 28 v

so sol er ein ren[n]tarsch for fur auß bitte[n]
vnd sich do mit bedecken für geschoff
dann manig man ist sein vmb das
leben komen das er sich ploß vnd un=
gewaffent seins haubizs sich 4 beschen[en]
wolt dar vor sol sich ein yeder from[m]er
man hueten

fol. 28 v

then he should request a protective shield¹⁸²
and he should cover himself with it from the fire
which causes many men to
lose their lives as you are unprotected and
go unarmed against their howitzers
which is what any decent man should try
to avoid.

So man vor dir ligt es seÿ in einer

vest oder in es seÿ in ainer stat vnd
du sichst das sie dir zu nachtet an die
mawr rüsten oder gangen oder ob man
nit vor dir ligt oder ob dich sunst ge=
dunckt man seÿ zu deiner vesten geschlich=
en so nym[m] speiß glas ain pfunt hartz
drew pfunt swebels ain pfunt salpetters
ein pfunt koln vnd mach dar auß sin=
wellin kuglin vnd mit wercken soltu in
zu sam[m]e knetten vnd wen[n] du sein be=

If someone besieges you in a

castle or be it in a town, and
you find that they get ready to come closer to
your walls, or, if you are not
under siege, but you think that
someone has come close to your defensive structures
then take *speiss glass*,¹⁸³ one pound of resin,
three pounds of sulphur, one pound of saltpetre
one pound of charcoal, and turn this into
round balls.¹⁸⁴ Knead all of it together with old cloth.
if you need to

¹⁸¹ Metaphorical expression with the meaning of 'not admitting responsibility or sense of guilt for any of the consequences' or more generally 'avoiding the consequences'.
¹⁸² 'renntarsch' translated as 'Kampfschild' – A protective shield used in tournaments, used as a protective device.

¹⁸³ Also described as 'speißglaß' (Freiburg Ms. 362, fol. 79 v) or 'spießglas' (Stainer (1529), 202) which was interpreted by Nibler as a 'group of ore (metal sulphide)' ('Spießglanz, artenreiche Gruppe von Erzen (Metalsulphid)') (Nibler, 202). Kramer believes it is 'antimony sulphide, Sb₂S₃' but there is no evidence provided why this would be the case (Kramer (2001), 54). It could also be a mere container, a 'glass for something' but from the context it is more likely to be an ingredient.

¹⁸⁴ In Freiburg Ms. 362, fol. 79 v: 'sibentzig kugel'n'; in Heidelberg, Cod. Pal. germ. 122, fol. 26 r: 'sibitzig', in Stainer (1529), 202: 'sibentzig kugel'n'; or in Göttingen 2° Cod. Ms. philos. 64, fol. 132 v: 'sibentzig'. No reference found for 'sinwellin', but it is most likely that it refers of the quantity or shape.

darfft so wirff ein kugelein hÿm auß
 das print gar lang vnd auch gar laut
 vnd leucht schon das du wol sichst ob
 yemant her zu ge oder nit sie were[n] auch

throw one ball outside
 that burns a long time and is very noisy
 and shines so that you can be sure whether
 someone has come close or has not,

fol. 29 r

auch zu prennel[n] **Wie man ein wun=
 derlich pulfer machen sol das selb=
 pulfer auch die art hat wa man es
 hin legt da es trucken leit so enprent
 es von im selber nicht aber wenn dar
 auff regent oder beschut wirt so enprint
 es do von**

fol. 29 r
 also¹⁸⁵ to burn. **How you make miraculous
 powder, the same
 powder which has the ability, when you
 put it down and it is dry, not to
 burn by itself. But when
 rain falls on it, or it is shot at, then it starts to
 burn.**

Wiltu ein gut pulfer machen das
 gar wunderlichen ist leg es sech=
 zehen wochen auff ein dach oder wa du
 wilt alle die weil vnd es trucken leit so
 print es nit aber als pald es da auff
 regent oder man es beschüt so print es
 gar grymlichen vast also solt du es mach=
 en nym[m] salniter vnd funff salp hirtis z
 tar bonel z ß vnd pulfer das vnder ein
 ander vnd nym[m] einen weissen kysling
 stain vnd prennene den zu ainem kalck

If you want to make good powder that
 is quite marvellous, then put it on
 a roof, or where else you want, for sixteen weeks
 so that it is allowed to dry and it
 will not burn until rain
 falls on it or until it is shot at. Then it burns
 grimly and quickly. To make it you should
 take *salniter*,¹⁸⁶ and five *salp hirtis*,¹⁸⁷
 half a pound¹⁸⁸ of *tar bone*/¹⁸⁹ and powder [*mix*] it
 together. And take a white pebble
 stone and burn it to chalk.

¹⁸⁵ Repetition of '*auch*', presumed scribal error – not translated.

¹⁸⁶ Alternative term for 'saltpetre', possibly making some judgement on purity.

¹⁸⁷ No meaningful translation could be established for this term. '*Hirtis*' appears to be a genitive, but not clear what this may relate to.

¹⁸⁸ 'z' abbreviation for pound; 'ß' abbreviation for 'semi', 'half'.

¹⁸⁹ No meaningful translation suggestion could be established. It could be that this may be a scribal error for '*carbones*' => 'charcoal'. Heidelberg, Cod. Pal. germ. 122, fol. 26 v, it is '*i car bones z*' and broken after '*car*' at the end of the line.

vnd stoß den ungeloschen kalck wol vn[d]
tu z des kols dar zu vnd dreier pfeng
nig swer campfer vnd temperier das
wol vnter ein ander vnd laß es wol

20

fol. 29 v

1 trucken werden **Wie man ein gut weiß puch=
sen pulfer machen sol**

Wiltu machen ein gut weiß pulfer so
nym[m] ain pfunt salpeters vnd ein
pfunt swebels ain halb pfunt salbonis oder
albranne vnd der[r] das wol in einem hafn
vnd stoß das vnter ein ander zu pulfer wiltu
dan[n] das es vast weiß vnd starck werd so tu
salarmoniak vnd camfer nach gewicht dar
vnder als vor geschriben ist so hast du ein
gut weiß pulfer **Wie man rot puchsen pul=
fer machen so**

10

Wiltu machen ein gut rot pulfer so
nym[m] aber geleich gewicht vnd
salpetter vnd swebel vnd nym[m] anderhalb
vierdung rotzs sandels vnd mal das so du
yin[n]er cleiner magst oder kast vnd stoß dise
stuck gar wol zu samen in einem morser
vnd wiltu es vast starck han so tu dar=

15

Grind the quicklime well and add
a pound of charcoal to it and three penny's
weight of camphor and mix it
together well and let it dry

fol. 29 v

out well. **How you make good
white gunpowder.**

If you want to make good white powder:
take one pound of saltpetre and one
pound of sulphur, one half of a pound of sandal wood¹⁹⁰ or
white poplar wood. Put all of it into a bowl
and grind it together into powder. If you
want to make it very white so that it becomes strong then add
salammoniac and camphor as weight to it
as is stated above. Then you have good
white powder. **How you make red
gunpowder.**

If you want to make good red powder, then
take equal weights of
saltpetre and sulphur and take one and a half
quarters of red sandal wood which you can grind as
finely as possible. Grind these
ingredients together thoroughly in a mortar.
If you want to have it very strong then add to it

¹⁹⁰ The author uses a range of different spelling but from the context it is likely that it refers to 'sandal wood'. Sandal wood has the reputation to be very fragrant for a prolonged period of time. Arguably, in this instance it is used as a colorant to make the powder red – sandal wood is used as common colouring ingredients in cooking and dyeing (see Chris M. Woolgar (2018), 'Medieval Colour and Food', *Journal of Medieval History* 44, 1-20, 15). However, it is less clear why the red colorant is mentioned in a section making 'white' powder which may be a transmission error.

20 vnder als vor geschriben stet **Wie man ein plaw puchsen pulfer machen sol**

Wiltu ein plawb pulfer machen so n̄ym[m]

fol. 30 r

1 salpetter als vor geschriben stet vnd tu korn plomen dar zu vierthalb lot ein halb pfunt sulsarboni holz vnd stoß dise stuck gar wol vnter ein ander so wirt es plaw 5 knoln vnd laß dann die knollen vast wol trucknen so hastu plaw pulfer sarbonim fur den kol vnd sterck das pulfer als vor

Wie man ein gel puchsen pulfer machen sol

Wiltu ein gel pulfer machen so nym[m]

10 aber salpetter swebel ein geleich gewicht als vor vnd nym[m] ein halb pfunt spitandi vnd stoß das auch wol vnder einander vnd wilt du es starck haben so nym[m] die stuck dar zu die du vor mals 15 dar zu genomen hast do solt wissen das dise stuck nicht als genzlich vnd als schnel mugen sein als die pulfer mit den koln die sein wol als arck Auch ist zu wissen das manig y pulfer gar starck vn[d] stercker ist dan[n] ob es sunst gar vast wer 20 nun von den dreien stucken **Wie man die al=**

ler pösten fewrpfel machen sol die yema[n]t

what has been described before. **How you make blue gunpowder.**

If you want to make blue powder, then take

fol. 30 r

saltpetre as is stated above and add corn flowers to it. One quarter of a lot, one half of a pound of sandal wood and grind these ingredients well together so that it becomes blue *knollen* [or, lumps] and then let the *knollen* dry out and you have blue powder of sandal wood for the charcoal and strengthen the powder as before. **How you make yellow gunpowder.**

If you want to make yellow powder, then take

saltpetre, sulphur, both in equal measures as before, and take half a pound of spikenard¹⁹¹ and grind them together well. And if you want to have it strong, then take the ingredients and grind them together as you have done before. You should know that these [powder] recipes are not as complete and as fast as the powder with the charcoal which is very strong. Also you have to know that plenty of powder is not strong and it is stronger when it comes from just the three ingredients. **How you make the best of all fire arrows which have ever**

¹⁹¹ 'spicanardi' according to Hassenstein (1941), 40, has been translated as 'indische Narde, eine gelbe Blume', or 'Speik' – no reference provided.

fol. 30 v

gehaben mag

Wiltu die pösten fewr pfeil mach die
 yemant gehaben mag so nym[m] v
 pfunt salnitter vnd ein pfunt swebel ein
 halb pfunt kols vnd stoß das in eine[m] mor=
 ser gar wol vnder einander vnd tu olio
 benedicto vnd gepranten wein dar vnder
 als vil als sein genug ist vnd mach eine[n]
 taig dar auß vnd knit des taigs an die
 pfeil als vil du sein haben wilt vnd tu
 die an eine[m] stecken in eine[m] warme[n] offen dz
 es wol ertrucken vnd der[r] dar nach nym[m]
 in her auß vnd schab vnd formier in mit
 einem messer als er sein sol vnd uberzeuch
 in mit einem cleinen saubern tuch vnd be=
 wind in mit faden wol vnd swein in in
 swebel merck eben **Wie man über laut**
schiessent pulfer schuß tun mug

Wiltu einen uber lauten schuß tun
 so leg ein vas zwischen den clotz
 vnd das pulfer vnd tu ein tröpflein queck=
 silbers innen zu dem widloch ein so clopft

fol. 30 v

been made.

If you want to make the best fire arrows
 which have ever been made: take five
 pounds of salniter, and a pound of sulphur, one
 half of a pound of charcoal and grind them
 together in a mortar and add *oleum*
*benedictum*¹⁹² and brandy to it
 in sufficient quantity. Make it into
 paste and kneed the paste around
 an arrow as big as you want to have it. Put it on
 a stick and place it into a warm oven so
 that it dries well. After it has dried take it
 out [*of the oven*] and sharpen its tip with
 a knife as it should be and cover it
 with a small clean cloth and wind
 some string around it and note to soak it in
 sulphur. **How you can**
make overly loud powder shot.

If you want to create an overly loud shot,
 then place a hair between the plug
 and the powder and add a drop of
 mercury into the touch hole. This makes it

¹⁹² '*Oleum benedictum*' literary could just be 'blessed oil'. It has been referred to as being various substances, 'also called *oleum philosophorum* or *oleum laterium*', which would make it 'Oil of brick', and described as 'a clear red oil, the result of pyrolithic distillation of olive oil' (Kramer (2001), 58), or 'mixture containing oil and tar' ('*Teerölgemisch*', Nibler (2005), 30). Partington assumes this to be 'a light coal-tar fraction (*Teeröl*, *Benzol*)', but also raises doubts on what exactly it may have been (Partington (1960 [1999]), 156). As the term cannot be confirmed it was decided to leave it in the original.

fol. 31 r

¹ er laut uber vast wiltu ga gewiß schuß
 tun die gewer sein so lug das du aller erst
 wissend seÿ wie ver es tragen muge wie
⁵ vil des pulfers seÿ wie swer der stain seÿ
 gegen dein pulfer vnd die clotz gleich vn[d] eins
 holz sein vnd die pisen gleich sein vnd ge=
 leich getriben werden vnd das die puchß
 gewiß stand vnd das sie sich nit entrüste
 also da die clotz gleich getriben sind das
¹⁰ sÿ nicht für das ror auß gangen vnd nit
 für das ror ein getriben werde Mit sunder
 hüt dich das die puchs auff recht stand
 vnd auff recht lig das ein rad ein halms
 nit hoher ste wan[n] das ander Vnd wen[n]
¹⁵ du die puchsen mit diser lere also geladest
 so kanst du keinen schuß fellen **Ain frag**
in welcher maß ein puchs sein muß die
aller weitzt scheust vnd die antwürt
dar über

Aber tut der maister

²⁰ ein frag in welcher maß ain puchs
 sein muß die aller weitzt schüst antwort
 wen[n] ein puchs ein venediger zentner scheüst

fol. 31 v

¹ die scheust aller weitest **Ain andre frag**
von der puchsen

Aber ein andre frag ob die puchs

fol. 31 r

bang very loudly. If you want to make certain that your shot
 is reliable then make sure that you firstly
 are well informed as to how much it can carry, how
 strong your powder is, how heavy your stone is
 against your powder, and whether your plugs are equal [*in size*] and
 out of the same wood. The wedges need to be the same,
 and need to be driven the same way, your gun
 needs to stand firmly and must not be able to move.
 When you have driven in the plugs, [*make sure*] that they
 do not stick out at the front of the barrel and that they are not driven in too
 deeply. Especially, you have to be
 careful that the gun stands straight and
 sits level so that one wheel is not a blade of grass
 taller than the other. If you load a gun
 following these instructions
 no shot should miss. **A question on**
what the dimensions of a gun have to be that
fires the longest distance and the answer
to it.

But if a master asks

the question what the dimensions of a gun
 have to be to fire the longest distance then answer
 that when a gun fires a Venetian hundredweight

fol. 31 v

then it fires the longest distance. **Another question**
about the gun.

But to the other question whether a gun fires a longer

5 weiter schieß die cleine ror haben
oder grosse ror sprich ich weich puchs ror
hat das das ror funff clotz lang sein die
puchsen sein die pesten wan[n] die kurtzen
mugen nündert hin geschiessen **Aber ein
frag wie die puchs aller past lige**

10

Ein frag ob die puchs paß hert lige
oder lind sprich ich wenn sie hert
ligt so spricht hertes wider hertes vnd
mag nit gesten dar vmb sol man die
puchsen in lindes holtz legen Man sol
auch hinder die puchsen pley giessen y zweir
vinger dick vmb das daz sie ainen linden
stoß haben Man sol sie nit tieffer legen
wan[n] ains halms prant über das halb=
tail in so ligt sie maisterlichen wol **Wa
mit man ein yedlich puchsen sie sey groß
oder clein prechen mag**

20

Wiltu ein puchsen prechen wie groß

fol. 32 r

1 wie starck sie sey so nym[m] dreierley gutes
pulfers vnd lad einen drittail der puch=
sen do mit vnd schalch einen püchem clotz
dar ein vnd vermach den stain mit gute[m]
5 pissen ze ring vmb all vmb vnd tu queck=

distance which has a smaller barrel or
a larger, I say: the gun barrel
that is five plugs long is
the best of the guns. If they have to
be shorter, they shoot less far. **But to the question
how best to place a gun.**

To the question whether a gun is better
placed on a harder or a softer base, I say: if it is on a hard base
and hard against hard, it is not good and
should not be. That is why you should
place the gun on lime [or soft] wood. Behind
the gun you should pour some lead, two
fingers thick so that it can hit something
soft. You should not place it lower than
when one blade of grass burns over a half
part.¹⁹³ Thus it will sit expertly. **How
you can break¹⁹⁴ any gun whether it is big
or small.**

If you want to break a gun however

fol. 32 r

strong it may be, then take three parts
good powder and load a third of the
gun with it and drive a beech plug
into it. And seal it with a stone and with
wedges all around the stone and add mercury

¹⁹³ Not clear what this refers to.

¹⁹⁴ This could also be translated as 'burst' implying that it would render the gun useless which could not be repaired.

silber oben zu dem widloch ein so pricht
sie an zweifel **Aber wie man ein puchsen
prechen sol**

Aber zu dem selben
lad die puchsen gleich als vor vn[d]
nez das pulfer an dem cloz vnd schütt dan[n]
zu dem widloch wein hin ein vnd tu das
pulfer hin ein dar auff vnd zind sie an et
fragit

**Wie man ein puchhs laden vnd an=
zunden sol das man da von komen mag an
schade[n]**

¹⁵ **S**o du ein puchsen geladest vn[d]
du sie beschiesen wilt so nÿm[m] ein pfre=
men vnd stoß in durch das widloch hin ein
piß auf den poden durch das pulfer ab
vnd hab das zund pulfer peÿ dir dem man
do spricht paulums currasine vnd see es
dem prinnenden nach vnd tu sein so vil=
dar ein das du das widloch fülleest wann

fol. 32 v
die pösen pulfer sein gar heiß vnd scharpf
vnd an zinden das pulfer behend in der puch=
sen vnd ob das pulfer inder puchsen verdor=

into the touch hole, then it will break
without fail. **How you break
a gun.**

But [add] to the same
load as before and
wet the powder near the plug and pour
into the touch hole wine and add
powder to it and light it. And
I ask:

**how do you load a gun and light
it so that you can get away without
harm.**

When you have loaded a gun and
when you want to fire it, then take an
awl¹⁹⁵ and push it through the touch hole
right to the bottom through the powder.
And have the tinder powder with you which
is called *paulum currasine*.¹⁹⁶ Make sure to put it to
the burning [powder] and add to it
as much as fills the touch hole when

fol. 32 v
the bad powder is not hot or fiery.
And light the powder speedily in the
gun and if the powder has been spoiled in the

¹⁹⁵ 'pfriem' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/pfriem.h2.0m_1514157328).

¹⁹⁶ The translation for this term could not be established. Other *Firework Books* refer to this section as 'pulvris guvrusine' (Freiburg Ms. 362, fol. 84 r) or 'pulvris curasine' (Strasbourg Ms. 2259, fol. 6 r) which has been interpreted as 'priming powder' (Nibler (2005), 54, footnote 123). Kramer translates this as 'pulvris dura sine' without any translation or explanation provided (Kramer (2001), 44).

5 ben wer so hilf im das pulfer das es pis=
sen muß du solt aber treg pulfer auf die
puchsen vnd das zuntloch legen auf das
an zünd pulfer vmb das daz du do von
kumen mugst du solt dich hietten das du
nym[m]er das selb gut pulfer auff dem wid=
loch an zundest an das treg pulfer das
10 soltu alweg nur an zinden **Item disem
nachgeschriben capittel was waffen vnd
guter gewonhait ein yedlicher puchsen
maister an zin haben sol vnd auch maß
15 kunst erkennen sol**

Dise stuck gehören einem yedlichen puch=
sen maister zu das er sie an im hab
Des ersten sol er got eren vnd foderlichen
vor augen haben vnd in forcht dan[n] ander
20 raißleut vnd wenn er mit der puchsen oder
mit dem pulfer vmb get so hat er seine[n]
grossen feind vnder handen vnd also muß

fol. 33 r
1 er alweg drineltig sorg haben Er sol sich
auch bescheidenlich mit der welt halten
mit er do wandelt Er sol auch behertzter
sein vnd manhaft vnd sol sich auch trest=
5 lich in kriegten stellen wann man grossen
trost von sölichen leuten nympt Dar vm[b]

gun. What helps you is that the powder should be biting,¹⁹⁷
then you should carry the powder to the
gun, place it on the touch hole on to the
tinder powder so that you can get away
with it. You should be careful
never to light the good powder on the touch
hole. The slow powder
you can always light. **Here this
chapter written below [//ists] which arms and
good habits should be part of any master
gunner who wishes to learn
the method.**

This part is what each master
gunner has to have within himself.
Firstly, he should honour God and keep Him foremost
in his eyes, and respect other
travellers. And when he handles a gun or
powder he has his
great enemy in his hands. He

fol. 33 r
always has to be three times more careful. He should be
modest within the wordly [*status*]
he is in. He should be steadfast
and manly and should provide comfort
in war where he also can draw great
comfort from these people. For that reason, he

¹⁹⁷ From the German 'beissen' which is likely to refer to the acidic nature of the powder (*Frühneuhochdeutsches Wörterbuch Online*, Def. 3, http://fwfb-online.de/go/passen.s.3v_1513616100).

sol er sich tröstlich vnd bescheidenlich hal=
 ten dan[n] ander reissig leut Der maister
 sol auch künne[n] schreiben vnd lessen wan[n]
 er kund anders der stuck nicht behalten
 die zu diser kunst gehore[n] es sey mit dissul=
 ieren seperiern sublimiern oder conuertiern
 vnd manig ander stuck die dar zu gehore[n]
 Dar vmb muß ein maister die geschrift
 kunnen Er sol auch all stuck die so her zu
 gehören es sey von wilden oder zame[n] sach=
 en oder von swebel können beraitten von
 erst untz an das end Er sol auch alles
 das kunnen ordiniern zu vesten erckern
 oder mawren fur katzen schirme[n] fur angan
 vnd was dar zu gehört Er sol auch dreÿ
 dinc wissen von dem tragman vnd mensure[n]

should behave modestly and comfortably, more so
 that other travelling people. The master should
 know to write and to read as
 he could not retain the details
 that belong to this method; be it dissolving,
 separating, sublimating, or converting,
 and the many elements it takes.
 That is why the master must know how
 to write. He also [*must know*] all the parts,
 whether it is the wild or tame¹⁹⁸ elements
 or the sulphur preparation,
 from the beginning to the end. He should also
 know how to coordinate matters, in castles,
 in alcoves, or in walls, for cats, shields, and for advances¹⁹⁹
 and all that comes with it. He should also know three
 things about the loads and the measures.

fol. 33 v
 er sol sich auch erberklichen vnd frumckliche[n]
 ziechen mit wortten oder mit wercken peÿ
 den leuten vnd sol besunnen sein zu allen
 zeitten vnd zu allen zeit stund besunder
 sich hueten vor trünckenheit **Item wie**
sich ein yedlich puchsenmaister halten sol
so er mit pulfer vmb get das es im kein
schaden tun mag

fol. 33 v
 He should behave honestly and reliably
 with words and deeds towards
 other people. He should be calm at all
 times and at all hours. He should be especially
 careful to avoid drunkenness. **Here [*is written*] how**
any master gunner should behave
when handling powder so that it does not cause him
any harm.

¹⁹⁸ As an opposite to 'raw' or 'wild', and could equally be translated as 'raw' or 'processed'.

¹⁹⁹ For the attack ('*an gan*'), to advance, to 'set alight'. It could be that this may refer to the chemical element Manganese (which would not make sense from the context) or (largely contextually) a mangonel, but as three minims are unlike to have been omitted, it was left untranslated.

Item wie ein maister sich halten sol
 10 so er mit pulfer vmbget das im das
 pulfer keinen schaden bringet wann der
 15 dunst [vn[d]] der dampf ist ein rechte vergift
 dem menschen vnd ist auch vnder den
 dreien stucken salpetter swebel vnd kol
 keins sunderbar dem menschen schedlich
 er gesein zu niessen vnd wan[n] sie vnder
 ein ander komen vnd getempert werden
 20 so schaden sie dem haubt vnd dem herz=
 en vnd besunder so feült es die lebern
 Der aller grest schad dar an ist ist der
 dunst oder der tampf der do von dem
 verprun[n]en pulfer gat wiltu dich dar=

fol. 34 r

1 vor hueten so lug das du nit nüechter
 do mit vmb gest vnd huet dich vor wein
 das du sein nit zu vil trinckst do solt
 5 linde kost niessen wan[n] wenn du zu vil
 mit dem gezeug vmb gangst so gewinstu
 gern das getwang vnd du solt die vil
 zimlichen niessen abentz vnd morgens
 vor essich vnd aÿre hut dich was aber
 feucht vnd kalt ist das macht du wol
 10 wiessen vnd was hert vnd trucken sey
 vor dem soltu dich hueten **Wa ein yedlich=**
er puchsen maister aller sicherst sten mug
so er die puchsen auß lassen wil

Here [is written] how a master should behave
 when handling powder so that the
 powder does not cause him any harm as the
 steam and vapour are real poisons
 to humans. And even if out of the
 three parts, saltpetre, sulphur, and charcoal,
 none of them are uncommon and harmful to humans
 when they are consumed. When they come
 together and are mixed together,
 then they are harmful to the skin and the
 heart, and it especially fouls the liver.
 The biggest damage from it is the
 steam or the smoke that comes
 from the burnt powder. If you want to

fol. 34 r

protect yourself from it, then make sure that you are not handling it on an empty
 stomach, and be careful about wine
 so that you do not drink too much. You should
 take in mild food for you are handling the
 ingredients frequently. You may find that you get
 stomach cramps. You should eat moderately
 in the evenings and in the mornings
 abstain from vinegar and eggs. Moist
 and cold [food] you can consume well.
 You should be aware of what is hard and dry
 and you should avoid it. **How any**
master gunner position is the safest of all
when the gun is emptied.

Wann du ein puchsen auß laden wel=
 lest so soltu wissen das du ny[?]dert
 sicher pist dann du standest über ort
 das ist auf zehen schrit von der puch=
 sen zwischen dem podem vnd der feÿtte[n]
 der puchsen **Wie man ein gute[n] zunder sie=
 den sol**

15

Wiltu einen guten zunder
 siedem so nÿm[m] die vorgeannten
 laug die man pulfert zu dem salpetter

20

fol. 34 v
 vnd sich schneid den zunder dar ein vnd
 schneid in auff sechs sturck vnd pulfer
 vnd stoß in so hastu guten zunder **Wie
 man gar gut kugel pulfer machen sol**

1

Item du solt neme[n] zweÿ pfunt salpeters
 ein pfunt swebels ein vierdung kolin
 vnd zerlaß den swebel in ainem tegel
 vnd schut den salpetter vnd die kolin wol
 gestossen dar in vnd zeuch eine[n] grossen
 vaden dar durch das werden die aller
 pesten swebel kerze[n] die yemant gehabe[n]
 mag auch laß es kalt werden in dem te=
 gel so hastu das kollen pulfer das man

10

If you want to empty a gun
 then you need to know that you are never
 safe unless you stand at a place
 which is ten steps away from the gun
 between the floor and the side
 of the gun. **How you make good
 tinder.**

If you want to make good tinder
 then take the aforementioned
 lye which was made when the saltpetre was turned into powder

fol. 34 v
 and cut pieces of tinder into it.
 Cut it into six pieces²⁰⁰ and grind it
 into powder. Then you have good tinder.²⁰¹ **How
 you shall make good ball powder.**

Here you should take two pounds of saltpetre,
 one pound of sulphur, one quarter of charcoal
 and let the sulphur melt in a pot.
 And add the saltpetre and the charcoal
 by grinding it well and pull a large piece
 of string through it, and this becomes the
 best sulphur candles which anyone can ever
 have. Let them cool down in a pot
 and you have [*the best*] *Knollenpulver*

²⁰⁰ Presumably scribal error, more likely to be 'stuck'.

²⁰¹ This section does not make sense. Compared to other *Firework Books* there seems to be a line or two missing, and this could be a scribal error. Other *Firework Books* refer in this section that 'the tinder should simmer for six hours, and then it should be allowed to dry, and then it should be pulverized' (Freiburg Ms. 362, fol. 87 r).

15

vinden mag **Welch zunder der aller aller pest ist**

Item nuß pawme[n] zunder ist der aller peste zunder vnd der prunstigst zunder den yemant gehalten mag **Wie man ein verborgen fewr machen sol auff zwen dreÿ oder vier funfft sechs siben oder acht tag das es dann erst enprint vnd flam[m]et**

20

fol. 35 r

1 **W**iltu ein fewr verporgen han auff dreÿ vier oder acht tag so nym[m] zweÿ tail joto~~æ~~ mris ein tail hartz ein tail wachs ii tail sal= petter ein vierding weiß dennes holz vnd zelaß das vnder einander vnd zeuch eine[n] langen zachen dar durch vnd zund ab vn[d] laß es dann wider ab das es nit lauter prün[n]e vnd das es sich nach vnd furpaß muß schmelzen vnd wart wann die glock schlach das du es an zündest vnd nÿm[m] eben war wie ver es in einer stund prünne[?]

10

you can find.²⁰² **Which tinder is the best of all.**

Here, tinder from a nut tree is the best of all tinder and the fastest burning tinder anyone can have. **How you make a hidden fire in two, three, or four, five, six, seven, or eight days that only starts to burn then and catches fire.**

fol. 35 r

If you want to keep a fire hidden for three, four or eight days, then take two parts *jotomris*,²⁰³ one part of resin, one part of wax, two parts of saltpetre, one quart of white wood from a fir tree, and let it melt together. Drag a long piece of string²⁰⁴ through it and light it. Put it out so that it does not burn further, and smoulders bit by bit and melts. And wait when the bell tolls so that you light it and take note how far it has burned in an hour.

²⁰² It appears most likely that the scribe made an error here, and conflates ‘ball powder’ and ‘Knollenpulver’. In Heidelberg, Cod. Pal. germ. 122, 31 r, this section is in the same sequence as l.34 but instead of ‘*kugel pulfer*’ it mentions ‘*knollen puluer*’ while stating the same end product ‘*Knollenpulver*’.

²⁰³ A translation for this ingredient could not be established. This component is an addition compared to other *Firework Books*, e.g. Freiburg Ms. 362, fol. 87r. In Heidelberg, Cod. Pal. germ. 122, fol. 31 v, ‘*rötämil*’, Heidelberg, Cod. Pal. germ. 502, fol. 34 r, ‘*ytotomrl*’, and Dillingen Ms. XV 50, fol. 26 v, ‘*jetams*’. In other *Firework Book* copies this section is missing completely, e.g. Dresden Ms. App. 463.

²⁰⁴ Two possibilities: a) ‘hook’ (‘*Zacken*’) – less likely through context, b) More likely to be ‘string’ or ‘wick’ (Definition 2, *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018 – particularly used in Bavarian context).

mug das maß behalt vnd zaichen den
 zachen mit dem meß als lang er seÿ vn[d]
 recht wie vil der meß seÿ als vil stund
 prunnet auch diser zach vnd zu welcher
 stund du gern ein fewr habest so heb
 in swebel kerzen dar an so hastu ein fewr
 do solt einem zachen vmb ein stecken win=
 den das er nach ein ander abschmelze[n] muß
²⁰ **Wie man ein fewr machen sol das einer
 tregt an groß bekimernuß ainem halben
 oder ganzen tag vnd nacht vnd das er**

fol. 35 v

¹ **auf dem selben fewr ein swebel kerzen
 an zunden mag wan[n] er kompt an die
 statt do er fewr prauchen wil**

⁵ **W**iltu ein höflich fewr machen so
 nym[m] groß mist pinzen in gutem
 als in den weiern vnd in den mosern stat
 vnd schut die pinzen in guten wein dar
 in salpetter gesoten seÿ vnd nÿm[m] die her=
 auß vnd trucken die pinzen an der sunne[n]
 vnd zeuch im die groben ausser haut ab vn[d]
 hab in an ein prinenden koln das er das
 empfacht du tregst einer spanne[n] lanck

Take the measure and make a
 mark which is as long and
 straight as any measurement would be for many
 hours with a wick, and for any
 hours you may want to have fire.²⁰⁵
 Put sulphur candles to it and this way you have fire
 that has a wick which you can wind around a stick
 so that it can melt one after the other.
**How you make a fire that you can
 carry with great care one half or a
 full day and night and**

fol. 35 v

**with the same fire you can light sulphur
 candles when you arrive at the
 city where you need the fire.**

If you want to create a 'courtly' fire,
 then take large mixed reeds which are good
 as they stand in the ponds and in the marshlands.
 Put the reeds into a good wine in which
 saltpetre had been dissolved. Take them out,
 and dry the reeds in the sun.
 Peel off the outer skin and
 place them in burning charcoal, so that they
 catch fire and can be carried a span²⁰⁶ long and for

²⁰⁵ This is using two separate time measurements: first, using the bell chiming to measure one hour; second, using the wick to measure multiples of the hour in order to have a time-sensitive fuse.

²⁰⁶ The measurement of the New High German 'Spanne' as a length of hand was only defined later (in 1618 – *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

ein meil wegs weren vnd wen[n] du zvilte
ein fewr machen oder haben so hab ein swebe=
el kerzen dar an so hast du fewr **Ein be=
sundre gute lere auff salpetter zu kauf=
fen der erst von venedig komen ist das
man an dem kauff nit betrogen werd**

15

Wiltu ein besundre ler halben auff
salpetter zu kauffen als er von venedig
kompt so du kompst über ein geschür mit
salpetter so stoß die hand dar ein vnd wirt

20

fol. 36 r

sie naß so wirt er nit gut beleibt sie aber
trucken so wirt er gut **Aber wie man salpette[er]
kauffen sol**

1

Aber salpetter verkauffen versuch in mit
dem mund ist er reiß pitter vnd gesalze[n]
so ist er nit gut ist er aber puzenlich vnd
suslich vnd vast übel so ist er gut **Aber wie
man salpetter kauffen sol**

5

Aber salpetter zu kauffen der zapfent vn[d]
gelat salpetter ist gut aber der rauch=
zapfent salpetter ist nit gut rauch gemall[e]n
salpetter ist nit gut **Indisem nach geschrib[e]n
Capittel stet gar äygentlich geschriben wie
man gut swebel ol machen sol das nutz vnd**

10

a mile on the road. And if you want to
make a fire, or to have one, then have a sulphur candle
ready to have a fire. **A special
instruction on how you buy saltpetre
which has come from Venice so that you are not
being defrauded at the purchase.**

If you want to have special instructions on
how to buy saltpetre as it comes from Venice:
if you come across a dish with
saltpetre put your hand it it and if

fol. 36 r

if it is wet then it is not good; if it stays
dry then it is good. **But how do you buy
saltpetre.**

But if you want to sell²⁰⁷ saltpetre try it in your
mouth. If it is quite bitter and salty,
then it is not good. If it is, however, mild
and sweet and almost sickening then it is good. **But how
do you buy saltpetre.**

But if you want to buy saltpetre which is icicle shaped and
smooth saltpetre, [then] it is good saltpetre. But smoky,
icicle shaped saltpetre is not good, ground, smoky
saltpetre is not good. **In the chapter written
below is actually written how
you can make good oil of sulphur²⁰⁸ that is useful**

²⁰⁷ In German, 'buy' and 'sell' are the same word field 'kaufen' and 'verkaufen', something that may be less clear in English.

²⁰⁸ Or, 'sulphuric acid'.

15 gut wirt vnd alles fewrwerck vnd besunder
vnder alles pulfer denn es hitzigt vnd sterckt
vnd hebelt alle stuck für verderben war
zu man es praucht

20 Also soltu swebel öl machen nym[m] sweb
el wie vil du wilt vnd stoß in gar
wol vnd tu dar zu salsparatu[m] auch wol
gestossen vnd wol gemischt vndereinander

fol. 36 v
1 vnd schüt dar zu accetu[m] benedistillatu[m] vnd
vnd laß es wol sieden in einel[m] verdeckten
haffen piß das der haffen wol trucken werd
vnd tu das in ein ro[n]turbit vnd ain alambte
dar auff vnd leuter das gar wol vnd
setz das auff ein offelin auff die aschen
vnd mach ein gefug fewr piß es auch
tropflin vnd mach dar auß ein groß fewr
das du kainen dunst mer sechst do von
10 gen Ditz öl ist auch gut zu medicinas
vnd ist auch gut zu dem pulfer vnd
gibt dem pulfer kraft vnd behelt es für
verderben Item nym[m] kampfram z i petrali
z iii arsenicu[m] et decarbonibus vite oleum

and good for all fireworks and especially
for all powder. As it is hot and strong
and moves all parts, make sure it does not get spoiled
as you may need it.

And when you want to make oil of sulphur then take
as much sulphur as you want and grind it well
and add to it *salsparatum*,²⁰⁹ grind it
well and mix it well together.

fol. 36 v

Add to it *acetum bene distillatum*²¹⁰ and
let it boil well in a covered
pot until the pot has dried out well.
Place it into a cucurbit,²¹¹ and put an alembic
on top of it, and let it purify well.
Place it in an oven on ashes
and make a moderate fire until it
starts to drip. Then turn it into a large fire
until you cannot see any more steam coming
from it. This oil is also good as medicine
and is good for powder. And it
provides strength to the powder, and protects it
from getting spoiled. Take 1 pound of camphor, 3 pounds of petroleum,
arsenicum et decarbonibus,²¹² vite oleum

²⁰⁹ Possible scribal error; likely to be 'salpraticum' (see, for example, Dillingen Ms. XV 50, fol. 27 v, or Freiburg Ms. 362, fol. 87 v).

²¹⁰ See footnote above. The addition of 'bene' may imply that 'distilled oil' ('*aceto distillato*') may even be sold in different forms with this version being of higher quality.

²¹¹ In other *Firework Books* this is referred to as a '*alempft*' (Freiburg Ms. 362, fol. 87 v) or '*kukurbit vnd alent*' (Stainer (1529), 33), or '*kachibit*' (Dillingen Ms. XV 50, fol. 27 v) = something related to a '*Destillierkolben*', or '*kupfferin beckin*' = copper pot (Nibler (2005), 29); or 'cucurbit' as base unit to an alembic.

²¹² The precise nature of this ingredient is unclear. Freiburg Ms. 362 refers to the ingredients at this stage as '*arsenicum de carbonibus*' (fol. 87 v) which is mirrored in the Stainer print (Stainer (1529), 33).

15

sulpuntis ay et ii vnd tu das in ainen
 haffen vnd vermach das wol mit einer
 bastet z tu essich dar zu bene distillatis
 vnd prenn aquam fortem herauß **Wie**
man das aller pest oleu[m] co[m]pij[la]tu[m] distillatu[m]
machen sol zu welcherley fewrwerck das
praucht wenn das enprint so print es so
grimlich vast das es nyemant erleschen

20

fol. 37 r

kan noch mag all die weil es zeug hat

fol. 37 r

it nor would want to as it contains material.²¹⁶

Nym[m] mitram ellectam z i thuris menstus
 pistus ay et sublimatu[m] argentu[m] vinu[m]
 in campram z i arsenic[m] z i in salarmo[n]iack
 z v i salpratica z iii in hebratica z ii salniter
 z v salphir vinu[m] z v ¶ aquam vite mensu=
 ram ß vnd tu dise stuck vndereinander wol
 gestossen vnd tu dar zu i mensis olie oline
 et distillabitur z iii vinu[m] distillatus vnd
 lug das kein fewr dar zu kum oder es
 mocht nyemant erleschen dan[n] mit aschen
 also hastu das pest oleo co[m]positis distillatis

10

sulphuris,²¹³ each at 2 pounds. Place it in a
 bowl and seal it well with a
 paste.²¹⁴ Add vinegar and distill it well
 and you will have burnt out *aqua forte* as a result. **How**
you make the best *oleum compilatatum distillatum*²¹⁵
which you need for many fireworks. You
need it for lighting it because it burns so
fast that no one can or would want to extinguish

Take 1 pound of *mitram ellectam*, *thuris menstus*
pistus, and *argentum sublimatum*, wine in camphor,
 1 pound of *arsenicum*, and 1 pound of salammoniac,
 and 6 pounds of *salpratica*, 3 pounds of *hebratica*, 2 pounds of *salnitre*,
 and five pounds of *salphir vinum*, and 5 pounds of *aqua vita mensuram*.
 And put all these ingredients together, grinding them
 well. Add to it 1 pound of *olie oline et*
destillatur and 3 pounds of distilled wine. Make
 sure that no fire gets to it, or no
 one could extinguish it. In the ash
 you have the best *oleo compositis distillatis*.²¹⁷

²¹³ It is unclear what this ingredient is intended to be. Freiburg Ms. 362 refers to the ingredients at this stage as ‘*vite oleum sulfuris*’ (which is mirrored in Stainer (1529) as ‘*vitriolum sulphur*’, and in Dillingen Ms. XV 50 (fol. 27 v) as ‘*vitriolum sulphuris*’.

²¹⁴ Other *Firework Books* refer to this as ‘*pedast*’ (Freiburg Ms. 362, fol. 87 v) or ‘*petast*’ (Dillingen Ms. XV 50, fol. 27 v) = ‘*Destillierhalm*’. The suggested translation ‘paste’ here is based on the original word used.

²¹⁵ It is not clear what this term refers to. It is a section could not be found in most other *Firework Books*.

²¹⁶ The implication is that this is highly flammable, and adding water to it would make the fire burn more vigorously.

²¹⁷ It was not possible to establish a meaningful translation for the ingredients without additional information and context required. This section is not replicated in many other *Firework Books*. The two notable exceptions are the Dillingen Ms. XV 50 (fol. 27 v):

Wie man verdorben pöß pulfer wider pringt vnd es im wern sol

¹⁵ **E**s du ein pulfer schaidest vnd du es wider vnderinander temperiern wilt so nym[m] zway pfunt salpetters vnd ein lb als er dir indem sack beliben ist vnd nutz das also her auß als vil sein dan[n] ist vnd tu weder swebel noch kol dar zu vnd stoß das ab tum acceto distillato vnd laß das gar wol trucke[n] an der sunne[n] vnd tu con

fol. 37 v
nortainu[m] dar zu so hastu gut pulfer er=
nert von dem pössen **Aber wie man sal=
petter leuttren sol**

⁵ **W**iltu salpetter leuttren als du wol waist so ným[m] in vnd schlach in

How you bring back spoiled, bad powder and how it can become new again.

When you separate the powder and you want to mix it together again, then take two pounds of saltpetre and one pound²¹⁸ which has remained in the bag. Take as much of it as possible and add neither sulphur nor charcoal to it and grind into it *acceto distillato*²¹⁹ and let it dry out well in the sun and add

fol. 37 v
*connortainum*²²⁰ to it, and you have good powder renewed from bad. **But how you shall purify saltpetre.**

If you want to purify saltpetre as you know well, then take it and put it

Nym mirram cloctam vi thwe mestr pict aij z solimatu[m] argintu[m] vinu[m] pitampffan z l chr z senitu z l salarmoniack z vi salpartica z l pi hebrayca ß vr tu dise stark vnder ain ander wol ge stossen vn[d] tû dar zû ain meß oliu[m] oline + disstillabitum z iii vrtu[m] distillate[m] vn[d] lüg das kain für dar zû komen müg oder es möcht nieman erlöschten denne mit aschen. Also haust du das aller best oleu[m] col[m]paitu[m] distillatu[m].

and Darmstadt Ms. 1074 (fol. 33 v):

Nym mirvram clertra[m] zi thuris menstis pistis ay et sublimate[m] argentu[m] vinuu[m] in campfram zi arsenic[m] zi in salaram[n]iak z vj salpratica z ij inhebratica z ij salniter z x salphir vinu[m] z v aqua[m] vite niefirra[m] ß vn[d] diese stuck vntter einandr wol gestossn vnd ihn darzu 1 mensis olie iline et distillabi[tur] zm vnu[m] distillate[um] vnd lug daz chain fewr darzu kum oder es mocht niemant erlesche[n] dann mit aschn also hast du das peßt oleu[m] conport[is] distillat[um].

²¹⁸ Likely scribal omission; must have been sulphur and charcoal.

²¹⁹ Kept in its original as it is not certain what this refers to. Hassenstein refers to it as 'distilled vinegar' ('Tropfessig'; Essig, der durch tropfweises Destillieren gereinigt ist' Hassenstein (1941), 39) and others followed (e.g. Nibler (2005), 9, and Kramer (2001), 28). It certainly seems to be an ingredient known to any practitioner.

²²⁰ Not clear what this term refers to. In other manuscript it is described as 'confortium' (Freiburg Ms. 362, fol. 82 v), 'confortatium' (Stainer (1529), 28). Kramer interprets this as a 'reinforcer' (Kramer (2001), 40).

durch ein reittern vnd was in der reittern
 beleibt das seud in harn der von wein=
 sey gemacht als lang als man visch
 seut vnd geuß in dann ab vnd laß in
 sten piß er kalt wirt Zu dem andern=
 mal so seud in in wein als vor Zu dem
 dritten mal so seud in in acceto distillato
 als vor Zu dem vierden mal sued in
 in vino distillato als vor Und also hastu
 salniter s[al]p[r]at[ica] in quartu gradu doch schut
 alwegen des salpetters wasser gar wol

**Wie man stangen auß auß puchsen schiess[e]n
 ssol**

Wiltu stangen oder pfeil auß
 der puchsen schiessen sol so lad
 die puchsen dreÿ tail mit pulfer vnd
 man ein linden clotz auß leim als der
 clotz zu der puchsen sein sol vnd spitz die

fol. 38 r
 1 stangen als sie für den clotz gehört in das
 ror vnd schlach oben ein hülzein zweck
 zwischen die puchsen vnd die stangen vn[d]
 mach ein stül der sich hoch oder nider

through a sieve.²²¹ What remains in the sieve
 boil in urine which has been made from wine
 as long as you would boil a fish.
 Pour it [*the reduced liquid*] off and let it
 rest until it has cooled down. The second time,
 boil it [*the saltpetre crystals*] in wine as before. The
 third time, boil it [*as above*] in *acceto distillato*²²²
 as before. The fourth time, boil it
 in *vino distillato*²²³ as before. And thus you have
salniter salpratica in ‘*quartu gradu*’. Make sure
 that you pour away the saltpetre water.²²⁴

**How you fire rods out²²⁵ of
 guns.**

If you want to fire rods or arrows out
 of guns, then you should load
 the guns with three parts of powder and
 make a soft (or lime) wood plug out of clay so that the
 the plug sits [*tightly*] in the gun.²²⁶ Sharpen

fol. 38 r
 the rod which has to be in front of the plug, and put it into
 the barrel. Drive in a wooden twig
 between the gun and the rod and
 make a rest which can be raised or lowered

²²¹ ‘reiter’ is defined as ‘a coarse sieve, especially used for sifting wheat’ (*Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

²²² Presumably here ‘distilled vinegar’, but it is not clear what the benefit would be.

²²³ Presumably here ‘distilled wine’, but it is unclear what chemical reaction this would cause.

²²⁴ This presumably refers to the water in which the saltpetre crystals were formed.

²²⁵ Repetition of ‘auß’ – appears to be a scribal error – not translated.

²²⁶ This presumably is a reference to its size and shape.

5 laß treiben vnd leg den[n] die stangen dar
 auff das sie der puchsen geleich sech so mag
 dann die stang geleich von der puchsen
 gen vnd wann du sie geladest so zund sie
 and vnd lauß sie lauffen **Wie man einen
 hagel schiessen sol**

10

Wiltu einen hagel schiessen so mach
 eine[n] herten clotz der vmb das
 halbtail kurtzer seÿ dan[n] er prait seÿ vn[d]
 lad den geleich an die puchsen vnd lad
 vier stain i in den clotzen das sie den clotzen
 nit an rwre[n] vnd schlach wol geprantent
~~wet~~ leim dar ein der mit porzis mit vierol
 vnd mit salz vnd mit puppill[i]n saft wol
 gepert seÿ vnd stoß den[n] vil stain die in
 der maß sein als die aÿr oder grosser vn[d]
 vermach es dan[n] aber mit dem vor gena[n]te[n]
 leim piß das die puchs vol werd vnd

20

fol. 38 v

1 schlach sie mit einem tvibel vast wol auff

and place the rod onto it
 so that it stays level with the gun. This
 way the rod can leave the gun level
 and when you have loaded it, light it,
 and let it run. **How you fire a
 hail of shot.**

If you want to shoot a hail of shot, make
 a plug of hard wood which
 is half as short as it is wide. And
 load it tightly in the gun. Then load
 four stones ahead of the plug so that they
 do not touch it. And add well burned
 clay²²⁷ which has been enriched with *porzis*,²²⁸
 with *vierol*,²²⁹ with salt, and with *poplar juice*.²³⁰
 Then, drive in more stones
 which are of the same size or bigger and
 seal it with the aforementioned
 clay so that the gun is full and

fol. 38 v

hit it with a rammer tightly together.

²²⁷ Scribal error in original – crossed out. Translates as ‘wine’.

²²⁸ This term could not be identified. In Freiburg Ms. 362 the German original is ‘*porf*’ (fol. 88 r), in Dillingen Ms. XV 50, fol. 28 r, it is ‘*porris*’, and in the Stainer print as ‘*porren*’ (Stainer (1529), 34).

²²⁹ The term used here is unclear but it is most likely to relate to a particular type of oil. In the Freiburg manuscript the German original is ‘*vye*l’ (could just mean ‘oil’) (fol. 88 r) and it is not listed in the Stainer print.

²³⁰ Kramer suggests ‘virgin’s milk - calomel Hg₂Cl₂ as preservative’ but how this conclusion was reached is not explained in detail (Kramer (2001), 58). In Dresden Ms. App. 463, fol. 62 r, ‘*Pappel safft*’ (‘juice of poplars’) and in Freiburg Ms. 362, fol. 88 r, ‘*pupillen safft*’ (‘juice of pupilla’). In Stainer (1529) this is transcribed as ‘leeks’ and ‘juice of poplars’ (‘*Porre*’ and ‘*Pappelsafft*’, Hassenstein (1941), 74). The meaning of the addition is not clear. One other suggestion could be from ‘*purpul*’ or ‘*purpur*’ – from ‘*purpura*’ – the colour ‘purple’. This would provide a reason for this addition as it would dye the powder purple.

einander vnd lug das du die puchhs ver=
sorget das nichtzs vor ir seÿ vnd auch
in gut noch nutz noch behender seÿ **Wie**
5 **man einen igel schiessen sol vnder eim folck**

Wiltu einen igel schiessen vnder
eim folck von vierhundert stucke[n]
vnd nach dem vnd die puchhs ist so lad
die puchhsen gar starck mit eine[m] püchem
10 clotz vnd haiß dir ein eÿsnein plochlein
fur den clotz machen als der clotz preit seÿ
vnd haiß dir machen so nil eÿsner starck
Wie man auß der puchhsen behendlich vnd
gewiß vnd gewer lern schiessen sol

Wiltu behend vnd wol lern schies=
sen so nym[m] stain geleich in die
puchhs gehoren vnd swem den in hartz
vnd in wachs vnd lad die puchhsen mit
leim vnd mit den[n] staine[n] vnd mit pis=
sen an stopfen vnd also machtú behend
20 schiessen benefencio **Wie man auß der**
puchhsen schiessen mag mit wasser an pul

fol. 39 r

Be careful that the gun does not have
anything in front of it and that it is looked
after, and in working condition. **How**
to fire a hedgehog²³¹ into a crowd.
If you want to shoot a hedgehog into a
crowd of four hundred people,
depending on the gun, then load
the gun tightly with a beech
plug. And have a small iron sheet made
for the plug which is as wide as the plug,
and have made as many²³² as you have iron pieces.²³³
How you fire quickly and accurately
and how you learn to fire accurately.

If you want to learn to shoot well and quickly,
then take a stone which is the same size as the
gun and soak it in resin
and in wax. And load the gun with
clay and the stone, and fill it up with
wedges, and you can shoot quickly
and very well.²³⁴ **How you**
fire a gun with water

fol. 39 r

²³¹ Kramer translates this as 'grapeshot' (Kramer (2001), 58) – which makes sense from the context, but could not be substantiated from the original word.

²³² Possible scribal error. More likely from context to be 'vil'.

²³³ Compared to the Freiburg manuscript the text here seems to be incomplete. Freiburg Ms. 362 contains two more lines which explain this section in more detail: fol. 88 r: '*als denn verschiessen wilt vnd lad die hart für das blächlin das vor dem klotzen ist*' which could be translated in relation to the above as 'which you can fire. Load them tightly to the plate where the plug is'.

²³⁴ The word in the original is 'benefencio', and it is presumed that it is a misspelling of 'beneficio'.

1 **pulfer also das das wasser das pulfer
verwischet vnd als wert vnd als starck
mit scheust als mit pulfer**

Wiltu mit wasser schiessen das du
dann kain pulfer prauchst vnd
stercker vnd weitter scheust dan[n] ob du das
pest pulfer hest das ye gemacht ward
so nym[m] salpetter vnd distiller das zu was=
ser vnd den swebel auch zu öle vnd salar=
moniak auch zu wasser vnd nym[m] oleum
benedictum auch dar zu nach gewicht
als du wol hern wirst wann du das was=

ser zu same[n] pringen macht so nym[m] sechs
tail salpetter wasser zwaytail swebel=
wasser zwaytail salarmo[n]iak zwaytail
deoleo benedicto vnd lad die puchsen
vast mit clotzen vnd mit staine[n] vnd geuß
dise wasser in die puchsen ain zechen tail
vnd zünd sie an mit zucken das du do
von komen magst vnd luge das die
puchts vast starckt sey mit disem wassern
scheust du mit einer gemaine[n] puchsen

fol. 39 v

1 ob dreÿ tausent schrit weit es ist aber
gar köstentlich **Wie weit man schieß von
gemaine[n] oder zu geleuten starcken pul=
fer schiessen mag**

**in the powder when water has got
into the powder and it is as strong and worthy
to fire as it is with [dry] powder.**

If you want to fire with water so that you
do not need any powder [*at all*], and to
fire more powerfully and further then you would with the
best powder that was ever made:
take saltpetre and distill²³⁵ it to water
and the sulphur to oil, and salammoniac,
and also to water. Also take *oleum
benedictum* which you have weighed
as much as you want to hear. In order to bring the
water together, take six
parts of saltpetre water, two parts of sulphur
water, two parts of salammoniac, two parts of
oleum benedictum. And load the gun
tightly with a plug and with a stone and pour
this water into the gun, up to one tenth of a part [*of the gun*].
Light it it with tinder so that you
can get away. Make sure that the
gun is very strong. With this water
you can fire with a common gun

fol. 39 v

up to three thousand paces but
this is rather costly. **How far you fire
with common or with purified, strong
powder.**

²³⁵ Possible scribal error. More likely to mean 'dissolve'.

5 **E**in gemainer schuß von der puchs
vnd von pulfer ist funfzehen hun=
dert schrit weit oder in der selben maß
aber von gelauterte[n] pulfer funffund=
zwaintzig hundert schrit weit **Das ma[n]**
10 **kamer puchsen getrawen sol wie sie ist**

Aber ein andre ler sich das du kamer
puchsen nichtzs getrawst sie sey
clein oder groß vnd sie sey beschlagen
der nicht sie sey übel oder wol geladen
15 wie die puchs sey so hüt dich nichtzs dest[o]
mýnder dar vor Auch lug wen[n] du sie
ladedst das kein eysen das ander rwr wan[n]
das pulfer mocht villeicht do von enzündt
werden **Wie man ein gut conferttet mach=**
20 **en sol das zu allem fewr wreck gar gut**
vnd nutz ist

Ným[m] ein pfunt geschla=

A common shot from a gun
with [common] powder goes fifteen hundred
paces, or, with the same measurements
from purified powder twenty-five
hundred paces. **That you**
236 **trust chamber guns as they are.**²³⁷

But other instructions [teach] you that you
cannot trust chamber guns: whether they are
small or large; whether they have been repaired;
whether they have been loaded badly or well.
What ever state a gun is, do not take less care
about it. And make sure when you
load it that no iron touches any other as
it may set the powder
alight. **How you make good paste**²³⁸
238 **which is useful and good for all**
fireworks.

Take one pound of 'beaten water'²³⁹

²³⁶ Likely to be pocket or hand guns, as the context refers to the size only. In other Firework Books the term 'kamer' is not mentioned in this section, e.g. Freiburg Ms. 362, fol. 88 r, or Dresden Ms. App. 463, fol. 63 v.

²³⁷ Sentence structure incomplete; sense not clear.

²³⁸ Kramer translates this as 'intensifier' without explanation (Kramer (2001), 59), while Nibler describes it as 'strengthened' ('Verstärkungsmittel' Nibler (2005), 31). It is likely to be something which improves some of the quantities of the powder, but it is unclear that the word states this, hence translated into 'paste'. Other Firework Books refer to this as 'confortet' (Freiburg Ms. 362, fol. 88 v) and 'confort' (Dillingen Ms. XV 50, fol. 29 r).

²³⁹ Not clear what 'beaten water' refers to. Kramer (2001) interprets this as 'geschlagenes wasser [urine]' (Kramer (2001), 59) while Nibler interprets it as 'lukewarm water' while providing some critical commentary. He doubts Kramer's assumption that this could relate to urine, and wonders whether it could refer to the temperature of water, thus translates it as 'lukewarm water' ('Kramer vermutet hier „abgeschlagenes Wasser“, also Harn, aber es ist offen, ob der Ausdruck um 1400 gebräuchlich war, und was Harn im Rezept soll. Schmeller kennt (ab-)schlagen in diesem Sinne nicht! Denkbar ist auch „geschlagenes wasser“ = „überschlagenes Wasser“ => lauwarmes Wasser.' (Nibler (2005), 57).

gens wasser pleÿ dreÿ pfunt sweb

fol. 40 r

- 1 els newn pfunt salpeters ein pfunt salar=
mo[n]iak arsenicum ß mercuriu[m] sublimatu[m]
ein pfunt vnd leg die in einem hafem wol
gestossen vnd tu dar zu pawmöl da es
5 ploß über die materÿ auff gang vnd
vermach den hafem wol mit gepran=
tem leỹm das der dunst nit do von mügt
vnd tu den hafem über ein gefug fewr
vnd laß in als lang ob dem fewr vnd
10 prich in auff so ist er worden Item trück=
en es ein manet an der sunne[n] so vil vnd
du sein prauchen wilt das übrig laß
in dem hafem Item hüt dich das vnder
zehen pfunden nit mer nempft den[n] sechs
15 lot vnd besunder zu fewr pfeiln vnd
zu fewr kugeln ist es die pest kunst
die yemant gehalten mag **Wie man**
auß einer puchs etwen vil clotz mit aine[m]
anzünden schiessen sol vnd das yedlich
clotz sein besunder clepsi tut vnd doch
mit mer dan[n] zu mal an gezundt wirt

Wiltu ein clotz puchsen beschiessen mit

three pounds of lead, nine

fol. 40 r

- pounds of sulphur, one pound of saltpetre, and a pound of
salammoniac, *arsenicum*, and *mercurium sublimatum*.
Put them all into a bowl, and grind
them well. Add to it some tree oil so that it
covers the ingredients. Seal
the pot well with burned
clay so that no steam can escape from it.
And put the pot into a moderate fire and
let it stay for some time on the fire.
Break it open and it is done. Let as much as you want
dry in the sun for a month.
The remainder you can keep
in the pot. Be careful that out of
ten pounds you do not take more than six
lots. Especially for fire arrows and
for fire balls this is the best 'art'
which anyone may want to have. **How you**
fire many plugs out of a gun with one
light, and each plug
has its special clap.²⁴⁰ **And you have**
more than you require to set it alight.

If you want to fire a plug gun²⁴¹ with

²⁴⁰ In the meaning of a 'loud bang'.

²⁴¹ Kramer asserts that this refers to a 'type of charge' not a 'type of gun' (Kramer (2001), footnote 16). However, not every gun takes this kind of load – they also need to be lit from the front. See Leng (2000), 104-105, and also Biringuccio (1959), 425-428, where they are described as fire tubes.

fol. 40 v

1 sechs oder zechen clotzen sie sein eysnein
oder pleyein vnd ye ein stuck nach dem
andern get so tu zu dem ersten als vil
pulfers in die puchsen als lang die clotz
5 sein vnd schlach den clotz auff das pulfer
vntz das sie vol werd es sol ein yedlich
clotz ein durch geng plöchlein haben
das das fewr von einem durch das ander
gen mügt Die plochlein sullen in der maß
10 groß sein als ein spindel spitz vnd laß
pulfer durch die löcher vnd stoß ein
swebel kertzen dar ein vnd zünd es an
so clopft einer nach dem ander piß das
die pichs ler wirt **Wie man einen pfal**
15 **in einem weg verprennen mag wie tieff**
er stet

Wiltu einen pfal verprenne[n]

in einem weg wie tieff er stet
so ^{nyv[m]} ludern vnd netz die in oleo benedicto
20 cu[m] aqua salniter als vor in disem pûch
stet vnd bewind das pfal mit disen
ludern vnd scheusch einen prin[n]enden
fewr pfeil in ainen pfal so enzunden die

fol. 40 v

six or ten plugs which are made out of iron
or lead, and one piece goes off after the other,
then first add to the gun as much
powder as the plug is long.²⁴²
Drive the plug onto the powder
until it fits tightly. Each
plug should have a small piece of metal
so that the fire can go from one through to
the next. The pieces of metal should have a hole
the size of the tip of a spindle, and this lets
the powder through the holes. Insert a
sulphur candle and set it alight.
This way one knocks one after the other until
the gun is empty. **How you**
25 **burn down a pole²⁴³ on a path however deep**
it stands.²⁴⁴

If you want to burn down a pole

on a path however deep it stands
then take some cloth and wet it [*the cloth*] with *oleum benedictum*
and salniter water as has been described in this book above.
And wrap these cloths around the
pole and shoot a burning
fire arrow at the pole. And it [*the arrow*] lights

²⁴² Meaning 'the same amount of powder as the plug is wide'.

²⁴³ This relates to a wooden 'pole, post, stake' but the context is not sufficient as to what function the pole has at this point.

²⁴⁴ Kramer suggests that this could be translated as a pole in a 'pool', 'pond', or 'ditch' (all of which in their function as 'way marker'). However, this is cannot be evidenced from the context (Kramer (2001), 59).

fol. 41 r

¹ ludern vnd prinne[n] all die weil sie
 clein feuchtein von dem wasser gehaben
 mag wann die lauttern haben vmb den
 pfal gar vast gepunden and er erst
⁵ wan[n] sie prinnen in dem wasser wol auf
 vier und zwanzig stund ee das wol=
 len verprinnen die feuch schlech alweg
 von dem wasser and das fewr an den pfal
 piß das er verprint **Wie man auß ainer
 puchsen gewiß schuß schiessen sol**

¹⁰

Wiltu auß einer puchsen schiessen ge=
 wiß schuß so sich das du den erste[n]
 schuß nit zu hoch schiescht oder du macht
 komen pald in kainem mer Auch soltu
¹⁵ wissen die gewicht des stains vnd des clotz
 vnd des pulfers vnd sein kraft solt du
 wol wissen was es tragen mag als du
 wol hast in disem pûch Wiltu sicher
²⁰ vor der puchsen sten das sie dir kein
 laid tu so lug des ersten das du in dem
 namen gottes nicht schiest **Wie man
 fewr stain auß einer pleienden oder werck**

fol. 41 v

¹ in ein fest stat wffen sol

Wiltu fewr stain auß ainer pleien=

fol. 41 r

the cloth and all of it [*the pole*] will burn as it
 is a little wet from the water.
 The cloth has to be tightened
 neatly around the pole. It will
 burn away completely in water after
 burning four and twenty hours.
 The fire is driven away
 by the water but the fire stays with the pole
 until it has burned down.²⁴⁵ **How
 to fire an accurate shot from a gun.**

If you want to fire a shot out of a gun
 accurately then make sure that the first
 shot is not too high or you may
 not make another one. Also you should
 know the weight of the stone and the plug
 and the powder and its power. You should
 know well what it can cope with as you
 have had described in this book. If you want
 to stand safely in front of the gun so that no harm
 will come to you, make sure first of all that you do not fire
 in the name of God. **How you throw
 a fire stone from a gabion or from a siege tower into**

fol. 41 v

a fortified town.

If you want to throw a fire stone

²⁴⁵ The assumption here is that the fire is not extinguished completely but keeps burning due to the very wet pole.

den oder werck weffen so nym[m] de[n]
stain als in das werck oder das pley
5 gewerffen mag vnd swem[m] in in sweb=
el vnd in hartz vnd wirff in dan[n] in
puchsenpulver vnd mit den zwilchein
tûchern über var den stain oder über=
zeuch in vmd swem in aber in swebel
10 vnd in hartz vnd nym[m] vnd wirff in
dan[n] aber in puchsenpulver vnd nym[m]
denn barchat tuch vnd stoß es in den
swebel vnd hartz vnd über zeuch den
stain aber do mit vnd see oben an ein
15 clein puchsen pulver dar auff die weil
das tuch naß ist vnd wen[n] du den
stain werffen wilt so leg zunder hartz
dar an vnd zund das wan[n] du dan[n]
das werck laust lauffen so print es
20 in dem seckel vnd tut vast grossen
schaden in vesten vnd in stetten **Wie**
man gar gut fewr pfeil machen sol

fol. 42 r

1 **W**iltu gar gut fewr pfeil machen so
nym[m] dreÿ pfunt salpetters ein pfunt sweb=
els ein halb pfunt kols vnd stoß das zu pul=
fer vnder einander vnd bint das pulver zu

from a gabion or from a siege tower, then take
the stone you want to throw from a siege
tower or a *pley*.²⁴⁶ And soak it in sulphur
and in resin and put it into
gunpowder. And brush a cotton
cloth over the stone or polish
it and soak it once again in sulphur
and in resin and take it and put it
into the gunpowder again. And take
fustian cloth and put it into the
sulphur and the resin and wipe
the stone with it. Make sure that a
little gunpowder stays on it as the
cloth is wet. And when you
want to throw the stone, add tinder resin
to it and light it. When you let
the siege tower do its work, it burns in its
bag and causes great
damage in castles and in towns. **How**
to make a really good fire arrow.

fol. 42 r

If you want to make good fire arrows then
take three pounds of saltpetre, one pound of sulphur,
one half of a pound of charcoal, and grind it together
into powder. Bind the powder together with

²⁴⁶ Seems more likely to be referring to a short form of '*pleienden*' for 'gabion', and not lead ('*Blei*') as the stem may suggest. The use of a shortened form may imply a familiarity with siege devices both by the author and any potential reader. Nibler interprets these as 'incendiary devices which were projected via slings' but that does not seem to be clear from the original (Nibler (2005), 32).

- 5 samen mit geprantem wein vnd mach den[n] ein clein stecklein auß parchat tûch als lang als der pfeil sey vnd tu den taig in den sack vnd stoß den pfeil dar durch vn[d] verpind in mit einem vaden hynden an vnd vornan vnd swem es in swebel oder in hartz vnd laß es trucken werden so hast du gar gut fewr pfeil **Wie man macht das sich wasser enzundet**
- 10 **W**iltu machen das sich wasser en= zundet so nym[m] unerloschen kalck vnd laß vil swebels an der wag vnd auß der materÿ mach ein dach vnd spreng dar auff wasser so enzûnt es sich vnd geuß öl dar auff so j list es **Wie man swebel öl machen sol**
- 15 **W**iltu machen swebel öl das dir zu starckem fewr pulfer gut
- 20 fol. 42 v
seÿ vnd nutz so nym[m] aÿr tottern die hört ge= soten sein vnd stoß die in einem morser gar wol piß das sie werden als ein schmaltz so nym[m] dan[n] lebendigen swebel wol gestossen vnd durch ein tûch gesaigt vnd misch es
- brandy and make a small bag out of fustian cloth which is as long as the arrow. And put the paste in the bag and punch the arrow through and tie it with a piece of string at the back and the front. And soak it in sulphur or in resin and let it dry out, then you have a very good fire arrow. **How you make water set itself alight.**
- If you want to make water that sets itself alight, then take quicklime and leave a lot of sulphur on the scales. And make a pile out of these and sprinkle water on it.²⁴⁷ This will set it alight. And pour oil on it to extinguish it. **How you make sulphur oil.**²⁴⁸
- If you want to make sulphur oil that is good and useful for strong fire powder
- fol. 42 v
then take egg yolks which are hard boiled and grind them in a mortar until they become like lard. Then take the native sulphur which has been ground well and has been passed through a cloth. And mix them

²⁴⁷ Assuming that it is the same quantities of quicklime and water. However, this is not made clear in the text. Quicklime, or, Calcium oxide (CaO), is highly flammable, reacts with water.

²⁴⁸ It is not clear what sulphur oil is intended to be or is meant to achieve. Sulphur cannot be dissolved in oil. As the recipe does not list quantities it does not provide enough context to recreate the recipe.

durch ein ander vnd rüer es vast das es ein materÿ werd vnd tu es dann in ein kurbs vnd pren[n] es auß zu ol als du wol waist **Wie man ein fewr machen sol do mit alexander das lant agarzono= rum verprant**

10

Wiltu fewr machen do alexander mit das lant agarzenoru[m] ver=prant so nym[m] palsam ein pfunt gloriat ein pfunt öl vnd ayr funff pfunt lebend=igs kalcks zehen pfunt vnd reib den kol mit dem öl das es ein confet werd vnd bestreich dan[n] den stain do mit oder kraut oder was fruchtig sey das enzünt sich mit der materÿ von dem ersten regen der dar auff kompt vnd verwiest es als sampt vnd spricht aristotiles das

20

fol. 43 r
das fewr zehen jar werhaftig sey **Wie ma[n] ein fewr mache[n] sol wen[n] der regen dar auff kumpt das es sich selber erzündent**

1

Wiltu ein fewr wann der regen dar auff kompt das es sich enzundet

5

together and stir it strongly, so that it becomes one consistency and put it into a cucurbit²⁴⁹ and burn it into oil as you know well. **How you make a fire which was used by Alexander to burn the land of Agarzonorum.**²⁵⁰

If you want to make the fire with which Alexander burnt the land of Agarranora, then take a pound of balsam, a pound of oil of turpentine,²⁵¹ a pound of oil, five pounds of eggs, and ten pounds of quicklime. And grind charcoal together with the oil [*mixture made above*] so that it turns into a paste. And spread it over the stone, over the plants, and over all that is fruitful so that it catches fire with this mixture at the first rain which falls on it and it becomes one. And as Aristotle says that

fol. 43 r
the fire truly burns for ten years. **How you make a fire which lights itself when rain falls on it.**

If you want to make fire which lights itself when rain falls on it then

²⁴⁹ Augsburg manuscript, III, 1.2°.44, fol. 48 r: 'kukerbit'.

²⁵⁰ This is presumably a reference to Greek fire. This section has previously been added in some *Firework Books*, referring to it as 'Agarranora' or 'Aggarorum', e.g. Munich Cim. 30150, fol. 145 r, and Dillingen XV 50, fol. 30 v. It was not possible to ascertain what land this term relates to. It is one rare reference to an historical context, and requires the audience to have an understanding of who Alexander was and why or how to set fire to a country.

²⁵¹ The Kassel manuscript 4° Ms. math. 14 refers to it here instead as 'terpentine, which is called people's resin' ('*terbentin, dz feirs luter hartz*', fol. 41 v).

nym[m] lebendigen kalck vnd ein wenig gum-
 merabicum vnd swebel vnd linsad öl vnd
 das mach alles mit ein ander das es ein
 materÿ werd vnd mach dar auß ein pild
 vnd spreng dar auff wasser so enzünt es
 sich vnd mit der selben materÿ machtu
 wol ein yedlich hauß verprennen wann
 der regen dar auff get

10

**Wie man ein fliegend fewr machen sol das
 do fert in die höch vnd verwiest was es
 begreift**

15

Wiltu machen ein fliegend
 fewr das do fert in die höch wa
 du wilt so nym[m] ain tail coloflinia das ist
 kriechisch hartz vnd zway tail lebendigs
 swebels vnd dreÿ tail salniter das reib
 alles gar klein vnd reib es dan[n] mit eine[m]
 clemem linsad öl oder loröl das es dar in

20

fol. 43 v
 zergen das es ein confet werd vnd tu das
 in ein estain ror die lang seÿ vnd gee dan[n]

1

take quicklime, and a little
 gum arabic, and sulphur, and linseed oil, and
 mix it all together so that it turns into one
 consistency. Make a sample from it²⁵²
 and sprinkle water on it and it will start to
 burn. With the same mixture you can
 burn down any house
 when rain falls on it.

**How you make flying fire
 which flies up in the air and drives away
 everything near it.**

If you want to make flying
 fire that flies [*high*] up in the air when
 you want it to, then take one part of *coloflinia*,²⁵³ which is
 greek resin, two parts live
 sulphur, and three parts salniter. Grind it
 together finely and add to it a
 little²⁵⁴ linseed oil or laurel oil so that they melt together

fol. 43 v
 and become a paste. Place it
 in a stone gun²⁵⁵ which is long. Go ahead

²⁵² *Frühneuhochdeutsches Wörterbuch Online*, Def. 6, 'Beispiel' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/bild.s.2n_1513344239).

²⁵³ No exact modern translation could be traced. Heidelberg Cod. Pal. germ. 562 refers to it as '*colosania Dz ist kriechisch hartz*' (possibly 'kolophonium which is Greek resin' – see Nibler (2005), footnote 253: "*colosania*" => "*colofania*" => "*Kolophonium als „kriechisch hartz“ ist ziemlich sicher im Vergleich mit „callofonna“ in Cpg 562, 4“*); Kassel 4^o Ms. math. 14 refers to it as 'Greek tar' ('kriechisch pech'), fol. 42 r.

²⁵⁴ In the meaning of 'little quantity'.

²⁵⁵ This could be a '*Steinbüchse*', and would be one of the first times that the term was mentioned. See chapter 4 for more details. Other manuscripts refer in this section to '*aichin ror*' (Dillingen Ms. XV 50, fol. 31 r), '*aicheny rören*' (Stainer (1529), 35), or '*eychne rören*' (Egenolph (1529), 41) which would imply 'made out of oak' and has been

vnd zünd es an so vert es wa du das ror
hin kerst vnd wüst was du begreifest mit
dem fewr **Wie man gar ein starck fewr
pulfer machen sol**

Wiltu machen ein starcks fewr pulfer
so nym[m] alkiträm das ist gloriat vn[d]
swebel vnd öl vnd äyr tottern auß geprant
das nym[m] als mit ein ander geleich tailung
vnd rest das in ainer pfannen gemeinklich
peÿ dem fewr ob einen kohn das es ein con=
fet werd vnd nym[m] dar zu das viertail
wachs dar vnder das es sich mit einander
misch als ein materÿ vnd tu es dann in
einrinden plat die wol gestrichen seÿ mit
öl vnd vmb vach es mit wachs vnd wen[n]
du es nützen wilt so leg die materÿ an ein
stat das es luftig seÿ vnd wen[n] der wint
dar zu get so wirt es priment vnd ver=
wiest alles das das es begreift vnd ist
das man wasser dar auff geust so gewint

fol. 44 r
es tetlich flammen vnd wa man die materÿ
also berait auff ein holz schreibt do enzint
es sich von der sunnen wann es die hitz
begreift vnd verprent es alles **Wie man**

and light it and it flies where you point the barrel
to. And now you know what to do with
this fire. **How you make really strong fire
powder.**

If you want to make strong fire powder
then take liquid tar, which is oil of turpentine,
sulphur, oil, and egg yolk which have burnt out.²⁵⁶
Take equal parts
and place them in a pan together
next to a charcoal fire. [*Mix it*] so that it turns
into a paste. Then add a quart of
wax to it and mix it together so that it becomes
one consistency. And then place it into
a calf's bladder which has been coated with
oil, and seal it with wax. When you want
to use it, take the mixture to an airy place
and when the wind gets
into it, then it will burn. And it
will spread to everything it touches. If
you pour water onto it then it will burst into

fol. 44 r
actual flames. If you spread the mixture thinly
on wood then it will start to burn
by the action of the sun when heat gets
to it and everything will burn. **How you**

interpreted by Nibler and others as a scribal error. As Heidelberg Cod. Pal. germ. 562, fol. 4 r, lists it as 'eyseñn rôr' it has generally been interpreted as 'iron' ('eisern', Nibler (2005), 60). Only Darmstadt Ms. 1074, fol. 31 r, copies the l.34 wording with 'esten ror'. Other manuscripts, such as Freiburg Ms. 362, omit this section completely.

²⁵⁶ No explanation what that means. Nibler (2005) and Kramer (2001) also do not comment. This could simply suggest older eggs.

5 **versuchen so das salpetter gut sey vnd recht geleutert sey**

Wiltu versuchen ob salpetter gut sey vnd recht ge= leutert so nym[m] sein ein wenig vnd leg es auff ainen gluenden koln print es dan[n] schon anspringen vnd das er nit über sich pratzelt so ist er gut vnd gerecht

10

Wie man salpetter versuchen sol ob er mit salz gefelscht sey oder nicht

Wiltu salpetter versuchen ob er mer salz in im hab oder nit oder ob er nicht mer gefelscht sey so nym[m] sein als groß als ein halbe welsche nuß vnd leg es auff ainen gelweden koln oder auff ein prant der wol gelwe print er denn schon auff dem prant also wol vnder sich so ist er gut vnd gerecht pratzelt er aber sich als der salz in ein fewr wirft das

15

20

fol. 44 v

1 ist ein zaichen das er nit wol geleutert ist vnd mer salz da peÿ ist **Wie man salpetter an fewr versuchen sol**

Auch mocht man salpetter wol ver= suchen an fewr wer salpetter nem als groß als ein welsche nuß vnd tu das

5

ascertain that saltpetre is good and has been purified well.

If you want to ascertain whether saltpetre is purified well and properly then take a little and place it onto glowing charcoal. If it starts to burn straightaway and if it does not spit, then it is good and proper.

How you find out whether saltpetre has been adulterated with salt or not.

If you want to find out whether saltpetre contains more salt or not, or whether it is no longer adulterated with salt then take as much as half of a walnut and put it on top of glowing charcoal or on a fire that burns well and yellow. If it burns straightaway on the fire on its own then it is good. But if it sizzles, as if some salt was thrown into the fire, then this

fol. 44 v

is a sign that it is not well purified and that it contains more salt. **How you try out saltpetre without a fire.**

You may also try out the saltpetre without a fire. Take as much saltpetre as the size of a walnut and put it

10 in ein schutzelein das nit schmalzig sey
 vnd geuß dar an ein weing lauters=
 wasser das kalt sey vnd laß es dar in
 sten ein cleine weil vnd saig dan[n] das
 wasser ab vnd versuch es in dem mund
 ist es vast gesalzen vnd hat der salpetter
 vast abgenommen das sein vil mynder
 ist dann vor das get von salz zu ist sein
 aber nit vil minder worden denn vor
 so ist er gut vnd gerecht **Wie man sal=
 petter leuttern sol der vor auch geleutert
 ist vnd doch nit auff sein recht stat ge=
 nug ist**

20

Wiltu salpetter leuttern der dich nit
 gut dunkt vnd der doch vor
 geleutert ist so nym[m] ein kesel vnd mach

fol. 45 r

1 den gar schon das kein schmaltz oder nichtz=
 rt vaistes dar an sey vnd tu dar ein pru[n]=
 nen wasser vnd laß es warmen das=
 dich dunck es wöl schier an heben zu sie=
 den vnd schut den salpetter dar ein vnd
 5 laß in sitlich siedem das er nit uber laufft
 Hat er auch schawm das macht du wol
 herab werffen mit einem schonen leffel

in a bowl which is not greasy²⁵⁷
 and pour over it a little pure²⁵⁸
 water which is cold and let it
 rest for a while. Then drain the
 water and try it in your mouth.
 If it is very salty, then it has less
 saltpetre or it has lost some [of the saltpetre] it had
 before, as this comes from the salt.
 But if it is not much less than before
 then it is good and proper. **How you purify
 saltpetre which has already been purified
 but is not yet in the right
 state.**

If you want to purify saltpetre which does not
 appear to you to be good even after it has been
 purified, then take a pot and make

fol. 45 r

sure that it had no lard or anything
 with fat in it and add some water from a
 well. Warm it gently,²⁵⁹ so that
 it seems to you that it will soon start to
 boil and add the saltpetre to it.
 Let it boil gently so that it does not boil over.
 If there is froth then you can skim
 it off with a good spoon.

²⁵⁷ In the meaning of 'free of lard'.

²⁵⁸ Could be 'distilled' or 'clean' – not clear from the context.

²⁵⁹ Presumably by placing it on a heat source, not specified here.

10 wann er zwen well oder dreÿ tut so nym[m]
 ein saubers holz vnd stoß das dar ein vn[d]
 tropfe die tröpflein auff ein gelwende koln
 oder auf ein prant prinnen die tropfen
 die von dem holtz wallen so hat er sein
 genung Auch mochst du es sust wol ver=
 suchen wann du nÿmpst vier helmlein
 oder funffe vnd stiest die in den kesel vn[d]
 ließ die tropflein auff ein hosen vallen
 oder sunst auff ein wullin tuch würden
 denn die tropflein an dem tuch als eyß=
 20 tropflein so het er sein aber genug Dar
 nach laß den kessel uber schlachen das
 er kalt werd vnd saig dann das wasser

fol. 45 v

1 durch ein zwifach leine tuch oder durch
 eins das dick sey vnd saig in in ein schone
 beckin wer sein aber als vil so saig in in
 ein schön schaff oder in ein weite prenten
 5 dar ein macht du wol legen † vier heltz=
 lach oder fuffe vnd setz es do nÿemant
 dar zu gang vnd laß es sten zwenn tag
 vnd nacht so sichst du wol ob es sich
 an hat gehenckt vnd gesammet so saig

When it has welled up two or three times then take
 a clean piece of wood and dip it into the pot and
 drip a drop onto a glowing piece of charcoal
 or onto a fire. If the drops
 which come from the piece of wood flare up then it is
 [purified] enough. You may also want to try
 taking four or five pieces
 of straw and dipping them into the pot.
 Then let the drops drip on your hose
 or elsewhere onto a woollen piece of cloth.
 If the drops on the piece of cloth become like drops of
 ice then it has boiled enough. After
 this let the pot be set aside so
 that it can cool down. And drain the water

fol. 45 v

through a double linen cloth or through
 one that is thick. Drain it into a nice
 bowl which is big enough for everything you drain –
 a nice bucket²⁶⁰ or a wide barrel.²⁶¹
 In it you place four pieces of
 wood, or five, and place it [*the container*] in such a way that no one
 has access to it and let it stand for two days
 and nights. This way you can see whether it has
 formed and collected. Then drain

²⁶⁰ A 'scheff' or 'scheffel' is a container, often made out of wood, especially used for cereals (*Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

²⁶¹ A 'brente' is defined as a 'wooden container, especially for milk, cured meat, fish, or wine' ('*hölzernes Gefäß, besonders für Milch, gesalzenes Fleisch, Fisch, Wein*', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/brente.s.1f_1513373142) – this statement refers to two types of containers, the second one bigger, more like a tub.

10 dann das wasser ab in ein sauber schir
 vnd nym[m] den salpetter vnd trucken den in
 eim peck oder wer sein als vil so tu es
 auff ein léderlachen so wirt er gut vnd
 gerecht hüt dich all zeit vor schmalz
 15 Dar zu nym[m] das ander wasser das du
 abgesoten hast vnd seud es ander weid
 in eine[m] kessel vnd tu ein geleich als
 vor hernach geschriben stet was dann
 dar an beliben ist das samet sich das
 20 du es auch vinst **Wie man salpetter leut=
 tern sol der roch abgenumen wirt vnd
 nit geleutert ist**

fol. 46 r

1 **W**iltu salpetter leuttern der roch ist
 der abgenomen ist vnd nit geleutert ist
 so nym[m] ein scharpf laug oder tu aber
 kalck in ein schaff vnd geuß wasser dar
 5 zu vnd rier es vmb mit einem stecken
 als ein kalkas vnd laß es stan über nacht
 so wirt es dester leuter vnd tu das in
 ein sche[e]n kessel vnd wen[n] es warm wirt
 so schüt den salpetter dar ein vnd laß
 10 in wol sieden vnd greiff mit einem lef=

off the water into a clean bowl.
 And take the saltpetre and dry it in
 a pot, or – if there is a lot – put it
 on a leather cloth and it will be good and
 proper. Be careful at all times not to add
 any grease. Take the second water which
 you have drained off, and boil it once more
 in a pot. Do the same as
 has been described below. What
 remains is all that
 you can get. **How you purify
 saltpetre which has been taken off raw and
 has not been purified.**

fol. 46 r

If you want to purify saltpetre which is raw
 and has been taken off²⁶² or which has not been purified,
 then take a sharp²⁶³ lye or put
 chalk in a bucket²⁶⁴ and add water to
 it. Stir it with a stick
 like chalk and let it stand overnight.
 This way it will become purer. Put it [*the mixture*]
 in a nice pot and, when it has warmed up,
 pour the saltpetre into it and let
 it boil strongly. Reach to the bottom

²⁶² In the sense of 'scraped off' – no physical description 'off where' provided.

²⁶³ This presumably means 'strong'.

²⁶⁴ As before – larger container (see below).

fel an den poden was stain dar in sein
 die sam[m]en sich an den poden die tu her
 auß vnd schwamm in wol vnd lug das
 er nit über gee vnd das nichtzs schmalzt=
 15 igs dar zu kom Wenn du versuchen
 wilt ob er sein genug hab so stoß ein
 holz dar ein vnd trewff es auff ein ge=
 lwenden kolin print es denn so hat er
 sein genug oder versuch in mit eim
 20 helmlein an eim tuch wirt es dann tropf=
 lein als eÿß so hat es sein aber genug
 so laß es kûlen vnd saig es durch ein

fol. 46 v

1 dick leine tuch oder durch ein filzhut in
 ein peckin were sein aber als vil so seich
 in in ein schenß schaff oder in ein prente[n]
 vnd laß sten aine[n] tag vnd ein nacht dz
 5 man es nit rier vnd leg oben dar ein ein
 wenig heltzlach vnd lug dann dar zu
 ob es sich gesamet hab vnd an gehenckt
 hab hat es sich nicht angehenckt vnd
 gesam[m]et so laß dennoch ein tag vnd ein
 10 nacht sten vnd saig dan[n] das wasser
 ab in ein sauber geschir vnd trucken
 den salpetter in aim schenen peck auff
 einem offen oder auff einer lederlachen
 vnd nym[m] das wasser das du abgesoten

[of the pot] with a spoon. Whatever stone²⁶⁵ has
 collected at the bottom [of the pot] take it
 out. Let it froth and make sure
 that it does not boil over and that nothing
 greasy can get to it. When you want to find
 out if it has been enough dip a
 piece of wood into it and drip it onto
 some glowing charcoal. If it burns then it is
 enough. Or, try it out with a
 piece of straw on a piece of cloth. If a drop
 turns into ice then it is enough.
 Let it cool down and drain it into a bowl through

fol. 46 v

a thick linen cloth or through a felt hat.
 If there is a lot then drain it
 into a nice bucket or into a barrel
 and let it stand one day and one night. [Make sure] that
 you do not stir it but add
 a few pieces of wood to it.²⁶⁶ Have a look whether
 something has formed and attached [to the lattice].
 If it has not formed and
 Collected, then let it stand for a [further] day and
 night. And drain off the water
 into a clean bowl and dry
 the saltpetre in a nice bowl on
 the oven or on a leather cloth.
 Take the water you have poured

²⁶⁵ This presumably means 'grit' or other 'impurities'.

²⁶⁶ 'heltzlach' contains the collective suffix 'lach' which means a small quantity.

15

hast vnd seud es anderwierd vnd laß
 es lenger sieden denn vor vnd tu nü ge=
 leicht als du im vormalis gethan hast
 Was dann dar in ist das sammelst sich
 das du es auch vinst **Wie man puchsen**
pulfer machen sol zu puchsen oder zu
fewrpfählen

20

Wiltu pulfer machen
 zu puchsen oder zu fewrpfählen

fol. 47 r

1 so stoß den salpetter besunder vnd mal
 in als clein das er sich reden laß durch
 ein engs siblein als ein pfeffer sib macht
 du das nicht gehaben so nym[m] einene wei=
 ten peitel vnd peutel ~~win~~ dar durch in
 ein schaff vnd was in dem peutel beleibt
 oder in dem sib das stoß anderweid piß
 du es als hin durch peuteIn mugst vn[d]
 tu den gebeuteiten salpetter besunder vn[d]
 tu den swebel auch besunder vnd laß
 yedlichs besunder den salpetter vnd den
 swebel vnd die kol **Wie man ein gemein**
puchsen pulfer machen sol

10

Wenn du wilt ein gemein pulfer
 machen so nym[m] vier pfunt od[er]

15

off and boil it again and let it
 boil for longer than before and now do the
 same as you have done before.
 What is left in it, will form itself,
 for you to find. **How you make gun**
powder for guns or for
fire arrows.

If you want to make powder
 for guns or fire arrows

fol. 47 r

then grind the saltpetre thoroughly and grind it
 so finely that it runs through
 a fine sieve such as a pepper sieve.
 If you do not have one of these, then take a broad
 bag²⁶⁷ and pour it [*the saltpetre*] through it
 into a bucket. Grind what remains in the bag
 or in the sieve again until
 you manage to get it [*all*] through the cloth.
 And keep the bagged saltpetre separate.
 Do this carefully to the sulphur [*too*] and keep
 the saltpetre and the
 sulphur and the charcoal carefully.²⁶⁸ **How you make common**
gunpowder.

If you want to make common powder
 then take four pounds or

²⁶⁷ This refers to 'beutel' (as is likely from other texts [e.g. Freiburg Ms. 362, fol. 80 v: 'wyten roggen bütel vnd büttel in da durch' = 'roggen peytel' => 'Roggenbeutel' which is hung at the bottom end of a sieve in milling to sieve out impurities). (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/beutel.s.0m_1513517452).

²⁶⁸ Presumably meaning 'separately'.

vier gewicht salpeters vnd nym[m] zway
 pfunt swebels vnd ein pfunt koln das
 haist ein gemain pulfer misch es wol
 durch einander das pulfer ist gut auff
 den kauff vnd mag man es wol geben
 für ein gut gemain pulfer **Wie man ein
 pesser pulfer machen sol einem piderman**

20

fol. 47 v

auff sein schloß

1

Wiltu machen ein pesser pulfer
 einem piderben man[n] auff sein
 schlosch oder hauß der do spruch mach
 mir ein gut pulfer so nym[m] funff pfunt
 salpeters vnd zway pfunt swebels vn[d]
 ein pfunt koln vnd misch es wol durch
 einander das wirt ein gut pulfer **Wie
 man ein pulfer machen sol das noch
 stercker scheust**

5

10

Wiltu machen stercker pulfer
 das noch stercker scheust wen[n]
 der ains so nym[m] sechs pfunt salpeters
 vnd zwey pfunt swebels vnd ain pfunt
 kols das wirt ein gut starck pulfer vnd
 scheust weit **Wie vil man der dreier stuck
 salpeters swebels vnd kol ir yedlichs**

15

four weights of saltpetre and take two
 pounds sulphur and one pound of charcoal and
 this is called common powder. Mix it together
 well and the powder is good to
 be sold and can pass as
 good common powder. **How you
 make better powder than an honest man**²⁶⁹

fol. 47 v

in his castle.

If you want to make a better powder
 than an honest man in his
 castle or house who told me: 'make
 me a good powder'. Take five pounds of
 saltpetre and two pounds of sulphur and
 one pound of charcoal and mix it together
 well [and] then it will be good powder. **How
 to make powder which fires even
 stronger.**

If you want to make an even stronger powder
 that fires more strongly than
 the others, then take six pounds of saltpetre,
 two pounds of sulphur and one pound of
 charcoal. This makes a good strong powder and
 fires long distances. **How much can you take
 of the three ingredients of saltpetre, sulphur, and charcoal**

²⁶⁹ This could be 'upstanding man' or 'man of integrity' – from the twentieth century onwards, the term 'biedermann' obtained a negative connotations – no such reference in *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/biederman.s.0m_1513801728.

auff das swerst gewicht vnd nit mer zu einem pulfer genemen mag

²⁰ Auch mocht man wol ein pulfer machen das man nem ein pfunt koln vnd zweÿ pfunt swebels vnd siben=

[bottom margin right] thalb lb

fol. 48 r
thalb pfunt salpeters nit mer was man mer salpeters nem zu so vil swebels vnd koln das wer nit gut wann es sunst ein starcks gutz pulfer ist **Wie man ein puch= sen pulfer herter vnd zu resch[e]n knollen pulfer machen sol**

¹⁰ **W**iltu ein puchsen pulfer machen herten wann du es dann schon gemischt durch ein ander vnd wol von welcher michtung du es gern[e] hast so tu sein ein ainen grossen morser als vil als oder in ainem stampf als vil du dar in gehaben macht vnd begeuß das mit guten wein essich vnd stoß das wol vn=

before it gets too heavy and cannot be made into powder any more.²⁷⁰

If you want to make good powder then take a pound of charcoal, two pounds of sulphur, and seven and a half pound²⁷¹

fol. 48 r
a half pounds of saltpetre – no more saltpetre than this [*should be added to*] so much sulphur and charcoal as this would not be good. It is otherwise a strong good powder. **How you make gun powder harder²⁷² and into strong²⁷³ Knollen pulver.**

If you want to make gunpowder to be harder when you have already mixed it well together into the mixture you would like. Put as much as [*you want*] into a large mortar or into a stamp mill²⁷⁴ as much as you want to have. Add to it good wine vinegar and grind it together

²⁷⁰ The term 'heavy' is used in the sense of 'imbalanced' here. The issue of ratios has long been a question of scholarly debate. See chapter 4 for more details.

²⁷¹ This note is made at the bottom of the page, most likely as a binding notation as it is at the end of one gathering.

²⁷² It is not clear what the scribe means when he describes the powder as 'harder'. It is most likely that it would make it more resilient to external influences.

²⁷³ 'Resch' often refers to 'fast' and 'speedy'; in this context it is more likely to refer to 'strong' or 'fresh' (see definition 2, *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

²⁷⁴ Such as the one depicted on fol. 87 r (see depiction of illustration at the end of chapter 2).

- 15 dereinander mit einem hultzeim klupfel
vnd mach das also feucht mit dem es=
sich das es sich zu samen trucken laut
vnd pallen wie groß du dann die pul=
fer kugeln wilt machen dar nach nym[m]
ein gleschten swebel vnd tiff tegelin
oder ein nepflein oder ein krupfire schal
vnd truck es also naß dar ein als der
- 20
- 1 fol. 48 v
als der einem keß in einem napf deucht
vnd stre es dann um[b] auff ein pret so get es
gern auß der pulfer kugeln macht du mach=
en als vil als du pulfers hast Ist es in hais=
sem sumer so mag man die kugeln wol der=
ren an der sunne[n] were des nit so müst ma[n]
sie derren in einer stuben die müst man senf=
tigklich ein haitzen vnd müst das tun auff
zehen tag Die kugeln sol man dann neme[n]
vnd sol sie legen in ein dür vaß oder in ein
dür legel vnd setz es an ein trucken stat
do es nit feuchtin hat Das pulfer nimpt
- 10
- well with a wooden pestle.
Make it damp with the vinegar
so that it can be dried together.
You can make powder balls as large
as you would like. Take
*extinguished sulphur*²⁷⁵ and a deep pan²⁷⁶
or a small dish or a copper bowl
and press it into as wet [*as possible*] as if²⁷⁷
- fol. 48 v
you were putting cheese into a dish.
Then turn it upside down on a wooden board and it
comes out easily. Make as many powder balls
as you have powder. If it is a hot
summer, then you may want to dry your balls
in the sun. If it is not, then you have to
dry them in a [*heated*] room. You must warm
them up slowly and you have to do this over [*a period of*]
ten days. You can take the [*dried*] balls
and place them in a dry barrel,
or in a dry store. Put it in a dry place
where it is not damp. The powder
- ²⁷⁵ This may be a reference to 'getötetem' or 'gelöschtem' sulphur. Reference to Christoph Entzel's *Traktat von metallischen Dingen*, 1608, or Franz August von Wasserberg's *Chemische Abhandlung vom Schwefel*, 1788; or, even, in much earlier text such as the fourteenth-century Konrad von Meigenberg, *Buch der Natur* 'Lebendiger Schwebel – erleschter oder toter Swebel' (480) – available as edition by Franz Pfeiffer ed. (1861), *Konrad von Meigenberg: Das buch der natur*, Stuttgart: K. Aue <https://archive.org/details/dasbuchdernatur00pfeigoog/page/n548> – accessed 27 March 2019. Alternatively, this could be a scribal error, as other manuscripts list a number of different containers in which the powder can be mixed together, e.g. Freiburg Ms. 362 refers to it as a 'small glazed bowl' ('verglest sinwel' (fol. 80 r)). If the latter was the case, 'swebel' would be a scribal error.
- ²⁷⁶ 'Container which can be placed into the fire' – could also be 'crucible' but unlikely in this context (see 'Tiegel' – *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).
- ²⁷⁷ Repetition of 'als der', most likely to be scribal error – not translated.

nit ab vnd ist gut wie lang es wert
vor allen dingen so man das pulfer
trucket in der stuben oder süst so sol mal
sein wol hüetten vor fewr vnd vor liecht
wan[n] es kind nyemant erretten es geschech
grosser schad **Wie man fewrpfheil machen
sol die gut sein**

15

Wiltu machen gut fewr pfeil so mach
secklach von parchat vnd nym[m] pul=
fer das do gemacht sey vnd scheub es in die

20

fol. 49 r
secklach so du herrest mugest vnd pind es
zu vmb vnd vmb mit zwifachen faden
so du herrest mugest vnd nym[m] ein eyßen
ain swebels oder das gefiert sey das als
groß sey als das pfeil eyßen vnd stoß es
do mitten durch das secklein nach der leng
vnd scheub das eysen do hin ein vnd über
zeuch in mit swebel so hastu einen guten
pfeil **Wie man fewr pfeil machen sol wie
wie lang sie ligen das sie nit rostig werde[n]**

fol. 49 r

the bag to get hard and tie it
around it with a double thread
so that it hardens. Take a [piece of] iron,
which is round²⁷⁸ or four-cornered, which should
be as big as an arrow iron, and push it
right through the bag lengthwise,
and slide the iron into place.²⁷⁹ Cover it [the bag]
with sulphur and you have a good
arrow. **How you make fire arrows which
can be stored for a long time and do not turn rusty.**

Wiltu fewr pfeil machen die do lige[n]
wie lang du wilt so pich die eyßen
das sie nit rostig werden so ligen sie wie
lang du wilt **Wie man fewr pfeil machen**

10

will not deteriorate, and it is good as long as it lasts.
Of all things, if you dry the powder
in the heated room or elsewhere, then be
very careful about fire and about light
as no one can be saved and it could cause
great harm. **How you make fire arrows
which are good.**

If you want to make good fire arrows, then take
a fustian bag and take the powder
that has been made and push it into

fol. 49 r

the bag to get hard and tie it
around it with a double thread
so that it hardens. Take a [piece of] iron,
which is round²⁷⁸ or four-cornered, which should
be as big as an arrow iron, and push it
right through the bag lengthwise,
and slide the iron into place.²⁷⁹ Cover it [the bag]
with sulphur and you have a good
arrow. **How you make fire arrows which
can be stored for a long time and do not turn rusty.**

If you want to make fire arrows which can be stored
for as long as you want, then cover the iron in pitch so
that they do not get rusty and they can be stored for as
long as you want. **How you make fire arrows**

²⁷⁸ The literal translation here implies 'sulphur' but that is most likely to be a scribal error. In other versions of the *Firework Books* this is referred to as a 'synbel' or 'sinwel'.
Stainer (1529), 235, 'synbel' = 'sinwel' => 'rund', Schmeller II, 291 – see Heidelberg Cod. Pal. germ. 122, fol. 44 r, and Göttingen 2° Cod. Ms. philos. 64, fol. 143 v: 'sinwel'.

²⁷⁹ It is not entirely clear what action is intended to be done here.

15 **sol die sich selber an zünden wann sie kome[n]
an die stat do sie hin geschossen werden**

Wiltu fewr pfeil namchen die sich sel=
ber enzünden die man nit anzun=
den darff so nym[m] zunder schneyd in als preit
20 als zwen helm sein vnd zwaier zwercher
vinger lanck die scheub vornan in das seck=
lein do das eÿsen her auß get nach der

fol. 49 v
1 leng das es das pulfer erlang so enzint es
sich selber wann du wilt **Wie man ein
puchsen auß lassen sol die lang gelegen
ist vnd nicht lassen wil**

5 **H**ast du ein puchsen die geladen ist die
lang gelegen ist vnd nit auß wil
gen so nym[m] ein lad eÿsen vnd treib die ku=
geln hin ein paß oder den klotz vmb ein
zwerchen ~~vinger~~ halm oder mer vnd
10 rawm das widloch mit einem griffel
vnd see ein gut pulfer dar ein vnd zind
es an so get es **Wie man ein gluend ku=
geln auß einer puchs schiessen sol das
sie verprent war an sie geschossen wirt
in holtz werck**

**which catch fire themselves when they reach
a town when they are fired at it.**

If you want to make fire arrows which catch
fire themselves and which do not need to be set
alight, then take tinder, cut it as thick as
two straws and two small fingers'
breadths long, push it into the front of the bag
where the iron comes out lengthwise

fol. 49 v
so that the powder catches fire by itself
when you want it to.²⁸⁰ **How you empty
a gun which has been lying around for a long time
and should not be fired.**

If you have a loaded gun which has been
lying for a long time and [*the charge*] does not want to come out²⁸¹
then take a loading iron and push in the
ball a little. Or, move the plug
by [*the size of*] a small piece of straw or more.
Clear the touch hole with a stick
to see that good powder can get it and light it
as well as it goes. **How you fire
a glowing ball out of a gun which
will burn when it hits a
wooden structure.**

²⁸⁰ The implication is that you have to light the fuse before firing, but not stated here.

²⁸¹ As in 'cannot be fired'. '*aus/assen*' implies a wide range of possible actions, but it does not necessarily suggest 'letting off'.

Wiltu ein pleÿ puchsen laden so lad
 es mit einer kugel vnd haÿß dir
 machen ein eÿsne kugeln die gerecht dar
 ein seÿ vnd leg ein nassen hader auff die die pleÿ
 kugeln vnd haÿß die eÿsneÿn kugeln vast
 gelwend machen vnd leg sie mit einer
 zangen in die puchs auff den hadern das

20

fol. 50 r

tüst du wol an allen schaden vnd zind es
 an was dann die kugel beriert von holz
 do es innen steckt das verprint als **Wie**
man guten zunder machen sol

1

Wiltu machen guten zunder so nym[m]
 buche swem vnd haw die ausern
 rinden herab vnd nym[m] glut vnd aschen als
 die aÿmrigen das da vast vnder ein ander
 glwt vnd nym[m] ein haffen vnd scheid
 den swam zu stuck weiß als prait als

5

10

If you want to load a lead gun²⁸² then
 load it with a ball. And have
 an iron ball made which is the right size
 and put a wet piece of cloth²⁸³ on the lead
 ball and heat up the iron ball so that it almost
 glows and put it in the gun with
 some tongs, in front of the other,

fol. 50 r

and this will cause all the damage. Fire it [*the gun*],
 and any wood the ball touches,
 or gets stuck into, will burn. **How**
you make good tinder.

If you want to make good tinder, then take
 beech sponge,²⁸⁴ and cut off the outer
 bark, and take embers and ash as they
 are glowing²⁸⁵ which almost glow together.
 Take a bowl and split
 the sponge into pieces the width

²⁸² 'Lead' presumably refers to the ball and not the gun, similar to the term *Steinbüchse*. Alternatively, it could related to a gun on a gabion (see fol. 41 v).

²⁸³ This is the same as in the Göttingen 2° Cod. Ms. philos. 64, fol. 144 v: '*hadern*'; or the Heidelberg Cod. Pal. germ. 122, fol. 44 v: '*hadern*'. See *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/hader.h1.0m_1513543590.

²⁸⁴ It is not clear whether this refers to bark, a particular fungus, or to the beech wood soaked in some particular substance. However, the fungus – as it described in German as a sponge – seems more likely.

²⁸⁵ In Strainer (1529) this section refers to '*einmeerung*', and Nibler in his synoptic comparison of Freiburg Ms. 362 and Strainer (1529) argues that '*einmeerung*' = '*aimern*, *emmern*' => 'hot ash', 'embers' ('*heiße Asche*', '*Glut*'), as also referred to by Schmeller I, 75, who has references this for Munich Cgm. 4902. Hassenstein (1941), 77, translates it as 'bucket' ('*Eimer*') which seems to be incorrect. Heidelberg Cod. Pal. germ. 122, uses '*vnd nim die glüt vnd aschen als die aÿmrigen Das das vast vnder ain ander glüt*' (fol. 45 r) just as Göttingen, 2° Cod. Ms. philos. 64, which describes it as '*vnd nÿm glut vnd aschen als die aÿmrigen das da fast vnd ainand[er] glut*' (fol. 145 r). Following the etymology of '*ember*' it would refer to the '*ammer*' (def. 2) in relation to 'a spark glowing underneath ashes ('*unter der Asche glühender Funke*', *Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/ammer.h2.1f_1515305643).

ein hand vnd eins vingers dick vnd schüt
 es in den haffen vnder die äymrigen der
 glut vnd leg ein lecke schwam dar auff
 vnd ein leg der koin vnd aber ain leg des
 swams vnd tu es als oft piß das der ha=
 fen vol werd vnd geuß dar über ein was=
 ser das oben dar über ge vnd teck in zu
 vnd setz in hin vnd laß in sten auff zehen
 tag vnd wenn er nit wasser hab so
 vil in wider vnd nym[m] in vnd wasch in
 auß rein vnd sauber das kain asch oder
 kot dar in seÿ vnd reüch in an einen va=

15

20

fol. 50 v

den vnd henck in auf zu dem offen oder an
 ein sunnen vn[d] laß in wol trucken das er dür
 werd **Wie man zunder machen sol**

fol. 50 v

and hang it over an oven or put it in the
 sun and let it dry out well until it is [*completely*]
 dry. **How you make tinder.**

Wiltu in aber gern haben das er
 nicht riech oder schmeck so nym[m]
 sein als vil als du sein wilt vnd leg in
 in einen essich vnd laß in dar in ligen ein
 tag vnd nacht vnd henck in auf vnd laß
 in trucken so wirt er gut **Wie man ein**
eÿsne tüll zu einem haußpfeil herten sol
das er als hert wirt als ob er fein stech=
lein wer vnd auch als nutz auff platen

If you would like to have it that

it [*the tinder*] does not smell or taste, take
 as much as you want and place it
 into a bowl of vinegar and let it rest in it
 for one day and one night. And hang it up and let
 it dry and it will be good. **How you harden**
an iron tip into a house arrow²⁸⁶
so that it becomes so hard like a thin
stick and also can be used against plate

10

²⁸⁶ It is not clear what is meant by the term 'house arrow' ('*Haußpfeil*'). Plenty of speculative interpretations are offered from Hassenstein's 'an arrow that can be fired at a house' ('*gegen ein Haus zu schießender Pfeil*'), Hassenstein (1941, 77) to Nibler's admittedly hypothetical explanation that it relates to an arrow, the head of which was fastened in a more secure way to be able to be fired effectively against 'plate or mail armour' ('*Platten und Ringharnische*', Nibler (2005), footnote 270).

harnasch vnd ring harnasch als ob er
stechlein wer vnd also macht du auch
wol da mit herten welcherley du wilt
das eysen ist

15

Wiltu herten ein eysne tül zu eine[m]
hauß pfeil geschunt oder was
du gern wilt so nym ein kraut das haist
verbena etlich haissen es eysen kraut vn[d]
das hat plaube plomein Das selb ist
das recht vnd das sol man nemen mit

20

fol. 51 r
dem stengel vnd mit dem kraut als es do
stat vnd sol es stossen in einem morser
dar nach sol man es auß trucken durch
ein tuch als vil du mugst vn[d] tu das wasser
in ein glaß dar nach nim als vil wassers
als vil du sein nemst zu bedurffen zu der
hert vn[d] als vil mans harn der nit warm
sey gleicher weis als vil als gens vnd
misch vn[d] rier es durch ein ander vn[d] nach
ostern so ma[n] die ecker praucht so vint man

1

5

10

armour and mail armour
like a knife. And make [it] also
as hard as you like
so that it is like iron.

If you want to harden an iron tip to become a
sharpened house arrow,²⁸⁷ or what
you would prefer. Take a herb that is
called *verbena* or is commonly called ‘iron herb’ and
which has blue flowers. The same is
the right one.²⁸⁸ And you shall take it at

fol. 51 r
the stem and with the herbs as it
stands and grind it in a mortar.
Afterwards you press it through
a cloth as much as possible and you put the
water [of the *liquid*] in a glass flask. Afterwards you take as much water
as you think is necessary for it to
harden and as much man’s urine that is not warm
in the same manner, the same quantity as the other²⁸⁹ and
mix it and stir it together. And after
Easter when you prepare the fields you find

²⁸⁷ Alternatively, this could be read as ‘geschundet’ (Göttingen 2° Cod. Ms. philos. 64, fol. 145 v) – ‘schinden’ – to ‘skin’ or ‘strip’ or here ‘sharpen’. Other *Firework Books* refer to this as ‘forged’ (‘geschmiedet’, Stainer (1529), 36).

²⁸⁸ *Verbena* or *Vervain* is a genus in the family *Verbenaceae*. It has been commonly used in medicine, herbalism, and folklore since Egyptian and Roman times (Malcolm Stuart ed. (1979), *The Encyclopedia of Herbs and Herbalism*, London: Orbis, 279). It has been referred to as a ‘wonder drug’ with multiple uses, one of them is the ‘ability to harden iron – a claim made by Paracelsus’ (Francis B. Brévar (2008), ‘Between Medicine, Magic, and Religion: Wonder Drugs in German Medico-Pharmaceutical Treatises of the Thirteenth to the Sixteenth Centuries’, *Speculum* 83, 11, footnote 22).

²⁸⁹ ‘*als vil als gens*’ refers here to ‘*als vil als yenes wasser*’ (Göttingen 2° Cod. Ms. philos. 64, fol. 146 r, or Stainer (1529), 42), or in Heidelberg Cod. Pal. germ. 122, fol. 45 v and 46 r, ‘*als vil als gens wassers*’. Etymologically, it appears that this derives from ‘*jenes*’ – ‘the other’.

wirm die haissen egerling die sein klein
 vn[d] haben groß köpff macht du der geha=
 ben so truck sie auß vn[d] tu das selb wasser
 vn[d] er das hert wasser vn[d] wen[n] du es herte[n]
 wöllest so soltu es nit rot lassen werden
 dz es nit zu haiß werd vnd stoz es dann
 als ver du es herte[n] wilt in das wasser
 vn[d] laß die hitz vo[n] im selber wider vergen
 piß das es gotfarb fleck gewin[n] so küel es
 wider in der selben hert vn[d] laß es so pey
 beleiben liestu es gar plaube werden so
 wird es gar waich Et sic est finis

15

20

worms which are called 'engerling' which are small and
 which have large heads. You can catch them
 and dry them out and place them in the same water
 and before the water hardens. And when you want it to
 harden, then do not let it turn red,
 that it does not get too hot. And plunge it into water
 because you want to harden it.
 And let the heat come off from itself
 until it gets gold coloured blotches.²⁹⁰ Then cool it
 down again in the same hardening [water]. But if you let it
 turn blue, then it becomes
 soft. And here is the end.

²⁹⁰ Nibler suggests that something must be missing as it would need to be heated up again, before cooling it down (Nibler (2005), note 277). From the context it is not clear how he reached that conclusion.

Royal Armouries I.34 – part 2

fol. 52 r

¹ wiltw ein hoflich kwnst mache[n] vo[n] eine[m] fewr das
einer tawsent an einem stwrn ab treibt ab ma[n] vor
eine[m] slos oder stat stwrme[n] wolt so merck dÿ her noch
geschribe[n] kapitell wi dws mache[n] solt vo[n] welche[m]
zeug wn gewicht je mer ma[n] mit waser dar auf
gewst je wnsicher di lewt dar pei sint

Wiltw dise vor geschribe[n] veur mache[n] so

¶ volg disem noch geschribe[n] kapitell noch
wi dw das fewr werck fasen solt vn[d] vo[n] welche[m]
zeug das vinst dw her nach geschribe[n] zw[m]
ersten am an vang so los dir mache[n] ein veslein als
gros dw eß hawe[n] wilt das einer wber ein mann[e]
oder zine[n] gewerfe[n] mag da mit ma[n] ein stwrn ab
treibt vn[d] loß dirs vo[n] holz dick mache[n] vn[d] woll gepunte[n]
das es an dem bwrff nit zw vall vn[d] piche[n] mer merck
wi dw den zeug vase[n] sollt der do ein das vaß gehort
nim ein geleiche wog un[d] leg auf das ein teill v lb
am gewicht vn[d] auf das ander teill der wog v lb
salp[eter] vn[d] nim den den salp[eter] heher ab vn[d] wig iii lb

fol. 52 r

if you want to make a ‘courtly art’¹ of the fire[work],² which
will fend off a thousand in an attack, [or] to make an attack
in front of a castle or a town, then note the
written chapter below: what you should do, which
ingredients and what weights [to use], the more water you
pour onto it, the less safe people are with it [i.e. when handling it].³

If you want to make the fire[work] indicated above, then
follow the chapter written below:

how you should handle the firework, and about which
ingredients [to use] – you will find that in what is written below.
First, to begin with, have made a small barrel
as big as you would like it, so that you can throw it
over a man and over the battlements to fend off an
attack. Have a thick piece of wood made and tie it well together
so that, when you throw it, it does not fall apart. Note
how you gather the ingredients which have to go into the barrel.
Take a well-balanced pair of scales and put onto one side 5 pounds
of weight and on the other side of the scales 5 pounds
of saltpetre. And take the saltpetre off and weigh 3 pounds

¹ The expression ‘*hoflich kwnst*’ has been translated to ‘courtly art’ throughout part 2. ‘Courtly’ refers to a skill and knowledge which would be of relevance at court. It has (as mentioned in part 1) an aspirational aspect; the fact that it appears more often in part 2 may indicate that this aspiration was more pronounced at the time of production of part 2. ‘*kwnst*’ or ‘*kunst*’ refers to ‘art’ and has itself multiple meanings. For a discussion on these terms see chapters 4.

² The original often refers to it as ‘fire’ (‘*fewr*’ or ‘*feur*’) but often this reference is related to ‘firework’. For this reason this has been changed throughout the text.

³ The explanation about the use of water is not very clear. It could be that this is a metaphorical expression known to the reader, or an expression which could related to the processes and ingredients (in neither case would water help the process of producing good quality gunpowder). It could also be that petroleum and resin cannot easily be extinguished with water alone.

20 salp[eter] salz nim den das salz her ab vn[d] wig i lb
 schwefells nim den schwefell ab vn[d] wig mer ii lb
 gwz sisch pulferß vn[d] nim das pulfer ab vn[d] wig i lb
 gemalle[ne] faul[en] puche[n] holz das vinst dw her nach geschrib[en]
 25 wi dws male[n] solt vn[d] itliger zeug sol klein gestosen
 sein sam wolz dw pulfer dar auß mache[n] vn[d] misch
 den rein vnter ein ander vn[d] nim ein weiz spen sip
 vn[d] ris den zeug dar dwrch das es sich mit ein
 ander vor ein vn[d] wen das geschit so loß wnter
 dem stamfp stossen so wirt es dester pesser vn[d] wen

fol. 52 v

1 das geschit so nim den selbe[n] zeug vn leg ein leg
 ein das vaß vn[d] nim vn[d] mach vo[n] alte[n] seille[n] zoche[n]
 geflochte[n] eins vinger dick vn[d] seud in salp[eter] auf ein
 stwnd vn[d] loß den trucke[n] an der swne[n] oder ein den
 5 stwben vn[d] schwem si den in harz vn[d] geus ein weng
 oliw[m] pretoliu[m] wnter das harz das all vinst dw her

of saltpetre salt.⁴ Then take the salt off [*the scales*] and weigh 1 pound
 of sulphur. Take off the sulphur and then weigh 2 pounds
 of good gunpowder. Take the powder off and weigh 1 pound
 of ground-up rotten beech wood which you will find described below
 how to grind it. All the ingredients should be ground together finely
 if you want to make good powder out of them and mix
 them together well. And take a wide,⁵ tautly strung sieve⁶
 and force the ingredients through it so that they are mixed well.
 And when that is done [*i.e. mixed well*], then grind [*the mixture*]
 in a stamp mill⁷ – the more, the better. And when

fol. 52 v

that is done, then take the same ‘thing’ [*i.e. the mixture*] and put it
 into a barrel. And take and make out of old bits of rope a wick⁸ which is
 braided and one finger thick.⁹ Boil it in saltpetre for an
 hour and let it dry in the sun or in a
 warm room. Then soak it in resin and add to
 the resin a little *olium petroleum*¹⁰ – all of which you will

⁴ Not sure what the author meant with an ingredient ‘saltpetre salt’ as the main state for saltpetre is in crystalized state. This raises the question of what state the main ingredient ‘saltpetre’ is meant to be in.

⁵ Not clear whether this refers to the mesh size or the size of the sieve itself.

⁶ Not clear what ‘*spen*’ refers to. It could be a name of a sieve (size unclear), or a reference to the material it is made out of. No reference was traceable regarding its use, its size, format, or function. It could even relate to the density of the sieve

⁷ The stamp mill is depicted in fol. 87 v. The main function of the stamp mill is grinding the mixture and mixing it, not compressing. The illustration at fol. 87v depicts both an hourglass (suggesting the need to do the grinding for a minimum amount of time) and the master gunner standing at the side supervising the grinding. He also has a specific tool in his hand which could be understood to be aiding in the task (see depiction of illustration at the end of chapter 2).

⁸ ‘*zoche*’ can be a range of different items: stick, string, and also wick or fuse (‘*holzscheit, knüppel, or Stock*’, but also ‘*docht, lunte, zündstrick*’, *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018). Here translated as ‘wick’ as it is mainly aimed to burn and not only act as a fuse.

⁹ Ordinarily, rope would be twisted. To braid or plait rope means that it is slightly less flexible, but has more integral stability.

¹⁰ It is virtually impossible to trace what exactly ‘*olium petroleum*’ refers to. From the context, it is likely to be a form of petroleum, and that the tautological use of the term was a rhetorical aid, perhaps emphasising that it was petroleum of good quality.

nach geschriben wan das fewr bwrst dester herber
 vn[d] leg der selbe[n] zoche[n] awf das vor genant pulfer
 ein leg vn[d] wider ein leg pulfer vn[d] leg dÿ leg alß
 lang piß das vaß auf das halb teill vol burt vn[d]
 loß dir den mache[n] kegel vn[n] murbe[n] eise[n] alß dw her
 nach gemolt vinst an dem lxxxv plat wi si sein swle[n]
 vn[d] las si mit gwte[n] sich pulfer in aller der moß
 alß ein pusche[n] vn[d] leg ir ein das vaß das auf das halb
 teill gefult ist alß vil dwr habe[n] x oder xx dar nach
 alß dw daß fewr dester wnsicher habe[n] willt vn[d] leg
 den deß vor genant pulfer dar auf vn[d] ein leg zoche[n]
 vn[d] leg dÿ leg alß lang piß das vaß vol burt vn[d]
 zu oberst leg ein wenig sich pulferß vn[n] daß an zwnte[n]
 wege[n] vn[d] slach den das vaß zw vn[d] mach an den
 zu geslage[n] pode[n] pei v locher mit eim negber eins
 finger groß vn[d] zunz da pei an wan dw darft dich
 nicht forchte[n] vn[d] loß an gen vn[d] auch nicht zu lang
 das eß nit auf dÿ kegel prin wan eß schlug dw
 den haß ab vn[d] burß das faß den hin ab an den

find described below. When the fire burns strongly¹¹
 put the same braided rope on the aforementioned powder
 in [the barrel], and add a layer of powder and a layer [of rope]
 until the barrel is half full. And
 have a ball¹² made for you out of soft iron¹³ as you
 can find drawn later on sheet 95¹⁴ how it should be.
 And fill it [the iron ball] with good gunpowder in the same way as [you would]
 for a gun.¹⁵ And put it [the ball] into the barrel which is filled
 half full, and add [a further] ten or twenty [balls]
 if you want to have the fire[work] be more unsafe.¹⁶ And put
 the aforementioned powder on top of it and add the braided rope.
 And put them one on top of the other until the barrel is full to the top.
 Right on top put a little gunpowder so that it can be lit more easily.
 And hammer the barrel closed and make five holes¹⁷ in the
 sealed bottom with a drill,¹⁸ each one
 finger wide. And when you light it you must have
 no fear. And you must let it catch alight, but do not wait so long
 that it burns down to the ball, otherwise it will knock
 your head off and will burst the barrel. Then take it to the [front of the]

¹¹ It is not clear what the reference about the fire refers to. It could be that the resin may benefit from warming up (e.g. softening it to ease it being mixed with the other ingredients).

¹² German does not distinguish between 'cone' (in New High German 'Kegel') and 'ball' (in New High German 'Kugel'), but it is more likely to be 'cone' rather than 'ball'. For consistency reasons, however, it will be translated as 'ball'. The original term could be either singular or plural; plural is used here, as subsequently the verb indicates more than one ball.

¹³ The German could imply brittle or soft, referring to the status of the iron, its flexibility and physical characteristics.

¹⁴ The insert of sheet number is in different coloured ink and is probably a later addition as the number is slightly longer than the space provided. This could refer to both fols. 95 r and v. Both folios depict fire arrows and some of their content (see depiction of illustrations at the end of chapter 2).

¹⁵ One possible assumption here may be that this related to the compressing of gunpowder (which needs to be compressed but not too much).

¹⁶ Likely to be in the meaning 'aggressively', or even 'deadly' or 'lethal' as it must refer to being 'unsafe' for the opponents.

¹⁷ Likely to refer to these holes as 'touch holes' – not specified in the text.

¹⁸ See I.34, fol. 7 r, as well as related footnote.

stwr̄m so host dw d̄y pesten stwr̄m feur do nimant
sicher pei ist

fol. 53 r

wiltw ein hoflich kwnst mache[n] das auch zw̄m stwr̄m
sint vn[d] heist ein stwr̄m fewr vn[d] ist nimat sicher dar
pei hwndert schrite[n] on geferlich so folg disem noch
geschribe[n] kapitell noch vn[d] wen dws wase[n] wilt alß
dw her nach geschribe[n] vinst so ge weislich da mit
wmb vn[d] vor sich dich vn[d] ander leut das eß sich
nicht enzwt wan groß schwede[n] da vo[n] mochte[n]
twr̄me[n] vn[d] den leute[n] dy heiß ab schlug

Wiltw dise vor geschriben fewr werck mache[n]

so volg disem noch geschribe[n] kapitell noch wi
dws mache[n] solt vn[d] von welche[m] gewicht des
zewgs zu erste[n] loß dir mache[n] ein vaß vo[n] dicke[m]
holz vn[d] woll gepunte[n] alß vor wen das geschit so nim
ein geleiche[n] wog die geleich vn[d] recht sei leg auf ein teil
der wog alß dws wege[n] wilt am gebicht viii lb
vn[d] leg den der gege[n] auf das ander teil viii lb
salp[eter] vn[d] leg den salp[eter] ab vn[d] leg auf dy wog iiiii lb
am gebicht vn[d] leg auf das ander teil wog iiiii lb
schwefell vn[d] leg den schwefell ab leg auf wog ii lb
am gewicht vn[d] dar gege[n] auf das and[ere] teil ii lb
gestosser kolle[n] vn[d] nim di kolle[n] ab vn[d] leg auf i lb
am gewicht auf dy wog der teil eins gege[n] i lb
gestosen harz vn[d] wig den mer ein lb des vor genant[en]
puche[n] faulen gemalle[n] holz das her nach geschribe[n] stet

attack, and thus you have the best attack fire [work] from which no one
is safe.

fol. 53 r

**If you want to make a ‘courtly art’ for attack
and which is called attack fire [work], and which is dangerous
and no one is safe [within] a hundred paces, then follow the
chapter written below. And if you want to know how,
you will find it below. And treat it with caution
and be careful for yourself, and for other people, so that it
does not catch fire. This [car] cause a large amount of damage which
can knock down towers and knock off the people’s heads.**

If you want to make the firework described above

then follow what is written in this chapter [as to] how you
should make it, and the weight of [each of the]
ingredients. First have a barrel made of thick
wood which is tied¹⁹ together well. When that is done, then take
a well-balanced pair of scales which are good and level. Place on one side
of the scales, when you are ready to weigh it, 8 pounds in weight.
And put on the other side against it 8 pounds
of saltpetre. And take off the saltpetre and put on your scales a weight
of 4 pounds and put on the other side 4 pounds
of sulphur. And take off the sulphur and put on the scales a weight of
2 pounds, and put on the other side 2 pounds
of ground charcoal. And take off the charcoal and put on a weight
of 1 pound, and on the other side, against it, 1 pound of
ground resin. Then weigh up, furthermore, one pound of the aforementioned
ground-up rotten beech wood which is described below

¹⁹ The original implies ‘tied’, but it is not clear whether the material used is referred to, or any particular part of the barrel.

an dem lv plat da dw den rauch geschriben vinst
 da vinst dw wi dw das holz male[n] solt losse[n] vn[d] nim
 dÿ stwck alle[n] zw same[n] vnd misch dwrch ein ander awer
 dw must itlich stück vor rein stosse[n] vn[d] rede[n] sam wolst
 dwu[n] pwlfen dar auß mache[n] vn[d] wen das geschit so
 nim ein weiz spen sip vn[d] ris den zeug dar dwrch
 das er sich vereyn vn[d] nim den ein nab vo[n] eim wagner
 di do ganz sei las an pede[n] orte[n] dar an lege[n] ij ring

fol. 53 v

1 vo[n] aich gerte[n] gemacht vn[d] loß in auß pore[n] vn[d] alß hoch
 alß das vor geschriben vaß das der pode[n] fur mug vn[d] slach
 den grosser ort der nab wntel[n] zw mit eim aiche[n] kloz vn[d]
 verpor in rein vn[d] mach ein kreuz kerbe[n] an dem verslage[n]
 pode[n] vmb des wille[n] wen den stock ein das vaß sezt das
 er sich dester e enzwnt mer por dwrch den kloz ein zwnt
 loch piß an das pulfer vn[d] nim den den selbe[n] stock vn[d] vaß
 in voller sisch pulfer auf das herzt vn[d] slach ein kloz dar
 fur vn[d] verpor in alß vor vn[d] nim den vn[d] se ein das vor

on sheet 55.²⁰ There you will find the description of the smoke,²¹ and there you will find how you have to have the wood ground. And put all the ingredients together and mix them thoroughly. But you have to grind any small pieces down properly if you want to make fine²² powder out of it. When that is done, then take a wide, tight sieve and force the ingredients through it so that they become one. And take a wheel hub from a wagon builder which is complete [*in one piece*].²³ Have two rings

fol. 53 v

made from oak twigs placed onto it at both ends. And have [*a hole*] drilled as long as the aforementioned barrel so that it comes through the bottom. And force an oak plug into the larger end of the wheel hub. And make sure it fits tightly.²⁴ And make a cross groove in the sealed end so that when you place the stick²⁵ into the barrel it catches light more easily.²⁶ And drill through the [*oak*] plug a touch hole until you reach the powder. And take the same stick and fill it full of gunpowder up to the top. Hammer a plug onto it and tighten it as before. And take it and make sure that the

²⁰ This number does not refer to an illustration, but to a later description in the text. This is the only time the author makes this reference to another part of the text, and not (as happens more frequently) to an illustration in a later folio. This may imply that the text contained previously known elements of text, and is not a continuous record of an experiment.

²¹ Not clear what 'smoke' this is referring to. One possibility is that this may be related to the white dust of rotten beech wood.

²² The literal meaning is 'thin' but it is likely that it is used in the sense of 'fine' or 'finely ground'.

²³ In the sense of 'not broken' as one piece of wood. There are a variety of possible interpretations of this. It could either relate to a wheel hub which has not yet had the spokes (or their holes) added to it. This way it would have more structural integrity (important for an incendiary device). Alternatively, it could refer to a wheel hub which is completely finished (with holes, and possibly also with spokes) which would give the wheel hub additional channels for any explosion to escape through.

²⁴ The original implies a drilling or twisting motion to check that it fits tightly.

²⁵ Could relate to what is from the sixteenth century onwards known as a '*instock*'. However, the context is not very clear. The use of the definite article implies that the author may not have to tell the reader what the stick is. It is most likely that the stick acts as a fuse or as a stabilising element.

²⁶ The implication here is that the sealing of the end of the wheel hub means that any powder inside would be in a more confined space, and thereby more powerful and effective.

10 geschriben [n] vaß an dem podel [n] ein wenck sich pulfers vn [d] sez
den stock dar auf ein das nab vn [d] loß dir mache [n] kegell
di hinte [n] spizig sent alß dw gemolt vinst an dem _____
15 plat vn [d] loß vo [n] murbe [n] eise [n] mache [n] vn [d] lanck das dws vo [n]
awsen dwrch das was schlecht piß an den stock awer dw
must vor durch das vaß locher pore [n] als dick di kegell
sint vn [d] las di selbe [n] kegell in aller der mos alß ein hant
pusche [n] e dws hin ein schlecht vn [d] nim den der vor genant [en]
alte [n] seill der zoche [n] in salp [eter] gesote [n] vn [d] harz geswemt vn [d] leg
20 ein leg vmb den stock vn [d] des vor genante [n] pulferß vo [n] viii
teil salp [eter] gemacht ein leg auf di zoche [n] vn [d] awer ein leg
zoche [n] vn [d] leg di leg alß lang piß das vaß vol burt vn [d]
leg zw oberst ein wenig schiß pulfer vn [d] slach den das
vaß zw vn [d] mach durch den podel [n] bei v locher eins
finger groß da zunt bei an vn [d] saum dich nit lang wan
dws wn dir werfe [n] wilt so hast du dÿ peste [n] slachent fewr
25 da nimant sicher sei ist am stwrmen

fol. 54 r

1 **wiltw awer ein hoflich stwrren fewr mache [n] das vill
mer schede [n] da vo [n] kwm dan vo [n] den vor genante [n]
fewr [en] wan si sint stercker vn [d] herber**

5 **W**iltu dise her nach geschriben [n] fewr werck mache [n]
so volg disem noch geschriben [n] kapitell noch alß dw

barrel described earlier has a little bit of gunpowder at the bottom. And insert
the stick into the wheel hub. And have made for you balls
which are pointed at the end as you find painted on sheet²⁷.
And let them be made of soft iron and [let them be] long enough for you
to [reach it] from the outside through the barrel up to the stick. But beforehand
you have to drill holes in the barrel the size of the balls.²⁸

And let the same balls [be made] the same size as you need for a hand
gun. Before you hammer it in, take the
old rope pieces described earlier which were soaked in saltpetre and resin, and put
then bit by bit around the stick. And take the said powder of 8
parts of saltpetre and put it on the pieces of rope. And place
those pieces of rope into the barrel until the barrel is full. And
place on top a little gunpowder and seal the
barrel shut. And make five holes one finger wide
to set it alight at the bottom [of the barre]. And do not wait too long before
throwing it away from you. This way you have the best striking fire [work]
that no one is safe against when attacking.²⁹

fol. 54 r

**But if you want to make a 'courtly' attacking fire [work] which causes
much more damage, as it is stronger and more severe
than the aforementioned fire [work].**

If you want to make the firework described below
then follow this chapter written below as you will

²⁷ Space for folio number left but not inserted, which looks like a scribal omission. It is possible that the author refers to fol. 89 r or fol. 89 v, but with some reservations; another possibility is that the page has not been drawn (or was forgotten by the artists), which is the reason why the text keeps it blank.

²⁸ The literal translation is 'as big as the balls are'.

²⁹ It is unclear what exactly the recipe is trying to achieve. The key terms used, such as barrel, hub, rope, powder and stick are very generic, and unless the context is known can be very ambiguous.

hore[n] bwrst zw[m] erste[n] nim ein nab als vor vn vaß
 dar ein gut sich pulfer auf das herzt vn[d] mach vnts
 dwrch den verschlage[n] kloz ein zwt loch vn[d] ein kreuz kerbe[n]
 awer dw scholt den stock vor rain pinte[n] losen[n] mit gute[n] ringe[n]
 mer wen dw den stock halbe[n] gelade[n] hast so leg dar ein ain
 geladen[n] kegel al dw her nach gemolt vinst mit zencke an
 dem lxxxiiii plat vn[d] sez den stock ein das vas awer dw solt
 an podel[n] des faß sich pulfer ton das sich der stock da von
 enzwnnt mer los dir mache[n] eise[n] mit feder[n] di dwrch das
 vas gen an den stock vn[d] ause[n] vernagelt um des wille[n] das
 sich der stock nit werrwckt vn[d] mach de[n] stock owe[n] zw mit
 eim aiche[n] kloz vn[d] verpor in genau alß vor mer e dw de[n]
 stock ein das vaß sezt so se an poden vnter den stock guz
 pulfer das sich der stock enzunt wen das geschit so nim
 alte auf getrifelt seill vn[d] seud in salp[eter] vn[d] loß trucke[n]
 vn[d] nim stein als groß dÿ hwner air vn[d] vmb wint
 di stein mit den alte[n] saille[n] vn[d] tauf si ein schwefell
 vn[d] aß pallent sol si in pulfer vn[d] swem si den in pech
 vn[d] auß dem pech wehent in das hernach geschriben
 weiß pulfer das zw dem rauch gehort vn[d] nim den
 der vor genante[n] zoche[n] in salp[eter] gesote[n] vn[d] in pech geswemt

hear.³⁰ First, take a wheel hub as before and fill it
 with good gunpowder up to the top. And make a touch hole
 through the sealed plug³¹ and make a cross groove.
 But before [this] you should have made the [bundle of] sticks tied with good rings,³²
 add more [rings] when you have loaded the [bundle of] sticks half [way]. And
 put a loaded ball into it [the bundle] as you find drawn later – jagged as on
 sheet 89.³³ Place the [bundle of] sticks inside a barrel. But you should
 put [some] gunpowder at the bottom of the barrel so that the [bundle of] sticks
 catches light from it. Furthermore, have made for yourself an iron with feathers³⁴
 which goes through the barrel to the [bundle of] stick and which is nailed on, so that
 the sticks do not move anymore. And seal off the [bundle of] sticks on the top with
 a piece of oak wood and drill [a hole] exactly as before. And before you
 place the sticks in the barrel, put at the bottom underneath the stick good powder
 which allows the sticks to be lit. When that is done, take
 old unravelled rope and soak it in saltpetre and let it dry.
 And take a stone as big as a chicken egg, and wrap
 the old rope around the stone, and soak it in sulphur.
 And as quickly as possible put it in powder, and soak it in tar,
 and from the tar³⁵ take the white powder
 described below which is part of the smoke. And take the
 said rope, soaked in saltpetre and in tar,

10

15

20

25

³⁰ This is a rare reference which may refer to the usage of this text, giving the impression that it was more likely to have been read out and presented orally instead of having been read in silence.

³¹ The original implies a hitting or beating action, but for clarity it was changed here to 'seal'.

³² The assumption here, supported by the illustrations depicted on fol. 89 r, is that this stick is not a single stick but a bundle of sticks. This is not made clear in the text, but it would explain the illustrations and the actions described.

³³ As above, the page number reference is in different ink, but appears to be in the same hand. This page reference is not entirely clear. From the context the section could apply to both fols. 89 r and 89 v, but also fol. 88 v.

³⁴ What the original implies when referring to a 'feather' is not clear. One possibility is that the iron is made as thinly as a feather, and into a hollow tube, thus acting as a fuse.

³⁵ It is not clear what the term 'wehent' relates to at this point. The word is related to 'wind' and it may be a reference to the stench of tar. Not translated in this instance.

vn[d] leg ein leg auf den pode[n] des vaß vn[d] ein leg des vor genante[n] pulfer vn[d] das vo[n] viii teil salp[eter] vn[d] vo[n] iiiii teill swefell vn[d] vo[n] ii teill kolle[n] vn[d] i teill harz i teill faul puche[n] gemalle[n] holz das pulfer hast dw an dem liii plat vn[d] auf das selbig pulfer ein leg der vm bvnte[n] stein vn[d] wider zoche[n] vn[d] wider stein vn[d] leg

30

fol. 54 v

1 vn[d] leg die leg alß lang piß das vas vol bwrt awer dw magst woll der vor genante[n] spizige[n] gelade[n] kegell vor ein den stock slache[n] alß wil dw bilt wmb des wille[n] das ma[n] dester vn[d] sicher dar pei ist vn[d] leg zw oberst ein wenig gwz sisch pulfers vo[n] des an zwnte[n] wege vn slach das vas zw vn[d] mach an pode[n] pei v locher alß vor **wiltw awer ein pesre kwnst mache[n] vo[n] einem rawch das ein ma[n] mocht ein her ab treibe[n] an ein stwrwm da ma[n] stwrme wolt oder ans eine[m] sloß reuche[n] das di dar ine[n] kein geschick mochte[n] hawe[n] noch mit ir wer zw verkome[n] mochte[n] zu wer vn[d] merck dise her nach geschribe[n] kapitel**

5

10

and put it into the bottom of the barrel. And add the aforementioned powder, and that of 8 parts of saltpetre, and of 4 parts of sulphur, and 2 parts of charcoal, and 1 part of resin, [and] 1 part rotten ground beech wood. [This is] the powder you have on sheet 53.³⁶ And into the same powder add coloured stone around it and more rope and more stone and

fol. 54 v

continue to do so until the barrel is full. But you can put the aforementioned pointed loaded balls to the [bundle of] sticks as much as you would like. The reason is that it is better and safer that way. And put on top a little good gunpowder so that you can light it, and seal the barrel shut. and make five holes in the bottom as before. **But if you want to make a better 'art',³⁷ of a smoke, which you use to drive away an attack, [or if] you want to attack. Or, [if] you want to smoke out a castle so that those inside [the castle's inhabitants] have no chance to defend themselves [against it]. And note this in the chapter written below.**

If you want to make the said smoke, then follow

the chapter written below. First, have a barrel made which is of strong wood and well fastened together so that it can be thrown. And when this is done, then take a well-balanced pair of scales. And add to one side [of the scales]

15

Wiltw dise[n] vor geschribe[n] rawch mache[n] so volg disem noch geschribe[n] kapittel nach zw ersten loß dir mache[n] ein veslein alß vor vo[n] starcke[m] holz vn[d] woll gepwnte[n] vo[n] des werfe[n] wege[n] vn[d] wen das geschit so nim ein geleiche[n] wog vn[d] leg auf das ein teill

³⁶ This appears to be in the same hand and similar ink but the scribe left some space after the number. This could imply that the page number was meant to be longer when the original text was written.

³⁷ As described before, 'kwnst' can refer to a range of issues, and in this case it is more likely to refer to 'device' or 'technique'. To keep the imprecise nature of the original it left as 'art'.

iiiii lb gewicht vn[d] nim den dar gege[n] auf das and teil
 iiiii lb salp[eter] vn[d] nim vn[d] leg den salp[eter] ab vn[d] leg auf
 ii lb am gebicht vn[d] leg den auf das ander teil
 ii lb schweffell vn[d] nim den schweffell ab vn[d] leg auf
 ii lb am gewicht vn[d] leg auf das and[ere] teil d[er] wog
 ii lb gestose harz vn[d] durch ein sep gerede[n] leg ab nim
 i lb am gewicht vn[d] leg auf das and[ere] teil d[er] wog
 i lb salp[eter] salz nom das salz ab vn[d] vn[d] leg auf
 i lb am gewicht vn[d] leg auf das ander teil
 i lb gemale[n] faulz puche[n] holz awer dw must
 itlig vor klein stose[n] sain wolß du pulfer dar auß
 machen vn[d] merck wi dw das holz malle[n] solt losen

fol. 55 r

1 vn[d] male[n] zw[m] erste[n] nim fawl puche[n] holz das awf
 dem stock erfawlt sei vn[d] an der farb weiß mer nim
 den das selbig holz loß dwn schneide[n] vn[d] dar nach rein
 dere[n] vn[d] dar nach vnter dem stamfp stossen vn[d] las dar
 5 nach malle[n] vn[d] wen das aiß geschit so misch den zeug
 vnter ein ander vn[d] ris in durch ein weiz sip vmb dez
 wille[n] das es sich vor ein vn[d] nim ein ol krugell vn[d] faß
 vol das eß loß sei vn[d] musterß wi eß tut ob eß gerecht
 sei welch zw saz zw vil oder wenig sei dar nach richt
 10 dich vn[d] nim den der vor genante[n] zoche[n] vo[n] alte[n] seille[n]
 in salp[eter] gesote[n] vn[d] har geschwemt vn[d] nim des vorgnant

4 pounds of weight, and add against it to the other side
 4 pounds of saltpetre. And take the saltpetre off, put it down and place
 2 pounds of weight, and add to the other side
 2 pounds of sulphur. And take the sulphur off and place [on the scales]
 2 pounds of weight, and add to the other side of the scales
 2 pounds of ground resin which is driven through a sieve. Take it off and take
 1 pound of weight and add to the other side of the scales
 1 pound of saltpetre salt. And take off the salt and place
 1 pound of weight. And add to the other side
 1 pound of ground-up rotten beech wood.³⁸ But you have to make
 sure that all the parts are finely ground if you want to make powder out
 of it. And note how you should grind down the wood:

fol. 55 r

first, grind the rotten beech wood which has
 rotted on the stick [i.e. on its branches], and which is white in colour. Take
 this wood and let it be cut. And then let it
 dry and after that have it ground in the stamp mill. And let it all be
 ground. And when it is all done, then mix the ingredients
 together and run [the mixture] through a wide³⁹ sieve so that
 it all mixes together. And take an oil flagon⁴⁰ and fill it to the top [with the mixture],
 so that it is loose [i.e. not compressed] and is just like it has to be. You should be
 careful that each component is not too much or too little. Make sure you follow
 this. And take the aforementioned piece of rope from old rope
 which has been soaked in saltpetre and floats [i.e. reached saturation point].

³⁸ This recipe is missing charcoal. It could be that this is a scribal error, or that charcoal was the one ingredient which was so commonly available that they would not need to specify it in the recipe. This hypothesis may be less likely considering the other details in the recipes provided.

³⁹ This could mean 'big in size' or 'coarse' – but it is not clear from the context.

⁴⁰ This is likely to refer to the container, but not to any oil being required.

weiss pulferß vn[d] leg ein leg ein das vaß eins zwere[n]
 vinger dick vn[d] der zoche[n] ein leg vn[d] wider deß
 weise[n] pulfer ein leg vn[d] wen dw das vaß auf das
 halb teil gefast hast so leg dar ein der vor genante[n]
 15 gelade[n] kegell pei r vn[d] des weise[n] pulfer ein leg dar
 auf vn[d] wider zeche[n] vn[d] leg dy leg auß lang piß das
 vaß vol burt vn[d] slach den das vaß zw vn[d] dw vor
 zw[m] oberst ein leg sisch pulfers vo[n] des an zwente[n] wege[n]
 20 vn[d] mach dwrch den poden pei v anzunt locher vn[d]
 loß den wol an gen e dws auß y burfft
wiltw awer ein hoflich kwntst machen vo[n] eine[m] fewr
das dw well auß einer pwsche[n] schise[n] magst
da mit dw ein itlig slosch auß fewren magst
das es nimat ab gelesche[n] mag wan di kwgel
schlog hwndert di helß ab

25

Wiltw dise ver geschriben[n] sischent fewr machen
 so volg disem noch geschriben[n] kapitell noch wi
 dw dise fewr werck mache[n] solt vn[d] vo[n] welche[m]

fol. 55 v

1 zeug vn am an vang so nim dy weite der puschen
 dar auß dw das fewr sische[n] wilt vn[d] nim den stein
 dester kleiner vmb des willen wan di kugel bwrt mit
 harz wber zog als dw her nach geschriben[n] vinst dar
 5 wmb must dw der kugel enpfor losse[n] vn[d] loß dir den kugel

5

And take the aforementioned white powder and place it in the barrel one big⁴¹
 finger thick, and add the [soaked] piece of rope. And on top of that put more of
 the white powder. When the barrel has been
 filled half way, then add the said
 loaded balls. Add the white powder on top
 and on top of this add more pieces of rope. Keep doing this until the
 barrel is full. Seal the barrel shut, but before that
 put some gunpowder on top [of the barrel] so that you can light it.
 And make five touch holes at the bottom and
 let it be lit well before you throw it [towards the enemy]
But if you want to make the ‘courtly art’ of fire[work]
which you can fire out of a gun
so that you can set light to any kind of castle with fire[work]
which no one can extinguish, and the ball will
knock off the heads of a hundred [men].

If you want to make this fire[work] described which you can shoot [out of a gun]
 then follow this chapter written below on how you
 should make this firework, and out of which

fol. 55 v

ingredients. In the beginning, take the width of the gun
 you want to fire. Take a stone
 which is a little smaller [than the barrel] as the ball will be
 covered with resin as is described below. When
 firing you have to let the ball escape.⁴² Have made for yourself balls

⁴¹ The origin of ‘zwere’ or ‘zawere’ is not very clear. The dictionary references only relate to a verb ‘zweren’ as ‘to stir’ (‘verühren, mischen’, *Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/anzweren.s.3v_1513721470) which would not fit in this context. It is more likely that this is a version of ‘heavy’ (‘schwer’) – see also at subsequent folios, also for ‘zawere’.

⁴² It is not clear what this relates to. The word refers to ‘rise’, ‘escape’, or ‘slip out’ – which would make sense when referring to a ball coated in resin. Alternatively, it could relate to ‘arise’.

fwr̄m di ine[n] hol sint vn[d] vo[n] murbe[n] zeug un[d] ein gute[n] alß
 dicke[n] vn[d] loß locher auf den seite dar ein furme[n] alß
 weit das di kegell dar ein gen vn[d] alß dw her nach
 geschribe[n] vinst vn[d] aber ein loch in di kugel geen
 dem pulfer sack wm des wille[n] das sich di kugell
 enzwt vn[d] wen das alß geschit so loß dw kegell
 schmide[n] vo[n] murbe[n] eise[n] alß gefurmt vinst an dem
 lxxxxv plat gemolt an der feur kugell vn[d] faß den
 ein di kegell guz sich pulfer vn[d] lad di kegell in
 alle der moß alß ein hant pusche[n] vn[d] leg auf das
 zwnt loch guz zwnt pulfer vn[d] vmb winz mit
 hanf werck ein zaverē[n] halem dick auf das hergt
 vn[d] tauf si in lebentig schwefell den vinst dw ein
 der apentecke[n] vn[d] vinst an dem lxxxvi plat wi dw
 in mere[n] sollt vn[d] ge weislich da mit wm wen dw
 di kegell taufen wilt das der schwefell nit prine[n]
 wert wan eß schlwg dir den haß ab vn[d] wen das
 alß geschit vn[d] nim gafer auch ein der apentecke[n] alß
 vil dw wilt der kugell mache[n] vn[d] kweck silber vn[d] faß
 der zweier stwck itlige ein ~~geß~~ genß veder voll
 vn vor machs genau mit wasch vn wm winz

fol. 56 r

auch mit hanf werck vn[d] wint alcwege[n] ein feder gaffers
 wm[d] ein feder kweck silberß zu same[n] vn[d] tauf si den auch

to fire which are hollow inside and of brittle material. They have
 to be of good thickness. And have made for yourself some holes at the side,
 wide enough so that the ball can be put inside as you find
 described below. But make a hole in the ball
 [for] the powder bag in order that the ball
 is lit. And when this is done, then have forged a ball,
 formed out of brittle iron, as you find drawn on
 sheet 95 as a fire ball. And fill the
 ball with good gunpowder and load it
 all to the level as it is [required] for a hand gun. And place good gunpowder
 on the touch hole and wrap around it some
 hemp which has the thickness of a heavy piece of straw. Press it together
 and drip onto it native sulphur as you find it
 in an apothecary and which you can find on sheet 86.⁴³ [It shows] how
 to make more of it and how to handle it carefully when you
 drip it on the balls so that the sulphur does not catch fire as
 this could knock your head off. And when that
 has been done and take camphor,⁴⁴ also from the apothecary, as
 much as you want to make a ball as well as [taking] mercury.⁴⁵ And then take
 two small pieces each which fill a goose⁴⁶ feather.
 And seal it [*the feather*] thoroughly with wax and wrap it

fol. 56 r

also⁴⁷ with hemp and wind the feather of camphor
 around the feather of mercury. And soak them both

⁴³ This most likely refers to fol. 86 v. However, it is not very clear what the reference to an illustration adds in the understanding of the text.

⁴⁴ This can also spelled as 'gaffer' or 'gaffran' ('Kampfer', *Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/gaffer.h2.0m_1514701431).

⁴⁵ It is likely that the implied action is to cover the ball with mercury, but that is not explicitly stated in the text.

⁴⁶ Scribal error, crossed out of misspelling of 'genß'.

⁴⁷ The use of 'also' could imply a repeated motion of layering the tasks, but that is not explicitly stated in the text.

in schwefell vn vor sich dich vor feur we[n] das alß geschit
 so merck wi dw den zeug mache[n] solt nim ein leg auf
 5 iiiii lb an gewicht vn leg aud das ander teil der ge[n]ge
 iiiii lb salp[eter] vn[d] nim den salp[eter] ab vn[d] leg auf di wog
 ii lb am gewicht vn leg auf das ander teil wog
 ii lb salp[eter] salz vn[d] leg das salz ab vn[d] leg auf wog
 ii lb am gebicht un[d] leg aud das ander teil wog
 10 ii lb schwefell vn[d] nim de[n] schwefell ab vn[d] leg aber
 ii lb auf am gewicht vn[d] auf das ander teil wog
 ii lb sisch pulfer vn[d] nim das pulfer ab vn[d] leg auf
 ii lb am gewicht vn[d] auf das ander teil der wog
 ii lb lauter gestosen harz vn[d] leg das harz ab nim
 15 i lb am gewicht vn leg der ge[n]ge auf di wog
 i lb faulß gemale[n] puche[n] holz vn[d] solt itilzig klein
 lose stose[n] vn[d] malle[n] sam wolstw sisch pulfer dar auß mache[n]
 vn[d] misch den rein wnter ein ander vn[d] vidz dwrch
 ein weiz sip das es sich vorein vn[d] wem dws den vase[n]
 20 wilt so ge weislich da mit wmb das eß sich nit enzunt
 wan eß slwg dir den haß ab zu[m] erste[n] wen dw an fast
 zw vase[n] so mim guz schiß pulfer das dwr sei vn[d] faß
 ein dy kugell auf das virteill vn[d] hert nim den der
 vor genante[n] gelade[n] kegell di in schwefell geswemt sint pei
 25 x vn[d] faß ein di kugell vn[d] tail si geleich ein mit eim holz
 vn[d] nicht mit eim eise[n] da hwt dich vor vn[d] nim dÿ ij
 feder mit dem gafer vn[d] kweck silber leg si auch hin ein
 wan das dut den schade[n] nim den den ob geschribe[n]
 zeug den dw gemacht hast vo[n] iiiij gebicht salp[eter] vn[d] fw

in sulphur. Be careful [to stay away] from fire when this is done.
 Then note how to make the ingredients: put on [the scales]
 4 pounds of weight and put on the other part against it
 4 pounds of saltpetre and take off the saltpetre and add to the scales
 2 pounds of weight and put on the other part of the scales
 2 pounds of saltpetre salt and take off the salt and put on the scales
 2 pounds of weight and put on the other part of the scales
 2 pounds of sulphur and take off the sulphur and put
 2 pounds of weight and on the other part of the scales
 2 pounds of gunpowder and take off the powder and place
 2 pounds of weight and on the other part of the scales
 2 pounds of ground resin and take off the resin. Take
 1 pound of weight and put against it on the scales
 1 pound of rotten ground beech wood. And you should grind it
 all down finely and pound it if you want to make gunpowder out of it.
 And mix it well together and press it through
 a wide sieve so that it comes together. And when you want to handle
 it, then treat it carefully so that it does not catch fire
 as it could knock your head off. Firstly, when you want
 to use it, take good gunpowder which is dry and fill
 your ball by a quarter and let it go hard. Then take
 the said, loaded ball which has been soaked in sulphur roughly
 ten times.⁴⁸ And take the ball and split it evenly with a piece of wood,
 and not with an iron, of which you must be cautious. And take the two
 feathers with the camphor and the mercury, place them inside [the ball] –
 that will cause all the harm. Then take the ingredients
 written above which you have made of four weights⁴⁹ of saltpetre and fill

⁴⁸ It is not clear what this refers to. It is likely to be a time period, but it was not possible to ascertain its length. The *Frühneuhochdeutsches Wörterbuch* refers to 'pe' as 'approximately', 'somewhat' (Def. 20 and 23: *annähernd, ungefähr*, *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/bei.h2.7pr_1514510828).

⁴⁹ The manuscript does not mention pounds at this instance, and it is not clear from the context whether it could be another weight measure.

- 30 di kwgell voll auf das herzt awer dw magst auch
wol oliwm pretoliu[m] dar wnter ton das vinst dw
das vinst dw an dem lx**plat her nach geschribe[n]
- fol. 56 v
- 1 so wirt das fewr dester herber vn[d] zu oberst alß sich
di pusche[n] vn[d] dÿ kugel gege[n] ein and[er] enzunte[n] soll so
faß ein dy kugell zu oberst ein finger dick gwt sisch
pulfer awer das wer das gewist das dw das zunt
loch der fewr kugell her auß kerest vn[d] lwzt di kwgell
vn[d] vor damese[n] in aller der moß alß ein stein vn[d] raumest
das zwnt loch der pusche[n] vor ewen ein das dir di
pusch nit versaget wan es wer ein erweit di vor nicht
wer vn[d] zunt den di kugell vore[n] in der pusche[n] an oder
im werck dar auß dw das fewr sische[n] wilt vn[d] loß dÿ
kwgell wol an gen wen das alles geschit awer wer dw
solt vor di fewr kwgell in harz sweme[n] wen dws gefast
hast vn[d] e dwst ein di pusche[n] legt ein fart oder iiij
moll nim ein kesell zw slach dar ein lawter harz
vn[d] vnschlig vn[d] des her nach geschribe[n] oliu[m] petroliu[m]
vn[d] probirß awf eim spon ob eß zech sei ist eß gerecht
so swem den dy kwgell ich wil dir mer ein wnter
scheid gewe[n] ab dw wolst dwrch ein gewalt mit der
kwgel sischen alß dwrch ein mawr zwische[n] rigell gemawrt
- 10
- 15
- the ball up to the top. But you may also
want to add *olium petroleum* to it which you find
described on sheet 60 below.⁵⁰
- fol. 56 v
- The fire[work] becomes more severe, most importantly, when
the gun and the ball together set each other alight.
To do so, place a finger width of good gunpowder
on top of your ball. But who would have known that the touch
hole of the fire ball has to be turned outside.⁵¹ And you light the ball
and from 'damesen'⁵² in all their sizes as a stone. And clear out
the touch hole of the gun each time so that the
gun does not fail. Should it do so, do not widen
it [*the hole*]. And then light the ball beforehand in the gun or in
the firework where you want to fire from. And let the
ball develop well⁵³ when all this is done. But
soak the fire ball in resin when you have filled
it and before you put it into the gun. A fourth⁵⁴ or four
times take a cauldron and place into it a lot of resin
and melt it [*together with*] the *olium petroleum* described later.
And try on a piece of wood whether it has thickened and is ready and right,
then soak the ball. I want to give you more [*details*] to
tell them apart than as you will find out by the force with which
the ball fires through a wall or between tiled walls.
- 50 Folio number in same size lettering, seemingly from the same hand, but written with different colour ink from the rest of surrounding text. The point refers to the section
at the top of fol. 60 r making 'a courtly art of burnt oil'.
- 51 It is not clear what this refers to. It is likely that this is suggesting an additional fuse to reach the touch hole.
- 52 It is not clear what this refers to. It could be a locality, a stage in the process of loading the gun, or even a verb.
- 53 In the sense of 'to start' (Def. 3: 'seinen Anfang nehmen, beginnen', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/angehen.s.3v_1514047428).
- 54 The origin of 'fourth' is not entirely clear in this context. It would be a version of 'fourth' ('viert', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/gepr%C3%A4cht.s.2n_1513289500).

20 so loß dir wber di kugell ii ring schmide[n] eins halbe[n]
 zwerhe[n] finger dick vn[d] zweier finger prait kreuz
 weiß ds das zwut loch dwrch dy ring ge der kugel
 vn[d] ausen zwische[n] di ring sisch pulfer vn[d] mit hanf
 werck wezoge[n] vn[d] den in dem vor genante[n] harz
 25 geswemt vn[d] ge weislich damit vm das dir kein fewr
 ein den keselell kum waa eß keme[n] groß schwede[n] da w[o]
 dw macht auch wol gwt fewr pfeil w[o] dem zeug mache[n]

fol. 57 r

1 **wiltw awer ein hoflich kunst mache[n] vo[n] einem heim
 lichen fewr das heist heimlich das einer zw wegen
 prengt das einer pei im treit oder eine das ma[n] sein
 5 sein nit ine[n] burt in moß eins trammers es sei in har
 schnur oder in nodel pein oder prot das ma[n] fein
 nit schmeckt das winst dw her nach gemalt an
 dem lxxxx plat gemolt in welcher furm dwß mach
 wilt dar nach richt dich**

10 **Wiltw dise[n] her nach geschribe[n] heimlich fewr
 mache[n] so volg dise[n] nach geschribe[n] kapitel**

Have two rings forged on the ball, one small
 half a finger thick and one two fingers wide. Make a cross
 where the touch hole goes through the ring into the ball.
 From the outside between the rings [*place some*] gunpowder and
 cover it with hemp material. Soak it in the resin described earlier
 and do that carefully so that no fire
 gets into the cauldron as it would cause great harm. This way
 you can make good fire arrows from the ingredients.

fol. 57 r

**But if you want to make the ‘courtly art’ of a secret
 fire[work] that is called ‘secret’ [*because it is a secret*] as one can manage to
 achieve, which you can have with you, or one that you
 do not have to set alight. It is the size for a ‘tramer’,⁵⁵ be it ‘strand
 of hair’, or ‘needle bone’,⁵⁶ or ‘prot’⁵⁷ which you cannot
 taste. You will find it drawn later at
 sheet 90⁵⁸ in the form you want to make it
 then you should follow [*this*].**

If you want to make secret fire[work] as is described below,
 then follow the chapter written below.

⁵⁵ There is little evidence what this could refer to. It clearly relates to a familiar item in size. The *Bayerische Wörterbuch*, vol. 1, 567, lists as ‘dreom’, ‘drommeter’, or ‘tremmeter’ as ‘arrow’ (‘Pfeil’). Scheller’s *Bayerisches Wörterbuch* (col. 661-2) refers to ‘tremel’ or ‘dreemel’ as a ‘piece of stick which could be used as a level’ (‘Stangenstück, das als Hebel dienen kann’), i.e. a crow bar. The verb ‘tremen’ refers to ‘wedge out’ indicating a possible reference to a tool in a workshop. Either could be a possible fit within this context.

⁵⁶ ‘Needle bone’ (‘Nadelbein’) is described by Grimm as a ‘box for needles made out of bone’ (‘Nadelbüchse aus Bein’, *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018). Most needles at that time were made out of bone.

⁵⁷ The sequence of these words is not clear. It seems a sequence of various domestically known items of uncertain size and use. In this context it appears to refer to smaller sizes. The only reference to the lemma ‘prot’ is related to ‘bread’ (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/brot.s.2n_1513846425), but it is not clear what this should relate to. One theory is that could be ‘as small as breadcrumbs’ but that seems quite speculative.

⁵⁸ Fols. 90 r and v depict the actions of the master gunner in the field (see end of chapter 2 for depiction of illustrations).

noch zv[m] erste[n] nim eins puche[n] faulle[n] holz
 das auf dem stock erfault sei vn[d] an der varb
 weiß awe mis pau[n] holz wer auch gut vn[d] nim daß
 selbig holz vn[d] loß ~~ein schneide[n] vn[d] drefe[n] vn[d] dar nach~~
~~water dem stamff stosse[n]~~ klein schneide[n] das eß in ein neue[n]
 hafe[n] mug gen vn[d] faß den hafe[n] voll vn[d] nim ein neue[n]
 stwerze vn[d] vor streich den hufe[n] genau das kein dwnst
 da vo[n] mug kwme[n] vn[d] mach dar wm ein gelut vs kolle[n]
 auf vi stwnd das eß zw kolle[n] verprint vn[d] deck den
 hafe[n] auf vn[d] lesch di kolle[n] ab mit schnell kraut wasser
 ab vn[d] deck den hafe[n] wider zw das kein dwnst da w[o]
 mug vn[d] nom di selbe[n] kolle[n] auß vn[d] loß si klein stosse[n]
 vn[d] dwrch ein heres sip gerede[n] so hast dw dÿ pesten
 kole[n] an rauch vn[d] schmack wen das alleß geschit so heb
 den wider an vn[d] kauf di peste[n] feinwet so dws gefinde[n]
 magst vn[d] schneid si al preit alß dw her nah gemolt
 vinst an dem xxxv plat vn[d] nom den vn[d] neß zw alß
 dy hor flechte[n] einß vingerß lanck vn[d] faß dar ein der

15

First, take some rotten beech wood
 which has rotted on the stick and which is white
 in colour, but some brown wood would also be fine. And take
 the same wood and let it be⁵⁹
 cut thinly so that it fits into a new
 bowl. And fill up the bowl and take a new
 lid and seal the bowl so firmly that no smoke
 can come out of it. And place it into some embers from charcoal
 for six hours so that it burns into charcoal. Then lift the cover
 of the bowl and extinguish the charcoal with greatercelandine⁶⁰ water.⁶¹
 Cover the bowl again so that no smoke can come out of it.
 Take the charcoal from it and let it [*the new charcoal*] be ground finely
 and run it through a hair sieve,⁶² and you have the best
 charcoal which smells and looks good.⁶³ When all this is done,
 pick it up again. And buy the best canvas⁶⁴ you can find
 and cut it lengthwise as you find drawn
 on sheet 90 [or 95].⁶⁵ Then take and wet two
 hair plaits, one finger long, and pour the above mentioned

20

25

⁵⁹ Deleted text not added in translation: 'cut thinly and let it dry out and grind it thereafter in the stamp mill'.

⁶⁰ 'Schellkraut', or 'Schellwurtz', refers to '*chelidonium maius*', or 'greatercelandine' or 'tetterwort', a herbaceous perennial commonly used in herbal medicine as a mild analgesic. It contains sap which at first is yellow, but on exposure to air turns a red colour (Heinrich Marzell (1943), *Frühneuhochdeutsches Wörterbuch der Deutschen Pflanzennamen*, Leipzig: Hirzel, vol. 1, 923-5). John Gerard's *The herball or Generall historie of plantes* (1597) states that 'the juice of the herbe is good to sharpen the sight, for it cleanseth and consumeth away slimie things that cleave about the ball of the eye and hinder the sight and especially being boiled with honey in a brasen vessell'.

(Maud Grieve (1971), *A Modern Herbal: The Medicinal, Culinary, Cosmetic and Economic Properties, Cultivation and Folk-lore of Herbs, Grasses, Fungi, Shrubs, & Trees with All Their Modern Scientific Uses, Volume 1*, New York: Dover), 179 – see also *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018, '*chelidonium*', mostly '*chelidonium maius*').

⁶¹ This is likely to refer to some liquid with acidic properties, probably greatercelandine soaked or diluted in water, or distilled.

⁶² A 'hair sieve' implies a thin sieve; this is not a term used before, but used again in fol. 58 r.

⁶³ The literal translation means 'in smoke and taste'.

⁶⁴ This is likely to refer to some form of fabric. '*Leinwat*' is described in the *Frühneuhochdeutsches Wörterbuch* as 'canvas material, cloth' ('*Leinwand als Stoff, Tuchmaterial*', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/leinwat.s.1fn_1518829027).

⁶⁵ This is more likely to be 95, but even then not conclusive, or hugely helpful.

ob genante[n] gestose[n] kolle[n] auf das herzt vn[d] ne den

fol. 57 v

1 wider zu vn[d] saf awer ein alß vor vn[d] ne[e] vn[d] faß alß

lang piß du der schnur hast auf v oder vi od[er] x stwnd

alß vil dwr hawe[n] wilt du soit di fstwnd vor lege[n] vn[d]

an streiche[n] d dws auß geist den diß ds prauche[n] vn[d]

5 lege[n] vm deß wille[n] das si not vor kwrzt dar vnter

werde[n] mit der varb an zu steiche[n] di her nah geschrib

stet wen das geschitg so nin parchat vn[d] loß dir secklich

mache[n] alß dw gemolt vinst eß sein zosp oder nodel pein

oder andre dinck dy eim kromer zw stend dar nach

10 richt dich wn[d] merck den wi dw den zeug mache[n] solt

der ein di parchet muster gehore[n] dar da an fewre[n] soll

zw[m] erste[n] nom ein geleiche wog vn[d] leg auf am gebicht

vi lb vn[d] aud das ander teil da gegen dem gebicht

vi lb salp[eter] vn[d] nim den salp[eter] ab vn[d] leg auf dy wog

15 ii lb am gewicht vn[d] dar gege[n] auf das ander teil

ii lb schwefelß vn[d] nom den schwefell ab vn[d] leg auf

i lb am gebicht vn[d] leg auf das and[re] teil der wog

i lb salp[eter] salz vn[d] nim das salz ab vn[d] leg auf

i lb am gebicht vn[d] leg aud das ander teil wog

20 i lb linter kolle[n] vn[d] leg di kolle[n] ab vn[d] leg aud ain geb

i lb vn[d] aud das abder teil gege[n] dem gebicht

ground charcoal onto it until it is fully covered. And sew it

fol. 57 v

up and soak it as before. And sew it and soak it for a lengthy

time until you have a string [of them] for five or six or ten hours,

depending how much time you have. You should put them in front of

the fireplace and paint them. Pour away all that [the liquid] you do not need. And

place [them] so that they are not crossed over each other,⁶⁶ and

paint them with the colour which is described below.

When that has been done take fustian⁶⁷ and have made for yourself

little bags which you can find drawn. They are 'plait'⁶⁸ or 'needle bone'

or other things as used by a merchant.⁶⁹ Follow

this and note how you have to make the ingredients

which are put into a template made out of the fabric and which can be set alight.

First, take a well-balanced pair of scales and put on them

6 pounds of weight and on the other side against the weight

6 pounds of saltpetre and take off the saltpetre and place on the scales

2 pounds of weight and against [it] on the other side

2 pounds of sulphur and take off the sulphur and put on

1 pound of weight. And put on the other side of the scales

1 pound of saltpetre salt. And take off the salt and put on

1 pound of weight. And put on the other side of the scales

1 pound of lime wood charcoal and take off the charcoal and put on one side

1 pound and on the other side against the weight [put]

⁶⁶ To avoid that they do not stick together after they dried.

⁶⁷ As in part 1, this is more likely to refer to a form of coarse wool (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/barchent.s.0m_1513750868).

⁶⁸ Not entirely clear what this refers to. It looks that the terms relate to domestic items of different shapes and sizes. One possible speculation is the reference in the *Althochdeutsches Wörterbuch* where 'cosp' is referred to as 'clasp' ('Klammer, Verbindung', *Althochdeutsches Wörterbuch Online* - accessed 22 March 2018). It could also relate to a 'plait' ('zoppf') as stated further down in the text.

⁶⁹ From the context it looks likely that these refer to different sizes which may have been known at the time.

i lb gestosse harz das lauter sie vn[d] leg harz ab leg auf
 i lb am gebicht vn[d] auf das ander teil dar gege[n]
 i lb gemalle[n] puche[n] faule[n] holz alß sw wr geschriben
 vinst an dem iv plat wu dws male[n] solt losse[n] vn[d] loß de
 itilig klein stesse[n] sam wolstu pulfer dar auß vn[d] misch den
 rein unter ein ander vn[d] ridz dwrch ein wet splen] das

25

fol. 58 r
 1 eß sich vorein vn[d] loß vntr dem stamot stosse[n] vn[d] ful dÿ seck
 lein vo[n] parchet gemacht auf das herzt ider dy zosp
 oder di nodel pein vn[d] zw oberst ein wenig guz sisch pulfer
 des geleiche[n] ein di schnur mit kolle[n] gefast an den ort alß
 das zw same[n] burst nee[n] vn[d] nom den der schnur alß lanck
 5 dw di stund lege[n] wilt vn[d] stoß ein dÿ vor genante[n] parchet
 mister vn[d] neß zu haufe[n] vn[d] wen das geschit so merck wi
 dws an streiche[n] solt das im der rauch vn[d] schmack vor ge[t]
 das ma[n] sein nit schmeckt so dws heimlich ein lege[n] wilt
 merck ewe[n] zu[m] erste[n] nim gaffer ein der apentecke[n] auf
 ein lot vn[d] geschelt mandell kere[n] wan der gafer let sich
 nit stosse[n] vn[d] nim alwer broß vn[d] auf ein achteill lb
 gestosse[n] sandelß der durch ein hereß sip gerede[n] sei aber

10

1 pound of ground resin which is pure. And take the resin off and put
 1 pound of weight and on the other side against
 1 pound of ground-up rotten beech wood as you find written
 on sheet 60. You should let this be ground and let it
 be pounded into small pieces to make powder of it. And mix it
 well together and put it through a wide sieve so that

fol. 58 r

it comes together⁷⁰ and have it ground under the stamp mill. And fill the little bags,
 made out of fustian, until they are full, either [with] the 'plait'
 or the 'needle bone'. On top add a little good gunpowder
 which is equally surrounded with the cord and charcoal at the point
 where you have to sew it up. And take from a cord which is as long
 as an hour is laid,⁷¹ and push into the aforementioned fustian
 template and wet it thoroughly.⁷² When that is done, note that
 you need to paint it so that the smell and taste⁷³ is gone [from it]
 so that you cannot taste⁷⁴ it and so that it can be stored in secret.
 Therefore, note first to take camphor from the apothecary, about
 one lot, as well as peeled almond kernels, if the camphor cannot be ground
 on its own. And take half a shoot⁷⁵ and for an eighth of a pound of
 ground sandal wood⁷⁶ which has been filtered through a hair sieve. But

⁷⁰ This is likely to be read in the sense of 'mixing well'.

⁷¹ Not clear what this expression refers to.

⁷² The literal meaning is 'in a pile', but a figurative meaning can be more 'plentiful' or 'often'.

⁷³ Literally, the terms used are 'smoke' and 'taste', but the expression seems to refer to the appearance.

⁷⁴ It is more likely that this refers to the smell, but to distinguish from the section before, 'taste' was left in the translation.

⁷⁵ The reference for this is 'Spröß' or 'Knospe' (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/bros.s.0m_1513594193).

⁷⁶ 'Sandal wood' (Latin: '*Santalum*') is very heavy and has a strong fragrance which it retains longer than most other woods. It also is used as colouring agent in dyeing processes, and cooking (Woolgar (2018), 2-3). This means that this reference may refer to odour and visual appearance to distinguish the arrows from each other. '*Santalum Album*' produces sandal wood oil, distilled from the wood (Michael Allenby ed. (2013), *A Dictionary of Plant Sciences* (3rd edition) Online, <http://www.oxfordreference.com/view/10.1093/acref/9780199600571.001.0001/acref-9780199600571-e-6037#> - accessed 1 April 2019).

15 zipreß holz wer auch gut vn[d] tu den di stuck zu same[n]
 in ein glese[n] hafe[n] vn[d] geuß dar an schelkraut waser vn[d]
 deck den hafe[n] zu auf iii tag vn[d] geuß den mer schelkraut
 waser dar an vn prante[n] wein vn[d] stoß in eim morser
 vn[d] zwungs dwrch ein tuch vn[d] nim meng vn[d] deß durch
 zwunge[n] waserß vn[d] mach ein varb vn[d] los warm werde[n]
 20 vn[d] ein wenig leim waserß das di varb nit ab ge[ht] vn[d]
 streich den di fewr an vn[d] loß trucke[n] so hastu gute heim
 liche fewr vn[d] rauch vn[d] schmack
wiltw gwt fewr pfeil mache[n] di zech prinen so
volg disem noch geschriben[n] kapitel noch merck wi dw
 25 **den zeug mache[n] solt vn[d] vo[n] welche[n] gebicht streich**
si rot an mit leim farb . . gr . . za . . kusber

Wiltw dise vor geschriben[n] fewr pfeill mache[n]
 so volg disem kapittel noch wi duß mache[n] spot
 30 zw[m] erste[n] loß dir mache[n] eise[n] einß halbe[n] such
 lanck alß dw ein diesem puch gemolt vinst wi si sein

fol. 58 v

1 swlt gestalt vn[d] vo[n] dem peste[n] eise[n] vn[d] nim den parchet
 vn[d] loß si an dem rauche[n] ort zu same[n] neen
 vinst an dem plat wi preit vn[d] lanck dws schneide[n]
 solt vn[d] loß si an dem rauche[n] ort zu same[n] neen
 5 vn[d] eng vn[d] ker si den wmb das di net hin ein kwm
 vn[d] vaß si den deß her nach geschriben[n] zeugs vol
 vn[d] auf das herzt vn[d] nom den ein wog vn[d] leg auf

cypress wood would also be good. And then put all the ingredients together
 in a glass bowl and add greatercelandine water. And
 cover the bowl for four days and pour more greatercelandine
 water into it as well as brandy. Grind it in a mortar
 and force it through a cloth and take a bit of the
 forced-through water, and make [*this into*] a colour. And let it warm up
 and [*take*] a little clay water so that it does not lose the colour and
 then paint the fire[work] and let it dry out. Then you have good secret
 fire[work] in smell and taste.

If you want to make a good fire arrow which burns battlements then follow this chapter that follows. Note how you shall make the ingredients and of which weight, paint it red with clay colour. . . Rare . . Precious.⁷⁷

If you want to make the fire arrow mentioned above then follow this chapter how to make it.
 First, have made an iron [*arrow*], one which is half as long as you find drawn in this book, where its

fol. 58 v

shape is shown, and made from the best iron. And take the fustian and let it be sewn together tightly in the smoky place.⁷⁸
 You find on this sheet how wide and long you should cut it and let it be sewn together tightly in the smoky place.
 And turn it inside out so that nothing can get inside.
 And fill it up with the ingredients described below until they are full. And take a pair of scales and put on [*it*]

⁷⁷ These fragments of text are unique in this text. Often the scribe finishes lines half way and continues to fill the rest of the line with some decorations. However, in this context what looks like decoration also includes some words, or fragments thereof, which are included in the translation.

⁷⁸ It is not clear from the text what place this refers to. What is required is to have a place where the fustian can dry out thoroughly.

viii lb am gebicht vn[d] der gege[n] auf das and[re] teil
 viii lb salp[eter] vn[d] nim den salp[eter] ab vn[d] leg auf
 iiiii lb am gebicht vn[d] leg auf ander teil d[e]r wog
 iiiii lb schwefell vn[d] leg den schwefell ab vn[d] leg auf
 ii lb am gebicht vn[d] auf da and[re] teil wog
 ii lb linter kolle[n] leg kolle[n] ab vn[d] leg auf wog
 i lb am gewicht auf das and[re] teil dr wog
 i lb des vor genante[n] faule[n] gemalen holz vn[d]
 loß itilig klein stosse[n] sam wolst fisch pulfer dar auß
 mache[n] vn[d] misch den wnter ein ander vn[d] rid durch
 ein weiz sip das eß sich vorein vn[d] loß den dy eise[n]
 an schweste[n] vn[d] stoß geleich dwrch di vor gefult
 secklein vn[d] pinz obel[n] vn[d] vntel[n] hart zw vn[d] wen
 das geschit so hert si den in dem hernach geschribel[n]
 hert waser do hab den pfeill ein auf das lengst
 das einer macht ein pater noster spreche[n] vn[d] loß
 den truckel[n] an der swne[n] oder stwbe[n] vn[d] huz vor
 fewr vn[d] streich den rot an mit der leim farb
 vn stoß dien einß zwere[n] daume[n] lanck in schwef
 vn[d] so hast dw di peste[n] fewr pfeil di nimat macht

fol. 59 r

1 **wiltw awer gret fewr pfeil mache[n] so folg dise[n]
 nach geschribel[n] kapittel noch vn[d] di sint nit alß
 gech als di vor genante[n] vn[d] streich pls an vn[d] faß
 in alle der moß alß vor**

5 **W**iltw di vor geschriben fewr pfeil mache[n] so
 merck zw erste[n] im an fang loß dir fewr

8 pounds of weight and against [it] on the other side
 8 pounds of saltpetre and take off the saltpetre and put on
 4 pounds of weight and put on the other side of the scales
 4 pounds of sulphur and take off the sulphur and put on
 2 pounds of weight and put on the other side of the scales
 2 pounds of lime wood charcoal. Take off the charcoal and put on the scales
 1 pound of weight, on the other part of the scales
 1 pound of the rotten ground described earlier wood and
 let it be ground finely as if you would want to make fish powder⁷⁹ out
 of it. And mix them together and run them through
 a wide sieve so that they become one. And take your iron [arrow]
 which is heavy and push it through the filled
 small bag. And tie it at the top and bottom tightly. When this is
 done, harden it with the hard water
 described below. Place the arrow [in the water] for as long
 as one can say the *Pater Noster* and let it
 dry in the sun or inside, but be careful about
 fire. And paint it red with clay paint
 and push it into sulphur for a moment with a heavy thumb
 and then you have the best fire arrows which anyone can make.

fol. 59 r

**But if you want to make a great fire arrow, then follow this
 chapter written below – and they are not as quick as
 those previously mentioned. And paint them blue and fill
 them all using the measurements as before.**

If you want to make the fire arrows mentioned above then
 note first, to begin with, have yourself [made] a fire

⁷⁹ Most likely referring to ground fish bones.

pfeil eise[n] schmide[n] alß vor vn secklich vn faß
das noch geschriben pulfer dar ein awer eß burt
andeiß am gebicht zw gen dan for leg auf di wog

¹⁰ vi lb am gebicht vn[d] auf das ander teil der wog
vi lb salp[eter] vn[d] leg den salp[eter] ab vn[d] leg auf wog
ii lb am gewicht vn[d] auf das ander teil dr wog
ii lb schwefell vn[d] nim den schwefell ab vn[d] leg auf
i lb am gewicht vn[d] auf das ander teil auf wog
¹⁵ i lb linter kolle[n] vn[d] nom di kolle[n] ab vn[d] leg auf
i lb am gebicht vn[d] legeg auf das ander teil
i lb gemale[n] faule[n] puche[n] holz vn[d] loß itlig vor
klein stosse[n] sam wohlt fisch pulfer mache[n] vn[d] misch de[n]
rein vnter ein ander vn[d] loß vnter dem stamfp stose[n]
²⁰ vn[d] faß den alß vor vn[d] streich an so hastu gut fewr
pfeil di lanck sam prine

**wiltw awer gut fewr pfeil mache[n] so merck ebe[n]
vo[n] velche[n] zeug dwö vassen solt vn[d] streicht sy pran**

Wiltw di vorgeschriben fewr pfeil mache[n] so vaß
in alle der moß alß vor mit den eise[n] vn[d] secklein
awer der zeug muß an der wog anderß wer[de]n
zu erste[n] nom ein geleiche wog vn[d] wig vi lb salp[eter]
vn[d] ii lb schwefelß i lb salp[eter] salz i lb linter kolle[n] i lb
gestose[n] lawter harz das klein gestese[n] sei vn[d] vn[d] misch

fol. 59 v

¹ wnter ein ander vn[d] hert si ein dem noch geschriben
hert waser vn[d] halz dar ain alß lang einer mocht

arrow forged from iron and a cloth bag. And put
the powder together as described below. But it is proper⁸⁰ to
check the weight and place on the pair of scales
6 pounds of weight, and add to the other side of the scales
6 pounds of saltpetre. And take the saltpetre off and place on the scales
2 pounds of weight, and add to the other side of the scales
2 pounds of sulphur. And take the sulphur off and place on the scales
1 pound of weight, and add to the other side of the scales
1 pound of lime wood charcoal. And take off the charcoal and place on the scales
1 pound of weight. And add to the other side
1 pound of ground-up rotten beech wood and have it ground
into small pieces, in the same way as fish powder is done. And mix it
together. And have it ground together in the stamp mill
and fill it up as before and paint it. Then you have a good fire
arrow which burns slowly.

**But if you want to make good fire arrows, then note
which ingredients you should know and paint them brown.**

If you want to make the fire arrows described before, then take
all the measures as before with the iron and the cloth bag,
but the ingredients on the pair of scales have to be different.
First, take the same pair of scales and weigh up 6 pounds of saltpetre
and 2 pounds of sulphur, 1 pound of saltpetre salt, 1 pound of lime wood charcoal, 1
pound of ground pure resin which has been finely ground. And mix

fol. 59 v

it together and harden it in the hard water
described below. Keep it in it [*the water*] as long as it takes you

⁸⁰ 'eß burt' in the sense of 'to be appropriate', 'to be proper' (Definition 3: 'sich gehören, geziemen; notwendig, üblich sein', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/geb%C3%BCren.s.3v_1513310169).

ein pater noster spreche[n] vn[d] loß den trucke[n] vn streich
si mit der varb an pran vo[n] des gernerck wege[n]
**wiltu awer fewr pfeil mache[n] di auf das lengst
prine[n] vn[d] streich si swarz an vo[n] deb gernerck wege[n]**

Wiltw awer pfeill mache[n] auf das lengst

zw prine[n] so merck vn[d] loß dir eise[n] mache[n]
alß vor vn[d] fase[n] mit alle[n] dinge[n] vn[d] herte[n]
so nim iii lb salp[eter] iii lb schwefel i lb linter kolle[n]
vn[d] mach dar auß den zwug zu de fewr pfeille[n]

**wiltw ein hwbliche kwnst mache[n] von eine[m] hert waser
dar inen dw eine[n] itingen fewr pfeil herte[n] must wa[n]
dw des nit tust so ist der fewr pfeill vor nichte vn[d]
magst auch wol pulfer dar ine herte[n] wan es vor
dirbt nit vn[d] wirt dester peser vn[d] nimt nit ab**

Wiltw dise vor geschriben hert mache[n] so merck
ewe[n] nim xxx moß esig vn[d] wig dar gege[n]
alß schwer salpeter vn[d] nim v lb gemalle[n]
wait asche[n] auf ein moß schel kraut waser

vn[d] iii teill lawter waserß ii lb pilsen some[n] vn[d] schut
di stuck all zw same[n] in ein kessel vn[d] loß side[n] auf
ein firtel stund vn[d] nim den den vor genante[n] fewr
pfeil den dw gemacht hast e dw in mit der fabr
an streicht halt in ein den kessel alß lang einer
macht ein pater noster spreche[n] vn[d] loß den rein truck
vn[d] streich den it der leim farb an wer aber das

to say the *Pater Noster*. Let it dry and paint
it with the colour brown so that you can remember them.
**But if you want to make fire arrows which burn longer
then paint them black so that you remember them.**

But if you want to make arrows so that they
burn the longest, take note and have made for yourself some iron
as before and gather together with all the things and harden them.
Then take 3 pounds of saltpetre, 3 pounds of sulphur, 1 pound of lime wood
charcoal and make the material for the fire arrow out of it.
**If you want to make a 'courtly art' of hardening water⁸¹
in which you have to harden any kind of fire arrow. If
you do not do this, then the fire arrow becomes useless. And
while you may have powder hardened inside, it will
not go off, and it will get better, and will not get worse.**

If you want to make the hardening [*water*] described earlier, then note
therefore to take 30 measures⁸² of vinegar and weigh against it
the same amount of saltpetre. And take 5 pounds of ground
white ash to a measure of greatercelandine
and 3 parts of pure water, 2 pounds of fungi spores. And pour
the ingredients all together into a pot, and let it simmer for
a quarter of an hour. And take the aforementioned fire
arrow which you have made, before you paint it
with colour, put them into a pot for as long as
you would take to say a *Pater Noster*. And let them dry thoroughly
and paint them with the clay colour. If that does not

⁸¹ This reference to 'hert waser' could refer to a particular type of water, or to what the water achieves. From the context the translation used the latter as the process would harden the arrows, which in turn would help their use in combat. See chapter 4 for more details.

⁸² 'moß' or 'maß' can be translated into a range of different types of measurements, all of them measuring volume. See *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/bechermas.s.2n_1513585950 and http://fwb-online.de/go/aufhaufen.s.3v_1513609850.

di hert ab wolt neme[n] so nimst lauter waser vn[d] mereß
 si vn[d] halt di kunst vor porge das dus nit lerst das
 das si nit gemei wert wa[n] eß ist nit zu gerote[n] zu fewr
 pfeille[n] wan[n] er leit I gar das er nit vor durbt

30

fol. 60 r

1 **wiltw awer ein hoflich kwnst mache[n] vo[n] oll geprunt
 vn[d] heist oliu[m] pretoliu[m] vn[d] gut zu alle[n] fewrwerck**

Wiltw diz vor geschriben ol prene[n] so volg
 disem noch geschriben kapitel noch wi dws
 mache[n] solt zu erste[n] nim ein neue[n] glesen hafe[n]
 grab in ein di erde das er mit dem prort
 ii vinger wber di erde[n] ge nim ein neue[n] lauge[n] hafe[n]
 der an dem pode[n] locher hab vn[d] sez in ein den glese[n]
 hafem mit dem pode[n] alß dw gemolt vinst an dem
 lxxxx plat | vn[d] for streich in rein mit har laim do man
 mit fwrmt vn[d] leg den auf dem poden ein den locheret
 hafem auf ein fir dug lebentig schwefell den mer
 vnter anderm schwefell wiß wi dw eiteill lebentige
 schwefell ii lb vnter vii lb gemein schein vn loß
 in vnter ein ander zu gen vn[d] geuß in den auß das
 heist lebentiger schwefell wan i lb dut alß vil alß
 swnst v lb vn[d] wen das geschit so leg ein hant foll
 schwel kraut | mit den burzell ein den hafe[n] auf den

10

15

harden them, then take purified water and add to
 it. **And keep this ‘art’ secret so that you do not teach what
 is not meant for everyone, when it is not advisable to have fire
 arrows, when they work⁸³ and when they do not go off.**

fol. 60 r

**But if you want to make a ‘courtly art’ of burnt oil
 which is called *olium petrolium* and which is good for all fireworks.**

If you want to make⁸⁴ this oil described above, then follow
 this chapter written below on how to
 make it. First, take a new bowl made out of glass,
 bury it in the ground so that its rim
 is two fingers above the soil. Take a new bowl filled with lye
 which has holes in the bottom and place in the glass
 bowl with its bottom as you can find drawn at
 sheet 90.⁸⁵ And spread on it clay mixed with hair⁸⁶ which
 is used to shape it. Put into the bottom of the
 bowl with holes a quarter part of native sulphur which is whiter
 than the other sulphur. Put 2 pounds of native
 sulphur into 7 pounds of common sulphur and let
 it come together. Pour it out, and it is
 called native sulphur where 1 pound is enough for as much as
 5 pounds otherwise. And when this has been done, put a hand full of
 greatercelandine with its roots into the bowl on top of the

⁸³ ‘*Etwas leiden*’ can be understood with a positive connotation of ‘permitting, enabling’ (Def. II, 2 ‘*gestatten, erlauben*’, *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

⁸⁴ The original uses ‘burn’ (‘*prene[n]*’) which could be a reference to the production process. The context implies a state of purification of the oil.

⁸⁵ The number is added in different coloured ink, same hand. It is not clear what this refers to on fol. 90 r and v (see end of chapter 2 for depiction of illustrations).

⁸⁶ This presumably refers to clay mixed with hair to strengthen it.

schweffell vn[d] wasch vor rein vn[d] nim ein kraut mit
 heist metron [*superscript text in same hand*]
 burzell vn[d] wasch auch rein des nim auch alß vill
 alß deß schelkraut vn[d] nim den kimg holz das do gron
 sei alß klein das eß ein de hafe ge awer wacheltrein
 holz weholtz wer pesser vn[d] auf das holz leg auf ein hant vol
 lauter gestose[n] harz vn[d] aber schel kraus vn[d] metron
 vn[d] holz vn[d] mach di leg alß dws an gefang
 hast piß der hafe[n] vol burt nim ein neue sturtzte[n]
 vor streich den hafe[n] mit dem vor genante[n] laune[n]
 vn[d] mach dar vm ein gelut mit kolle[n] vn[d] loß di gelut
 ab prine[n] vn[d] prich den den haffe[n] auf vn[d] raum in

sulphur. Wash it properly and take the herb [greater celandine],⁸⁷ which
 is called 'metron',⁸⁸
 [its] roots and wash it well. Then take as much as the
 greater celandine and take pine⁸⁹ wood which is green
 and so small that it fits into the bowl – but 'wacheltrein'⁹⁰
 wood would be better.⁹¹ And put on the wood a lot
 of ground resin and greater celandine and 'metron'
 and wood and put them in one after the other as you have started
 until the bowl is full.⁹² Take a new lid,⁹³
 fill up the bowl with the said alum.⁹⁴
 And make some embers with charcoal and let the embers
 burn down. And break open the bowl and clear it

fol. 60 v

out. Let the bowl rest, and add into it all the
 measures as before, and seal it again, and burn it a 'quart',
 or four hours for as long as you want to have oil. And you
 will let it burn twice, and when you bring it back

fol. 60 v

den auß vn[d] laß den haffe[n] sten vn[d] leg in aller der
 moß ein alß vor vn[d] streich wider zu vn[d] pren ein fart
 oder iii stund alß vil dw des olß hawen wilt vn[d] wirst
 den noch zwir prene[n] vn[d] wen dw das erst wider

⁸⁷ This is what the text refers to, but it is only called by the generic term 'herb'.

⁸⁸ No reference could be traced for this. It could be a scribal error of spelling, or a local name which is no longer known or recorded.

⁸⁹ This could also read be 'kung'. It not clear from the context what this refers to. It requires a type of wood, but the term could be either as an adjective (related to size, colour, shape, etc.) or as a compound noun (a specific name or a more generic term similar to 'royal wood', i.e. high quality wood). More likely, however, is that it is a scribal error and was intended to read 'kien', i.e. pine wood ('Fichte', *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/kien.s.0m_151884486).

⁹⁰ No reference could be traced for this type of wood. Is not even clear whether it relates to a particular type of tree or a usage of the wood. For example, see 'Wachtelholz' which is described in Grimm as a 'piece of wood used to fold collar shirts' ('ein Holz, das dazu dient, den Hemdkragen zu fälteln', *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018).

⁹¹ Presumably this implies some interaction with resin, but not made clear in the text.

⁹² It is possible that this process is referring to layering, but not entirely clear from the text.

⁹³ In the *Frühneuhochdeutsches Wörterbuch Online*: 'gekleyberte Sturzen' refers to a form of a bucket; it implies a wooden container brought together with glue or iron ('Gefässe, Trichter, in die oder mit denen Flüssigkeit gegossen wird') or in the sense of a 'lid' ('Topfdeckel', *Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/b%C3%8ctner.s.0m_1519240106).

⁹⁴ Likely to refer to 'alum' ('Alaunen', *Frühneuhochdeutsches Wörterbuch Online*, http://www.fwb-online.de/go/alaun.s.0m_1513751058).

5 ein sezt auf das halb teil des hafens so leg auf das holz
 vn[d] nim ein lot mekwriu[m] swplimatu[m] leg auf holz das
 vinst ein der apentecke[n] vn[d] ful den den hafe[n] volent
 zu mit den kreuter vn[d] holz vn[d] harz vn[d] leg di leg
 alß lang piß dw den hafe[n] erfulst vn[d] vor streich in
 10 alß vor mach dir wm ein gelut auf ii stund vn[d]
 vn[d] prich den hafe[n] auf vn[d] raum in auß alß vor vn[d]
 sezsetz zw[e]i lezte[n] mol ein alß im an fang mit dem schwefel
 vn[d] di zweirlei kreuter vn[d] holz piß auf das halb teil
 15 des hafens vn[d] nim auf i lb oliu[m] prettoliu[m] ein d[e]r
 apentecke sez mit der pusche[n] ein den hafe[n] vn[d] fwl in
 follent zu mit den kreuter vn[d] holz vn[d] harz vn[d] mach
 dar um ein gelut vn los ab prine[n] vn[d] prich den
 hafe[n] auß vn[d] raum auß vn[d] heb den vnter hafe[n] auß
 der erden so hast dw das pest ol zw mancher lei fewr
 wercke dw mach auch wol mit lein ol mere[n]
 20 **wiltw awer ein hoflich kunst mache[n] vo[n] einem**
waser das mit dw ein itilig pusche[n] mit ab kelten
mast ab dir so vill schwß des das dir di pusch
erhizest das du kein schwß dorst ton so volg
disem noch geschriben kapitell noch

Wilt diß vorgeschriben waser mache[n] so volg
 disem nach geschriben kapitell noch zu erste[n]
 nim xxv lb weinstein xv lb wait asche[n]
 der gemalle[n] sei vl lb salp[eter] salz schut das

to one part of the bowl, then place a piece of wood on it
 and take one lot of *mercurium sublimatum*, which you can
 find in an apothecary, to the wood, and fill the bowl completely
 with herbs and wood and resin. And place one on top of the other
 until the bowl is full. And cover⁹⁵ it
 as before and make warm embers for two hours. And
 break open the bowl and clear it out as before. And
 place it for the two last times as in the beginning with sulphur
 and two types of herbs and wood until you have filled the bowl
 half way.⁹⁶ And take 1 pound of *olium petroleum* from the
 apothecary, and place it into a pot with a brush.⁹⁷ And fill it up
 completely with the herbs and wood and resin. And place embers
 around it and let it burn down. And break open the
 bowl and clear it out. Lift up the lower pot from
 the ground, and you have the best oil for all types of firework
 to which you can also add linseed oil.

**But if you want to make a ‘courtly art’, of a
 water with which you can cool down any gun
 which has been fired a lot so that the gun
 has become so hot that you cannot fire from it anymore, then follow
 the chapter written below.**

If you want to make the water written about above, then follow
 this chapter written below. First,
 take 25 pounds of cream of tartar, 15 pounds of white ash
 which has been ground, [and] 6 pounds of saltpetre. Put it

⁹⁵ In the sense of ‘smooth, seal, cover’ (*‘abstreichen’*, definitions 9 and 10, *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/abstreichen.s.3vu_1513744469).

⁹⁶ This action seems to imply that the process applied here is a reduction of liquid, but it is unclear what it would achieve with *olium petroleum*.

⁹⁷ ‘puschen’ is used throughout the text to stand for ‘gun’ (*‘Büchse’*). However, this would not make sense in this context. It is more likely to refer to a ‘brush’ (from ‘busch’, *Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/busch.h1.0m_1513568092).

fol. 61 r

¹ zw same[n] in ein neusch schaf vn[d] misch vnter ein ander
vn[d] nim den den hefe[n] dar auß die meschingflacher gise[n]
oder di rot schmit vn[d] faß in den vol des gemiste[n] zeug
vn[d] vn[d] sez in ein wint ^{offen} dar ine di rot schmit gisse[n] vm[b]
⁵ mach dar wmb ein glwt vo[n] kolle[n] vn[d] loß prine[n] auf ij
stwnd vn[d] stoß vnter weille[n] ein den hafe[n] mit eim
eisen das eß sich hin noch sez vn[d] schwt den auß dem
s hafe[n] vn[d] sez der hefe[n] alß lang ein alß vil dw deß
waserß hawe[n] wilt vn[d] loß den prene[n] in der moß alß
den prante[n] wein vn[d] geuß den in gleser vn mach
di geleß genau zu vn[d] wen dws prauche[n] wilt ab
dir ein pusch haiß burt das dw nit gesische[n] mocht
so nim des geprante[n] waserß vnter ein halbe[n] aimer
vn kul die pusch da mit ab so scheust dw an alle sorg
das der pusche[n] kein schade[n] prengt

¹⁵

fol. 61 r

all together in a new barrel and mix it together.
And take all that is left [and] pour into a brass bottle
or [a bottle] which is from a brass smith. Take all the ingredients mixed together⁹⁸
and place them into a wind oven,⁹⁹ one which is used by a brass smith to smelt.¹⁰⁰
Get embers from the charcoal and let it [what is in the oven] burn for two
hours. And stir it occasionally in a pot with an
iron [poker] so that it finally settles down. Then pour it out of
the pot and keep the remainder for as long as you want
to have the water. And let it burn¹⁰¹ with a measure of
brandy and pour it into glasses, and seal the
glasses well as you will need it when
your gun will get so hot that you cannot fire it anymore.
Then pour the burnt water into half a bucket¹⁰²
and cool down the gun with it. This way, you see to it that all the precautions
[are taken] that no harm is done to the gun.¹⁰³

⁹⁸ German original unclear.

⁹⁹ The term 'offen' is written in the manuscript in superscript, and appears to be written in the same hand, which suggests that the author added it after reading the text again. This most likely refers to a fireplace or forge with the added possibility of air supply to make the embers as hot as possible (as a blacksmith would use).

¹⁰⁰ The literal meaning of 'gissen' is to 'pour', but it is more likely that it refers to the brass smith's action here.

¹⁰¹ Here this implies to have it 'reduced' or 'concentrated'.

¹⁰² This could either imply the size of the bucket, or that it is a bucket which is half-filled with water.

¹⁰³ Text ends half-way down one page.

Chapter 4: Analysis of the text

Rainer Leng describes the *Firework Book* as a ‘recipe collection of chemical knowledge’.¹ He mentions this in order to distinguish it from related manuals, such as the later *Büchsenmeister* Books,² all of which developed their own momentum in relation to distribution, use, and functionality. Berg and Friedrich are more specific, describing it as an ‘instruction for making saltpetre, gunpowder, and various incendiary devices’.³ They also single out the *Firework Book* as the first extant publication which collates practical knowledge related to a technical profession written in German, or any other vernacular European language. This chapter shows that it is far more than a ‘collection of chemical knowledge’, in that it provides a detailed analysis of the content of the *Firework Book* following on from the edition and translation just provided. Analysis will begin with the structure of the *Firework Book* and its key sections – building on chapter 1 – discussing in particular the Master Gunner’s Questions, the master gunner’s core attributes, key terminology, and then in more detail the bulk of the *Firework Book*’s recipes.

Master Gunner’s Questions and attributes

As explained in chapter 1, the traditional sections of the *Firework Book* form a relatively regular pattern, with a preamble, the Master Gunner’s Questions (usually twelve), a section on the discoverer of the gunpowder, and a section related to the skills and attributes of a master gunner followed by a list of individual recipes and advice on ingredients, gunpowder, handling cannons, and other incendiary devices. The reason why there is a section on skills and attributes is because the observation of these will establish the person’s inner worth. In

¹ Leng (2000), 12.

² The modern German term ‘*Büchsenmeister*’ implies that the master gunner has an input in the manufacturing process while in a fifteenth-century context, all references of ‘*puchsen maister*’ (or similar) seem more related to the Early New High German term ‘*Konstabel*’, describing an individual in charge of the handling of an artillery piece, later on a title as a non-commissioned officer in an artillery unit. The *Frühneuhochdeutsches Wörterbuch Online* definition of ‘*Büchsenmeister*’ was changed after discussions with the editorial team following my suggestion (15/2/2018) to exclude ‘maker of guns’ as all references refer to the role of person in charge in situ, and no references are related to the production. (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/b%C3%BCchsenmeister.s.0m_1513302890). There is a distinct difference to the role of ‘*Büchschmied*’ – the smith in charge of the manufacture of a gun (*Frühneuhochdeutsches Wörterbuch Online*, http://fwb-online.de/go/b%C3%BCchschmied.s.0m_1513341043).

³ Berg/Friedrich (1994), 170.

the context of fifteenth century morality, how a person behaves is an indication of their professionalism and ethical outlook. A master gunner has to be able to read and write; he also had to be of the right temperament and aptitude which provide a moral code to which he should adhere – thus showcasing the close relationship between etiquette (personal comportment and behaviour) and ethics.⁴

The Master Gunner's Questions follow a strict rhetorical principle which is different to the style applied in any of the later pieces of text in the *Firework Book*. They usually contain the twelve questions, stating whether and how:⁵

- (1) the fire or the gas drives the projectile out of the gun;
- (2) sulphur or saltpetre provide the strength to the shot;
- (3) a projectile flies further with more or less powder;
- (4) a plug should be softer or harder;
- (5) a stone should sit tightly or loosely in the gun;
- (6) wedges used should be made out of soft or hard wood;
- (7) wedges should be thinner or thicker;
- (8) the projectile sealed most effectively in the gun;
- (9) mixing powders increases the power of a shot;
- (10) a projectile should touch the plug in the gun;
- (11) ground powder or *Knollenpulver* is stronger; and
- (12) to find the most advantageous proportions of powder quantity and projectile weight.

⁴ The *Firework Book* clearly shows markers of emerging professionalism, e.g. a standard of conduct, a system of training, and a sense to keep ones knowledge within their professional community. This subject has been discussed in various fields, in most detail within the medieval medical profession. See Toby Gelfand (1993), 'The history of the medical profession', in William F. Bynum and Roy Porter eds., *Companion Encyclopaedia of the History of Medicine*, London/New York: Routledge, 119-50.

⁵ There are occasionally exceptions to the twelve questions, e.g. Berlin manuscript germ. fol. 710a only lists ten questions, and Berlin manuscript germ. quart. 1187 lists only eleven questions.

These questions address the core elements of gunpowder artillery; they do not address tactics or subtle differences, but highlight the basics, from how to load and fire the gun to core observations of powder in the period. As early as 1889-91, their importance was acknowledged by Max Jähns who referred to the twelve Master Gunner's Questions as the epitome of gunpowder artillery of the fifteenth century.⁶

The questions have consistently been referred to as a 'catechism', akin to religious teachings, according to the way the rhetorical question is followed by an explanatory answer.⁷ This style, directly addressing one actual or imagined individual in a one-to-one teacher-pupil relation, is a familiar rhetorical format which was used in a wide range of instructional and didactic texts.⁸ It must have been such a familiar context that it continued to appear in later *Büchsenmeister* Books. These questions are highly formulaic and became a standard of artillery training into the seventeenth century.⁹ They were also carried through into the English language, as, for example, in the 1647 publication of *The Gvnners Glasse* which lists the instructions of an experienced gunner to an apprentice.¹⁰ This rhetorical style of questions and answers provides a good indication of the use of the *Firework Book* as a teaching tool. Within the subject field it follows in the footsteps of Theophilus' *De diversis artibus* in the twelfth century, a text which provided detailed insight into the techniques used for a wide range of material arts.¹¹

⁶ He describes it as the '*artilleristische Schibolet des 15. Jahrhunderts*' which literally translates into the 'sextant or calliper of artillery in the fifteenth century' (Jähns (1889-91), 386). Later, he elevates the Master Gunner's Questions to describe them to have 'transmitted for one and a half century the kernel of artillery knowledge' ('*durch anderthalb Jahrhundert den Kern des artilleristischen Wissen überliefert hat*', Jähns (1889-91), 395). He also refers to a sign of *Firework Books* being updated over time, and claims that questions 6 and 7 (related to the wedges) were changed in later *Firework Books* when gunpowder artillery had changed, and the lengthening of a gun, made out of one piece, improved the accuracy to such an extent that wedges were no longer required. (Jähns (1889-91), 397). Unfortunately, this observation could not be verified as the later version referenced ('*Manuskript des Berliner Zeughauses von 1454*') has been lost since Jähns's survey was produced.

⁷ Jähns (1889-91), 395, Schmidtchen (1977), 179, or Leng (2002), vol. 1, 199.

⁸ This includes the medical model of the Salernitan questions and the later scholastic university model. See Brian Lawn (1963), *The Salernitan Question: An Introduction to the History of Medieval and Renaissance Problem Literature*, Oxford: Clarendon Press, especially 92-112, for its use in the vernacular texts.

⁹ One example mentioned by Jähns is the *Kunstbüchlein von Geschütz und Feuerwerk*, published by De Bry in 1619 (Jähns (1889-91), 395).

¹⁰ See William Eldred (1646/47), *The Gvnners Glasse*, London: T. Forcet Boydell, *Early English Books Online*, http://0-gateway.proquest.com.wam.leeds.ac.uk/openurl?ctx_ver=Z39.88-2003&res_id=xri:eebo&rft_id=xri:eebo:image:113975:7 – accessed 20 April 2018.

¹¹ Theophilus focusses in particular on painting, glassmaking, and metalwork. The author's name is likely to have been a pseudonym used by Roger of Helmarshausen, a Benedictine monk, metal worker, and goldsmith.

Interspersed in the seemingly loosely structured list of recipes and instructions is a section on the attributes and skills that a master gunner should possess. It mentions that a good master gunner should fear God, display courage, pragmatism, and be able to read and write. Furthermore it relates to the master's ability to lead a balanced lifestyle (not over-indulging on alcohol or on specific food), and be of moderate temperament. The value and importance of listing these qualities is debateable. It is not clear whether they should be viewed as similar to twenty-first-century health warnings of 'not eating fatty foods' or 'binge drinking', and thus representing a reaction to such behaviour being widespread, or, whether they are more of a reassurance for anyone selecting a new apprentice by considering these moral and general attributes for safe handling of gunpowder.¹² In I.34, this section comes relatively late in the text (fols. 32 v ff.) – while most *Firework Books* have this section near the beginning, after the general introduction – but all copies of the *Firework Book* contain the same core elements. It could be seen as a link to the introductory section of the *Firework Book* and appears to read similarly as a device for insurance or threat, having spelled out the key attributes of a master gunner as it would void any comeback should a master gunner behave differently from the instructions expressed in the text.

The majority of the *Firework Book* text consists of a wide range of recipes and notes, with seemingly little discernible structure and some repetitions. This range implies that the book was not meant to be read from cover to cover, but instead to be used in its individual sections, and that it was helpful to have more information provided, even if it was repeating an earlier section. It is less clear, however, why their order changes from copy to copy.

Gerhard Kramer (1996 and 2001) is very specific in his analysis of the *Firework Book* composition, distinguishing between what he calls earlier and later sections, called by him 'strata'. In total, Kramer subdivides the *Firework Book* into in three stages of writing:

His main work *De diversis artibus* was an often published, copied and translated from its original Latin (John G. Hawthorne and Cyril Stanley Smith eds. (1979), *Theophilus. On Divers Arts*, New York: Dover, xv-xviii).

¹² See Rainer Leng (1999), 'Gründe für berufliches Töten. Büchsenmeister und Kriegshauptleute zwischen Berufsethos und Gewissensnot', in Horst Brunner ed., *Der Krieg im Mittelalter und in der Frühen Neuzeit: Gründe, Begründungen, Bilder, Bräuche, Recht (Imagines medii aevi 3)*, Wiesbaden: Reichert, 307-48, 318-20, and Leng (2002), vol. 1, 201-2.

1. Produced around 1380: The Master Gunner's Questions and the core components on the ingredients and the powder (in I.34 this equates to fols. 2 r – 20 r, and fols. 20 v – 25 v, fols. 29 r – 32 v, and fol. 34 r).
2. Produced around 1400: The 'Preamble', the 'invention' of gunpowder, and the gunner attributes, and the epilogue (in I.34 this equates to fols. 1 r – 2 r, fols. 20 r – 20 v, fols. 25 v – 29 r and fols. 32 v – 34 r);
3. Produced before 1432: 'postscript' (in I.34 this equates to fols. 29 r – 32 v, fols. 34 r – 51 r).¹³

The difference in format of the *Firework Book* (where the first section is a very close match to most copies in sentence structure, word selection, and rhetoric devices; the later sections with less coherence and looser structure) led to the assumption that 'the second section was added in a later production stage'.¹⁴ However, the text produced in all the *Firework Book* manuscripts which have been viewed continues without interruption, and does not indicate a break in the production stages.

It would indeed be useful to see the chronological development in the *Firework Book* text. However, Kramer fails to provide any substantiating evidence for any of these assertions. There is little to be gained in looking for earlier or later sections of the *Firework Book* as it quickly enters speculative territory. It is more likely that the first few folios of the text would have formed the better known sections, but the second part is not sufficiently different to give any indication of a change in technology, or language or style of writing. Moreover, the surviving corpus of *Firework Books* does not include a surviving *urtext* (it may even be questioned whether an *urtext* ever existed). The basis for speculation thus appears slender.

I.34 contains more than what has traditionally been viewed as a *Firework Book*. While the first 51 folios are similar in many copies, parts 2-4 (second text part on fols. 52 r – 61 v, the blank section on fols. 61 r – 83 v, and the illustrations on fols. 84 r – 115 r) contains further recipes and instructions which give some indications of users and practitioners of the

¹³ Kramer (2001), 10-2, and Kramer (1995), 98-120, where more explanations are provided for the subdivisions; however, the argument is partial, and cannot fully be reconstructed. It largely revolves around speculation on whether one should be written before another without explanations of the choice of dates.

¹⁴ Berg/Friedrich (1994), 219.

Firework Book. More beneficial than the above divisions is a detailed analysis of content and terminology.

Key terminology

One major challenge throughout the entire 61 folios is the lack of clarity about key ingredients and terminology used – both in the original and in translation. Producing a translation has made this lack of clarity even more apparent, and highlighted shortcomings in previous studies of the *Firework Book*.

Core terms such as ‘gun’ (*‘puchse’* or *‘püchse’*), ‘barrel’ (*‘ror’*), ‘powder’ (*‘puluer’* or *‘pulfer’*), ‘plug’ (*‘clotz’*, *‘klotz’*, or *‘klotzen’*), ‘chamber’ (*‘kamer’*) all require explanation. While these elements may appear obvious, modern scholars often allow their knowledge of later periods to influence their understanding of what was actually going on in this field in the fifteenth century.

Hence, a ‘gun’ is understood to be the entire piece which is loaded with powder and a ball without any specification as to whether this may have included the carriage. Apart from two exceptions, on fols. 31 v and 41 r, the *Firework Book* does not specify the size, format, mounting, and firing of the gun and no description is given as to the length or size of barrel. Nor is there any indication as to the range of these guns which was not a priority in early gunnery;¹⁵ in the fifteenth century, guns were used at relatively short range as direct shots.¹⁶

What is called ‘barrel’ on the other hand I understand to be the chamber of the gun, the section where the gunpowder charge is placed. It is sealed by the ‘plug’ which normally needs to be rammed into the barrel to be entirely inside it, sitting flush with its end. The ‘barrel’ is also often called the ‘chamber’. ‘Powder’ is used as a generic term for a mixture of ingredients which are brought together as described in detail. There is, however, no indication about the consistency of the powder, whether flour, lumped, *Knollenpulver*, or otherwise.

¹⁵ Kay Smith (2005) and Kelly DeVries (published under former name of Robert Douglas Smith), *The Artillery of the Duke of Burgundy, 1363-1477*, Woodbridge: Boydell, 211.

¹⁶ Glenn Foard and Anne Curry (2013), *Bosworth 1485: A Battlefield Reconsidered*, Oxford: Oxbow, 136.

The 'plug' is referred to on sixty separate occasions. In most cases it refers to the piece of wood used to seal the end of the barrel with the powder. In one case it is referred to when firing a 'plug gun' ('*Klotzbüchse*').¹⁷

Dealing with these terms in English (and Early New High German) is a challenge. The terms might appear straightforward, but give scope for interpretation. The same applies to the term '*Büchsenmeister*' (see chapter 1) which for the purpose of the translation has been translated as 'master gunner' or 'gun master'. This is to distinguish between the head of a gun troop and someone skilled in handling guns as discussed in chapter 5.

Similarly, caution is needed when referring to guns or ammunition. For example, what can be understood by a '*Steinbüchse*' ('stone gun') is largely a post-medieval term to describe a particular type of gun –and incidentally may receive its first mention in fol. 43 v ('*estain ror*') in a *Firework Book*. The term 'stone gun' is generally used to describe a gun which fires one or more stone projectiles before iron or lead shot became the standard. It can be seen in parallel with the chronological material culture periods (such as 'bronze age' or 'iron age') which have been retrospectively applied to people living in particular times. Most German scholarship refers to the seminal works by Schmidtchen which provide an overview of the *Steinbüchsen* type.¹⁸ His research was built on a century of scholarship investigating this terminology by Essenwein, Jähns, Romocki, Rathgen, and Feldhaus.¹⁹ However, this does not mean that a *Steinbüchse* would only fire stone projectiles. Stone, lead, and iron were all used as ammunition, as often composite shots 'made out of more than one material'.²⁰ Cast iron only came to be frequently used in the 1470s.²¹ The research work led by Glenn Foard at the battlefield site of Bosworth has shown a large amount of ammunition of varying sizes, many of which contain iron or lead.²² However, projectiles which had been entirely made

¹⁷ See Leng (2000), 104-105, Smith (2002-2016), mainly 2002 and 2003, and early sixteenth-century Biringuccio (in Cyril Stanley Smith and Martha Teach Gnudi eds. (1990), *The Pyrotechnia of Vannoccio Biringuccio*, New York: Dover, 425-8) for references to this technique, which was commonly used against horses, but does not fire long distances.

¹⁸ Brought together in Schmidtchen (1977), 12-82, and in subsequent publications by the same author.

¹⁹ Their major outputs to mention are von Essenwein (1877), Jähns (1878-80) and (1889-91), Romocki (1895), Bernard Rathgen (1928), *Das Geschütz im Mittelalter*, Berlin: VDI-Verlag, and Feldhaus (1931).

²⁰ Smith/DeVries (2005), 247.

²¹ Smith/DeVries (2005), 253.

²² Foard/Curry (2013), mainly chapter 7, and especially 147-9.

out of stone rarely register in the archaeological survey.²³ This transitional phase is reflected in the terminology used in the *Firework Books*. The terms ‘stone’ (*‘stein’*) or ‘ball’ (*‘kugel’* or *‘kegel’*) are all used, but it is not clear whether the material they are made of is always known to the author (or even relevant).²⁴ *‘Kugel’* is more often used in relation to ancillary incendiary devices such as fire balls.

Fol. 39 v has a section on a ‘chamber gun’ which may be more likely to refer to a smaller hand-held gun than a chamber gun itself. This section, when mentioned in other *Firework Books*, does not use the term ‘chamber’.²⁵

The text also uses a range of seemingly standard technical terms which may not always be easily explained. A term such as *‘stuck’* – meaning ‘elements’, ‘parts’, or simply ‘thing’ – is a collective term similar to *‘stuff’* (*‘zeug’*).²⁶ It is unclear whether this is a deliberately broad term, or, whether an experienced practitioner would know to which item it refers.

The major part of the *Firework Book* (including RA I.34) is a listing of various instructions and recipes in relation to gunpowder artillery. In total, I.34 part 1 contains 112 instructions which can be subdivided into the four main categories: ingredients, gunpowder, on guns and techniques, and auxiliary incendiary devices. Inevitably, there are some overlapping cross-references, and sometimes a section could be part of more than one category.

Ingredients

The core ingredients of gunpowder are saltpetre, sulphur, and charcoal. Out of the 42 subsections on ingredients alone in I.34’s part 1, 26 relate to aspects of saltpetre with the majority on purifying saltpetre (ten sections), buying saltpetre (four sections), acquiring saltpetre and making it usable (four sections), making stronger or better saltpetre (three sections), and subdividing saltpetre from other forms (three sections). The making of

²³ Stone projectiles cannot be detected by metal detectors, but only recognized by eye (through shape, size, petrology, or some combination of the three) by a trained archaeologist. On a former battlefield such identification is necessarily limited to items on the surface, while further uncertainties are introduced where projectiles have been changed in shape by firing, impact, or later plough damage.

²⁴ ‘Stone’ is used throughout, e.g. in the Master Gunner’s Questions, and fols. 7 v, 13 r, 15 v, 16 r, 20 v, 25 v, 26 v, 27 v, 31 r, 32 r, 38 r, 38 v, 39 r, 41 r, 41 v, 42 v, and 43 v. *‘Kugel’* or *‘kegel’* appears less frequently in fols. 1 v, 7 r, 7 v, 28 v, 34 v, 40 r, or 50 r.

²⁵ See Freiburg Ms. 362, fol. 88 r, or Dresden Ms. App. 463, fol. 63 v.

²⁶ ‘Arsenal’ translates into German as *‘Zeughaus’*, which literally means ‘the house of stuff’.

saltpetre was complex: as the HO Group research has shown, to make saltpetre it requires the addition of urine to animal waste-enriched soil over a prolonged period of time, followed by a process of filtering and reduction through boiling.²⁷

From a twenty-first-century perspective it is virtually impossible to establish what the exact ingredients would have been, or their level of purity and strength. While we may have a modern equivalent to the medieval name, it is by no means a like-for-like equation that the modern element is the same as the medieval. The same applies to its purity and its chemical composition. This in turn raises questions about whether it is possible to recreate these compositions, and if so whether the results of these experiments will be subject to a not dissimilar level of uncertainty.

The prominence of sections on saltpetre production and purification suggests that the producer of the *Firework Book* may not have been experienced in the extraction of saltpetre (and may only have known about it second-hand). While he may well have heard some details on how it could be extracted or where it came from, it appears that all that is provided are assumptions which record hearsay ('from stables, mountains, or otherwise' in fols. 8 r, 12 v, 18 v, and 23 v) rather than actual experience of producing it himself, hence, giving us the impression that the author did not fully understand how the process worked.

The section on how to grow saltpetre in stables or on walls (fol. 8 r) has been the subject of repeated experiments and could not be recreated. It has been discredited by scholars as producing the wrong type of salt.²⁸ It is most likely that if the author of the *Firework Book* had known how to make saltpetre he would have written it down. Significantly, this differs from the refining stages, which have been proven to be working recipes and can be recreated.²⁹ Taken together, these facts imply that users of the *Firework Book* would

²⁷ Smith (2002-2016), mainly 2013 and 2014 reports. The HO Group: Medieval Gunpowder Research started in 2002 and has been instrumental in investigating the compositions and properties of medieval gunpowder and associated materials. All reports of the group's findings can be found at https://ahc.leeds.ac.uk/downloads/download/35/fields_of_conflict – accessed 8 February 2019.

²⁸ Geoff Smith (2015), 'Medieval Gunpowder Chemistry. A Commentary on the Firework Book', *Journal of the International Committee for the History of Technology*, 21, 147-66, 149-50, Emmerich Pászthory (1995), 'Salpetergewinnung und Salpeterwirtschaft vom Mittelalter bis in die Neuzeit', *Chemie in unserer Zeit*, vol. 29, issue 1, 8-20; or, Wilfried Tittman, Ferdinand Nibler, and Wolfgang John (2017), 'Salpeter und Salpetergewinnung im Übergang vom Mittelalter zur Neuzeit', Online publication, <http://www.ruhr-uni-bochum.de/technikhist/tittmann/4%20Salpeter.pdf> – accessed 12 March 2018.

²⁹ Smith (2002-2016), mainly 2013 and 2014 reports.

generally not have made their own saltpetre but would have acquired it from elsewhere. When it was for sale it may have been a product called 'saltpetre' but it may not have been very good quality (being contaminated with impurities) – hence the need for testing its taste (needs to be tangy) and placing one's hand into a barrel of saltpetre which needs to come out dry (on account of its hygroscopic nature). Before saltpetre production techniques were developed across Europe the only option to acquire saltpetre was to buy it (e.g. fol. 36 r). The fact that the text warns about saltpetre being adulterated with other salts gives an indication of the value of saltpetre and its retail attributes. It appears that it would still be more economical to use relatively expensive ordinary salt (NaCl) and mix it in with saltpetre to bulk it up.

There is a historiographical debate on the consistency of saltpetre, arguing whether saltpetre had to be potassium nitrate or could possibly also be calcium nitrate.³⁰ The textual evidence provided by the *Firework Books* provides no further insights. Experiments by the HO Group have shown that when saltpetre has been adulterated with ordinary salt there comes a point at which the mixture ceases to work in the same way as saltpetre alone; the question of whether it could be mixed with other nitrates could not be proven.³¹

Some of the recipes (e.g. fol. 11 r) are incomplete and cannot fully be recreated. This could result either from a scribal error or from the fact that the author felt that he was not required to state what may be obvious to a contemporary reader. On the other hand, it could be that he deliberately wanted to withhold information, but that seems rather unlikely at this point.³²

Compared to sulphur and charcoal, saltpetre seems to be the most problematic ingredient, or the one that can be modified the most, with the hope of improving it. This may explain why the text refers to the nature of saltpetre (fol. 23 v), and the various attempts and ways

³⁰ About debate on KNO_3 or $\text{Ca}(\text{NO}_3)_2$ see Tittmann/Nibler/John (2017). See also Smith (2002-2016), mainly 2004. Kramer claims to have been able to recreate it, but failed to provide evidence for this (see Kramer (1996), 45-56). See also Anthony De Reuck (2008), 'The Nature of Saltpeter in the *Firework Book*'. *Journal of the Ordnance Society* 20, 5-10.

³¹ Smith (2002-2016), mainly 2002, 2003, 2012, and 2013. Tittmann states that the HO Group may have proven something that cannot be proven. However, no such claim has been made in any of the works of the HO Group (Tittmann/Nibler/John (2017), 4).

³² The interpretation that *Firework Books* were part of a culture of secret knowledge, and only kept within closed societies has been raised on numerous occasions. There is, however, little evidence to sustain this claim. See below for more details.

of purifying it (fols. 17 r ff. and fols. 44 v – 46 v). It would also explain the repeated testing of saltpetre in different ways in three recipes (fols. 44 r – v), and the references to derivatives of saltpetre (such as *salpratica* (fol. 24 r) and saltpetre salt (fols. 16 r – v)).

One surprising placing of a section is on fol. 37 r which seems out of context, on ‘bringing back’ spoiled or bad powder. This is likely to have been a regular task of a master gunner. This section includes a small insertion on how to purify saltpetre. In other *Firework Books* this section appears much earlier in the text in a section on improving saltpetre. It is not clear why it is added at this stage; it could have resulted from a scribal oversight, thus being forced to add a core element out of context at a later stage. The fact that it refers to the term ‘*in quartu gradu*’ gives it an additional gravitas to imply that it is a section that must not be forgotten.³³ In other *Firework Books* this section is listed with other purifying techniques.³⁴ It is likely that the author had forgotten to add it earlier, and then remembered that it needed including here – even when the sections before and after are not relevant. This may in turn suggest how the *Firework Book* was produced: it was written down from memory, or dictated by someone, and the section order depending on the ability to memorize.

Compared to saltpetre there are very few sections on sulphur (purifying – fol. 19 r) and charcoal (fols. 13 r and 19 r – v), or making sulphur oil (fol. 42 v) – although their production stages are unclear, possibly suggesting that the author did not understand what he was copying or writing down.

The *Firework Book* includes a list of additional ingredients to be added to gunpowder (see for example fol. 5 v and 6 r), often in rather small quantities. It is debatable whether they made a difference. It could be that they provided a psychological effect in that the addition of something precious and rare could seem to make gunpowder even more special and

³³ In the second century, the Greek philosopher, physician, and surgeon Galen presented the principle of ‘degrees’ of strength or primary qualities of medical substances, which was further developed by Arnaldus de Vila Nova in the late thirteenth century. One of its core principles relates to the interaction of ingredients in recipes. This also appears in a cookery context, where every substance is categorized as hot, cold, dry, or wet. (See Joel Kaye (2014), *A History of Balance, 1250-1375: the Emergence of a New Model of Equilibrium and its Impact on Thought*, Cambridge: Cambridge University Press, especially 210-22). It seems highly likely that this concept would have been known to a reader with a certain level of education.

³⁴ See Freiburg Ms. 362, fol. 76 r, Dresden Ms. App. 463, fol. 19 r, or Dillingen Ms. XV 50, fol. 8 r. However, Heidelberg Cod. Pal. germ. 122, fol. 34 r, includes it at the same location in the text as in I.34.

impactful. These ‘special’ ingredients include brandy, camphor, salammoniac, mercury, salniter, urine, and a range of non-verifiable substances. Many post-medieval records continue to refer to the ingredients mentioned, but are not specific about their consistency or purity.³⁵ Discussions among modern gunpowder experts have failed to provide conclusive evidence.³⁶

The author uses about 20 ingredients as Latin terms, often without translation, such as *arsenicum album*, *atrimentum*, *sublimata mercurius*, and *salpertica*.³⁷ It is most likely that these were standard supplies to be found in an apothecary’s shop, but what exactly they were proves to be virtually impossible to ascertain. The spellings have been compared to other *Firework Books*, but even in modern editions of other *Firework Books* the modern translation of the ingredients, and any assumption of their chemical composition, is done so with a level of uncertainty and speculation. Any modern editions of *Firework Books*, published in German or English, appear to have been driven by editors with a background in the fields of chemistry, and the decisions on terms used is based on what should have worked rather than what information the text provides.³⁸ Tests by the HO Group have

³⁵ See Biringuccio (in Smith/Gnudi (1990)), 403-16, Partington (1960 [1999]), 324-29, or George Plimpton (1984), *Fireworks: A History and Celebration*, New York: Doubleday, 188. By the seventeenth century powder started to be standardized, and authors such as Babington (1635 [2018]) no longer refer to core ingredients of gunpowder.

³⁶ For some suggested explanations see Kramer (1995), 145-50, Kramer (2001), 72-6, Blosen (2006), 121-7, Alfred Geibig (2012), *Die Macht des Feuers – Might and Fire*, Coburg: Kunstsammlung der Veste Coburg, 7-10, and Smith (2015), 157-8. However, most of the points made seem to be hypotheses which require detailed testing. It seems clear that there is still a large amount of research to be done to clarify to what extent and in what form an addition of any of these ingredients would add to the performance of a gun.

³⁷ It is likely that these ingredients relate to:

Arsenicum album: a white substance, core ingredient used in medicine (Partington (1960 [1999]), 362).

Atrimentum, or *Atramentum*, as discussed above.

Oppermert: orpiment, an arsenic sulphide mineral widely used in medicine and painting; this refers to by Partington as ‘arsenic mineral’ (Partington (1960 [1999]), 284).

Sublimata mercurius: sublimate mercury (Partington (1960 [1999]), 152).

Salpertica: compound of saltpetre and brandy, camphor, salammoniac, added to powder with the intention that it ‘quicken and strengthens all powders’ (Partington (1960 [1999]), 155).

However, all these terms have been subject to intense debate amongst gunpowder experts, and there is not comprehensive agreement about their precise chemical properties and consistency (see, for example, Smith (2015), 157-8). Just as the purity of saltpetre is questioned in the *Firework Book*, it is likely that these ingredients would refer to a ‘semantic field’ of components, rather than to one single component. See, for example, Maxwell-Stuart (2008), x.

³⁸ Kramer (2001), 43, where ‘sublimato’ is translated as ‘mercury chloride, HgCl₂’ without any suggestion that the chemical formula may not be in the main text.

shown (more to be carried out in 2019-20) that the basic recipe of gunpowder is sufficient in almost all contexts to achieve an explosive effect.³⁹

Gunpowder

Plenty of scholarly discussion has taken place on the form and consistency of gunpowder.⁴⁰ While the quality and status of the ingredients for gunpowder are important, so is the texture and appearance of the powder itself. The *Firework Book* provides some helpful pointers, but falls short of a comprehensive answer. In total, 29 sections in I.34 relate to various elements on gunpowder.

They can be grouped into subsections on:

1. Making and preparing powder including ratio of ingredients used (fols. 6 r, 8 r, 14 r, 15 r, 20 v, 22 v, 39 v, 46 v, 47 r, and 47 v),
2. Regenerating powder that for one reason or another has deteriorated (fols. 6 v, 21 v, and 37 r),
3. Specialist types of powder (coloured, ball powder, and *Knollenpulver* – fols. 29 r, 29 v, 30 r, 34 v, and 48 r), and
4. ‘Very good’, ‘better’, ‘stronger’, ‘louder’, ‘even better’, ‘miraculous’, ‘the best’ and ‘the strongest’ powders (fols. 8 v, 9 r, 21 r, 29 r, 30 v, 47 r, and 47 v)

Subsection 1 deals with a wide range of powder preparation recipes and the importance of balancing all the core and supplementary ingredients. It is the largest subsection within the powder sections, and provides a number of different recipe mixtures. It prescribes that common powder should be at a ratio of 57% saltpetre:14% charcoal:29% sulphur (fol. 47 r) while basic powder should be at a ratio of 53:20:27 (fol. 20 v), the best powder at 57:5:38

³⁹ Smith (2002-2016), especially 2002 and 2003 reports.

⁴⁰ An overview can be found at DeVries/Smith (2012), 144-5, and Smith (2010), 55-69, but also Hall (1997), 67-87, Partington (1960 [1999]), 323-9, or for a more in-depth analysis on various aspects see Buchanan (1996) and Brenda J. Buchanan ed. (2006), *Gunpowder, Explosives and the State: A Technological History*, Aldershot: Ashgate.

(fol. 21 r),⁴¹ while even stronger powder should be at 67:11:22 (fol. 47 v). The maximum ratio of powder before it stops working (described as 'too heavy') is 71:10:19 (fol. 47 v).

Gunpowder ratio comparison table:

	Fol.	Proportions	Saltpetre	Charcoal	Sulphur
Wide firing	5 v	67:11:22	3 lb	2 quarts	1 lb (grey)
Good	6 r	67:11:22	3 lb	2 quarts	1 lb (grey)
Strong and fast	8 v	71:6:24	(3 lb)	1 quart	1 lb (good)
Even better	9 r	71:6:24	(3 lb)	1 quart	1 lb (good)
Basic	20 v	53:20:27	2 lb	3 quarts	1 lb
Best	21 r	57:5:38	150 lb	12.5 lb	100 lb
Miraculous	29 r			as before	
Loudest	30 v			add hair and mercury when firing	
Common	47 r	57:14:29	4 lb	1 lb	2 lb
Better	47 r	62.5:12.5:25:	5 lb	1 lb	2 lb
Even stronger	47 v	67:11:22	6 lb	1 lb	2 lb
Heaviest	47 v	71:10:19	7.5 lb	1 lb	2 lb

The subsection includes a section on how to separate out powder into its key components, which is an unlikely recipe, but might be necessary in extreme circumstances (fol. 6 v).

Recipes such as the one on how to make gunpowder for guns and fire arrows (fol. 46 v) again have a strong focus on the saltpetre component, here especially the grinding of it.

Subsection 2 lists instructions for the regeneration of spoiled gunpowder. This would be the bread-and-butter activity of a gun master as time, weather, or transporting gunpowder will always adversely affect it. However, it is not explained at what point a master gunner could work out whether a specific powder or one of its core ingredients has deteriorated (the main way of doing so is to fire it). An experienced gunner may be able to use his skills to compare look, taste and storage or transportation to previous experiences, but none of the instances are explained here.

⁴¹ The fact that the recipe advises to add to the 'best' powder 1 lot of camphor, 2 times 3.5 pounds of salammoniac, five lots of *arsenicum*, three lots of *demertius sublimato* and a little saltpetre water seems unlikely to make a substantial difference to its effectiveness (fol. 21 r). However, this is a research topic worth testing under modern scientific conditions.

Subsection 3 on various special powders raises a number of questions. Almost all *Firework Books* refer to the colouring of powder, but it is not clear how the colouring would have worked. While the added ingredient would indeed help to colour things blue, yellow, red, or white, the predominant colorant would be charcoal, which almost inevitably would make everything black. That is, unless charcoal was not added to the powder until later in the process. In a stress-infused combat position the colouring (as well as scenting it – as could be suggested with the very potent scent of sandal wood) could give the firing side an important advantage, saving precious seconds to go for the right mixture without losing valuable time.⁴²

It is less clear what ‘ball powder’ (*‘kugel pulfer’*, fol. 34 v) refers to. This can only be explained as a scribal error, where the author wrote ‘ball powder’ while meaning *Knollenpulver*.⁴³ *Knollenpulver* is a widely debated concept. It has a crucial role in the development of early gunpowder artillery. Scholars have long since discussed the development of powder in the fifteenth and sixteenth centuries.⁴⁴ As Bert Hall explains: ‘one fundamental fact that affects the ballistics of all gunpowder weaponry is how quickly powder burns’. The way to regulate this in later gunpowder technology was to control the ‘grain size of gunpowder’, which was called ‘corning’.⁴⁵ While ‘corning’ is not understood to have existed before the middle of the fifteenth century,⁴⁶ the *Firework Book* provides a predecessor of ‘corning’ in its *Knollenpulver*. Hall describes this powder as substantially more ‘durable, and resistant to spoilage’ and he uses the term ‘lump powder’.⁴⁷ It was

⁴² See Robin A. Donkin (2003), *Between East and West: The Moluccas and the Traffic in Spices up to the Arrival of Europeans*, Philadelphia: American Philosophical Society, 111-4, on the many uses of sandal wood including as sensory *aide memoire*.

⁴³ Even at the end of this section it is no longer described as ‘ball powder’ but rather *‘kollen pulver’* which only omits one consonant to make it *‘knollen pulver’*. See for comparison, Heidelberg Cod. Pal. germ. 122, fol. 31 r.

⁴⁴ See Bert S. Hall (1996), ‘The Corning of Gunpowder and the Development of Firearms in the Renaissance’, in Buchanan (1996), 87-120, for a detailed discussion on corning and *Knollenpulver* and its kinetic properties (see also Smith (2010), 65-9).

⁴⁵ Hall (1997), 68.

⁴⁶ Occasional corning was first recorded in 1407-1411 (Hall (1996a), 89, and DeVries (1996a), 123). This date has been moved gradually to be earlier, from the mid to the early fifteenth century (see Rathgen (1928), 109-36). Early debates on corning often relate to the sieve sizes being used. Corning is understood to increase substantially the efficiency and effectiveness of gunpowder (See Jähns (1889-91), 401, Romocki (1895), 182-5, Henry W. L. Hime (1904), *Gunpowder and Ammunition. Their Origin and Progress*, Waltham Abbey: Royal Gunpowder Mills, 182, Partington (1960 [1999]), 154, Hall (1996a), 87-106, Smith (2010), 65-9, and DeVries/Smith (2012), 153). ‘Corned powder’ was believed to have been too strong for early guns, which is why Hall only lists its widespread use in the sixteenth century (Hime (1904), 183-4, and Partington (1960 [1999]), 154).

⁴⁷ Hall (1997), 71.

produced by carefully grinding all the ingredients and mixing them before wetting the mixture with water or brandy to form lumps. These lumps were dried carefully without exposure to open fire or sparks. The fact that the eleventh question of the Master Gunner's Questions specifies the existence of *Knollenpulver* shows its importance and wide spread use.⁴⁸

Subsection 4 (about different levels of powder) is of particular interest. The comparatives ('better', 'louder', or 'stronger') or superlatives ('best' or 'strongest') are subjective terms. Without modern scientific equipment it is not possible to measure strength in a meaningful way, whether a shot was better or worse (it would also require a scale of measuring its effect as 'more or less lethal', 'more or less impactful', and so on). The range and impact of a shot varied hugely, and was dependent on a wide range of factors. It could be that certain mixtures were more suitable for particular circumstances and contexts. The mention of these subjective terms, however, has also another function. As stated above, it could be used for psychological effect, making the gunner (or his employee, employer, or patron) think that it was 'better' or 'stronger', therefore giving them a psychological boost in combat; it thus could be viewed as a marketing tool. Of particular interest is the section on 'louder shot'. This directly relates to the 'fear factor' that gunpowder artillery had on the battlefield or at a siege.⁴⁹ While it would be impossible to hit everyone with a shot, everyone would hear (and possibly smell) the gun fire and this would inevitably have an effect in battle. As far as could be ascertained, the instructions for these shots may not necessarily make them 'better' or 'stronger', but by adding an extra level of work in the powder production it would easily have made the producer *believe* that it added something extra to the powder and its use.

In the section on 'common', 'better', and 'even stronger' powder (fols. 47 r and 47 v) the crucial change is the ratio from 57% saltpetre to 14% charcoal and 29% sulphur for the common powder (57:14:29) to 62.5:12.5:25 in the 'better powder', and 67:11:22 in the

⁴⁸ The production of *Knollenpulver* is only briefly described on fol. 34 v.

⁴⁹ While there is little evidence of this being reported in the fifteenth century, there are records for this in the sixteenth century, e.g. the Cortés expeditions in Mexico made specific use of gunpowder artillery to scare indigenous people. (Matthew Restall (2004), *Seven Myths of the Spanish Conquest*, Oxford: Oxford University Press, 139-40).

‘even stronger’ powder. With modern mixtures based on a 75:10:15 ratio,⁵⁰ the ‘even stronger’ mixture comes closest to this. One possible reason for this generally low saltpetre ratio is the higher cost of saltpetre; but this argument is not very convincing, as the costs for sulphur would equally be high. However, if the technique of producing saltpetre had not been developed it could be explained that with limited saltpetre supplies at least ordinary powders could be produced.

Some of the listed recipes (fols. 8 v and 9 r) do not include saltpetre as an ingredient, but when the book later explains about making hundredweights, this calculation only adds up if saltpetre is included (at about three times the sulphur ratio). This is an example where the author either did not see the need to explicitly add something that was seemingly obvious, or alternatively a case where the scribe omitted to mention saltpetre at the earlier stage.

Most powder mixtures are relatively light on charcoal. From an economic angle, of the three core ingredients for the fifteenth-century practitioner charcoal would be the most attainable, while sulphur was the one which depended most on its purchase and an existing supply route (while sulphur was imported from Italy or Iceland, its purification process is relatively straightforward).

Modern mixtures of 75:10:10 have a substantially higher proportion of saltpetre than most of the recipes provided. Saltpetre, on the other hand, was the core ingredient which was the most complicated to purify and keep, and a mixture of purchase from abroad and local production was most likely. The making of saltpetre was complex. It then required multiple stages of filtration and reduction to produce raw saltpetre which needed further purification before use.⁵¹ By the mid-fifteenth century there is ample evidence of saltpetre production while, by the sixteenth century, it had reached industrial scales.⁵² Burgundian sources in the 1470s rarely mention charcoal in the mixture of gunpowder but frequently refer to saltpetre

⁵⁰ Smith (2010), 62. The first known suggested ratio on record is of 41:29:29, based on Roger Bacon’s recipe from between 1248-1267 (see DeVries (1996a), 123).

⁵¹ See Smith (2002-2016), Report 2014.

⁵² See Partington (1960 [1999]), 314-23, Simon Pepper and Nicholas Adams (1986), *Firearms and Fortifications: Military Architecture and Siege Warfare in Sixteenth-Century Siena*, Chicago: University of Chicago Press, for Tuscany, 8-17, and for England, Richard Winship Stewart (1996), *The English Ordnance Office, 1585-1625*, Woodbridge: Boydell Press, 80-95.

and sulphur.⁵³ The Burgundian troops on campaign in 1475 had a recorded 1,200 hand mills amongst their soldiers, as well as one windmill and four people employed as millers.⁵⁴ This seems to imply that grinding powder took place at the point of use, and that powder is likely to have been of different physical state when troops set out. It could also be that the mills were used to grind charcoal. Charcoal was widely available and the consistency (and the origin) of the charcoal was less important for making a successful powder.⁵⁵

It is no accident that a number of authors who have written about the *Firework Books* were chemists or physicists.⁵⁶ This provided detailed knowledge of one aspect of the subject, but working without substantial medievalist historical skills this made their work susceptible to criticism of lack of historical thoroughness.⁵⁷ As a result their translations and transcriptions deviate increasingly from the original as the text goes on, as they reflect the authors' frustrations at the above-mentioned shortfall of quantifiable, factual information in the recipes. It might be better instead to view the existing recipes instead as a representation of the knowledge available in the fifteenth century.

On guns and techniques, and how to use them

This category is strangely imbalanced, providing a relatively small amount of information for what must have been the majority of activities for a master gunner. A total of 30 sections are devoted to this, but half of them concern exceptional circumstances or projectiles (fire balls, flying fire, stakes, keeping fire secret and seemingly special measures) or how to be particularly 'frightening' (fol. 7 v). Comparatively few provide instructions on practical matters, e.g. loading a gun correctly and safely (fols. 15 v and 32 r), making stone and plug (fols. 13 r and 15 v), the range of guns (fol. 31 r), their mounting (fol. 31 v), instructions on how to fire accurately (fol. 41 r), and from key locations (e.g. gabions or siege towers, fol. 27

⁵³ Smith/DeVries (2005), 244-8.

⁵⁴ Kay Smith (2001) (published under former name of Robert Douglas Smith), 'Good and Bold: A Late 15th-Century Artillery Train', *Royal Armouries Yearbook 6 (2001)*, 88-97, 103, and Kay Smith and Kelly DeVries (2011) (published under former name of Robert Douglas Smith), *Rhodes Besieged*, Stroud: History Press, 341. The listing of the mills among other arms and armour devices, and not as general supplies, suggests that these mills were less likely to be used for grinding food product.

⁵⁵ Hall (1997), 89.

⁵⁶ Most notably Gerhard Kramer, James Partington, Ferdinand Nibler, and Wilfried Tittmann.

⁵⁷ Tittmann and Nibler on Kramer (Tittmann (2002) and (2017)).

v). Loading and firing are relatively straightforward processes, and it could be argued that they do not require further explanation.

One of the core questions of gunpowder technology is about the space required in the barrel for the powder to explode effectively.⁵⁸ As the first Master Gunner's Question explains, it is the 'vapour that drives the stone out of the gun', but the stone can only be driven if it is enclosed within the barrel, without space for the vapour to escape. On fol. 15 v a reference to the importance of the measurement of the inside of the gun has long been interpreted as the proportions of powder, plug, and stone. This section is repeated on fol. 31 v, but with different wording. The section is preceded by a very short section on the dimensions of a gun (fol. 31 r) – it is not entirely clear what is gained from this text segment which seems to provide a very different type of information.

There are very few other instructions on how to load or fire a gun under ordinary circumstances. Rather more effort is made to describe how to fire multiple shots (fols. 38 r and v), or how to fire when the powder is wet (fol. 38 v). All of these examples are rather short, and it could be argued that they were summarizing the daily tasks of a master gunner which would not require further explanation or detail.

The section from fols. 25 v – 27 v is uncharacteristically long and describes how to use a gun, setting it apart in the context of the much shorter sections before and after. In some studies of *Firework Books*, this section was referred to as the 'epilogue'.⁵⁹ In language and format – with a move away from down-to-earth practical explanations towards more general attitudes of a master gunner – it is in fact more reminiscent of the preamble at the beginning of the *Firework Book*.⁶⁰ In no *Firework Book* viewed, however, does this section appear at the end, which makes it unlikely to have been an 'epilogue'.

⁵⁸ These are usually described as five equal parts, made up by three parts gunpowder, one part free space (to allow the ignited powder vapour to expand), and the fifth part for the wooden plug to make the chamber air tight as described in Leng (2000), 41-4 and 87. The stone would be located outside the chamber. Kramer provides an alternative interpretation of 'one quarter to one third of the chamber' to be occupied by the powder (Kramer (2001), 23).

⁵⁹ Kramer (2001), 99, or the 'Einleitung' (Jähns (1889-91), 395).

⁶⁰ This section repeats phrases 'prince, earl, lord, knight, squire, or town' from the opening section, in the form of a listing of elements which must have had a recognition factor by a reader or audience.

The section on emptying a loaded gun (fol. 49 v) is potentially helpful (if it worked), but it is a question how often such a high-risk procedure would have been applied. Nevertheless, it may well have been the last option if, for one reason or another, it was not possible for the gun to be fired to empty its charge.

On fol. 32 r is a noteworthy section on how to break a gun. This section is relatively rare among the *Firework Book* manuscripts, and it is not clear to what this may refer.⁶¹ It could be that it was advice for last resort action when retreating from a battlefield so that a working gun would not fall into the hands of an opponent. The reverse of this section is picked up in the second part of I.34 where the text provides instructions on how to avoid the gun breaking (fol. 60 v – see below).

The aforementioned imbalance of ordinary vs. extraordinary circumstances raises questions on what was perceived to be ‘widely known’ and what were ‘extra beneficial facts’. There are many elements which are not explained in the *Firework Book*, and one may wonder why not. For instance, little reference is made to the ways of loading a gun, although the illustration in the Munich Cgm. 600 manuscript implies that guns were put upright for loading.⁶² This way it would be possible to wedge the stone in thoroughly without gravity pulling it sideways. It may be that at the time of production of the *Firework Book* this knowledge was either outdated or no longer worth mentioning, being too basic to be written down. No details are provided about the size of the gun (shorter or longer barrelled), the size of the powder chamber, or their design.⁶³

I.34 also makes little reference to the substantially different ways of using gunpowder artillery as a tactical device: in a stationary setting in a castle/town for defensive purposes, or on the road for use in battle. While early gunpowder artillery to defend towns and castles goes back into the fourteenth century (with associated records on the production of the cannon, the raw materials, the makers, and the profession), their use in open field warfare

⁶¹ Similar sections could only be traced in Darmstadt Ms. 1074, fol. 37 v.

⁶² See Leng (2000), 86, or Schmidtchen (1990), 198-9.

⁶³ This has long been a source of interpretation and discussion. Generally it is believed that the barrel of a gun was quite short and that the chamber was subdivided into five parts (based on the instructions in Munich Cgm. 600, but that still leaves much scope for interpretation. See Leng (2000), 46-7, and Schmidtchen (1990), 194-7, or even Hassenstein (1941), 100, or Kramer (2001), 23.

came only gradually.⁶⁴ A large logistical exercise was required to move and use them involving many interacting factors. Aside from the weight of the cannons it was necessary to know how to keep the powder dry and safe and how to adjust to the environment – landscape, weather, time of day, season. Further factors included the time available in which to fire, the whereabouts of trained staff, how to avoid accidents, how to persuade ‘rulers’ to enlist gunpowder artillery troops, and so on. While considerable resources were required, by the mid-fifteenth century the ability to move artillery was deemed to be a necessary component of warfare, but is a subject not mentioned in I.34.⁶⁵

On auxiliary incendiary devices

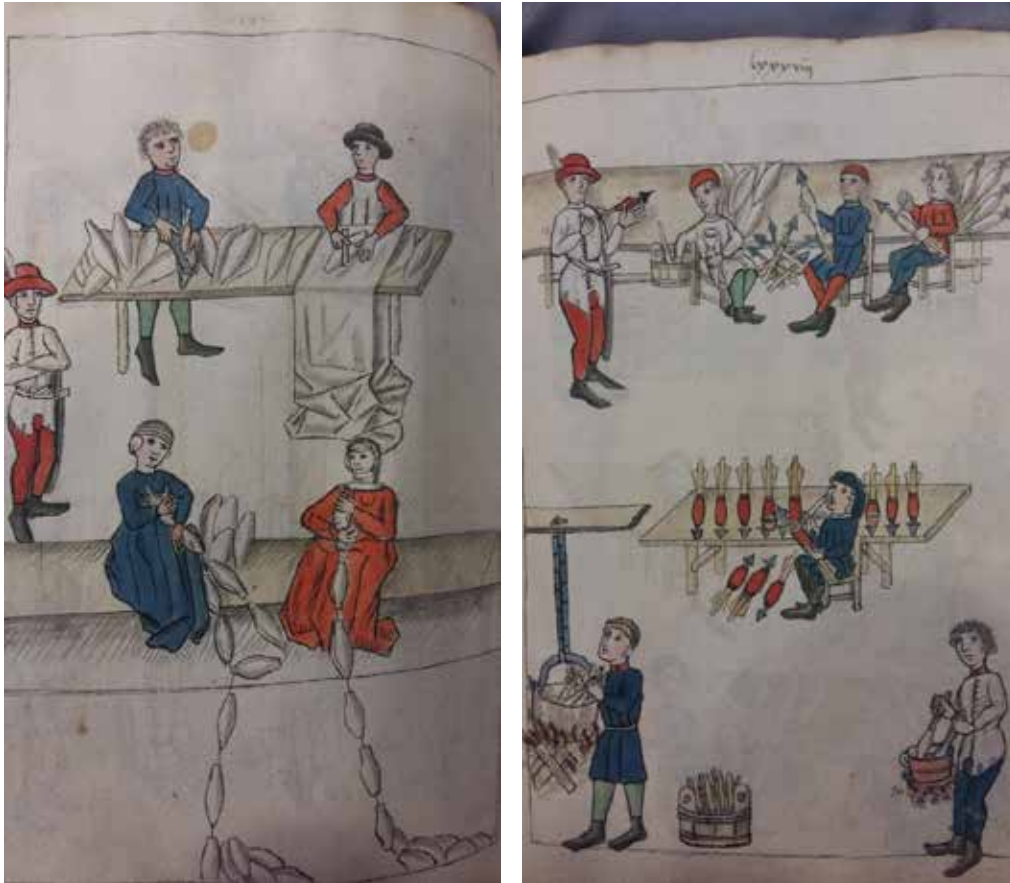
This category of the *Firework Book* is the smallest (with eleven sections) – at least in part 1 – and it includes a wide range of incendiary devices, only some of which may be fired from a gun. As they are all related to powder-making skills, they were probably tasks carried out by a master gunner.

By far, the largest subsection in this category concerns fire arrows (five sections on fols. 30 r, 41 v, 48 v, and 49 r). The instructions include storage advice which would suggest that the I.34 illustrations (fol. 87 v and 88 r) of a mass production of fire arrows may be a reflection of actual practice.⁶⁶

⁶⁴ There was a clear progression of use of gunpowder artillery in sieges, and with improvements in technology and the increased use of smaller guns, the use on the battlefield became more frequent (DeVries/Smith (2012), 140-7).

⁶⁵ Smith/DeVries (2005), 48-54.

⁶⁶ Reconstruction experiments by the HO Group have shown that the description of the production of fire arrows can be recreated. Omission of any of the suggested stages was likely to result in unsuccessful firing (see Smith (2002-2016), Report 2009).



Royal Armouries, I.34, fols. 87 v and 88 r (author, courtesy of the Royal Armouries).

Other incendiaries include fire balls (fol. 7 r), setting fire to a pole (fol. 40 v), setting water on fire (fol. 41 r), firing a 'glowing ball' (fol. 49 v), and making a hardened arrow tip (fol. 50 v). While these instructions seem to make sense overall, they all appear to be fairly high-risk. For instance, it is worth questioning why one would need to set a pole on fire. It could be that it was to act as a way marker, but surely this would be an extremely unlikely occurrence. Using quicklime would create a fire effect, but the risk of personal injury would be particularly high. A display or ceremonial use cannot be ruled out, but no record of such an occurrence could be traced. Firing a 'glowing ball' is not a section that is mentioned in most *Firework Books*.⁶⁷ It is a particularly hazardous endeavour to fire two balls in one gun, with the second ball heated up to a high temperature which would mean fitting it fairly awkwardly into the gun. The first ball was to serve as a safety device to keep the heated ball away from the powder. It is only in part 2 of I.34 that other incendiary devices, such as barrels and wheel hubs, are added as potential tools for defence and attack.

⁶⁷ This section can be found in Darmstadt Ms. 1074, fol. 51 r, and Dillingen Ms. XV 50, fol. 32 r, but not in Freiburg Ms. 362 and others.

The section on hardening an iron arrow head to make it into a ‘house arrow’ (fol. 50 v) occupies a special position within the *Firework Book* tradition. It appears at the end of the majority of *Firework Books*, and all manuscripts which are not perceived to be fragmented or incomplete seem to refer to this. Comparing this section in different copies of the *Firework Book* shows a closer match in the text used, word by word, word order, and seemingly fewer mistakes made.⁶⁸ This would be likely if this section indeed was the known, formal last part of a *Firework Book*. Any scribe would take particular attention to keep the text to the wording known to a potential reader. The ‘house arrow’ section seems, however, to be at odds in content and style with the rest of the *Firework Book*.

Throughout the *Firework Book* the term ‘*kunst*’ is used frequently (fourteen times as noun, and twice as adjective ‘*kunstlich*’); the literal translation of this term is ‘art’. Just as the English term ‘art’ developed in the late Middle Ages to mean ‘skills in doing something, esp. as a result of knowledge or practice’, ‘technical skill’, ‘practical application’, or ‘trade’,⁶⁹ the same applied to the German term. At times, it is referred to as ‘*besunder kunst*’ (‘a special art’). In the same context is the term ‘*Lere*’ used – it is some form of ‘instruction’, ‘recipe’ but its literal translation would be ‘teaching’.

For a twenty-first-century reader, a long-standing rivalry and distinction exists between ‘*ars*’ and ‘*scientia*’ which is typically translated into ‘art’ vs. ‘knowledge’. The Latin term ‘*ars*’ is applied to all things created, fashioned, or made by a human hand to distinguish it from all things in ‘nature’. This embraces the production of everyday items such as metal, wood, and wicker ware to more substantial productions such as the construction of cathedrals. The distinction between ‘knowledge’ and ‘art’ was already fully developed by the thirteenth century.⁷⁰ The Latin term *scientia* referred broadly to the accumulated written knowledge and theory associated with a particular subject area. A proper *scientia* was required for planning and constructing cathedral vaults with appropriate buttressing. For the thirteenth-century architect, Jean Mignot, this knowledge (*scientia*) also included his favoured

⁶⁸ See Dresden Ms. App. 463, fol. 71 v, Dillingen Ms. XV 50, fol. 32 v, Darmstadt Ms. 1074, fols. 54 r and v, Göttingen 2^o Cod. Ms. philos. 64, fols. 146 r and v, Heidelberg Cod. Pal. germ. 122, fols. 45 v and 46 r, Munich Clm. 30150, 149 r, as well as the prints by Stainer (Stainer (1529), 36) and Egenolph (Egenolph, (1529), 44).

⁶⁹ *Oxford English Dictionary Online*, definitions 1-3 – accessed 26 March 2018.

⁷⁰ One of the earliest examples in technical writings are the ‘sketchbooks’ of Villard de Honnecourt, produced around 1235. They combine the technological advances with function (what it is for) and design (what is achievable). See Popplow (2001), 254-8.

geometric and theological schemes. Apparently his French perspectives did not coincide with Italian regional preferences of the time and controversies arose. Theory and practice could not be separated in Mignot's mind. Similarly, Aquinas refers to theology as *scientia*.⁷¹ For medieval scholastics, the practice of an art (*ars*) without proper knowledge (*scientia*) would accomplish 'nothing'; the two were inseparable and one without the other would be *nihil*. Thus, the practice of 'art without knowledge is nothing' (*'ars sine scientia nihil est'*).⁷² A fifteenth-century author, editor, copyist, or reader of a text such as the *Firework Book* is likely to have been exposed to some levels of this dichotomy, but only to a limited extent. The structure of the twelve questions, their scholastic format and tone, as well as the ability to read and write and to know the occasional Latin term suggests some kind of grammar school education. However, it would be impossible to distinguish the different level of education between these groups of readers or users.⁷³

Building on the theme of '*scientia*', more populist modern publications view gunpowder as part of science, positioning it within the fields of early chemistry or alchemy, but often with little critical analysis.⁷⁴ Alchemy emerged in Western Europe via China and the Islamic world as a 'branch of knowledge', initially focussing on the 'possibility of changing one metal into another' while always having some more practical application such as in medicine. It quickly developed into an intellectual discipline with its own 'specialized vocabulary, symbols and images which often render alchemical texts more or less impenetrable'.⁷⁵ Maxwell-Stuart qualifies this by commenting that its 'obfuscating rhetoric' was introduced for the reason 'that alchemy was too dangerous a science to be put into the hands of the

⁷¹ Geoffrey Turner (1997), 'St Thomas Aquinas on the "Scientific" Nature of Theology', *New Blackfriars*, vol. 78, no. 921, 464-76, 469.

⁷² This quote is widely attributed to Mignot, see, for example, Otto G. von Simson (1988), 'The Gothic Cathedral: Design and Meaning', in Sylvia L. Thrupp ed., *Change in Medieval Society: Europe North of the Alps, 1050-1500*, Toronto: University of Toronto Press in association with the Medieval Academy, 168-87, 174. The connection between scholarly tradition and practical application can reach into all areas of technology. See, for example, Steven A. Walton and Thomas E. Boothby (2014), 'What is Straight Cannot Fall: Medieval Architectural Statics in Theory and Practice', *History of Science*, 52.4, 347-76, for the link of scholarly tradition and architectural developments.

⁷³ See David Sheffler (2008), *Schools and Schooling in Late Medieval Germany: Regensburg 1250-1500*, Leiden: Brill, 17-84, about levels of education, scholarly activities and their impact on fifteenth-century society in South-Western Germany.

⁷⁴ See, for example, Jack Kelly (2004), *Gunpowder: A History of the Explosive that Changed the World*, London: Atlantic, 109-11, Wayne D. Cocroft (2000), *Dangerous Energy: The Archaeology of Gunpowder and Military Explosives Manufacture*, Swindon: English Heritage, 4-5, Alfred W. Crosby (2002), *Throwing Fire. Projectile Technology Through History*, Cambridge: Cambridge University Press, 96, or Werrett (2010), 23-41.

⁷⁵ Maxwell-Stuart (2008), x.

ignorant or half-trained, and so constructing a kind of jargon would effectively confine its practice to those worthy and intelligent enough to use it for proper ends'.⁷⁶ Amongst those considered 'worthy and intelligent enough' were the friars. The thirteenth-century Franciscan friar and scholar Roger Bacon, in his *Opus Majus* of 1267, was the first to mention having witnessed gunpowder explosions without mentioning gunpowder directly. It could be argued that the reference to Niger Bertholdus (fol. 20 r), a 'necromancer and alchemist' who is attributed to have discovered gunpowder could be seen as a direct continuation from Bacon. It could even be argued that this is why Niger Bertholdus is often assumed to have been a Franciscan.⁷⁷

This said, the *Firework Books* and their use of chemical processes and interactions are otherwise distinctly different to the alchemical tradition. While gunpowder technology is understood to have travelled via similar geographical regions, it retained a relatively straightforward language, even if some parts of it are now difficult to understand as a result of a loss of practical knowledge. Nor did gunpowder technology hide behind an inaccessible language. This trend is mirrored in publications of alchemical texts into vernacular languages in the early decades of the fifteenth century.⁷⁸

While there are clear connections with the areas of interest of alchemy, gunpowder technology seems to fall into a somewhat different category.⁷⁹ *Firework Books* focus on how matters work, and to what effect, without a seeming intention to find out any reasons why, or any explanation for their working. This might explain why such works as the *Firework Book* were written in the vernacular and not in Latin. In contrast to the vernacularization debate where Latin texts were translated into the vernacular to act as an 'intellectual and social bridge' to a wider public, the *Firework Book* seems to have originated in German

⁷⁶ Maxwell-Stuart (2008), 73.

⁷⁷ For example, there is a statue of Bertholdus in front of Freiburg Town Hall presenting him as a Franciscan.

⁷⁸ Maxwell-Stuart (2008), 80. In the fifteenth century an increasing number of vernacular writings appeared across a wide spectrum of genres, many of them of a practical nature, from medicine, surgery, cookery, dyeing as well as alchemy. For discussions on vernacularization, see Pereira (1999) or Carmel Ferragud (1999), 'Vernacularization as an Intellectual and Social Bridge: The Catalan Translations of Teodorico's *Chirurgia* and of Arnau De Vilanova's *Regimen Sanitatis*', *Early Science and Medicine* 4/2, 127-48. Pereira argues that the development of 'instructive prose' ('*Lehrdichtung*') did not emerge earlier in Germany than elsewhere, but provides little evidence for this. (Pereira [1999], 347).

⁷⁹ The fact that one *Firework Book* copy, nowadays Kassel 4^o Ms. math. 14, is attributed to Albertus Magnus instead of the more mysterious figure of Niger Bertoldus provides a good example of a possible conflation of alchemy and gunpowder technology in the fifteenth century.

without a Latin predecessor, nor was it ever translated into Latin.⁸⁰ It is bypassing what was seen to be the language of learning and thus of large segments of technological writing.

In the *Firework Books* only a very small number of incidents occur in which the author uses Latin terms instead of German ones. When used (with the exception of some of the special ingredients), he provides both the Latin and the German. A good example for this is the ‘*exemplum*’ (fol. 2 v), a device used in a sermon as an illustrative point, but it is unclear whether it was meant to be a scientific term or a ‘term of art’. It is used in this context as a label to mark its special function within the German narrative text.⁸¹ Otherwise, the text is very careful to use non-technical terms in all instructions. Even if Latin terms are used, they are explained and translated, meaning that ‘*exemplum*’ is followed by a translation in German ‘*ein peispil*’. The same applies in the first of two listings of ‘*in quartu gradu*’ where the author immediately follows the Latin term with a translation into German ‘which is called the fourth’ (fol. 23 v).

In one case, the text lists ‘*benefencio*’ (fol. 38 v) which is most likely a misspelling of ‘*beneficio*’, and a possible indicator of some knowledge of foreign language terms, but lacking the certainty of how to spell it. In another case, the author uses the Latin term to explain the origin of saltpetre when stating that saltpetre is ‘called in Latin ‘rock salt’’ (fol. 23 v), without however providing any further explanation.

Very occasional references are made to theoretical models which were under discussion at the time. The second Master Gunner’s Question relates to a ‘system of qualities’ or ‘humouralism’, established by Greek, Roman, and Islamic physicians to describe a balanced body, and widely known and used in the fifteenth century.⁸² It refers to sulphur being ‘hot’ and saltpetre being ‘cold’, and the consequent need to balance ‘two opposing parts which do not [*normally*] tolerate each other’ (fol. 2 v). This reference is repeated later in the *Firework Book* in a section where saltpetre is described to be ‘by nature cold and dry’, while sulphur is described as ‘by nature hot and dry’ which the author goes on to say ‘easily

⁸⁰ Ferragud (1999), 140.

⁸¹ Nibler (2005), 49.

⁸² Sara M. Butler (2014), *Forensic Medicine and Death Investigation in Medieval England*, New York: Routledge, 224-7.

catches fire' (fol. 23 v). This is a clear reference to the humoral theories known at the time, and the understanding of the interrelation of the principles of qualities of substances.

The *Firework Book* contains many references which relate to good salesmanship; these include the preamble (equivalent to a twenty-first-century insurance advertisement), and the instructions on the attributes and behaviour of a good master gunner. Thus, the master gunner is presenting to any potential employer a range of options for using gunpowder technology in both defence and offence. This optionality, arguably, explains the sections on a wide range of powder options, such as 'good', 'better' or 'the best', as stated above, since what is best will strongly depend on the purpose and context.⁸³

Sometimes particular types of tree have become the name for a specific type of wood (or vice versa) such as '*linder holtz*' – this is both soft wood (as description of a generic characteristic of the wood) and 'lime wood' (as definition of a particular type of tree). In German, the term '*Linde*' is the word for the tree, and an adjective which could be translated as 'soft', 'mellow', 'calm' – often used in a figurative context.

The author is prone to using some rather imprecise technical terms. One example is on fol. 6 v: '*Seud das dar uber gang*' (the literal translation for this would be 'heat until it boils over'). The author frequently uses terms such as 'boiling over' or 'boiling hard', using an expression which would literally be translated as 'beaten over'. This implies that the water was heated to such a temperature so that liquid spilled over the edge. Technically, however, boiling is absolute and a harder or less hard boiling is not possible, while excess energy input (e.g. a high or hot flame) will make the conversion of water to steam at the bottom more aggressive.⁸⁴

As this text was written before the emergence of more widespread technical instructive texts, terms such as '*schaiden*' are not yet defined. This simple sounding term has been translated as 'to separate' or 'to break down' or 'to subdivide', and is used to describe a

⁸³ This theory was first put by Schmidtchen (1990), 30 – see below.

⁸⁴ Cooking recipes provide a wide range of terminology along similar lines. See, for example, terms such as 'simmer' or 'sizzle' which are described by the *Oxford English Dictionary* as 'to make a subdued murmuring sound under the influence of continued heat; to be at a heat just below boiling-point' and 'to burn or scorch so as to produce a hissing sound; to burn *up* with intense heat' respectively (*Oxford English Dictionary Online*, definitions 1 – accessed 24 February 2019).

number of different stages in the saltpetre production. Historically, the term came to be a specific chemistry expression by the eighteenth century.⁸⁵ While there may not have been an authorized vocabulary in the fifteenth century, nevertheless there was the need to describe what action took place. For the translation this provided a challenge not to become too technical, or more figurative, but rather to convey what actually seems to be happening.

The author uses a wide range of measurements, all of which were not completely standardized, and sometimes related to actual numerical descriptions, e.g. what is a quintal?⁸⁶ Does the timing of when the *Firework Book* was written make a difference? Sometimes it mentions different sizes of barrels, pots, sieves which – without context – are often too speculative to reconstruct.⁸⁷

It is not clear how much credence can be given to the accuracy of the measurements and weights provided (see also the section on the use of balancing scales below). What is likely though is that the proportion would be adhered to as stated. Debate amongst twentieth- and twenty-first-century gunpowder technologists has shown that adding some ingredients, such as camphor, or a wide range of different woods for charcoal, does not make any actual difference in efficiency, but it is likely that there would be the aforementioned psychological effect, or even an aesthetic one.⁸⁸ It is important, too, that adding these ingredients does not make matters worse. Hence ‘why not’.⁸⁹

In two instances, I.34 lists monetary values: fol. 17 v stating that ‘saltpetre which has been purified and cleaned’ would be worth ‘a guilder’. The other section is fol. 25 r where unpurified salammoniac is listed as costing ‘sixteen shilling and a haller per pound’ while the

⁸⁵ See Definition II. A. 1) a) *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online* – accessed 23 March 2018.

⁸⁶ Many measures and weights were local, and standardization was often attempted but not comprehensively followed through (see Harald Witthöft (2006), ‘Maß und Regio -- Herrschaft, Wirtschaft und Kultur. Von *aequalitas*, Einheitlichkeit und langer Dauer’, *Jahrbuch für Regionalgeschichte und Landeskunde* 24, 49-75, 49-51, or Jessica Dijkmann (2011), *Shaping Medieval Markets: The Organisation of Commodity Markets in Holland, c. 1200-c.1450*, Leiden: Brill, 203-13). At the same time, the difference of measures may not have had such an impact on the recipes as long as the ratio of the ingredients stays the same.

⁸⁷ It was only in the early nineteenth century that measurements of volume were standardized in Bavaria (even later for other parts of Germany). In the fifteenth century, measures were largely local, and the terminology and actual sizes varied substantially, with various attempts for harmonisation made. See, for example, Witthöft (2006), 54-9.

⁸⁸ See, for example, Smith (2015), 157-8.

⁸⁹ Many of these experiments can be tested in modern lab conditions, while others – such as the adding of mercury to the touch hole – would be harder to re-stage for reasons of health and safety.

costs of purified salammoniac would rise to ‘a guilder for one pound’.⁹⁰ Strikingly, in neither does the value of the equivalent change in other copies of the *Firework Book*.⁹¹ Assuming that the surviving *Firework Books* were produced over a period of more than 100 years, even modest estimates would require an adjustment for inflation or regional price fluctuations.⁹² This suggests an interrelation between the surviving *Firework Books* and may well indicate a lack of actual usage, as further discussed in chapter 5.

RA I.34 part 2

The second part of I.34 includes a total of fourteen separate sections from making incendiaries with barrels and wheel hubs, smoking out devices and fire balls to extreme fire and other instructions. This section moves away from firing cannons to focus on other things that catch fire, with a far greater emphasis on incendiary devices, and how to prepare them – compared to part 1. The skills and experience required, however, stay the same, and build on the part 1 elements on auxiliary incendiary devices. There is a different emphasis in the text and in the information offered, providing individual recipes in larger segments of text without even an attempt to link the individual sections. Gunpowder and incendiary devices are used to make fire barrels, fire balls, and other devices which can be projected at the enemy. It is not, however, explained how these incendiary devices might reach the enemy.

⁹⁰ See Freiburg Ms. 362, fol. 84 v, Dresden Ms. App. 463, fol. 50 r, Heidelberg Cod. Pal. germ. 122, fol. 22 v; and Dillingen Ms. XV 50, fol. 22 v.

⁹¹ See Freiburg Ms. 362, fol. 77 r, Dresden Ms. App. 463, fol. 23 r, Heidelberg Cod. Pal. germ. 122, fol. 16 r; and Dillingen Ms. XV 50, fol. 10 r; one exception is in Stainer (1529) which alters both the quantity produced and monetary value. Instead of one pound the print refers to ‘one hundredweight (*zentner*)’ which would be worth the equivalent of a florin.

⁹² The ground-breaking work by Thom Richardson on medieval inventories of the Tower Armouries, 1320-1410, lists the emergence of gunpowder manufacture in the Tower of London as early as 1346 (Roland Thomas Richardson (2012), *The Medieval Inventories of the Tower Armouries, 1320-1410*, PhD Dissertation University of York, http://etheses.whiterose.ac.uk/3919/1/Thom_Richardson_thesis_final.pdf – accessed 2 February 2017, 336). By the 1370s the production has been recorded at an ever increasing scale from there on in (Richardson (2012), 166-9). This clearly was in reply to an increase in demand, with the costs increasing for all the ingredients required.

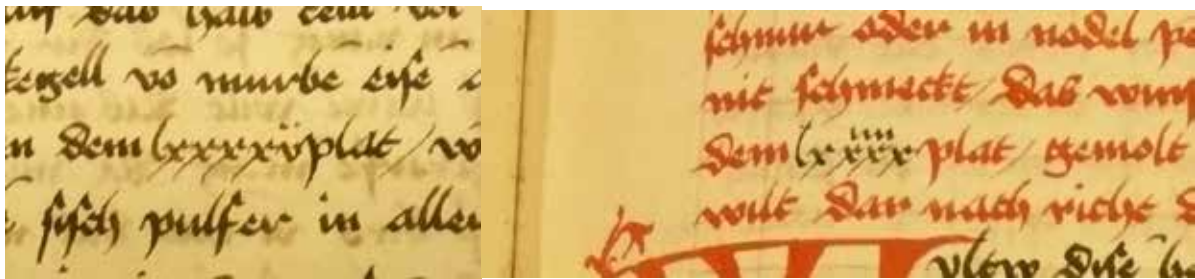


Royal Armouries, I.34, fol. 89 r – possible depiction of mass manufacturing wheel hub incendiaries – top right, and fol. 88 v – possible mass production of fire arrows (author, courtesy of the Royal Armouries).

Unusually for most *Firework Books*, part 2 of I.34 makes numerous references to illustrations located at the end of the manuscript. In contrast to Strasbourg Ms. 2259, in I.34 the sheet references are written in the same colour ink and apparently at the same time as the other text – seemingly with little or no hesitation by the scribe or copyist whether they refer to an actual page.⁹³ However, in I.34 all references to page numbers seem to have been added after the original text in brown/black was produced. The numbers added are always in a different size to the surrounding text. The only explanation is that the numbers were added after the illustrations were made, but within a brief timeframe shortly after the production of the text. On three occasions (fols. 52 v, 54 r, and 56 r) the number added is too big for the space provided and touches or overwrites the existing text. More frequently, the number is smaller than the space available (fols. 53 r, 54 r, 55 v, 57 r, 57 v, and 60 r), on

⁹³ The relationship of the Strasbourg manuscript to I.34 is discussed in chapter 2, where the sheet reference numbers are the same as I.34, but lacks the images.

one occasion (fol. 53 v) the page number is missing; most likely the author forgot to add the page number, or the illustration page had not (or not yet) been added to the illustrations. This provides some indication about the production of the I.34 manuscript as a copy produced in stages, by multiple authors, copyists, or scribes, and not the product of a single author.



Royal Armouries, I.34, fol. 52 v and 57 r (author, courtesy of the Royal Armouries).

The detailed use of scales is another important point to highlight. The text pays great attention to scales and their correct use, always making sure to remind the user to take items off the scales after weighing (fols. 52 r, 53 r, 54 v, 56 r, 57 v, 58 v, and 59 r – this section is only once mirrored in part 1 on fol. 14 r). There are a number of possible explanations: either the user (the author or the reader) was not very used to balancing scales, or the text expresses the need to remind the reader about this. It also highlights the need for accuracy with precious and dangerous materials, at the same time with the implication that any user of the text was less likely to be a skilled artisan and trader who would have been experienced in the use of scales.

In common with the beginning of the first part in I.34, the second part refers at various stages (in eight out of the twelve section headings) to the 'courtly art'. This term combines two complex issues: those relating to 'art' have already been discussed above. Both the terms 'courtly' and its German original 'hoflich' have modern connotation of chivalry, gentlemanliness, and high status. 'Courtly' in the context of the *Firework Book* refers to items which could be expected to be known, or appreciated at any of the courts stated in the preamble, whether that of 'any prince, earl, lord, knight, squire, or town'. This could be seen as a term of admiration, almost as an elevation of its seemingly mundane nature to something very special and noteworthy; at the same time, it indicates an aspirational and advertising aspect – capable of attracting any new reader/practitioner who, by reading this

text, might have aspired to be present at court to follow these instructions. This would also explain the increased use of ‘courtly’ in part 2 (eight times) – in comparison with part 1 (four times). This repeated use of ‘courtly’ emphasises the target audience of the *Firework Book*.

As previously indicated, along with the spread and development of gunpowder technology during the fifteenth century the role and position of gunner became increasingly specialized. Instead of making guns himself, most of the elements were commissioned to be produced by specialist craftsmen. This is reflected in the language used by the author of the second part of I.34 who was clearly further removed from the production stage. In contrast to part 1, here the author more frequently refers to ‘have made for yourself’ (fols. 53 v, 54 r, 55 v, 57 v, or 59 v – a rather odd phrase in the original, indicating a special emphasis) or ‘have made’ (fols. 52 r, 52 v, 53 r, 54 r, 54 v, 56 r, or 59 v) implying that he neither has the time/leisure nor knowledge to make specific equipment, and/or is financially affluent enough in an environment where he has sufficient tradesmen around him to commission items to be made. This relates specifically to components in iron and wood. The language makes the author appear much more a figure of authority who demands things to be done, rather than doing them himself.

Two sections (fol. 55 v and 57 r) are recipes which make little sense to a twenty-first-century reader. The author mixes a range of different balls and ingredients, but does not explain consistently what the end result is nor how the ingredients need to be put together to achieve it. Of interest here are the two headings (‘one hundred heads’, and ‘secret art’). Both imply a level of bragging or boasting along the lines of other marketing ploys mentioned above as nothing could either be verified or disproven.

The subsequent sections on fire arrows are very different in content and in style and are much more instructional. While they act as a stage-by-stage guide to follow in order to make fire arrows, the sections themselves get shorter as the explanations carry on, leaving some gaps in the production stages. This section builds on the instructions in I.34 part 1, but more emphasis is placed on the practical use of the fire arrows, how to produce them so that they have different properties, and how to mark them accordingly through colour.

The section on colouring arrows in white, red, blue, brown, and black (fol. 59 r) can be explained by subsequent use in combat so that the arrows can be distinguished, as they have different uses in a combat situation. The author refers to this by stating ‘so that you can remember them’ (fol. 59 v). Parallels can be drawn to I.34 part 1 where powder was mixed in different colours (fol. 29 v – 30 v). There the author fails to explain why the powder needs to be applied in different colours (or even how). Here the instructions relate to painting the outside of the fire arrow bag (made out of fustian wool). The instruction is entirely plausible and would be a sensible instruction for later use of the arrows. This could also be the case for the coloured powder mentioned in part 1, but only if charcoal was left out of the mixture (see above).

The section on how to harden a fire arrow with water (fol. 59 v) states that in order to make good fire arrows they should be made to burn slowly or have delayed ignition (i.e. only when they hit their target after flying).⁹⁴ This implies that soaking the arrow in water does benefit the result. However, if an arrow was not given sufficient time to dry it would make the arrow and its charge too wet which in turn would mean that it would not burn and explode at all. Soaking it too little would mean an explosion in flight, or a less effective result on impact. The wetting process shows close similarities to the production of *Knollenpulver*, but omits the essential drying stage (without which *Knollenpulver* would not work).

On fol. 60 r, I.34 focuses on ‘*olium petroleum*’ – used here as a generic term for all sorts of hydrocarbon products, often used for Greek fire but also for other forms of burning oils.⁹⁵ This recipe is hard to follow: either the author omitted some essential stages, or he himself did not understand how to make it. This could imply that this recipe was passed on to the author from elsewhere, without a practical testing of its validity. Reassuringly, at the end of this passage, the author confirms that this would be the ‘best oil’ for all types of fire. This statement gives the reason for including this segment in the text, but also reassures a potential reader that they may be in possession of the recipe for the ‘best oil’, even if they

⁹⁴ Described in more detail in Blosen (2006), xxx. It has been suggested that the key to a successful fire arrow was to treat the powder and the arrow after mixing it as firing the arrow without soaking it meant that it would most likely explode before hitting the intended target. While the HO Group carried out some experiments with fire arrows, more experiments in reconstructing fire arrows would be desirable. See Smith (2002-2016), especially the report of experiments in 2009.

⁹⁵ For a summary on the development of Greek fire, see Partington (1960 [1999]), especially chapter 1.

were not yet able to follow it. This provides some explanation of the use and function of these texts. It places the likely user as someone not (yet) skilled in the aspects of incendiary devices but potentially not at the absolute beginner stage.

The section on cooling a gun (fol. 60 v) raises a number of questions. While a gun warms up a little when firing, it cools down very quickly to a point when it would be safe to reload it. Hand guns may get hotter and be more likely to warm up, but not to such high temperatures as implied by the need for cooling.⁹⁶ It is also worth mentioning that heat on its own does not ignite powder; a spark is required. Hence guns were always swabbed after each shot to ensure that no embers remained. So why is this section included in a *Firework Book*? One theory may be that this is an indication of the background and interests of the author or the reader or the recipient of this section. Any experienced gunner must have known that the overheating of a gun would be extremely unlikely, but not so anyone with less front-line experience. It is conceivable that a medieval master gunner might well have worried that his gun might overheat, break, or fail with increased temperature, and a text section would act as reassurance. Equally, a less well-trained reader/recipient of the text (of whatever social status) may perceive that there might be a risk of overheating, and would feel reassured to find an instruction on how to prevent this.

In part 2, a range of ingredients are mentioned which do not occur in part 1, such as 'saltpetre salt' (fols. 52 r, 54 v, 56 r, 57 v, and 59 r) or 'ground-up rotten beech wood' (fols. 52 r, 53 r, 54 r and v, 55 r, 57 r and v, 58 v, and 59 r). Similarly, others are more clearly defined in part 2 such as the use of 'lime wood charcoal' (fols. 57 v, 58 v, 59 r and v) instead of merely 'charcoal'. The benefits of using lime charcoal were already described in part 1 (fol. 8 v), but that information was not repeated when charcoal was mentioned in subsequent sections. This suggests two possible explanations: a) gunpowder artillery had progressed by the time of the creation of part 2; or b) the eagerness of an individual to experiment with potential improvement of gunpowder to make up supply shortages for

⁹⁶ There are sixteenth- and seventeenth-century references to a gun overheating, but it would not have been possible to reload a gun in time. It was only by the nineteenth century that repeat fire in machine guns required cooling down with water. Recent test firings of a seventeenth-century gun, led by Fred Hocker at the Vasa Museum, Stockholm, were intending to include the measurement of the temperature of the gun, but the results have not yet been published. This 'myth' of a gun overheating continues to be repeated (e.g. Andrade (2016), 106).

ingredients or to improve effectiveness. He would not necessarily have possessed the technology to work out whether it improved or worsened the mixture but was nevertheless keen to write his 'discoveries' down. The latter seems more likely – as indicated by the individual's unfamiliarity with basic tasks such as the very detailed instructions on how to use scales.

Features common to both parts

Both parts 1 and 2 have a number of references to fish which is common to all other *Firework Books*. In part 1 it is largely used as a measure for time keeping: on fols. 5 r and 18 r 'poaching fish', and on fols. 22 v and 37 v to 'boil fish'. In part 2, the references on fols. 58 v and 59 r, refer to the making of 'fish powder'. This suggests practical knowledge of the maker on cooking or processing fish, and provides a clear positioning on the social stratum of the author of these *Firework Books*.

Throughout I.34, only four references mention the 'secrecy' contained in the *Firework Book*, and the associated request to keep the 'art secret so that you do not teach what is not meant for everyone' (fol. 59 v). This section comes at the end of instructions on how to harden iron arrowheads which is also the last section in part 1 of I.34 (fol. 50 v). This is a small number of references in the light of the widely-held assumption that secrecy surrounded gunpowder artillery.⁹⁷ The other three sections occur in part 1 where the secrecy refers to ways in which to keep any fire hidden (fol. 34 v) for covert operations to be ignited after numerous days (this is mirrored in a slightly different fashion on fols. 57 r and 58 r).⁹⁸

⁹⁷ The nineteenth-century *Le livre du secret de l'artillerie et de cannonier* by General Favé (one of Napoleon III's generals) which references the French translation of the *Firework Book* may be in parts to be blamed for it. 'Secret' here refers to 'something unknown' without the intent to keep it unknown. The *Oxford English Dictionary Online* definitions seem to suggest that the intent ('the aim of keeping something a secret') became more dominant from the nineteenth century onwards (*Oxford English Dictionary Online*, definition 1 – accessed 16 January 2019). Even earlier, John Wecker in his *Eighteen Books of the Secrets of Art and Nature*, published in 1660, gave rise to the concept of nature hiding its knowledge from individuals. If it really was intended to keep 'secret' other measures would have been put in place to ensure that it was kept unknown.

⁹⁸ No further explanation is given why it would not be for everyone (Is it too dangerous? Is it for economic reasons?). Space restrictions do not permit further discussion of the wider field of dissemination of knowledge, its perceived secrecy, and changes occurring during the fifteenth century (especially in German). The secrets of the *Firework Book* would fall mostly in Eamon's first definition in his 'taxonomy of secrets' as the 'social secret', 'involving the intentional suppression of information in order to protect knowledge from outsiders who might corrupt or abuse it'. (William Eamon (1994), *Science and the Secrets of Nature*, Princeton, NJ:

Very few actual scribal omissions – where the text copied from one copy to another misses out a single letter, word, or line of text – occur but there are other areas where some core key ingredients (such as saltpetre in gunpowder on fols. 8 v and 9 r, or charcoal on fol. 52 r) are missing. It could be argued that the item was too obvious to be listed, but it could also provide an indication of how the text was produced. It is clear that some texts had been produced from a copy of another *Firework Book* – hence the copying of the same amounts of currency even when they were written much later. Other manuscripts may have been based on knowledge recall of other manuscripts, or on dictation. Signs of oral transmission include the fact that many *Firework Books* contain several of the same paragraphs but in different order, indicating that the text was written down from memory (or had been dictated) and then recited to a scribe. This is reinforced by the reference ‘as you will hear’ on fols. 54 r and 19 v. These are stated at a common locations, just after the header or at the end of a section, but in all other cases the phrase used is ‘written below’ (e.g. fols. 5 r or 9 r, or 60 r or v). It is likely that either the writer or the person dictating them had the basic technical knowledge for most of the recipes. It is less likely that they knew where saltpetre came from, although they knew how to purify saltpetre and sulphur, how to put recipes together, and how to operate a gun. Furthermore, they possessed knowledge and experience of how to make incendiary devices, and understood each individual step. The rhetorical forms of question and answer do imply that the *Firework Book* was produced to inform a pupil or a new audience, but only by conveying basic, standard information without passing on additional ‘tricks of the trade’ learned by a master gunner with many years of active service. That is also why the language of the text is German, and very few technical terms, whether in Latin or any other language, are used. It is most likely to have been meant as an introductory piece of information upon which someone could build a future career.

Princeton University Press, 11). See also Pereira (1999), and more recently Sylvie Neven (2016), ‘Recording and Reading Alchemy and Art-Technology in Medieval and Premodern German Recipe Collections’, *Nuncius: Journal for the Material and Visual History of Early Modern Science* 31/1, 32-49.

Rainer Leng dispels some of the issues of secrecy of the master gunner knowledge which – to him – refers less to role specific technical knowledge but rather military secrets related to strength and weaknesses of own forces (Leng (1996), 315-6). There has also been some speculation that there were missing or deliberately misleading components in the recipes. Some *Firework Books* make a reference to the use of quicklime, which has been argued may render some recipes unusable. More detailed research would be beneficial in this area as the experiments carried out so far have been on a rather small scale and seem to only provide anecdotal insights. See, for example, Kramer (2001), 72, Smith (2002-2016), especially 2004 and 2005, and Smith (2015), 151.

To conclude: was there a distinctive change in the fifteenth century that brought about the emergence of the *Firework Book* (alongside other writings in vernacular German, often of a technical nature)? What they do provide is an insight to the level of the knowledge of the author (or originator) of a *Firework Book*, the state of the raw materials available, and a glimpse into the role of a master gunner, for instance the inclusion of fire arrows and incendiary devices. This knowledge seems to have been expanded in part 2, but it is not clear whether this indicates a change of practice or simply the filling of a perceived gap in what was present in part 1. Missing from the *Firework Books* – except in the illustrations in I.34 – are any instruction on the use of guns in battle, on strategy, or even how to mount them. They fail to explain whether a master gunner was involved (and at what level) in battle. They do, however, provide an indication of the transition towards further specialization, removing the master gunner from mundane physical tasks into the role of the person ‘in charge’. The final chapter will consider the status of the master gunner, and the use and the reception of the *Firework Book*, speculating on how it was used, if at all.

Chapter 5: The use and reception of the *Firework Book*

Preceding chapters have discussed the possible intentions and identity of the author or originator of the *Firework Book*. We now come to a fuller explanation of what the *Firework Book* was intended to be, how and in what form it was used after production, and in due course what it became. In doing so we need to discuss the status and identity of gunners, and also explore who might have owned the *Firework Book* in subsequent decades and centuries.

Arguably the most helpful explanation of the *Firework Book* comes from Bert Hall who described its requirements in various publications, with subtle distinctions. In 1979, he referred to it as ‘a practical, didactic manual for artillerymen and consists principally of recipes for pyrotechnic compounds’.¹ Later in the same article he went into more detail:

The *Feuerwerkbuch* [...] is obviously by a gunner for the use of other gunners. Most of its contents 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.²

For reasons already explored Hall’s interpretation of the *Firework Book* makes a lot of sense. The nature of the text, the quality of the production, the functionality and lack of flamboyant illustrations and illuminations in almost all copies – all of these seem to suggest that the *Firework Book* was intended to be used by other professionals and not by a wider, more general audience. However, Hall believed that its practical role and function – if indeed it ever was used as such – was short-lived, and that when the *Firework Book* came to ‘be printed, it functioned more as a collectors’ item for antiquarians’.³ Yet, Hall did not explain why he believed that the *Firework Book* had become obsolete. Clearly, if the printer felt it was worth setting it to print in 1529, there must have been a market for this kind of publication, and the book was surely less obsolete than he implies. It was certainly the case that by then gunpowder technology was more widespread, as was general public knowledge of its use, but there was also an apparent and continuous need to refer to these texts, perhaps for reassurance. Or, did the use of the *Firework Book* change between first publication and first print, a period of over a hundred years?

¹ Hall (1979a), 49.

² Hall (1979a), 54.

³ Hall (1997), 88.

To come closer to an understanding of those who produced a *Firework Book*, the starting point should be to consider who gunners were in the fifteenth century. What was their status in society, and how did they emerge?⁴ For Simon Werrett, they were ‘lowly, anonymous craftsmen, notorious for drunkenness, and mistrusted as outsiders’, and furthermore, that ‘the gunner’s status was lower even than that of the common soldier, for the nobility deeply resented the cannon’s power, to put them at the mercy of the vulgar, and commoners feared the terrible destruction by new-fangled ordnance’. However, Werrett’s bases his view on only two examples, one from a nineteenth-century secondary source written by a retired artillery officer, the other from a single 1588 account from a Flemish camp after the Armada.⁵ The fact is that little is known about a gunner’s background, his education, or his standing among fellow soldiers, especially in the fifteenth century. Rainer Leng describes them thus:

Most of the master [gunners] [...] had been working as black-smiths or metal-workers in medieval urban settlements. They left their traditional workplaces in order to specialize and thus to climb the social ladder. They often changed employers, they were very well paid and relatively rare. Lords and cities depended on their detailed knowledge of chemistry and weapon technology.⁶

Unfortunately, Leng provides no reference for this description and even goes as far as to attribute the ‘solitary travelling’ life-style as the reason for setting down the ‘technical know-how’ in writing, as it ‘was always in danger of being lost in perilous military engagement’.⁷ Although plausible this theory seems somewhat simplistic, if not circular, as very few biographical details survive for master gunners for the period.

A number of attempts have been made to piece together the little evidence there is about master gunners in the fourteenth and fifteenth centuries. Surviving records of master gunners are sparse from the late fourteenth century, becoming increasingly more substantial by the mid-fifteenth century, but all remain a patchwork of individual mentions

⁴ See Werrett (2010), 13-45, developing an idea raised by Steven A. Walton (1999), *The Art of Gunnery in Tudor England*, Toronto: PhD Dissertation University of Toronto, 280.

⁵ Werrett (2010), 13.

⁶ Rainer Leng (2004), ‘Social Character, Pictorial Style, and the grammar of Technical Illustration in Craftsmen’s Manuscripts in the Late Middle Ages’, in Wolfgang Lefèvre ed., *Picturing Machines 1400-1700*, Cambridge, MA: MIT Press, 88. In this article published in English, the translation does not distinguish sufficiently clearly between the different types of ordnance personnel, using interchangeably ‘master gunner’, ‘gun master’, ‘gun maker’, and ‘gunner’. It is likely that there was a substantial overlap between these roles while at the same time some distinct differences.

⁷ Leng (2004), 88-9.

of gunners in widely dispersed employment across Europe.⁸ Even the terminology used, for example ‘a gunner’, ‘a master gunner’, ‘a gunner’s troop’, or a ‘cannoneer’ cannot be fully ascertained until later centuries. There is thus a risk of imposing back-projected modern definitions on the terms, and thereby giving rise to misinterpretation.

The former Deputy Master of the Royal Armouries, Thom Richardson, dates the first recorded gunpowder production in the Tower of London to 1346, with the purchase of raw materials as well as already mixed gunpowder.⁹ However, the quantities mentioned would have allowed only for a very small number of shots to be fired. Quantities increased rapidly between 1400 and 1410.¹⁰ The first mention of a recipe in English has recently been traced to a manuscript which is likely to have been produced before 1450.¹¹ Most recently, and based on a substantially more comprehensive body of sources, the Southampton ‘Soldier in Late Medieval England’ project – which unfortunately ends in 1453 – has listed a substantial increase of gunnery units and individual master gunners in the decades up to 1453 (with the evidence remaining patchy).¹² This is not helped by a ‘surprisingly high turnover of personnel’ while other soldiers, such as archers, served as gunners at times which made King wonder about the ‘surprising lack of specialization’.¹³

⁸ Most recently, Knut Schulz (2016), ‘Büchsenmeister des Spätmittelalters: Migration und Ausbreitung des neuen Wissens’, in Eva Jullien and Michel Pauly eds., *Craftsmen and Guilds in the Medieval and Early Modern Periods*, Stuttgart: Franz Steiner, 221-42, 230-42, or Leng (1996), 303-320, Schmidtchen (1977), 176-196, or even earlier with Bernard Rathgen (1926), ‘Pulver und Salpeter vor 1450: Schießpulver, Kunstsalpeter, Pulvermühlen im frühen Mittelalter’, *Zeitschrift für Naturwissenschaften* 87, 64-100. Schulz as well as Schmidtchen highlight the internationality of the recorded master gunners, and the fact that there is a predominance of gunners recorded with an apparently German language background (Schulz (2016), 236).

⁹ Richardson (2012), 336.

¹⁰ Richardson mentions Ranulph Hatton’s account E 101/400/22–3 which records purchases of ‘584 lb of saltpetre, 96 lb of gunpowder, and a barrel of willow charcoal. Of this, after issues, 256 lb of saltpetre, 56 lb of sulphur, and the barrel of charcoal remained at the end of his account, E 101/403/20’. ‘In 1396-9 Lowick passed on 108 lb of saltpetre, and John Norbury bought in 1,000 lb of sulphur in addition, as well as 8,000 lb of ready-made gunpowder. 1,300 lb of gunpowder was then manufactured within the Tower, from 1,370 lb of saltpetre and 400 lb of sulphur, E 101/404/25.’ (Richardson (2012), 166-74).

¹¹ Trevor Russell Smith (forthcoming), ‘The Earliest Middle English Recipes for Gunpowder’, *Journal for Medieval Military History*. This is only a fragmental text of two folios listing the production of ‘good gunpowder’ and ‘colourful powder’ in London, Society of Antiquaries, manuscript 101, fols. 76 r and 76 v.

¹² There have been countless, sometimes contradictory attempts to establish the number of gunners in the fifteenth century. For a comprehensive overview on gunpowder artillery troops considered by the Southampton ‘Soldier’ project see Adrian R. Bell, Anne Curry, Andy King, and David Simpkin eds. (2013), *The Soldier in Later Medieval England*, Oxford: Oxford University Press, 194-202. The ordnance lists of the gunners’ guild of Ghent from 1480 to 1560 provide detailed listings of activities and numbers of master gunners in Ghent alone (unpublished document, then at the Bijloke Abbey and now in the STAM (Stad Museum), Ghent, Sint Antonius, 155/2).

¹³ King (2011), 66-74.

What we can say is that a master gunner was likely to have been an intelligent individual with the ability to read and write, and be at ease in social interaction with local lords (as their potential employees).¹⁴ Being a gunner was a dangerous business, and it is likely that anyone who chose this profession would have come from a lower class background with aspirations to rise in the ranks and grow rich.¹⁵ Those who were successful required a unique skill set to enable them to engage with an unfamiliar community and ascend rapidly through the social order – thus increasing the likelihood of resentment from their fellow soldiers.¹⁶

Hall's definition of a *Firework Book* as something written by a gunner for a gunner raises the question: what was it that the other gunner needed to know? Was it that the books contained knowledge which needed to be passed on, or did they serve a rite-of-passage function, by demonstrating their knowledge? Possessing a *Firework Book* would certainly have provided access to the basic skills required of a master gunner. The slight variations in and similar linguistic backgrounds of copies of the *Firework Book* would seem to suggest that the habit of copying (and 'improving' – either deliberately or accidentally) an earlier version was customary within a certain regional and linguistic group, but did not go beyond it.

What assumptions can, therefore, be made about those who kept copies of the *Firework Book* or similar texts? Were they actual practitioners of gunnery – whether master or apprentice gunners – or other interested parties? Leng argued that the emergence of the

¹⁴ This is closely mirrored by other professions at the time, such as the master mason. See, for example, John Harvey (1972), *The Mediaeval Architect*, New York, St. Martin Press, 69-86, or Walton (2014), 356-65. There are some parallels to the *Firework Book* text such as comprehensive knowledge of all aspects of the work ('jack-of-all-trades'), sense of how to operate equipment properly and safely, and some understanding of scholastic basics but merely applying it pragmatically.

¹⁵ Andy King challenges Werrett (2010) on rates of pay for ordnance companies. While King admits to pay being higher he attributes this to longer working hours and over time on religious festival days. He asserts that in an ordnance company little opportunity existed to make a fortune quickly (Andy King (2011), 'Gunners, aides and archers: the personnel of the English ordnance companies in Normandy in the fifteenth century', *Journal of Medieval Military History* 9, 65-75, 74). Neither Werrett nor King, however, consider the broader issue raised by Rainer Elkar of travelling tradesmen in the period, when migration of younger apprentices contributed substantially to the dissemination of technology and development ('*eine gleichmäßige Diffusion von Technologie und Fortschritt*', Rainer S. Elkar (1999), 'Lernen durch Wandern? Einige kritische Anmerkungen zum Thema Wissenstransfer durch Migration', in Knut Schulz ed., *Handwerk in Europa. Vom Spätmittelalter bis zur Frühen Neuzeit (Schriften des historischen Kollegs, Kolloquien 41)*, München: Oldenbourg, 213-32, 224).

¹⁶ Werrett (2010), 43: 'Gunners [...] engaged directly with the nobility as employees and clients. Many sought patronage by dedicating their works to noble artillery officers [...]', although the examples provided are from the first decade of the seventeenth century.

Firework Book, and other technical treatises in the fifteenth century, was the result of fast-moving technological innovation. This, he claimed, created a tension between individually acquired knowledge and diverse prior knowledge which brought about a pressing need for information from practitioners to be readily accessible to potential newcomers to the trade. He further identified an increasing desire from the side of the employer that a potential master gunner should come with references, proving his skills and expertise as a future employee.¹⁷ Meanwhile, Schmidtchen contributed his own theory to this discussion by stating that the manuscript not only served as an *aide memoire* for the master gunner or any family member or apprentice (who might be following the master gunner's trade), but also as an 'advertising effect to inform potential employers about their range of skills and expertise'.¹⁸ The more boastful elements in the text, as well as the repetition of the language certainly suggest a strong marketing element. This is coupled with a sense of boastfulness, or a passive-aggressive threat, that if gunners are not paid they can 'cause rotten harm' (fol. 26 r) by turning against their previous employers. However, all this is mere conjecture and cannot be substantiated by evidence from any of the manuscripts. The purposes served by a *Firework Book* after it was produced, and whether it was passed on from the master gunner to an apprentice or anyone else, are matters about which we can only speculate.

Turning to the manuscript evidence, this provides a set of clues which provides further insight to the discussion of who used *Firework Books*, and why. They were produced on good quality paper, and since each copy appears to be in a different hand the implication is that they were produced in a number of different locations. As mentioned in chapter 2, the water marks suggest that the geographic origin of the paper is Austro-Bavarian, from regions between the Rhine and the Danube. The regional dialects of the language differ from book to book, and at times even within a given manuscript. For example, according to Karin Zimmermann the language of part 1 of I.34 indicates that the scribe might have come from southern Bohemia, an area north east from Bavaria, and north of Passau. The language of part 2 is in a distinctly different dialect to that of part 1. Zimmermann identifies this as

¹⁷ Leng (2002), 105-6.

¹⁸ '... in Sinne eines Werbeeffects, zur Information potentieller Auftraggeber bezüglich ihrer Fähigkeiten...' (Schmidtchen (1990), 30).

more likely to come from a Bavarian region with some elements from Swabia, pointing towards a region to the west of Augsburg.¹⁹

Speculation has focused on whether the manuscripts were written by professional scribes or by professional gunners. In relation to I.34, Barter Bailey states that 'the compiler was adding to the collection or improving it as he compiled it, without taking the trouble to go back and eliminate duplication. The hand, however, is a regular copyist's hand rather than that of a man making a series of scribbled personal notes'.²⁰ This seems to imply that professional scribes were employed to produce the manuscripts.

The surviving *Firework Books* provide very little evidence of being much used. Hall comments that 'some of the copies I [Hall] have examined show stains and charring to indicate that they were used [...] in the workshop or arsenal'.²¹ However, it has not been possible to substantiate this theory. His comment refers to only two manuscripts,²² and it should be recognised that these are the exception rather than the rule. There is also no evidence that the spill (Munich manuscript) and the burn mark (Leipzig manuscript) occurred in the fifteenth century; the damage could have been caused centuries after production. Apart from these exceptions, none of the 61 other surviving manuscripts of the *Firework Books* viewed show signs of use, wear and tear, nota signs, spillage, discolouration, marginalia, marks, insertions, additions, or changes to the original text. At least some of these signs would be expected for books in common use, especially for those intended for practical purposes similar to cookery or surgery.²³ Does this suggest that the surviving copies are those which ended up not being used, or is it rather an indicator of why they were produced?

¹⁹ Personal correspondence with Karin Zimmermann, Deputy Head of Special Collections, Heidelberg University Library, and specialist on late medieval German manuscripts, email 21 March 2013.

²⁰ Barter Bailey (1996), 58, and Leng (2009), 147-8.

²¹ Hall (1979a), 54.

²² Hall specifies that the manuscripts in question were Leipzig Ms. 1597, 1 r-88 r, which shows a burn mark possible from a rod or poker, and Munich Cgm. 399, 1 r-48 v, which had one spillage on one folio. However, he admits that he may have overstated the usage signs. His revised theory about the *Firework Books*' usage is that the copies 'seem strangely pristine, especially [...] copies that are parts of a larger *Sammelcodex*, as if they were made as archival records that were not to be used in the field.' Personal correspondence with Bert Hall, email 23 February 2014.

²³ Joseph Burnley Trapp (1999), 'Literacy, books and readers', in Lotte Hellinga and Joseph Burnley Trapp eds., *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*, Cambridge: Cambridge University Press, 31-43, 40-41.

It is impossible to establish how many *Firework Books* were produced overall, and hence to ascertain what proportion of the genre is represented by the surviving manuscripts and prints.²⁴ Is what survives perhaps the majority of all that were ever produced? Or do they instead represent the very small number of those that became forgotten in libraries and collections? If the surviving *Firework Books* are a major proportion of all *Firework Books* ever produced, a number of likely conclusions follow: it can be assumed that practical use was not their main purpose, that their audience was a very small and select group of professional gunners, their patrons and their associates, and accordingly that they were to be treated with great care. If, on the other hand, the surviving *Firework Books* represent only a small proportion of once-existing *Firework Books* the opposite conjecture can be applied: that they were widely distributed and used in the workshop but also fragile, and that a large proportion would probably have been discarded and destroyed after use. Such an explanation could be compared to the maps of modern shipping companies where a copy of the map is kept on the wall of the headquarters, while other maps go out with the ships (experiencing substantially different levels of wear and tear). In late medieval cartography, the surviving maps were mainly high-status elite gifts presented to rulers which remained preserved safely in libraries – such as the Catalan atlas (c. 1380) presented to Charles VI of France, now in the Bibliothèque Nationale in Paris.²⁵

A *Firework Book* text is relatively short, and in most of the surviving cases, is bound together with one or more technical texts in vernacular German.²⁶ Almost all copies viewed appear to

²⁴ According to Hassenstein, the first printed edition was found as an appendix to *Flavii Gegetii Renati vier Bücher von der Ritterschaft* (Augsburg, 1529) – but only survives in Hassenstein (1941). Hall (1979a) refers to ‘two unrelated first editions’: Heinrich Stainer, Augsburg, 1529, and Christian Engenolph, Strassburg, 1529, the latter published under the title *Büchsenmeisterei: von Geschoss, Büchsen, Pulver, Salpeter, und Feuerwerk*. The two printers, Heinrich Stainer (also known as Steyner oder 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, to texts by Hans Sachs, Melanchton, Paracelsus, Erasmus of Rotterdam, Cicero, Petrarch, Plato, Ovid, and many others (Norbert H. Ott, ‘Steiner, Heinrich’, *Neue Deutsche Biographie* 25 (2013), 183 [Online-Version], <https://www.deutsche-biographie.de/pnd119838451.html#ndbcontent>, and Josef Benzing, ‘Egenolff, Christian’, *Neue Deutsche Biographie* 4 (1959), 325-326 [Online-Version], <https://www.deutsche-biographie.de/pnd122968468.html#ndbcontent> – both accessed 21 March 2019).

²⁵ See Paul Dean Adshea Harvey ed. (2006), *The Hereford World Map: Medieval World Maps and Their Context*, London: British Library, 408-9, and Evelyn Edson (2007), *The World Map, 1300-1492: The Persistence of Tradition and Transformation*, Baltimore: Johns Hopkins University Press, 1.

²⁶ Heidelberg Cod. Pal. germ. 502 is bound together with 123 unsorted recipes on horse medication, all written in different hands, while Heidelberg Cod. Pal. germ. 562 is combined with a text on defensive building structures and materials and a treatise on how to defend oneself while on the move, as well as 159 unsorted

have post-medieval bindings, and it is impossible to be certain about the original content. Whether these were originally grouped together at or shortly after production remains a question, and the I.34 version may well be an example of how *Firework Books* were initially intended to be used, starting with the 'core' text, followed by a second part for the 'recipient' of the book to list their own experiments, experiences, and recipes, and a final part on illustrations.²⁷

All *Firework Books* in existence are written in vernacular German with slight regional variations. What then does the choice of language indicate? A German vernacular is used throughout with an almost complete absence of Latin (even for the chemical elements).²⁸ Might this have been part of the 'graduation process' for a master gunner to demonstrate that they possessed the core skills and knowledge to write this text? In this case, the owner would not go out to buy a copy, but instead would be expected to commission or write his own copy. This would explain the differences in regional dialects expressed in the manuscripts, as well as the absence of illustrations and elaborate colorations (other than red rubrics and occasional initials) or any further attempts to make the *Firework Book* more decorative. If it was a private copy, the question arises as to whether it was intended to be read by anyone else, thus making the *Firework Book* a private and personal item. The printed version in 1529 suggests that, by that date, any once 'secret' knowledge of gunpowder technology had become 'public', but also suggests an interesting possibility that the text may well have included some deliberate obfuscations. This would mean that the *Firework Book* could be read by the general public while the recipes could not be recreated in full.²⁹

The *Firework Book* stresses that master gunners needed to be literate as otherwise they would be unable to memorize all the details of gunpowder technology. Hall explains the importance of the master gunner's ability to read and write, "*der Meister sol auch kennen*

recipes on medicine, charms, and potions. It seems to have been common practice to combine *Firework Book* texts with other medical and technical military texts of the period. However, it is not clear whether this is a medieval practice or only applied to the post-medieval period as the result of later rebinding.

²⁷ In this, I.34 shows some similarities to Strasbourg Ms. 2259 and New York Spencer Collection Ms. 104.

²⁸ See Mechthild Habermann (2002), *Deutsche Fachtexte der frühen Neuzeit. Naturkundlich-medizinische Wissensvermittlung im Spannungsfeld von Latein und Volkssprache* (Studia linguistica Germanica 61), Berlin: de Gruyter, 1-54.

²⁹ See chapter 4 for discussion on secrecy.

schreiben und lesen', [...] because without literacy he could not possibly 'keep in mind all the elements that belong to this art' (fol. 33 r). He concludes that this was not only the result of 'technological complexities' but that it also contributed to 'create a class of literate technicians who could and did speak for themselves, taking over the roles once held by physician-astrologers, alchemists or other interested amateurs of technology'.³⁰ This could explain the persistent presence of the mythical figure of Niger Bertholdus which provides a foundation story to an emerging profession of almost patron-saint status.

This level of literacy might not necessarily have applied to all users of the *Firework Book*. The repetitive nature of the introductory phrases '*Welch furst grauff her[r] ritter knecht oder stet*' would have been familiar even to someone barely literate, and provides a visually recognisable phrase comparable to widely used prayers, such as the *Pater Noster* or *Ave Maria*.

To better understand how the *Firework Book* was used, it is worth exploring the book trade and book ownership in the fifteenth and early sixteenth centuries. If the *Firework Book* was something that was intended to be owned by key professionals (current or aspiring gunners and their families), there must have been some network for acquiring a copy, either by personal contact, or by a wider distribution network. The fact that at least two printed versions were produced further suggests that there was an increasing demand for this type of publication. However, there is no evidence for the existence of any of these networks; hence much hangs on the already-discussed issue of the quantity in which the manuscripts that were produced.

In the early sixteenth century, from which time substantially more comprehensive records survive, printing and copying were carried out side-by-side in the same workshop, and by the same group of practitioners.³¹ Melanie Panse argues that when a book became popular it was set to be printed, while one-off copies were produced by hand, which implies both an existing demand and a buoyant market.³² For early printed books, little or no evidence survives for print-runs, reasons for printing, sale prices, or related information.³³ Evelyn

³⁰ Hall (1979a), 52.

³¹ David McKitterick (2003), *Print, Manuscript and the Search for Order, 1450-1830*, Cambridge: Cambridge University Press, 30-2 and 47-8.

³² Panse (2012), 10-5.

³³ Benito Rial Costas (2013), *Print Culture and Peripheries in Early Modern Europe*, Leiden: Brill, xix-xxiii.

Welch even goes so far as to state that bookshops worked more on a commission basis producing publications on demand, and suggests that ‘printed books were often sold unbound, and customers could choose how they wanted their edition collated’.³⁴ Personal books were produced on a pick-and-mix principle, thus making each book virtually unique.

One example of this is the *Household Book*, and a comparison with the genre may provide a possible insight into what the *Firework Book* was intended for. A *Household Book* was a private text compiled with the personal preferences of the author in mind. For example, John Paston commissioned his *Great Book* – a compilation of military treatises and texts of a historical and instructional nature – in the 1470s.³⁵ This genre was to become hugely popular in the latter part of the fifteenth century with instructional publications such as housebooks, commonplace books and household books, compendia of related tasks and chores, with often personally adjusted content, focusing on how to run all aspects of a household properly, or miscellaneous parts thereof.³⁶ The *Firework Book* shows signs of similar compartmentalization and of the compiler’s mix-and-match approach.

Turning now to what little is known about *Firework Books*, their owners at or after the time of production, and the survival of copies into the post-medieval period, the following survey

³⁴ Evelyn Welch (2005), *Shopping in the Renaissance: Consumer Cultures in Italy 1400-1600*, New Haven: Yale University Press, 151. Welch lists the library of one Zanobi di Mariano whose library inventory included 80 manuscripts and 141 printed books including 30 unbound copies of Josephus, *De bello iudaico* (Welch (2005), 331). Zanobi was an important Florentine *cartolaio*, whose life (1415-1495) coincided with the shift from handwritten to printed book. He first rented a shop in Florence in 1448 and produced manuscripts, as well as selling second-hand manuscript books (see Christian Bec (1969), ‘Une librairie florentine de la fin du xve siècle’, *Bibliothèque d’humanisme et renaissance*, 31, 321-32, 323).

³⁵ Still preserved in the British Library as Lansdowne Ms. 285.

³⁶ The genres of the medieval housebook and its post-medieval developments are discussed in detail by Graf zu Waldburg Wolfegg (1998). There are different cultural traditions for miscellanies of different kinds and scholars have argued that the housebook tradition developed in different directions through the later Middle Ages and early modern period across Europe. The Italian tradition is referred to as *Libri di Ricordanze* or *Libri di Famiglia* and dates back to the fourteenth century at least, e.g. Datini, a prominent and well-studied merchant of Prato was known to have one. In Germany, the housebook developed more of an official exemplary character. For the English household and commonplace book see David Parker (1996), ‘The Importance of the Commonplace Book: London, 1450-1550’, *Manuscripta* 40, 29-48, Julia Boffey (2000), ‘Bodleian Library, manuscript Arch. Selden. B.24 and Definitions of the ‘Household Book’’, in Anthony Edwards, Vincent Gillespie, and Ralph Hanna eds., *The English Medieval Book: Studies in Memory of Jeremy Griffiths*, London: British Library, Julia Boffey and John Thompson (1989), ‘Anthologies and Miscellanies: Production and the Choice of Texts’, in Jeremy Griffiths and Derek Pearsall eds., *Book Production and Publishing in Britain, 1375-1475*, Cambridge: Cambridge University Press; for the French tradition, see Gina Greco and Christine Rose, trans. (2009), *The Good Wife’s Guide: Le Ménagier de Paris, A Medieval Household Book*, Ithaca and London: Cornell University Press; and for the early-modern tradition, see Ann Moss (1996), *Printed Commonplace Books and the Structuring of Renaissance Thought*, Oxford: Clarendon.

will explore the various levels of provenance of copies of the *Firework Book*. One way is to aim to trace ownership backwards from the present-day. Another is to trace ownership forwards in time (from or near the author to later owners). If neither of these approaches enable the establishment of a continuous line of ownership, can glimpses of ownership be detected at any stage? And, is it possible to make any assumptions as to what the earliest known ownership may indicate?

Working backwards gives a multi-faceted picture of ownership of the existing known copies, with most of them entering public ownership in the mid-twentieth century. Tracing ownership further back is both arduous and challenging, as such records tend not to go back much before the early nineteenth century. Their ownership is linked to the rise of antiquarianism and the enthusiasm to catalogue and compile lists, which was not common practice before the nineteenth century. However, even then records such as the *Firework Book* could easily be overlooked or mis-catalogued because of its content or a misunderstanding of it. The provenance of the *Firework Book* can usually only be traced back to provincial libraries in the eighteenth and nineteenth centuries. Occasionally, there are glimpses of possible ownerships before this period but they are always accompanied by a common phrase used by librarians such as 'likely to have been in the possession of the duke since the establishment of the library'. Only three copies have references to the fifteenth century: Freiburg Ms. 362, with a textual addition at the end of the text of '*Anno trecesimo 2*', seemingly by the same hand, but in different coloured ink; the Dillingen manuscript at the end of the text providing a signature '1466 Jodocus Foelki presbyter' written in a different hand; and one of the Heidelberg manuscripts, Col. Pal. germ. 502, with a signature at the beginning showing it to have been the property of Johann von Mosbach.³⁷

³⁷ Also identified by Leng (2009), 183. Leng gives further information on the Heidelberg manuscript, Cod. Pal. germ. 502, saying that it was from the property of the Provost of Augsburg who was nephew of Pfalzgraf Friedrich I (1451-76) whose inheritance became part of the *Bibliotheca Palatina* ('*Besitzeintrag (?) des 16. (?) Jahrhunderts [...] aus dem Besitz des Domprobst zu Augsburg Johann von Mosbach, Neffe des Pfalzgrafen und Kurfürsten Friedrich I (1451-1476), aus dessen Nachlaß in die Palatina gelangt*'). Leng also provides details on two other manuscript origins:

p. 161: Heidelberg Cod. Pal. germ. 787: presumably at an early stage property of a master gun-maker ('*Zuerst vermutlich im Besitz eines Büchsenmeisters*') but no record when it entered the *Bibliotheca Palatina* (now Heidelberg University Library). Possibly mentioned in 1610 catalogue but not identifiable with certainty ('*nicht eindeutig identifizierbar*').

p. 190: Nuremberg Ms. 1481a: origins unknown; first recorded in private library of founder of Germanic National Museum, Hans von und zu Aufseß. Donated to the museum by the owner in 1852.

While the earliest records of the English Old Royal Library do not contain any *Firework Books* or similar technical treatises,³⁸ we know that gunpowder was being used both through the Tower of London records edited by Richardson and the earliest mention of a gunpowder recipe mentioned above. We might have expected *Firework Books* to have existed later on, yet even in the sixteenth century, customs rolls record imported books but only as ‘containing books of diverse histories’.³⁹ They rarely identified particular texts or editions, unless they were of more specific value – whether the result of their content or physical attributes.⁴⁰

Books were viewed as precious commodities and, therefore, were regularly mentioned in inventories and wills. However, those listings give only partial information as single volumes cannot usually be matched up with book lists of wills and inventories. Customs rolls give details on quantities of traded commodities without providing the details of individual items. All that can be ascertained is that books on hawking and hunting, veterinary medicine, and the art of war were widely circulated.⁴¹ For example, King Richard III is known to have owned a range of *De Regimine Principum* – a series of compilations of an instructional nature intent on making him a better prince – which, while not stating the individual components could well have included technical military treatises such as the *Firework Book*. It is highly likely that these compilations included texts of a more intellectual, strategic, and chivalric nature.⁴² Anything that was not part of devotional, romantic, or historical literature was perceived to be of lesser interest and was generally not specified in detail.⁴³ Manuscripts of a technical and secular nature, especially when written in the vernacular, were not usually individually described in catalogues, wills, book lists, or inventories. Even further afield, at the Portuguese Royal Court, King D. Duarte (1391-1438) was known to have been aware of firepower technology, and possessed an extensive library

³⁸ The collection was donated to the British Museum in 1757 by King George II. It was known as the ‘Royal Library’ until the arrival in the building of the library of King George III in 1828. (Manuscript material associated with this collection is in the Department of Manuscripts).

³⁹ Lotte Hellinga and Joseph Burnley Trapp eds. (1999), *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*, Cambridge: Cambridge University Press, 151: ‘*libris diversarum istoriarum*’.

⁴⁰ See Hellinga (1999), xxii-xxiv.

⁴¹ Margaret Lane Ford (1999), ‘Importation of printed books into England and Scotland’, in Hellinga (1999), 179-201, 180.

⁴² Anne F. Sutton (1997), *Richard III’s Books*, Stroud: Sutton, 283.

⁴³ Diane E. Booton (2010), *Manuscripts, Market and the Transition to Print in Late Medieval Brittany*, Farnham: Ashgate, 168, and Trapp (1999), 33: ‘[B]ooks are seldom mentioned, let alone particularized, unless they were especially prized or had some special association’.

in the 1430s, and had the unusual habit at the time of listing vernacular texts by title – yet no *Firework Book* or related text is mentioned.⁴⁴ Books were precious and listed in wills, but only those which were perceived to be of value (because of the content or the production cost/style) were specifically named. It has not been possible to find any *Firework Book* in any record of a fifteenth- or sixteenth-century book ownership list.⁴⁵

One may ask whether exploring the book trade and any available records could shed further light on the presence of books such as the *Firework Book*. Lotte Hellinga describes the ‘book trade’s importance as mediator between owner and reader’, and any book of interest would have been commercially available across Europe – yet, once again, available lists do not specify in sufficient detail the specific content of any vernacular secular texts before the eighteenth century.⁴⁶

Certain assumptions can be made as to who owned and kept books in the fifteenth century. A range of medieval books existed in libraries and in private possession,⁴⁷ with varied levels of readership and use,⁴⁸ from personal and lay to professional and scholarly use.⁴⁹ Reasons for ownership are unlikely to have differed from that of present day ownership, including monetary value, retention or acquisition of knowledge, entertainment, vanity, and pastimes. Books were viewed as assets and were used as dowry, gifts, and bequests, but only if the book in question was perceived to be of value.⁵⁰ Diane Booton’s classification of book acquisition in the fifteenth century by literary category places a *Firework Book* into her

⁴⁴ D. Duarte ‘contrasted deceitful alchemy and sorcery to marvels that he had himself witnessed such as water divining, miraculous cures and gunpowder’ (D. Duarte. *Leal Conselheiro*, 204-5, Iona McCleery (2009), ‘Both “illness and temptation of the enemy”: melancholy, the medieval patient and the writings of King Duarte of Portugal (r. 1433-38)’, *Journal of Medieval Iberian Studies*, Vol. 1, No. 2, 163-78, 172).

⁴⁵ The first mention of a book inventory by an English monarch is recorded in 1535 as 143 manuscripts and printed works seen by an anonymous French visitor to Richmond Palace. (Jenny Stratford (1999), ‘The Early Royal Collection and the Royal Library to 1461’, in Hellinga (1999), 255-266, 256).

⁴⁶ Hellinga (1999), xxi, and Ford (1999a), 179.

⁴⁷ Neil Ker’s list is a laudable but deeply flawed attempt to list books which were available in scriptoria and libraries in the Middle Ages. As he admits, the listings available are patchy, ‘for the majority [...] no medieval catalogues of book-lists survive’ (p. vii), and thus the main reliance is on referencing of medieval books in modern catalogues. Furthermore, he particularly excludes ‘cartularies, rentals, inventories, surveys, statutes of cathedrals and colleges, mortuary rolls, letter-books and all books concerned with business and administration’ (Neil R. Ker (1987), *Medieval Libraries of Great Britain*, London: Royal Historical Society, viii). Whether a *Firework Book* would fall under any of these categories could not be established.

⁴⁸ Trapp (1999), 34. He distinguished between ‘reading’ and ‘comprehending’, and lists the type of books as well as users on subsequent pages.

⁴⁹ Hellinga (1999), viii-ix.

⁵⁰ Booton (2010), 146-9, and 204: ‘Many early books and manuscripts circulated in passive ownership, that is, they were presented as gifts or descended by inheritance within a family’.

final category, namely, 'Medicine and Science'. This includes 'books best described as miscellaneous or unclassifiable, because the titles are unspecific, ambiguous, too general to categorize, or are part of collections not fully described in documents'.⁵¹ This makes one wonder how these items managed to survive at all until they emerged in the early nineteenth-century catalogues. Or, did only those copies survive which were fortunate enough to have librarians who kept books for books' sake – even if they did not understand their content?

Some records of book ownership survive from a number of personal libraries, ranging from royal households to personal local libraries belonging to those of lower nobility or of merchants or businessmen. Even for King Edward IV, founder of the Old Royal Library, no inventory exists for his books, nor is it possible to establish how much of his library survived. Insights of what might have been owned by Kings Edward IV and Henry VII can be gained by inclusions of their arms, badges, or other personal comments.⁵² Similarly, one of King Henry VII's leading supporters, John de Vere, the thirteenth Earl of Oxford (1442-1513), had the following listing of books recorded in his will (dated 10 April 1509) 'a book called a Cowcher', a 'mass-book', 'a masse boke wt clapsys of silver; iiij masse bokes written in velom; [...] ij half Legendes; ij printid masse bokis; vij Pricke song bokis bounde in leder; and xij Prick son bokis', and a 'gospel boke wt thone sde covered wt silver and a picktur of or Lorde' – yet when the list reaches non-devotional items it suddenly becomes substantially more generic: 'and a chest full of frenshe and englishe bokes' – without specifying any further details.⁵³

One of the leading late fifteenth- and early sixteenth-century merchant families, the Fuggers from Augsburg, based in the area where most *Firework Books* can be located linguistically, were prolific book buyers and collectors. Their libraries moved in various directions, the library of Ulrich Fugger (1441-1510) eventually passed, in 1567, to Heidelberg where it became the foundation of the *Bibliotheca Palatina*; the library of Johann Jakob Fugger (1459-1525 – his youngest brother) went to the *Hofbibliothek* of Albrecht V in Munich; and the library of Georg Fugger (1453-1506 – the middle brother) to the *k.k. Hofbibliothek* in

⁵¹ Booton (2010), 209.

⁵² See Janet Backhouse (1999), 'The Royal Library from Edward IV to Henry VII', in Hellinga (1999), 267-81.

⁵³ William St. John Hope (1914-15), 'The last testament and inventory of John de Vere, 13th Earl of Oxford', *Archaeologia* 66, 310-48, 300.

Vienna in 1654.⁵⁴ Significantly, the three libraries of Vienna, Munich, and Heidelberg have a combined holding of seventeen copies of the *Firework Books* in their collections today – just over a quarter of all existing manuscripts.

The Fugger libraries are known to have included a range of technical and medical texts, but usually only items of exceptional value were singled out for particular mention in earlier catalogues.⁵⁵ The catalogues available are based on records from existing book seller receipts and bills, bills from bookbinders, and from the early library inventories such as that of the library of Ulrich before it was transferred from Augsburg to Heidelberg in 1567. Paul Lehmann's two-volume publication on the Fugger library has brought together the surviving records on library holdings of the key members of the Fugger family, and the records repeat the common collective term 'various treatises in German' ('*allerlei teutsche tractatlin*') without being able to specify them further.⁵⁶ His lists, however, specify by title other technology-related publications such as combat and tournament manual manuscripts all of which include illustrations.⁵⁷ No evidence could be traced for the provenance of the *Firework Books* in Heidelberg in relation to the Fugger library, while the only reference in the Heidelberg manuscript Col. Pal. germ. 502 states on fol. 1 r that it was in the possession of a certain Johann von Mosbach, who describes himself as provost at Augsburg cathedral and who died in 1486.⁵⁸ Whether the manuscript was produced for Johann, or bought by him at a later stage is unclear.

⁵⁴ The provenance of these libraries and their contents are described by Paul Lehmann (1956 and 1960).

⁵⁵ Such as the 'Erotianus: Dictionarium medicum, vel, expositiones vocum medicinalium', CERL Thesaurus, cnp00986997 – accessed 27 February 2014. See also letter exchange between Anton Fugger and the Benedictine Monk Veit Bild about scientific books and their shared interest in acquisition (Paul Lehmann (1956), *Eine Geschichte der alten Fuggerbibliotheken*, Tübingen: Kommission für Bayerische Landesgeschichte/Schwäbische Forschungsgemeinschaft, 45).

⁵⁶ These include various scientific texts, but they are invariably grouped together as 'various unbound treatises in German' ('*Item ettlich deutsche ongebunden allerhand tractatlin*', Lehmann (1956), 405), 'various treatises and songs in German [...] a German book of additions with other treatises in German' ('*Ettlich deutsche tractetlin und lieder [...] deutsch rechenbuch mit andern deutschen tractetlin*', Lehmann (1956), 412), '42 pieces of various treatises in German' ('*zwei unnd vierzig stuck allerlei teutscher tractetlin*', Lehmann (1956), 435), 'Book on wounds and Surgery in the field. A further thirteen medical books and a cooking book' ('*Feldbuch der Wundartznei. Mehr dreizehn artzney büchlin unnd ein kochbuch*', Lehmann (1956), 447), or 'Furthermore, thirty three pieces in quarto printed in German related to medicine and cooking books' ('*Ferners auch ein unnd dreissig stuck in quarto. Allerlei deutsche truckt artzney, kochbuchlien*', Lehmann (1956), 450).

⁵⁷ Lehmann (1956), 596-597, mentioning a number of tournament and fencing books ('*Turnierbücher und Fechtbücher*').

⁵⁸ Berg/Friedrich (1994), 216.

Similar records are available from the former *k.k. Hofbibliothek*, now the Austrian National Library (*Österreichische Nationalbibliothek*) in Vienna, which had been established at some point before the first catalogue was compiled in 1576 by Hugo Blotius.⁵⁹ The holdings of the library are based on a combination of individual libraries and collections, most notably those of Duke Albrecht III (1365-1395), his son and successor Albrecht IV (1395-1404), the Habsburg Emperor Frederick III (1440-1493), and his successor Maximilian I (1493-1519). Ernst Trenkler attributes to Frederick III 69 texts,⁶⁰ and Maximilian I would have added to the collection through his marriages to Mary of Burgundy (1473) and Bianca Mary Sforza (1493), both of whom brought a large number of notable manuscripts into the collection. Listings on the content of the collection mention a range of religious and instructional texts, histories, legal and instructional treatises and other texts,⁶¹ but even Maximilian's will in 1518 produced only a generic list of the books he owned, referring to 'Boxes of individual leaves, bound books, chronicles, etc. to be kept safely and looked after'.⁶² Blotius's catalogue of 1576 has only survived in a fragmentary state. In total, it lists over 1,500 manuscripts, of which 1,039 were medieval and 599 from the sixteenth century. 104 of the medieval manuscripts were written in German vernacular.⁶³ Blotius did not apply a categorization system but listed his manuscripts in alphabetical order. His precision suggests that had there been a *Firework Book* in the collection at that time, it would have been mentioned. The closest text to a *Firework Book* in the catalogue is a '*Feuerbuch in folio manuscriptum 1556*' which is given a supplementary comment to classify it as philosophical treatise – not a reference usually attributed to a *Firework Book*.⁶⁴ It is noteworthy that this

⁵⁹ Josef Stummvoll (1965), 'Die Druckschriftenbestände der Österreichischen Nationalbibliothek und die Abstiebung des Alphabetischen Kataloges 1501 bis 1918', in Hans Striedl and Johannes Weider eds., *Buch und Welt: Festschrift für Gustav Hofmann zum 65. Geburtstag*, Wiesbaden: Harrassowitz, 108. Hugo Blotius (1534-1608) was made imperial court librarian in 1575. By then, the library was said to have contained c. 9,000 printed books and manuscripts. However, the exact date of the foundation of the library is unclear (see Ernst Trenkler (1968), 'Die Frühzeit der Hofbibliothek (1368-1519)', in Josef Stummvoll ed., *Geschichte der Österreichischen Nationalbibliothek. Erster Teil. Die Hofbibliothek (1368-1922)*, Wien: Georg Prachner, 1-58, 3-7, and 27-8).

⁶⁰ 35 theological, 10 historical, 8 mathematical, astronomical and medical, 16 on other sciences, and only two literary texts (Trenkler (1968), 11).

⁶¹ Trenkler (1968), 20-4.

⁶² '...all under khöcher, puecher, chronikhen und dergleichen trewlich zu verwaaren und zu fursehen bis auf unser lieben sun willen und weiter fursehung.' Haus-, Hof-, und Staatsarchiv, Urkunde Nr. 1117, dated 30 December 1518, quoted in Trenkler (1968), 39.

⁶³ Hermann Menhardt (1957), *Das älteste Handschriftenverzeichnis der Wiener Hofbibliothek von Hugo Blotius 1576*, Wien: Rudolf M. Rohrer, 31. See also Paula Molino (2011), unpublished PhD thesis, European University Institute, Fiesole, *L'impero di carta: Hugo Blotius, Hofbibliothekar nella Vienna di fine Cinquecento*.

⁶⁴ Menhardt (1957), 19.

Feuerbuch was recorded under a German title, while its content was in Latin.⁶⁵ There are also a number of sixteenth-century Arsenal Books (*Zeughausbücher* (C923, W5296, A265 – books incorporating inventories and regulations within an arsenal)), the first two of which are copies of Franz Helm's *Buch der probierenden Künste* (c. 1527/1535), while the third is an *Innsbrucker Zeughausbuch* (c. 1540-1560).⁶⁶ All include information about ammunition and fireworks, as well as supplies such as saltpetre, sulphur, and charcoal revealing some similarities to the *Firework Book*, but seemingly more for administrative than applied purposes.

At the *Österreichische Nationalbibliothek* in Vienna one copy of particular interest indicates that it may have come from a monastic library. Ms. Cod. 2952 is recorded in the catalogue as becoming part of the Vienna library via Linz from the Benedictine monastery of Mondsee in Upper Austria when it was suppressed by Emperor Leopold II in 1791. Leng assumes that the manuscript only entered the monastery in the sixteenth century, as it lacks the typical binding given to all codices by Abbot Benedict Eck (1463-1499).⁶⁷ It is interesting to note, however, that this copy of the *Firework Book* starts and finishes half-way down the page,⁶⁸ and that there are a substantially larger number of errors than in other *Firework Books*. The scribe or an overseer must have noticed them after writing, since there are numerous deletions and additions – few of which are of content-altering character.⁶⁹ This is the only copy in this format so far and its existence may strengthen the argument that what has survived are the archived copies rather than any copies for use.

The foundation of the *herzogliche Hofbibliothek* (Ducal Court Library) of the Wittelsbach family in Munich, has been attributed to Duke Albrecht V of Bavaria (1550-1579) who combined a number of libraries, including that of Johann Jakob Fugger, Johann Albrecht

⁶⁵ Today, it is catalogued as Cod. 10945 '*Instructiones germanicae de pyrotechnica praecipue de sic dictis bombardis et mortariis rite praeparandis*'.

⁶⁶ Menhardt (1957), 72, 99. The modern references to these are Vienna, *Österreichische Nationalbibliothek*, Cod. 10898, Cod. 10952, and Cod. 10815.

⁶⁷ Leng (2009), 241.

⁶⁸ It starts at fol. 32 r, after 14 lines of previous text, and finishes on fol. 80 r with a further 10 lines spare, followed by a treatise on weights and on powder recipes.

⁶⁹ For example: many deletions are simple repetitions of mostly single words, such as '*schirmen*' (fol. 36 r line 8) or '*sechs*' (fol. 48 r line 4); additions include single words or phrases such as '*als vor geschriben stat*' (fol. 39 v line 17) or '*in dissemin*' (fol. 54 v line 17). The scribe clearly did not consider the subject matter but purely copied everything that was there whether it was required for content or not. I noted more than 50 of these errors, while other *Firework Books* have none or one.

Widmanstetter (1506-1557), and Hartmut Schedel (1440-1514). The Ducal Court Library became the backbone of the Bavarian State Library (*Bayerische Staatsbibliothek*) and the latter was first catalogued in 1582, with no distinction made between manuscripts and early printed books, although it did distinguish between Latin and non-Latin texts and included technical and scientific texts. In total, the library is reported to hold over 300 manuscripts, and over 500 volumes containing 900 printed books.⁷⁰ Once again, the catalogue mentions no *Firework Books* by name, but refers to a copy of Robertus Valterius' *De Re Militari* and various fencing books ('*Fechtbücher*') but only listing those which include illustrations.⁷¹

All library listings differentiated between religious and secular books; those in Latin and various vernaculars, those with or without illustrations, but only itemized in particular those with spiritual or monetary value. Technical manuals and instructive texts of little perceived value – especially when lacking illustrations – containing lists, complete books or only parts thereof, were usually grouped into a generic category. It is unfortunate that the *Firework Book* falls into quite a few of these categories. It is relatively short, with hardly any illustrations, written in vernacular German, and with no discernible value to a lay reader or librarian. It can be argued, however, that the reason for the survival of I.34 with its subsections may be the fact that it included illustrations. This is also the case with most other surviving copies of the *Firework Book* which can be found nowadays bound together with other texts that include illustrations, including personifications of the planets and virtues in armour. This fact would have elevated its status substantially for a lay reader or librarian, and ensured that it was not broken up or discarded. Some modern scholars continue this collective catch-all terminology by failing to identify individual texts and instead only referring to them as 'impressive secular manuscripts'.⁷²

This chapter has explored the position of gunners in fifteenth-century society, their intended use of the *Firework Book*, by whom it was written, and its potential ownership. The evidence for all of these points is sparse and yet cumulatively and circumstantially

⁷⁰ See Hans Striedl (1953), *Der Humanist Johann Albrecht Widmanstetter 1506-57 als klassischer Philologe*, Wiesbaden: Harrassowitz, 4, and also Otto Hartig (1917), *Die Gründung der Münchner Hofbibliothek durch Albrecht V. und Jakob Fugger*, München: Königlich Bayerische Akademie der Wissenschaften, and Lehman (1956).

⁷¹ Hartig (1917), 341-5.

⁷² Backhouse (1999), 267.

compelling: we cannot ascertain the names of the authors of the *Firework Book*, but it is clear that each one must have been a trained individual within the world of gunpowder artillery in the earlier years of the fifteenth century, writing a manual for colleagues and apprentices to share and disseminate information. They may also have intended to elevate the status of gunpowder artillery into a literary-scientific genre. At the same time, a *Firework Book* could serve as powerful advertising tool for a master gunner to present to future employees.

The question remains as to whether the surviving *Firework Books* are a relatively small or a large proportion of all *Firework Books* ever produced. A clear distinction needs to be made between the user and the owner of the manuscript. The fact that in the post-medieval period the surviving copies are linked to libraries of the nobility, indicates a potential clientele. That said, was a copy of the *Firework Book* presented to them by the gunners, or was it part of the employment condition, or was it part of a later interest by the nobility to retain an archive copy for their library collection? The scribal errors identified in chapter 1 point towards it being a copy not made by a gunner but carried out as a commission by a future owner. The evidence as laid out above points strongly in the direction of substantially more copies having been produced, as technical vernacular manuscripts of this kind were particularly vulnerable to decay and destruction, and as a result being discarded – assuming here that the gunners had their own copies. Thus, it is most likely that those surviving were the archived copies, never actually used in practice, forgotten and left behind, or ‘dropped behind the sofa’. This would account for the very good condition in which they remain; despite being relatively low status manuscripts they have surprisingly few marks and blemishes.

Royal Armouries I.34 followed this tradition, but added to it. It was not broken up to be used for different purposes but was allowed to remain intact and live on as one unique book. It was both an archive copy as well as a copy that was added to post production, almost certainly by someone who had practical gunpowder experience. The second part made a link to the images which were still of a practical nature, and not decorative. At the same time, the addition of the images will have aided the survival of I.34 in its entirety.

Conclusion

The Royal Armouries manuscript I.34 provides a unique insight into fifteenth-century gunpowder technology.

This dissertation has presented a comprehensive diplomatic edition and translation of the manuscript. It has provided a critical analysis of the content and compared it to other surviving manuscripts of the genre. It has also provided a comparative analysis of the genre, and related texts, and a better understanding of its technical content.

Firework Books were produced within a short period of time by different scribes in the early part of the fifteenth century; their texts provided a comprehensive range of instructions which practitioners of gunpowder technology could follow step by step. While we cannot explain the purpose of the *Firework Book* with any certainty, the study and analysis above points towards likely answers to questions with which we began – by whom the book was made, for whom it was made, who kept it, and what happened to the manuscripts after they were written.

RA I.34 turns out to be a truly exceptional manuscript. It is a rare example of a copy which was seemingly not taken apart in the post-medieval period, and thus provides us with a glimpse of the use of the *Firework Book*: as a compendium, and as a notebook to be added to. This study has examined the manuscript content and the recipes contained within. It locates the *Firework Book* within an emerging tradition of technical military treatises and manuals. Having viewed almost all of the surviving 65 *Firework Book* manuscripts, not many apply a similar comprehensive range of information, as they have often been rebound with other texts. Only a very small number – such as RA I.34 – appear to remain in their originally bound format.

I.34 is unique in that it gives us several sections of a manuscript. The presence of part 2, especially, shows that there was continued usage and continued practice, and a development of a technology in use in the fifteenth century. I.34 is the only copy where there are both textual references to the illustrations, and the illustrations themselves. This section relating to the images will almost certainly have aided the survival of I.34.

This study points the way to future research needed in this field. Linguistic analysis may allow for a closer localization of each of the existing *Firework Books*, and a comprehensive comparison of all extant copies of the *Firework Book* remains a desideratum, not just comparing their content but also their codicological and library histories. Experimental archaeology may explore whether the diverse recipes work, whether the addition of ‘bonus’ ingredients effected a change in the powder and its properties. The valid work by the HO Group provided a good starting platform, ready to be built on with new scientific skills and equipment. More remains to be discovered. Equally, the world of economic records has barely been touched. Thom Richardson’s work on the Tower of London provides hints on records of saltpetre, sulphur, and other ingredient purchases into the fourteenth century, and more work on those and other related economic records may provide insights currently not known.

Most importantly, given the nature of earlier doubts and questions, it is now clear that the *Firework Book* does reflect practice in operation at the time of its production in the early fifteenth century, but also that there remains a gap between textuality and other sources available from the time. This is both a knowledge gap on the part of the modern scholar (whether as historian or technology expert) and a gap of knowledge for gunners at the time who were confronted by the difficulty of explaining their developing production methods in the context of a previously unfamiliar format of a text.

Bibliography

PRIMARY SOURCES – LIST OF KNOWN COPIES OF THE *FIREWORK BOOK* (TOTAL 65 MANUSCRIPTS – LOCATION OF THE PRIVATELY OWNED SWISS COPY UNCONFIRMED)

Manuscripts

- Austria-Vienna (Wien), Österreichische Nationalbibliothek
 - Cod. 2952, 31 v-80 r
 - Cod. 2987
 - Cod. 3062, 1 r-22 r
 - Cod 3064, 53 r-70 r
 - Cod. 10855, 56 r-69 r
 - Cod. 10940, 115 r-148 v
- Germany-Augsburg
 - Staats- und Stadtbibliothek, 2^o Cod. 164, fol. 1r-62v
 - Staats- und Stadtbibliothek, 4^o Cod. 129, fol. 35 r-99 v
 - Staats- und Stadtbibliothek, 4^o Cod. 143, fol. 1 r-43 v
 - Universitätsbibliothek, III. 1.2^o 44, fol. 2 r-52 v
 - Universitätsbibliothek, III. 1.8^o 59, fol. 2 r-35 r
- Germany-Bad Arolsen, Fürstliche Waldecksche Hofbibliothek, IV, Ms. 83
- Germany-Berlin, Staatsbibliothek zu Berlin – Preußischer Kulturbesitz
 - Manuscript germanica folio 710a, 1 r-26 v
 - Manuscript germanica folio 1117, 294 r-322 r
 - Manuscript germanica folio 1129, 68 r-82 r
 - Manuscript germanica quart. 621, 1 r-48 r
 - Manuscript germanica quart. 867, 1 r-41 r and 48 r-96 r
 - Manuscript germanica quart. 1018, 32 r-66 r
 - Manuscript germanica quart. 1187, 13 v-45 v
 - Manuscript germanica quart. 2041, 1 r-29 r
- Germany-Darmstadt, Universitäts- und Landesbibliothek, Ms. 1074, 1 r-52 v
- Germany-Dillingen, Studienbibliothek, Ms. XV 50, 1 r-33 r
- Germany-Dresden, Sächsische Landesbibliothek
 - Ms. App. 463, 8 r-72 v
 - Ms. C 262, 223 r-239 r
- Germany-Frankfurt a. M.
 - Universitätsbibliothek, Ms. germ. quart. 14 (Ausst. 48) 'Rüst- und Feuerwerkbuch'
 - Bibliothek, Institut für Stadtgeschichte, Reichssachen Nachträge, Nr. 741 'Anonymous, 'Büchsenmeister – fewerwercker''
- Germany-Freiburg i. Br., Universitätsbibliothek, Ms. 362, 73 r-89 r
- Germany-Gotha, Universitäts- und Forschungsbibliothek Erfurt-Gotha

- Cod. Chart A 756, 184 r-200 v
- Cod. Chart B 428, 1 r-48 v
- Cod. Chart B 1032 'Feuerwerk- und Büchsenmeisterbuch'
- Germany-Göttingen, Niedersächsische Staats- und Landesbibliothek, 2° Cod. Ms. philos. 64, 94 r-147 v
- Germany-Heidelberg, Universitätsbibliothek
 - Cod. Pal. germ. 122, 1 r-46 r
 - Cod. Pal. germ. 301, 6 v-20 v 'puchlein von pusschen schissen'
 - Cod. Pal. germ. 502
 - Cod. Pal. germ. 562
 - Cod. Pal. germ. 585
 - Cod. Pal. germ. 787, 2 r-26 r and 34 r-45 r
- Germany-Karlsruhe, Badische Landesbibliothek, Cod. St. Georgen 71, 131 v-[143?]
- Germany-Kassel, Universitäts – Landes – und Murhardsche Bibliothek, 4° Ms. math. 14, 1 r-46 r
- Germany-Leipzig, Universitätsbibliothek, Ms. 1597, 1 r-88 r
- Germany-Memmingen, Wissenschaftliche Stadtbibliothek, 4° 2.39, fol. 116 r-121 r
- Germany-Munich (München)
 - Bayrisches Hauptstaatsarchiv, Kurbayern, Äußeres Archiv 3904
 - Bayerische Staatsbibliothek, Cgm. 356
 - Bayerische Staatsbibliothek, Cgm. 399, 1 r-48 v
 - Bayerische Staatsbibliothek, Cgm. 599, 48 r-62 v
 - Bayerische Staatsbibliothek, Cgm. 734, 1 r-59 v
 - Bayerische Staatsbibliothek, Cgm. 973, 91 v-123 v
 - Bayerische Staatsbibliothek, Cgm. 4902
 - Bayerische Staatsbibliothek, Cgm. 5437, 1 r-8 v
 - Bayerische Staatsbibliothek, Clm. 30150, 94 r-150 r
- Germany-Nuremberg (Nürnberg), Germanisches Nationalmuseum
 - Ms. 719, 16 r-60 v
 - Ms. 1480 1 r-50 v
 - Ms. 1481a, 14 r-48 v
- Germany-Weimar, Herzogin Anna Amalia Bibliothek, Q 342, 55 r-82 v
- Germany-Wolfenbüttel, Herzog August Bibliothek
 - Cod. Guelf. 19.28. Aug. 2°
 - Cod. Guelf. 226 Extravag., 7 r-32 v
- France-Paris, Bibliothèque nationale, Ms. Latin 17873, 193 r-209 r
- France-Strasbourg, Bibliothèque Nationale et Universitaire, Ms. 2259, 1 r-18 v, 28 r-29 v
- Italy-Rome, Città del Vaticano, Bibliotheca Apostolica Vaticana, Cod. Pal. lat. 1889, 94 r-106 v

- Romania-Sibiu (Hermannstadt)/Bucharest, Arhivele Statului, Ms. Varia II, 374, 1 r-36 v
- Switzerland-formerly sold by Antiquariat Heribert Tenschert, Kat. XXV, Nr. 21, now Switzerland, private owner (no further information available), 83 v-94 r
- Switzerland -St. Gallen, Kantonsbibliothek, VadSlg Ms. 396, 1 r-46 r
- UK-Leeds, Royal Armouries, MS I.34, 1 r-61 r
- USA-Cambridge (Mass.), Harvard College Library – Houghton Library, Ms Type 320, 1 r-37 v
- USA-New York, Public Library, Spencer Collection, Ms. 104, 1 r-55 r

Early Printed versions

“Dye nachuolget vonn Büchen geschoß, Pulver, Feuerwerck...,” as appendix to *Flauii Vegetii Renati vier Bücher der Ritterschaft*. Augsburg: Stainer, 1529, 91r-101v – printed in Hassenstein (1941).

Büchsenmeysterei. Von Gschoß, Büchsen, Puluer, Salpeter vnd Feuerwerk etc. Strassburg: Christian Egenolph, 1529. [reprinted in Frankfurt/Main 1531, 1534 and 1550], Stadt- und Universitätsbibliothek Frankfurt/Main and Bibliothèque Nationale et Universitaire Strasbourg

“Petit tractié contenant plusieurs artifices du feu...” appendix to *Livre du canonnerie et artifice de feu* (Paris, 1561).

Feuer Buech, durch Eurem gelertten Kriegs verstenndigen mit grossem Vleis auss villen Probiertten Kunsten (1584).

Eldred, William (1646/47). *The Gynners glasse*. London: Printed by T. Forcet Boydel, and are to be sold at his shop in the Bulwark neere the Tower. *Early English Books Online*. http://0-gateway.proquest.com.wam.leeds.ac.uk/openurl?ctx_ver=Z39.88-2003&res_id=xri:eebo&rft_id=xri:eebo:image:113975:7 (accessed 20 April 2018).

Editions

Baetz, Manuel (2001). *Das Feuerwerkbuch von 1420. Faksimile mit Übertragung in modernes Deutsch*. Radolfzell: Survival Press.

Hassenstein, Wilhelm (1941). *Das Feuerwerkbuch von 1420. 600 Jahre Deutsche Pulverwaffen und Büchsenmeisterei. Nachdruck des Erstdruckes aus dem Jahre 1529 mit Übertragung ins Hochdeutsche und Erläuterungen von Wilhelm Hassenstein*. München: Verlag der deutschen Technik.

Kramer, Gerhard (1995). *Berthold Schwarz. Chemie und Waffentechnik im 15. Jahrhundert* Abhandlungen und Berichte des Deutschen Museums, NF 10. München: Oldenbourg.

Meyer, Werner (1981). ‘Eine Abschrift des Feuerwerkbuchs. Die Hs. XV 50 der Studienbibliothek Dillingen an der Donau’. *Liber Castellorum* (1981). 288-301.

SECONDARY SOURCES

- Alexander, Jonathan J. G., James H. Marrow, and Lucy Freeman Sadler eds. (2005). *The Splendor of the Word. Medieval and Renaissance Illuminated Manuscripts at the New York Public Library*. New York: Harvey Miller.
- Algazi, Gadi (1996). *Herrengewalt und Gewalt der Herren im späten Mittelalter: Herrschaft, Gegenseitigkeit und Sprachgebrauch (Historische Studien 17)*. Frankfurt am Main: Campus.
- Allenby, Michael ed. (2013). *A Dictionary of Plant Sciences* (3rd edition) Online. Oxford: Oxford University Press. (accessed 22 February 2018).
- Andrade, Tonio (2016). *The Gunpowder Age: China, Military Innovation, and the Rise of the West in World History*. Princeton and Oxford: Princeton University Press.
- Arnold, Klaus (1996). 'Bilder des Krieges – Bilder des Friedens'. In Johannes Fried ed. *Träger und Instrumentarien des Friedens im hohen und späten Mittelalter (Vorträge und Forschungen 43)*. Sigmaringen: Thorbecke.
- Arnoux, Mathieu and Pierre Monnet eds. (2004). *Le technicien dans la cité en Europe occidentale, 1250-1650 (Collection de l'Ecole française de Rome 325)*. Rome: Ecole française de Rome.
- Babington, John and John Droeshout (1635 [2018]). *Pyrotechnica or a Discoverse of artificiall Fire-Work*. London: Thomas Harper (Reprinted: Dehli: Facsimile Publisher).
- Backhouse, Janet (1999). 'The Royal Library from Edward IV to Henry VII'. In Lotte Hellinga and Joseph Burnley Trapp eds. *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press. 267-81.
- Barnes, Carl F. (2009). *The Portfolio of Villards de Honnecourt (Paris, Bibliothèque Nationale de France, MS Fr 19093): A New Critical Edition and Color Facsimile*. Farnham: Ashgate.
- Barter Bailey, Sarah (1996). 'The Royal Armouries "Firework Book"'. In Brenda Buchanan ed. *Gunpowder: The History of an International Technology*. Bath: Bath University Press. 57-86.
- Bassnett, Susan (2002). *Translation Studies*. 3rd Edition. London: Routledge.
- Baufeld, Christa (1996). *Kleines frühneuhochdeutsches Wörterbuch. Lexik aus Dichtung und Fachliteratur des Frühneuhochdeutschen*. Tübingen: Max Niemeyer.
- Baumann, Reinhard (1978). *Söldnerwesen im 16. Jahrhundert im bayerischen und süddeutschen Beispiel. Eine gesellschaftskritische Untersuchung (Neue Schriftenreihe des Stadtarchivs München)*. München: Kommissionsbuchhandlung R. Wölfle.
- Baumann, Reinhard (1994). *Landsknechte. Ihre Geschichte und Kultur vom späten Mittelalter bis zum Dreißigjährigen Krieg*. München: C. H. Beck.

- Bec, Christian (1969). 'Une librairie florentine de la fin du xve siècle'. *Bibliothèque d'humanisme et renaissance* 31. 321-32.
- Beck, J. H. ed. (1969). *Mariano Taccola, Liber Tertius de Ingeneis ac edifitiis non usitatis*. Milano: Edizioni il Polifilo.
- Beck, Theodor (1899). *Beiträge zur Geschichte des Maschinenbaus*. Berlin: Julius Springer.
- Bell, Adrian R. and Anne Curry eds. (2011). *The Soldier Experience in the Fourteenth Century*. Woodbridge: Boydell Press.
- Bell, Adrian R., Anne Curry, Andy King, and David Simpkin eds. (2013). *The Soldier in Later Medieval England*. Oxford: Oxford University Press.
- Benoit, Paul (1987). 'Artisans ou combattants? Les canoniers dans le royaume de France à la fin du Moyen Age'. *Actes de congrès de la Société des historiens médiévistes de l'enseignement supérieur public*. 287-296. https://www.persee.fr/doc/shmes_1261-9078_1991_act_18_1_1499 (accessed 25 April 2018).
- Benzing, Josef (1959). 'Egenolff, Christian'. *Neue Deutsche Biographie* 4. 325-326 [Online-Version]. <https://www.deutsche-biographie.de/pnd122968468.html#ndbcontent> (accessed 21 March 2019).
- Berg, Theresia and Udo Friedrich (1994). 'Wissenstradierung in spätmittelalterlichen Schriften zur Kriegskunst: Der 'Bellifortis' des Konrad Kyeser und das anonyme 'Feuerwerkbuch''. In Jan-Dirk Müller ed. *Wissen für den Hof. Der spätmittelalterliche Verschriftlichungsprozess am Beispiel Heidelberg im 15. Jahrhundert*. München: Wilhelm Fink. 169-232.
- Berninger, Ernst (2000). 'Die technischen Handschriften des 15. Jahrhunderts in der Bayerischen Staatsbibliothek München'. *Bellifortis, Clm 30150 (Patrimonia, 137)*. München: KulturStiftung der Länder und Bayrische Staatsbibliothek. 61-91.
- Berthelot, Marcelin (1891). 'Pour l'histoire des arts mécaniques et de l'artillerie vers la fin du moyen âge'. *Annales de chimie et de physique*. Series 6. Volume 24. 433-521.
- Biggs, Douglas, Sharon D. Michalove and A. Compton Reeves (2002). *Traditions and Transformations in Late Medieval England*. (The Northern World, 2). Leiden: Brill.
- Biggs, Douglas, Sharon D. Michalove, and A. Compton Reeves (2004). *Reputation and Representation in Fifteenth-Century Europe*. (The Northern World, 8). Leiden: Brill.
- Blosen, Hans and Rikke Agnete Olsen eds. (2006). *Kriegskunst und Kanonen: Das Büchsemeister- und Kriegsbuch des Johannes Bengedans*. Aarhus: Aarhus Universitetsforlag.
- Bodemann, Ulrike and Klaus Grubmüller (1992). 'Schriftliche Anleitung zu mündlicher Kommunikation: die Schülergesprächsbüchlein des späten Mittelalters'. In Hagen Keller, Klaus Grubmüller, and Nikolaus Staubach eds. *Pragmatische Schriftlichkeit im*

- Mittelalter. Erscheinungsformen und Entwicklungsstufen (Münstersche Mittelalter-Schriften 65)*. München: Wilhelm Fink. 177-93.
- Boffey, Julia (2000). 'Bodleian Library, MS Arch. Selden. B.24 and Definitions of the 'Household Book''. In Anthony Edwards, Vincent Gillespie, and Ralph Hanna eds. (2000). *The English Medieval Book: Studies in Memory of Jeremy Griffiths*. London: British Library.
- Boffey, Julia and John Thompson (1989). 'Anthologies and Miscellanies: Production and the Choice of Texts'. In Jeremy Griffiths and Derek Pearsall eds. *Book Production and Publishing in Britain, 1375-1475*. Cambridge: Cambridge University Press.
- Booton, Diane E. (2010). *Manuscripts, Market and the Transition to Print in Late Medieval Brittany*. Farnham: Ashgate.
- Brachert, Thomas (2010). *Nachträge und Corrigenda zum "Lexikon historischer Maltechniken. Quellen – Handwerk – Technologie – Alchemie, München 2001"*. Hildesheim: Hornemann Institut.
- Brévar, Francis B. (2008). 'Between Medicine, Magic, and Religion: Wonder Drugs in German Medico-Pharmaceutical Treatises of the Thirteenth to the Sixteenth Centuries'. *Speculum* 83. 1-57.
- Brock, Alan St. (1949). *A History of Fireworks*. London: Harrap.
- Brown, G. I. (1998). *The Big Bang: A History of Explosives*. Stroud: Sutton.
- Brunner, Horst (1996). 'Bilder vom Krieg in der deutschen Literatur des Mittelalters und der frühen Neuzeit'. In Dieter Rödel and Joachim Schneider eds. *Strukturen der Gesellschaft im Mittelalter. Interdisziplinäre Mediävistik in Würzburg*. Wiesbaden: Reichert. 101-14.
- Brunner, Horst ed. (1999). *Der Krieg im Mittelalter und in der Frühen Neuzeit: Gründe, Begründungen, Bilder, Bräuche, Recht*. Wiesbaden: Reichert.
- Brunner, Horst ed. (2000). *Die Wahrnehmung und Darstellung von Kriegen im Mittelalter und in der Frühen Neuzeit (Imagines medii aevi 6)*. Wiesbaden: Reichert.
- Buchanan, Brenda ed. (1996). *Gunpowder: The History of an International Technology*. Bath: Bath University Press.
- Buchanan, Brenda J. ed. (2006). *Gunpowder, Explosives and the State: A Technological History*. Aldershot: Ashgate.
- Bugge, Günther (1942). *Schieß- und Sprengstoffe und die Männer, die sie schufen*. Stuttgart: Franckh'sche Verlagshandlung.
- Butler, Sara M. (2014). *Forensic Medicine and Death Investigation in Medieval England*. New York: Routledge.

- Canning, Joseph, Hartmut Lehmann, and Jay Winter eds. (2004). *Power, Violence and Mass Death in Pre-Modern and Modern Times*. Aldershot: Ashgate.
- Carr, A. D. (2004). 'War in fourteenth-century Europe'. In Joseph Canning, Hartmut Lehmann, and Jay Winter eds. *Power, Violence and Mass Death in Pre-Modern and Modern Times*. Aldershot: Ashgate. 67-89.
- Chase, Kenneth (2003). *Firearms: A Global History to 1700*. Cambridge: Cambridge University Press.
- Cocroft, Wayne D. (2000). *Dangerous Energy: The Archaeology of Gunpowder and Military Explosives Manufacture*. Swindon: English Heritage.
- Connolly, David E. (2005). 'Background, Summary, and Aftermath of the 1548 Mining Law for the Schlackenwalden Tin Mines, Bohemia'. In Robert O. Bork et al eds. *De Re Metallica: The Uses of Metal in the Middle Ages*. Farnham: Ashgate.
- Contamine, Philippe (1984). *War in the Middle Ages*. transl. M. Jones. Oxford: Blackwell.
- Crosby, Alfred W. (2002). *Throwing Fire. Projectile Technology Through History*. Cambridge: Cambridge University Press.
- Curry, Anne and Elizabeth Matthew eds. (2000). *Concepts and Patterns of Service in the Later Middle Ages*. Woodbridge: Boydell Press.
- Curry, Anne (2011). 'Guns and goddams: was there a military revolution in Lancastrian Normandy 1415-50?'. *Journal of Medieval Military History* 8. 171-88.
- De Reuck, Anthony (2008). 'The Nature of Saltpeter in the *Firework Book*'. *Journal of the Ordnance Society* 20. 5-10.
- Derrida, Jacques and Lawrence Venuti trans. (2001). 'What is a "Relevant" Translation'. *Critical Inquiry*. Vol. 27. No. 2. 174-200.
- DeVries, Kelly (1995). 'The Impact of Gunpowder Weaponry on Siege Warfare in the Hundred Years' War'. In Ivy A. Corfis and Michael Wolff eds. *The Medieval City under Siege*. Woodbridge: Boydell.
- DeVries, Kelly (1996a). 'Gunpowder and Early Gunpowder Weapons'. In Brenda Buchanan ed. *Gunpowder: The History of an International Technology*. Bath: Bath University Press. 121-136.
- DeVries, Kelly (1996b). 'The Use of Gunpowder Weapons in the Wars of the Roses'. In Biggs (2002). 21-38.
- DeVries, Kelly (1996c). 'Gunpowder weaponry at the Siege of Constantinople, 1453'. In Yakoov Lev ed. *War and Society in the Eastern Mediterranean, 7th-15th Centuries*. Leiden: Brill. 343-62.
- DeVries, Kelly (1996d). *Infantry Warfare in the Early 14th Century*. Woodbridge: Boydell.

- DeVries, Kelly (1996e). 'The Use of Gunpowder Weaponry by and against Joan of Arc during the Hundred Years' War'. *War and Society* 14. No 1. 1-15.
- DeVries, Kelly (1997). 'The Technology of Gunpowder Weaponry in western Europe during the Hundred Years' War'. *XXII. Kongress der internationalen Kommission für Militärgeschichte*. Wien: Heeresgeschichtliches Museum. 285-99.
- DeVries, Kelly (1998a). 'The forgotten Battle of Beverhoutsveld, 3 May 1382: Technological innovation and military significance'. In Matthew Strickland ed. *Armies, Chivalry, and Warfare in Medieval Britain and France*. Stamford, CT: Paul Watkins. 289-303.
- DeVries, Kelly (1998b). 'Gunpowder weaponry and the rise of the early modern state'. *War in History* 5:2. 127-45.
- DeVries, Kelly (2003a). 'Review of Gerhard W. Kramer, ed., and Klaus Leibnitz, trans. *The Firework Book: Gunpowder in Medieval Germany (Das Feuerwerkbuch, c. 1440)*'. *Ambix* 50.2. 237-8.
- DeVries, Kelly (2003b). 'Reassessment of the gun illustrated in the Walter de Milimete and Pseudo-Aristotle manuscript'. *Journal of the Ordnance Society* 15. 5-17.
- DeVries, Kelly (2005a). "'The walls come tumbling down": the campaigns of Philip the Good and the myth of fortification vulnerability to early gunpowder weapons'. In L. J. Andrew Villalon and Donald J. Kagay eds. *The Hundred Years' War: A Wider Focus*. (History of Warfare, 25). Leiden: Brill. 429-46.
- DeVries, Kelly (2005b). 'Facing the new military technology: Non-trace Italiane anti-gunpowder weaponry defenses'. In Brett D. Steele and Tamera Dorland. *Heirs of Archimedes: Science and Art of War through the Age of Enlightenment*. Cambridge, MA: MIT Press. 37-71.
- DeVries, Kelly (2006). 'Sites of military science and technology'. In Katherine Park and Lorraine Daston eds. *The Cambridge History of Science. Vol. 3: Early Modern Europe*. Cambridge: Cambridge University Press. 306-19.
- DeVries, Kelly and Robert D. Smith (2006). 'Breech-loading guns with removable powder chambers: A long-loved military technology'. In Brenda Buchanan ed. *Gunpowder, Explosives, and the State*. Aldershot: Ashgate. 251-65.
- DeVries, Kelly and Robert D. Smith (2012). *Medieval Military Technology 2nd Edition*. Toronto: University of Toronto Press.
- DeVun, Leah (2009). *Prophecy, Alchemy, and the End of Time: John of Rupecissa in the Late Middle Ages*. New York: Columbia University Press.
- Dijkmann, Jessica (2011). *Shaping Medieval Markets: The Organisation of Commodity Markets in Holland, c. 1200-c.1450*. Leiden: Brill.

- Donkin, Robin A. (2003). *Between East and West: The Moluccas and the Traffic in Spices up to the Arrival of Europeans*. Philadelphia: American Philosophical Society.
- Duchart, Heinz ed. (2000). *Krieg und Frieden im Übergang vom Mittelalter zur Neuzeit. Theorie – Praxis – Bild*. Mainz: Philipp von Zabern.
- Eamon, William (1994). *Science and the Secrets of Nature*. Princeton, NJ: Princeton University Press.
- Edson, Evelyn (2007). *The World Map, 1300-1492: The Persistence of Tradition and Transformation*. Baltimore: Johns Hopkins University Press.
- Ehlert, Trude and Rainer Leng (2003). 'Frühe Koch- und Pulverrezepte aus der Nürnberger Handschrift GNM 3227a (um 1389)'. In Dominik Groß and Monika Reininger eds. *Medizin in Geschichte, Philologie und Ethnologie. Festschrift für Gundolf Keil*. Würzburg: Königshausen & Neumann.
- Ehlert, Trude ed. (2010). *Küchenmeisterei: Edition, Übersetzung und Kommentar zweier Kochbuch-Handschriften des 15. Jahrhunderts*. Frankfurt am Main: Peter Lang.
- Eis, Gerhard (1962). *Mittelalterliche Fachliteratur*. Stuttgart: Metzler.
- Elkar, Rainer S. (1999). 'Lernen durch Wandern? Einige kritische Anmerkungen zum Thema Wissenstransfer durch Migration'. In Knut Schulz ed. *Handwerk in Europa. Vom Spätmittelalter bis zur Frühen Neuzeit (Schriften des historischen Kollegs, Kolloquien 41)*. München: Oldenbourg. 213-32.
- Ertl, Thomas (2008). *Seide, Pfeffer und Kanonen: Globalisierung im Mittelalter*. Darmstadt: Primus.
- Essenwein, August von (1877 (new edition 1969). *Quellen zur Geschichte der Feuerwaffen. 2 vols*. Leipzig/Graz: Akademische Druck- und Verlagsanstalt.
- Feldhaus, Franz Maria (1906-8). 'Was wissen wir von Berthold Schwarz?'. *Zeitschrift für Historische Waffenkunde* 4. 65-9 and 113-8.
- Feldhaus, Franz Maria (1931). *Die Technik der Antike und des Mittelalters*. Widpark-Potsdam: Athenaion (reprint 1971).
- Feldhaus, Franz Maria (1954). *Die Machine im Leben der Völker. Ein Überblick von der Urzeit bis zur Renaissance*. Basel/Stuttgart: Birkhäuser
- Ferragud, Carmel (1999). 'Vernacularization as an Intellectual and Social Bridge: The Catalan Translations of Teodorico's *Chirurgia* and of Arnau De Vilanova's *Regimen Sanitatis*'. *Early Science and Medicine* 4/2. 127-48.
- Fiedler, Siegfried (1985). *Kriegswesen und Kriegsführung im Zeitalter der Landsknechte (Heerwesen der Neuzeit 12)*. Koblenz: Bernard & Graefe.

- Flachenecker, Helmut (2015). 'Kanonen, Räderuhr und Brille: Zur technischen Revolution des Spätmittelalters'. In Dorothea Klein ed. *Überall ist Mittelalter: Zur Aktualität einer vergangenen Epoche*. Würzburg: Königshausen & Neumann. 303-29.
- Foard, Glenn and Anne Curry (2013). *Bosworth 1485: A Battlefield Reconsidered*. Oxford: Oxbow.
- Forbes, Ir. R. J. (1965). '4000 Jahre Schwefel'. *CIBA Rundschau* 5/6. 2-18.
- Ford, Margaret Lane (1999a). 'Importation of printed books into England and Scotland'. In Lotte Hellinga and Joseph Burnley Trapp eds. *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press. 179-201.
- Ford, Margaret Lane (1999b). 'Private ownership of printed books'. In Lotte Hellinga and Joseph Burnley Trapp eds. *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press. 205-28.
- Fox, Robert ed. (1996). *Technological Change. Methods and Themes in the History of Technology (Studies in the History of Science, Technology & Medicine 1)*. Amsterdam: Harwood Academic.
- Friedrich, Udo (1996). 'Herrscherpflichten und Kriegskunst. Zum intendierten Gebrauch früher 'Bellifortis'-Handschriften. In Christel Meier, Dagmar Hüpper, and Hagen Keller eds. *Der Codex im Gebrauch. Akten des Internationalen Kolloquiums 11.-13. Juni 1992*. München: Wilhelm Fink. 197-210.
- Gaier, Claude (1973). *L'Industrie et le Commerce des Armes dans les Anciennes Principautés belges du XIII^e à la fin du XV^e siècle*. Paris: Les Belles lettres.
- Gaier, Claude (1995). *Armes et combats dans l'univers medieval I*. Brussels: De Boeck.
- Galluzzi, Paolo (1991). *Prima di Leonardo. Cultura delle machine a Siena nel Rinascimento*. Milano: Mondadori Electa.
- Geibig, Alfred (1996). 'Waffen und kriegerische Ereignisse'. In Lorenz Fried ed. *Chronik der Bischöfe von Würzburg 742-1495. Vol. VI: Die Miniaturen der Bischofschronik*. Würzburg: Ferdinand Schöningh. 217-85.
- Geibig, Alfred (2001). 'Pyrotechnic Devices from Coburg Castle'. In P. J. Turner ed. *Royal Armouries Yearbook Vol. 6*. Leeds: Trustees of the Armouries. 88-97.
- Geibig, Alfred (2012). *Die Macht des Feuers – Might and Fire*. Coburg: Kunstsammlung der Veste Coburg.
- Gelfand, Toby (1993). 'The history of the medical profession'. In William F. Bynum and Roy Porter eds. *Companion Encyclopaedia of the History of Medicine*. London/New York: Routledge. 119-50.

- Gerardy, Theodor (1964). *Datieren mit Hilfe von Wasserzeichen, beispielhaft dargestellt an der Gesamtproduktion der Schaumburgischen Papiermühle Arensberg von 1604-1650 (Schaumburger Studies, Band 4)*. Bückeberg: No publisher listed.
- Gerardy, Theodor (1980). Die Beschreibung des in Manuskripten und Drucken vorkommenden Papiers'. *Codicologia* 5. 37-51.
- Gessler, Eduard A. (1918). 'Die Entwicklung des Geschützwesens in der Schweiz von seinen Anfängen bis zum Ende der Burgunderkriege'. *Mitteilungen der Antiquarischen Gesellschaft Zürich* 28. 183-460.
- Gille, Bertrand (1956). 'Etudes sur les manuscrits d'ingénieurs du XVe siècle'. *Techniques et civilisations* 5. 77-86.
- Gille, Bertrand (1966). *The Renaissance Engineer*. London: Lund Humphries.
- Gillespie, Vincent and Anne Hudson eds. (2013). *Probable Truth: Editing Medieval Texts from Britain in the Twenty-First Century*. Brepols: Turnhout.
- Ginsburger, M. (1929). 'Les Juifs et l'art militaire au Moyen-Âge'. *Revue des Études Juives* lxxxviii. 156-66.
- Goetz, Dorothea (1985). *Die Anfänge der Artillerie*. Ostberlin: Militärverlag der DDR.
- Götze, Alfred (1967). *Frühneuhochdeutsches Glossar. 7th edition*. Berlin: De Gruyter.
- Graf zu Waldburg Wolfegg, Christoph (2000). 'Der Münchner „Bellifortis“ und sein Autor'. *Patrimonia* 137. München: KulturStiftung der Länder und Bayrische Staatsbibliothek. 21-60.
- Graf zu Waldburg Wolfegg, Christoph (1998). *Venus and Mars: World of the Medieval Housebook*. London: Prestel.
- Greco, Gina and Christine Rose trans. (2009). *The Good Wife's Guide: Le Ménagier de Paris, A Medieval Household Book*. Ithaca and London: Cornell University Press.
- Grieve, Maud (1971). *A Modern Herbal: The Medicinal, Culinary, Cosmetic and Economic Properties, Cultivation and Folk-lore of Herbs, Grasses, Fungi, Shrubs, & Trees with All Their Modern Scientific Uses, Volume 1*. New York: Dover.
- Grimm, Jacob and Wilhelm (1971). *Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online*. 16 vols. Leipzig: Hirzel. 1854-1961. http://woerterbuchnetz.de/cgi-bin/WBNetz/wbgui_py?sigle=DWB (accessed 22 February 2018).
- Grummit, David (2000). 'The defence of Calais and the development of gunpowder weaponry in England in the late fifteenth century'. *War in History* 7:3. 253-72.
- Habermann, Mechthild (2002). *Deutsche Fachtexte der frühen Neuzeit. Naturkundlich-medizinische Wissensvermittlung im Spannungsfeld von Latein und Volkssprache (Studia linguistica Germanica 61)*. Berlin: de Gruyter.

- Hagemann, Karen ed. (1999). *Landsknechte, Soldatenfrauen und Nationalkrieger. Militär, Krieg und Geschlechterordnung im historischen Wandel (Geschichte und Geschlechter 26)*. Frankfurt am Main: Campus.
- Hagenmeyer, Christa (1967). 'Kriegswissenschaftliche Texte des ausgehenden 15. Jahrhunderts'. *Leuvense Bijdragen* 57. 182-95.
- Hale, John Rigby (1990). *Artists and Warfare in the Renaissance*. New Haven/London: Yale University Press.
- Hall, Bert S. (1972). *The So-Called "Manuscript of the Hussite Wars' Engineer" and its Technological Milieu: A Study and Edition of the Codex Latinus Monacensis 197, Part 1*. (University of California, Los Angeles, Ph.D., 1971). Ann Arbor: University Microfilms.
- Hall, Bert S. (1979a). 'Der Meister sol auch kennen schreiben und lesen: Writings about Technology ca. 1400-ca. 1600 A.D. and their Cultural Implications'. In Denise Schmandt-Besserat ed. *Early Technologies* 3. Los Angeles: Undena Publications. 47-58.
- Hall, Bert S. (1979b). *The Technological illustrations of the So-Called "Anonymous of the Hussite Wars": Codex Latinus Monacensis 197. Part 1*. Wiesbaden: Reichert.
- Hall, Bert S. (1996a). 'The Corning of Gunpowder and the Development of Firearms in the Renaissance'. In Buchanan (1996). 87-120.
- Hall, Bert S. (1996b). 'The Didactic and the Elegant: Some Thoughts on Scientific and Technological Illustrations in the Middle Ages and Renaissance'. In Brian Baigrie ed. *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science*. Toronto: University of Toronto Press. 3-39.
- Hall, Bert S. (1997). *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics*. Baltimore MD: Johns Hopkins University Press.
- Hammer, Paul E. J. (2007). *Warfare in Early Modern Europe, 1450-1660*. Aldershot: Ashgate.
- Hanna, Ralph (2015). *Editing Medieval Text: An Introduction, Using Examples Derived from Richard Rollo, 'Super Canticum' 4*. Liverpool: Liverpool University Press.
- Hartig, Otto (1917). *Die Gründung der Münchner Hofbibliothek durch Albrecht V. und Jakob Fugger*. München: Königlich Bayerische Akademie der Wissenschaften.
- Harvey, John (1972). *The Mediaeval Architect*. New York, St. Martin Press.
- Harvey, Paul Dean Adshea ed. (2006) *The Hereford World Map: Medieval World Maps and Their Context*. London: British Library.
- Hassenstein, Wilhelm (1941). *Das Feuerwerkbuch von 1420: 600 Jahre Deutsche Pulverwaffen und Büchsenmeisterei*. Bücher der deutschen Technik. München: Verlag der Deutschen Technik GmbH.
- Hawthorne, John G. and Cyril Stanley Smith eds. (1979). *Theophilus. On Divers Arts*. New York: Dover.

- Hellinga, Lotte and Joseph Burnley Trapp eds. (1999). *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press.
- Hilaire-Perez, Liliane and Catherine Verna (2006). 'Dissemination of Technical Knowledge in the Middle Ages and the Early Modern Era: New Approaches and Methodological Issues'. *Technology and Culture* 47. No. 3 (July). 536-65.
- Hime, Henry W. L. (1904). *Gunpowder and Ammunition. Their Origin and Progress*. Waltham Abbey: Royal Gunpowder Mills.
- Hime, Henry W. L. (1915). *The Origins of Artillery*. London: Longmans.
- Huuri, Kalervo (1941). *Zur Geschichte des mittelalterlichen Geschützwesens aus orientalischen Quellen*. Helsinki: Finnische Literaturgesellschaft.
- Jähns, Max (1878). *Atlas zur Geschichte des Kriegswesens von der Urzeit bis zum Ende des 16. Jahrhunderts*. Berlin: Lith. Institut v. Wilh. Greve.
- Jähns, Max (1878-80). *Handbuch einer Geschichte des Kriegswesens von der Urzeit bis zur Renaissance. 2 vols*. Leipzig: F. E. Grunow.
- Jähns, Max (1889-91). *Geschichte der Kriegswissenschaften vornehmlich in Deutschland. 3 vols*. München and Leipzig: R. Oldenbourg
<http://archive.org/details/geschichtederkr00jhgoog> (accessed 22 March 2018).
- Jullien, Eva and Michel Pauly (2016). *Craftsmen and Guilds in the Medieval and Early Modern Periods*. Stuttgart: Franz Steiner.
- Kalning, Pamela (2000). 'Funktionalisierung von Geschichtsschreibung in Kriegslehren des späten Mittelalters'. In Johannes Burkhardt ed. *Krieg und Frieden in der historischen Gedächtniskultur*. München: E. Vögel. 31-43.
- Karg-Gasterstädt, Elisabeth and Theodor Frings (1952). *Althochdeutsches Wörterbuch*. Berlin: Akademie. Online http://awb.saw-leipzig.de/cgi/WBNetz/wbgui_py?sigle=AWB (accessed 22 March 2018).
- Karpienski, Marc-André (2001). 'Gunpowder and Cannons: Gunnery in the Late Middle Ages'. In Gerrit Dworok and Frank Jacob eds. *The Means to Kill: Essays on the Interdependence of War and Technology from Ancient Rome to the Age of Drones*. McFarland. 57-70.
- Kaye, Joel (2014). *A History of Balance, 1250-1375: the Emergence of a New Model of Equilibrium and its Impact on Thought*. Cambridge: Cambridge University Press.
- Keen, Maurice ed. (1999a). *Medieval Warfare: A History*. Oxford: Oxford University Press
- Keen, Maurice (1999b). 'The changing scene: guns, gunpowder, and permanent armies'. In Keen (1999a). 273-91.
- Kelly, Jack (2004). *Gunpowder: A History of the Explosive that Changed the World*. London: Atlantic.

- Ker, Neil R. (1987). *Medieval Libraries of Great Britain*. London: Royal Historical Society.
- King, Andy (2011). 'Gunners, aides and archers: the personnel of the English ordnance companies in Normandy in the fifteenth century'. *Journal of Medieval Military History* 9. 65-75.
- Kirchner, Joachim (1950). *Germanistische Handschriftenpraxis*. München: Beck.
- Klemm, Friedrich (1948). *Die Geschichte des technischen Schrifttums. Form und Funktion des gedruckten technischen Buchs vom ausgehenden 15. bis zum beginnenden 19. Jahrhundert*. München: Diss. Masch.
- Knobloch, Eberhard ed. (1984). *Mariano Taccola, De rebus militaribus (De machinis, 1449)*. Baden-Baden: Koener.
- Köhler, Gustav (1886-9). *Die Entwicklung des Kriegswesens und der Kriegsführung in der Ritterzeit von der Mitte des 11. Jahrhunderts bis zu den Hussitenkriegen*. 3 vols. Breslau: Koebner.
- Kortüm, Hans-Henning ed. (2001). *Krieg im Mittelalter*. Berlin: Akademie.
- Kramer, Gerhard W. (1983). 'Das Feuerwerkbuch, eine unausgeschöpfte chemie- und sprengstoffgeschichtliche Quelle'. *Nobel-Hefte* 49. 3/4. 89-99.
- Kramer, Gerhard W. (1995). *Berthold Schwarz: Chemie und Waffentechnik im 15. Jahrhundert*. Abhandlungen und Berichte der Deutschen Museum. N.F. Bd. 10. München: Oldenbourg.
- Kramer, Gerhard W. (1996). 'Das Feuerwerkbuch: Its Importance in the Early History of Black Powder'. In Buchanan (1996). 45-56.
- Kramer, Gerhard W. and Klaus Leibnitz (2001). *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.
- Kümper, Hiram (2005). *Regimen von der Wehrverfassung. Ein Kriegsmemorandum in der Gießener Handschrift 996, zugleich ein Beitrag zur städtischen Militärgeschichte des 15. Jahrhunderts*. *Berichte und Arbeiten aus der Universitätsbibliothek und dem Universitätsarchiv Gießen*. Vol. 55. Gießen: Universitätsbibliothek Gießen.
- Kyeser, Conradus, Udo Friedrich, and Fidel Rädle (1995). *Bellifortis Feuerwerkbuch, Codices figurati-libri picturati Bd. 3*. München: Edition Lengenfelder.
- Lawn, Brian (1963). *The Salernitan Question: An Introduction to the History of Medieval and Renaissance Problem Literature*. Oxford: Clarendon Press.
- Lazar, Thomaž (2015). *Poznosrednjeveško topništvo na Slovenskem. Raziskave dveh zgodnjih topov iz Pokrajinskega muzeja Ptuj-Ormož / Late-Medieval Artillery in Slovenia. A Study of Two Early Artillery Pieces from the Regional Museum Ptuj-Ormož*. Ljubljana: Narodni muzej Slovenije.

- Lefèvre, Wolfgang ed. (2004). *Picturing Machines, 1400-1700*. Cambridge, MA: MIT Press.
- Lehmann, Paul (1956). *Eine Geschichte der alten Fuggerbibliotheken*. Tübingen: Kommission für Bayerische Landesgeschichte/Schwäbische Forschungsgemeinschaft.
- Leicester, Henry Marshall (1956). *The Historical Background of Chemistry*. New York: Wiley.
- Leng, Rainer (1996). 'getruwelich dienen mit Buchsenwerk. Ein neuer Beruf im späten Mittelalter: Die Büchsenmeister'. In Dieter Rödel and Joachim Schneider eds. *Strukturen der Gesellschaft im Mittelalter. Interdisziplinäre Mediävistik in Würzburg*. Wiesbaden: Reichert. 302-21.
- Leng, Rainer (1999). 'Gründe für berufliches Töten. Büchsenmeister und Kriegshauptleute zwischen Berufsethos und Gewissensnot'. In Horst Brunner ed. *Der Krieg im Mittelalter und in der Frühen Neuzeit: Gründe, Begründungen, Bilder, Bräuche, Recht (Imagines medii aevi 3)*. Wiesbaden: Reichert. 307-48.
- Leng, Rainer (2000). *Anleitung Schiesspulver zu bereiten, Büchsen zu laden und zu beschiessen: eine kriegstechnische Bilderhandschrift im cgm 600 der Bayerischen Staatsbibliothek München*. Imagines Medii Aevi, Bd. 5. Wiesbaden: Reichert.
- Leng, Rainer (2001). *Franz Helm und sein 'Buch von den probierten Künsten': ein handschriftlich verbreitetes Büchsenmeisterbuch in der Zeit des frühen Buchdrucks*. Wiesbaden: Reichert.
- Leng, Rainer (2002). *Ars belli: deutsche taktische und kriegstechnische Bilderhandschriften und Traktate im 15. und 16. Jahrhundert*. Imagines medii aevi. 2 vols. Wiesbaden: Reichert.
- Leng, Rainer (2003a). 'Deutsche kriegstechnische und taktische Bilderhandschriften und Traktate. Festvortrag anlässlich der Verleihung des Werner-Hahlweg-Preises 2002 in Halle'. *Zeitschrift für Heereskunde* 67/3. 50-5.
- Leng, Rainer (2003b). 'Feuerwerk zu Ernst und Schimpf. Die spielerische Anwendung der Pyrotechnik im Lustfeuerwerk'. In Stefan Poser and Karin Zachmann eds. *Homo faber ludens. Geschichten zu Wechselbeziehungen von Technik und Spiel*. Frankfurt am Main: Peter Lang. 85-111.
- Leng, Rainer (2004). 'Social Character, Pictorial Style, and the grammar of Technical Illustration in Craftsmen's Manuscripts in the Late Middle Ages'. In Wolfgang Lefèvre ed. *Picturing Machines 1400-1700*. Cambridge, MA: MIT Press.
- Leng, Rainer (2008). 'Zum Verhältnis von Kunst und Krieg in den illustrierten Kriegslehren des 15. und 16. Jahrhunderts'. In Jutta Nowosadtko and Matthias Rogge eds. *'Mars und die Musen': Das Wechselspiel von Militär, Krieg und Kunst in der Frühen Neuzeit*. Münster: Lit Verlag. 33-58.
- Leng, Rainer (2009). 'Feuerwerks- und Kriegsbücher'. In Norbert H. Ott, Ulrike Bodemann and Gisela Fischer-Heetfeld eds. *Katalog der deutschsprachigen illustrierten*

- Handschriften des Mittelalters*. Vol. 4/2. München: C. H. Beck. 145-512.
<http://www.manuscripta-mediaevalia.de/?xdbcidn:%22hsk%200622a%22&dmode=doc#|3> (accessed 3 February 2017).
- Lindgren, Uta (2000). 'Technische Enzyklopädien des Spätmittelalters – Was ist daran technisch?'. *Bellifortis, Clm 30150 (Patrimonia)*, 137). München: KulturStiftung der Länder und Bayrische Staatsbibliothek. 9-20.
- Lohrmann, Dietrich (2007). 'Das Maschinenbuch des Konrad Gruter für Erich VII., König von Dänemark (1424)'. *Deutsches Archiv für Erforschung des Mittelalters* 63. Heft 1. 71-92.
- Long Pamela O. (1997). 'Power, Patronage, and the Authorship of Ars: From Mechanical Know-How to Mechanical Knowledge in the Last Scribal Age'. *Isis* 88.1. 1-41.
- Long, Pamela O. (2001). *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance*. Baltimore: Johns Hopkins University Press.
- Long, Pamela O. (2011). *Artisan/Practitioner and the Rise of the New Sciences, 1400-1600*. Corvallis, OR: Oregon State University Press.
- Lynn, John A. ed. (1990). *Tools of War: Instruments, Ideas, and Institutions of Warfare, 1445-1871*. Urbana: University of Illinois Press.
- Lynn, John A. ed. (1993). *Feeding Mars: Logistics in Western Warfare from the Middle Ages to the Present*. Oxford: Westview Press.
- Lynn, John A. (2004). *Battle: A History of Combat and Culture*. Cambridge: Cambridge University Press.
- Lynn, John A. (2008). *Women, Armies, and Warfare in Early Modern Europe*. Cambridge: Cambridge University Press.
- Mallett, Michael (2006). 'The transformation of war, 1494-1530'. In Christine Shaw ed. *Italy and the European Powers: The Impact of War, 1500-1530*. (History of Warfare, 38). Leiden: Brill. 3-22.
- Marzell, Heinrich (1943). *Frühneuhochdeutsches Wörterbuch der Deutschen Pflanzennamen*. Leipzig: Hirzel.
- Maxwell-Stuart, P. G. (2008). *The Chemical Choir: A History of Alchemy*. London: Continuum.
- McCleery, Iona (2009). 'Both "illness and temptation of the enemy": melancholy, the medieval patient and the writings of King Duarte of Portugal (r. 1433-38)'. *Journal of Medieval Iberian Studies* Vol. 1. No. 2. 163-78.
- McKitterick, David (2003). *Print, Manuscript and the Search for Order, 1450-1830*. Cambridge: Cambridge University Press.

- Menhardt, Hermann (1957). *Das älteste Handschriftenverzeichnis der Wiener Hofbibliothek von Hugo Blotius 1576*. Wien: Rudolf M. Rohrer.
- Merten, Bettina, Ulrich Reinisch, and Michael Korey eds. (2012). *Festungsbau: Geometrie – Technologie – Sublimierung*. Berlin: Lukas.
- Meyer, Werner (1981). 'Das Feuerwerkbuch'. *Burgen und Schlösser* 22. 74-8.
- Miller, Peter (2017). *History and Its Objects: Antiquarianism and Material Culture since 1500*. Ithaca and London: Cornell University Press.
- Moffett, Randall (2011). 'Military equipment in the town of Southampton during the fourteenth and fifteenth centuries'. *Journal of Medieval Military History* 9. 167-99.
- Molino, Paula (2011). *L'impero di carta : Hugo Blotius, Hofbibliothekar nella Vienna di fine Cinquecento*. Unpublished PhD thesis. Fiesole: European University Institute.
- Mortimer, Geoff ed. (2004). *Early Modern Military History. 1450-1815*. Basingstoke: Palgrave Macmillan.
- Moss, Ann (1996). *Printed Commonplace Books and the Structuring of Renaissance Thought*. Oxford: Clarendon.
- Multhauf, Robert Philipp (1966). *The Origins of Chemistry*. London: Oldbourne.
- Neddermeyer, Uwe (1998). *Von der Handschrift zum gedruckten Buch*. 2 vols. Wiesbaden: Harrassowitz.
- Needham, Joseph (1986). *Military Technology: The Gunpowder Epic (Science and Civilisation in China 5, 7)*. Cambridge: Cambridge University Press.
- Needham, Joseph (1994). *Military Technology: Missiles and Sieges (Science and Civilisation in China 5, 6)*. Cambridge: Cambridge University Press.
- Neven, Sylvie (2016). 'Recording and Reading Alchemy and Art-Technology in Medieval and Premodern German Recipe Collections'. *Nuncius: Journal for the Material and Visual History of Early Modern Science* 31/1. 32-49
- Nibler, Ferdinand (2003). 'Das Feuerwerkbuch: Eine verspätete Buchbesprechung etwa 600 Jahre nach dem Erscheinen des Feuerwerkbuches'. *Zeitschrift für Heereskunde* 67/2. 147-54.
- Nibler, Ferdinand (2005). *Feuerwerkbuch : Anonym, 15. Jahrhundert ; Synoptische Darstellung zweier Texte mit Neuhochdeutscher Übertragung*. [s. n.], [S. l.]. Online <http://www.feuerwerkbuch.homepage.t-online.de/> (accessed 22 February 2018).
- Nicolai, Ferdinand Friedrich von (1765). *Nachrichten von alten und neuen Kriegs-Büchern, welche den Feld- und Festungs-Krieg entweder abhandeln oder erläutern nebst einer kurzen Beurteilung derselben*. Stuttgart: No place of publication specified.

- Ohlsen, Rikke Agnete (2004). 'Johannes Bengedans finally found out'. In P. Ettel, Anne-Marie Flambard Héricher, and T. E. McNeill eds. *Château Gaillard, 21: Etudes de castellologie médiévale. La Basse-cour. Actes du Colloque international de Maynooth (Irlande), 23-30 août 2002*. Caen: Publications du CRAHM. 249-50.
- Oman, Charles W. C. (1953/60). *The Art of War in the Middle Ages, A.D. 378-1515*. Ithaca: Cornell.
- Ott, Norbert H. (2013). 'Steiner, Heinrich'. *Neue Deutsche Biographie* 25. 183 [Online-Version]. <https://www.deutsche-biographie.de/pnd119838451.html#ndbcontent> (accessed 21 March 2019).
- Panse, Melanie (2012). *Hans von Gersdorff: ‚Feldbuch der Wundarznei‘. Produktion, Präsentation und Rezeption von Wissen (Trierer Beiträge zu den historischen Kulturwissenschaften 7)*. Wiesbaden: Reichert.
- Päsler, Ralf G. (2005). 'Sachliteratur (Artillerie-, Fecht-, und Ringbücher)'. In Werner Paravicini, Jan Hirschbiegel, and Jörg Wettlaufer eds. *Handbuch Höfe und Residenzen im spätmittelalterlichen Reich, vol. 15.III: Hof und Schrift*. Ostfildern: Thorbecke. 573584.
- Pászthory, Emmerich (1995). 'Salpetergewinnung und Salpeterwirtschaft vom Mittelalter bis in die Neuzeit'. *Chemie in unserer Zeit* Vol. 29. Issue 1. 8-20.
- Parker, David (1996). 'The Importance of the Commonplace Book: London, 1450–1550'. *Manuscripta* 40. 29-48.
- Parker, Geoffrey (1988 – revised edition 2002). *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800*, Cambridge: Cambridge University Press.
- Partington, James R. (1960 [1999]). *A History of Greek Fire and Gunpowder*, with introduction by Bert S. Hall. Baltimore: Johns Hopkins University Press.
- Partington, James R. (1961-70). *A History of Chemistry*. 4 vols. London: Macmillan.
- Pepper, Simon and Nicholas Adams (1986). *Firearms and Fortifications: Military Architecture and Siege Warfare in Sixteenth-Century Siena*. Chicago: University of Chicago Press.
- Pereira, Michela (1999). 'Alchemy and the Use of Vernacular Languages in the Late Middle Ages'. *Speculum*. 336-56.
- Pfeiffer, Franz ed. (1861). *Konrad von Megenberg: Das buch der natur*. Stuttgart: K. Aue <https://archive.org/details/dasbuchdernatur00pfeigoog/page/n548> (accessed 27 March 2019).
- Plimpton, George (1984). *Fireworks: A History and Celebration*. New York: Doubleday.
- Pope, Dudley (1969). *Guns*. Feltham: Spring Books.
- Popplow, Marcus (2001). 'Militärtechnische Bildkataloge des Spätmittelalters'. In Hans-Henning Kortüm ed. *Krieg im Mittelalter*. Berlin: Akademie. 251-68.

- Prager, Frank D. and Ulrich Montag eds. (1971). *Mariano Taccola, De ingeneis*. Gustina Scaglia. Cambridge, MA: MIT Press.
- Prestwich, Michael (1996). *Armies and Warfare in the Middle Ages: The English Experience*. New Haven: Yale University Press.
- Prinzler, Heinz. W. (1981). *Pyrobolia: Vom griechischen Feuer, Schießpulver und Salpeter*. Leipzig: VEB Deutscher Verlag für Grundstoffindustrie.
- Quarg, Götz (1965). ‚Der Bellifortis von Konrad Kyesser aus Eichstätt 1405‘. *Technikgeschichte* 32, 293-324.
- Rae, John and Rudi Volti (1999). *The Engineer in History (Worcester Polytechnic Institute Studies in Science, Technology and Culture 14)*. New York: Peter Lang.
- Rathgen, Bernard and Karl Heinrich Schäfer (1917). ‚Feuer- und Fernwaffen beim päpstlichen Heere im 14. Jahrhundert‘. *Zeitschrift für historische Waffen- und Kostümkunde* 7. 1-15.
- Rathgen, Bernard (1926). ‚Pulver und Salpeter vor 1450: Schießpulver, Kunstsalpeter, Pulvermühlen im frühen Mittelalter‘. *Zeitschrift für Naturwissenschaften* 87. 64-100.
- Rathgen, Bernard (1928). *Das Geschütz im Mittelalter*. Berlin: VDI-Verlag.
- Rathgen, Bernard (1941). ‚Schiesspulver, Kunstsalpeter, Pulvermühlen im frühen Mittelalter‘. *Zeitschrift für Naturwissenschaften* 81. 3/4. 64-100.
- Reichmann, Oscar, Anja Lobenstein-Reichmann, Ulrich Goebel et al eds.(1976-). *Frühneuhochdeutsches Wörterbuch*. Berlin: De Gruyter. Online <https://fwb-online.de/> (accessed 22 March 2018).
- Restall, Matthew (2004). *Seven Myths of the Spanish Conquest*. Oxford: Oxford University Press.
- Rial Costas, Benito (2013). *Print Culture and Peripheries in Early Modern Europe*. Leiden: Brill.
- Richardson, Roland Thomas (2012). *The Medieval Inventories of the Tower Armouries, 1320-1410*. PhD Dissertation University of York. http://etheses.whiterose.ac.uk/3919/1/Thom_Richardson_thesis_final.pdf (accessed 2 February 2017).
- Rieckenberg, Hans Jürgen (1956). ‚Berthold, der Erfinder des Schießpulvers. Eine Studie zu seiner Lebensgeschichte‘. *Archiv für Kulturgeschichte* 36. 316-22.
- Robertson, Haileigh Elouise (2015). ‚Imitable Thunder‘: *The Role of Gunpowder in Seventeenth-Century Experimental Science*. PhD Dissertation University of York.
- Roelcke, Thorsten (1998). ‚Die Periodisierung der deutschen Sprachgeschichte‘. In Werner Besch, Anne Betten, and Oskar Reichmann eds. *Sprachgeschichte* 2.1 (2nd ed.). Berlin/New York: Walter De Gruyter. 798-815.

- Rogers, Clifford J. ed. (1995). *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe*. Oxford: Westview Press.
- Rogers, Clifford J. (2004). 'The Medieval Legacy'. In Geoff Mortimer ed. *Early Modern Military History, 1450-1815*. Basingstoke: Palgrave Macmillan. 6-24.
- Rogers, Clifford J. (2019). 'Gunpowder Artillery in Europe, 1326-1500: Innovation and Impact'. In Robert S. Ehlers ed. *Technology, Violence, and War: Essays in Honor of Dr. John F. Guilmartin, Jr.* Leiden: Brill. 39-71.
- Romocki, S. J. von (1895 [1983]). *Geschichte der Explosivstoffe*. Hannover: Gebrüder Gänecke [Hildesheim: Gerstenberg].
- Schmeller, Johann Andreas ed. (1872-1877 [2008]). *Bayerisches Wörterbuch. Vols 1&2*. München: Oldenbourg. <http://publikationen.badw.de/de/022964277.pdf> and <http://publikationen.badw.de/de/022964287.pdf> (accessed 24 March 2018).
- Schmidtchen, Volker (1977). *Bombarden, Befestigungen, Büchsenmeister: Von den ersten Mauerbrechern des Spätmittelalters zur Belagerungsartillerie der Renaissance – eine Studie zur Entwicklung der Militärtechnik*. Düsseldorf: Droste.
- Schmidtchen, Volker (1982). *Festung, Garnison, Bevölkerung: Historische Aspekte der Festungsforschung* (Schriftenreihe Festungsforschung 2). Wesel: Deutsche Gesellschaft für Festungsforschung.
- Schmidtchen, Volker (1990). *Kriegswesen in späten Mittelalter. Technik, Taktik, Theorie*. Weinheim: VCH.
- Schmidtchen, Volker (1996). 'Mittelalterliche Kriegstechnik zwischen Tradition und Innovation'. In Uta Lindgren ed. *Europäische Technik im Mittelalter. 800 bis 1400. Tradition und Innovation. Ein Handbuch*. Berlin: Gebr. Mann. 305-16.
- Schmidtchen, Volker (1999). 'Ius in Bello und militärischer Alltag – Rechtliche Regelungen in Kriegsordnungen des 14. bis 16. Jahrhunderts'. In Horst Brunner ed. *Der Krieg im Mittelalter und in der Frühen Neuzeit: Gründe, Begründungen, Bilder, Bräuche, Recht (Imagines medii aevi 3)*. Wiesbaden: Reichert. 25-56.
- Schneider, Karl (1868). 'Zusammenstellung und Inhalts-Angabe der artilleristischen Schriften und Werke in der Bibliothek Seiner Exzellenz des Herrn Feldzeugmeisters Ritter v. Hauslab'. *Mittheilungen über Gegenstände der Artillerie-und Kriegs-Wissenschaften. Hg. vom K. K. Artillerie-Committé*. Wien: Braumüller. 123-211.
- Schulz, Knut (2016). 'Büchsenmeister des Spätmittelalters: Migration und Ausbreitung des neuen Wissens'. In Eva Jullien and Michel Pauly eds. *Craftsmen and Guilds in the Medieval and Early Modern Periods*. Stuttgart: Franz Steiner. 221-42.
- Seel, Fritz (1984). 'Sulphur in History: The Role of Sulphur in "Black Powder"'. In Achim Müller and Bernt Krebs eds. *Sulphur: Its Significance for Chemistry, for the Geo-, Bio- and Cosmosphere and Technology*. Amsterdam: Elsevier.

- Sheffler, David (2008). *Schools and Schooling in Late Medieval Germany: Regensburg 1250-1500*. Leiden: Brill.
- Sherwood, Foster Hallberg (1980). *Studies in Medieval Uses of Vegetius' "Epitoma Rei Militaris"*. Los Angeles: PhD Dissertation University of California.
- Shrader, Charles R. (1979). 'A Handlist of Extant Manuscripts Containing the *De Re Militari* of Flavius Vegetius Renatus'. *Speculum* 33. 280-305.
- Singer, Charles ed. (1954-84). *A History of Technology* 2. Oxford: Clarendon Press.
- Smith, Cyril Stanley and Martha Teach Gnudi eds. (1990). *The Pyrotechnia of Vannoccio Biringuccio*. New York: Dover.
- Smith, Geoff (2012). 'The Pre-history of Gunpowder'. Self-publication
<https://independent.academia.edu/GeoffSmith17> (accessed 7 February 2019).
- Smith, Geoff (2015). 'Medieval Gunpowder Chemistry. A Commentary on the Firework Book'. *Journal of the International Committee for the History of Technology* 21. 147-66.
- Smith, Kay (1989) (published under former name of Robert Douglas Smith) and Ruth Rhynas Brown. *Bombards: Mons Meg and her Sisters*. London: Royal Armouries.
- Smith, Kay (1994) (published under former name of Robert Douglas Smith). 'Artillery and the Hundred Years War: myth and interpretation'. In Anne Curry and Michael Hughes eds. *Arms, Armies and Fortifications in the Hundred Years War*. Woodbridge: Boydell. 151-60.
- Smith, Kay (2001) (published under former name of Robert Douglas Smith). 'Good and Bold: A Late 15th-Century Artillery Train'. *Royal Armouries Yearbook* 6 (2001). 88-97.
- Smith, Kay (2002-2016) (partially published under former name of Robert Douglas Smith). *Reports of the HO Group Medieval Gunpowder Research*.
https://ahc.leeds.ac.uk/downloads/download/35/fields_of_conflict (accessed 8 February 2019).
- Smith, Kay (2002) (published under former name of Robert Douglas Smith). 'All manner of peeces: Artillery in the late medieval period'. *Royal Armouries Yearbook* 7 (2002). 130-8.
- Smith, Kay (2005) and Kelly DeVries (published under former name of Robert Douglas Smith). *The Artillery of the Duke of Burgundy, 1363-1477*. Woodbridge: Boydell.
- Smith, Kay (2010) (published under former name of Robert Douglas Smith). *Rewriting the History of Gunpowder*. Nykøbing Falster: Middelaldercentret.
- Smith, Kay and Kelly DeVries (2011) (published under former name of Robert Douglas Smith). *Rhodes Besieged*. Stroud: History Press.
- Smith, Trevor Russell (forthcoming). 'The Earliest Middle English Recipes for Gunpowder'. *Journal for Medieval Military History*.

- Spencer, Dan (2015). 'The Provision of Artillery for the 1428 Expedition to France'. *Journal of Medieval Military History* 13. 179-92.
- Spencer, Dan (2017). "'The Scourge of the Stones': English Gunpowder Artillery at the Siege of Harfleur'. *Journal of Medieval History* 43:1. 59-73.
- St. John Hope, William (1914-15). 'The last testament and inventory of John de Vere, 13th Earl of Oxford'. *Archaeologia* 66. 310-48.
- Stammler, Wolfgang et al. eds. (1933-1955). *Die deutsche Literatur des Mittelalters: Verfasserlexikon*. Berlin: Walter de Gruyter.
- Stewart, Richard Winship (1996). *The English Ordnance Office, 1585-1625*. Woodbridge: Boydell Press.
- Stone, Peter G. and Philippe G. Planel (2003). *The Constructed Past*. London: Routledge.
- Stratford, Jenny (1999). 'The Early Royal Collection and the Royal Library to 1461'. In Lotte Hellinga and Joseph Burnley Trapp eds. *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press. 255-266.
- Striedl, Hans (1953). *Der Humanist Johann Albrecht Widmanstetter 1506-57 als klassischer Philologe*. Wiesbaden: Harrassowitz.
- Stuart, Malcolm ed. (1979). *The Encyclopedia of Herbs and Herbalism*. London: Orbis Books.
- Stummvoll, Josef (1965). 'Die Druckschriftenbestände der Österreichischen Nationalbibliothek und die Abstriegung des Alphabetischen Kataloges 1501 bis 1918'. In Hans Striedl and Johannes Weider eds. *Buch und Welt: Festschrift für Gustav Hofmann zum 65. Geburtstag*. Wiesbaden: Harrassowitz.
- Sutton, Anne F. (1997). *Richard III's Books*. Stroud: Sutton.
- Tallett, Frank and D. J. B. Trim eds. (2010). *European Warfare: 1350-1750*. Cambridge: Cambridge University Press.
- Tittmann, Wilfried (1983). 'Der Mythos vom „Schwarzen Berthold“'. *Waffen- und Kostümkunde* 25. 17-30.
- Tittmann, Wilfried (1996). 'Die importierte Innovation. China, Europa und die Entwicklung der Feuerwaffen'. In Uta Lindgren ed. *Europäische Technik im Mittelalter. 800 bis 1400. Tradition und Innovation. Ein Handbuch*. Berlin: Gebr. Mann. 317-36.
- Tittmann, Wilfried (2000). "'Büchsenwerk" – die Kunst aus Büchsen zu schießen. Mit einer Entgegnung auf Klaus Leibnitz'. *Waffen- und Kostümkunde* 42. 141-82.
- Tittmann, Wilfried (2002). 'Das unaufhaltsame Ende von Berthold Schwarz. Anmerkungen zu Gerhard W. Kramer: 'Das Pyr Automaton – die selbstentzündlichen Feuer des Mittelalters''. Online publication <http://www.ruhr-uni-bochum.de/technikhist/tittmann/2%20Ende.pdf> (accessed 25 February 2015).

- Tittman, Wilfried, Ferdinand Nibler, and Wolfgang John (2017). 'Salpeter und Salpetergewinnung im Übergang vom Mittelalter zur Neuzeit'. Online publication. <http://www.ruhr-uni-bochum.de/technikhist/tittmann/4%20Salpeter.pdf> (accessed 12 March 2018).
- Tout, Thomas Frederick (1911). 'Firearms in England in the fourteenth century'. *English Historical Review* 26. 666-702.
- Trapp, Joseph Burnley (1999). 'Literacy, books and readers'. In Lotte Hellinga and Joseph Burnley Trapp eds. *The Cambridge History of the Book in Britain, Vol. III, 1400-1557*. Cambridge: Cambridge University Press. 31-43.
- Trenkler, Ernst (1968). 'Die Frühzeit der Hofbibliothek (1368-1519)'. In Josef Stummvoll ed. *Geschichte der Österreichischen Nationalbibliothek. Erster Teil. Die Hofbibliothek (1368-1922)*. Wien: Georg Prachner. 1-58.
- Turner, Geoffrey (1997). 'St Thomas Aquinas on the "Scientific" Nature of Theology'. *New Blackfriars*. Vol. 78. No. 921. 464-76.
- Vale, Malcolm (2001). *The Princely Court: Medieval Courts in North-West Europe, 1270-1380*. Oxford: Oxford University Press.
- Vaupel, Elisabeth (1996). 'Schießpulver und Pyrotechnik'. In Uta Lindgren ed. *Europäische Technik im Mittelalter. 800 bis 1400. Tradition und Innovation. Ein Handbuch*. Berlin: Gebr. Mann. 301-4.
- Verbruggen, Jan Frans (1977). *The Art of Warfare in Western Europe during the Middle Ages: From the Eighth Century to 1340*. Translated by Sumner Willard and S. C. M. Southern. Amsterdam: North-Holland Publishing.
- Von Simson, Otto G. (1988). 'The Gothic Cathedral: Design and Meaning'. In Sylvia L. Thrupp ed. *Change in Medieval Society: Europe North of the Alps, 1050-1500*. Toronto: University of Toronto Press in association with the Medieval Academy. 168-87.
- Wachinger, Burghart et al (1977-2008). *Die deutsche Literatur des Mittelalters: Verfasserlexikon, 2nd edition*. Berlin: Walter de Gruyter.
- Walton, Steven A. (1999). *The Art of Gunnery in Tudor England*. Toronto: PhD Dissertation University of Toronto.
- Walton, Steven A. (2005a). 'Proto-Scientific Revolution or Cookbook Science? Early gunnery manuals in the craft treatise tradition'. *Proceedings of Craft Treatises and Handbooks: The Dissemination Of Technical Knowledge in The Middle Ages, a conf. held in Cordoba, 6-8 October 2005*. Cordoba: Faculty of Arts.
- Walton, Steven A. (2005b). 'Mathematical Instruments and the Creation of the Scientific Military Gentleman'. In Steven A. Walton ed. *Instrumental in War: Science, Research, and Instruments between Knowledge and the World*. Leiden: Brill. 17-46.

- Walton, Steven A. (2008). 'Perception of the Performance of Cannon Shot before 1700'. *Journal of the Ordnance Society* 20. 69-80.
- Walton, Steven A. and Thomas E. Boothby (2014). 'What is Straight Cannot Fall: Medieval Architectural Statics in Theory and Practice'. *History of Science* 52.4. 347-76.
- Wecker, John (1660). *Eighteen Books of the Secrets of Art & Nature, being the Sum and Substance of Natural Philosophy*. London: Simon Miller.
- Weiss Adamson, Melitta (2014a). 'Vom Arzneibuch zum Kochbuch, vom Kochbuch zum Arzneibuch: Eine diätetische Reise von der arabischen Welt und Byzanz über Italien ins spätmittelalterliche Bayern'. In Andrea Hofmeister-Winter, Helmut Krug, and Karin Kranich eds. *Der Koch ist der bessere Arzt: Zum Verhältnis von Diätetik und Kulinarik im Mittelalter und der Frühen Neuzeit*. Frankfurt am Main: Peter Lang. 39-62.
- Weiss Adamson, Melitta (2014b). "'mich dunkcht ez sein knölllell": Von den Mühen eines bayrischen Übersetzers mittelalterlicher Fachliteratur'. In Lenka Vanková ed. *Fachtexte des Spätmittelalters und der Frühen Neuzeit: Tradition und Perspektiven der Fachprosa- und Fachsprachenforschung*. Berlin: De Gruyter. 143-54.
- Welch, Evelyn (2005). *Shopping in the Renaissance: Consumer Cultures in Italy 1400-1600*. New Haven: Yale University Press.
- Werrett, Simon (2010). *Fireworks: Pyrotechnic Arts and Sciences in European History*. Cambridge: Cambridge University Press.
- White, Lynn (1940). 'Technology and Invention in the Middle Ages'. *Speculum* 15. 151-9.
- White, Lynn (1962). *Medieval Technology and Social Change*. London: Oxford University Press.
- White, Lynn (1969). 'Kyeser's Bellifortis: The First Technological Treatise of the fifteenth Century'. *Technology and Culture* 10. 436-41.
- White, Lynn (1971). 'Cultural Climates and Technological Advance in the Middle Ages'. *Viator* 2. 171-201.
- White, Lynn (1974). 'Technological Assessment from the Stance of a Medieval Historian'. *American Historical Review* 2. 1-13.
- White, Lynn (1975). 'Medieval Engineering and the Sociology of Knowledge'. *Pacific Historical Review* 44. 1-21.
- Williams, A. R. (1975). 'The Production of Saltpetre in the Middle Ages'. *Ambix* 22. 125-33.
- Williard, Thomas (2015). 'Astrology, Alchemy and other Occult Sciences'. In Albrecht Classen ed. *Handbook of Medieval Culture*. Berlin: De Gruyter. 102-19.
- Witthöft, Harald (2006). 'Maß und Regio – Herrschaft, Wirtschaft und Kultur. Von *aequalitas*, Einheitlichkeit und langer Dauer'. *Jahrbuch für Regionalgeschichte und Landeskunde* 24. 49-75.

Woolgar, Chris M. (2018). 'Medieval Colour and Food'. *Journal of Medieval History* 44. 1-20.

Wunderle, Elisabeth (2006). *Die mittelalterlichen Handschriften der Studienbibliothek Dillingen*. Wiesbaden: Harrassowitz. 74-7.

Würdinger, Josef (1868). *Kriegsgeschichte von Bayern, Franken, Pfalz und Schwaben: Band II von 1347 bis 1506*. München: Literarisch-Artistische Anstalt der Cotta'schen Buchhandlung.