Prices of Weapons and Munitions in Early Sixteenth Century Holland during the Guelders War[1]

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1. Introduction

The adage that to have peace one has to prepare for war may not be of classical antiquity but the principle was known to Livy and the Ancients,[2] and so the influence of the weapons industry on world peace and economy hardly needs to be emphasized now. The purpose of this article is both to present data on retail prices of individual weapons and munitions of war in the first decades of the sixteenth century in Holland, and to show how the magistrates there prepared to defend their cities against an aggressor by purchasing weapons to arm the citizens. Prices quoted here for strategic commodities of war in the early sixteenth century complement those given by Posthumus in his survey of prices for the later sixteenth century and beyond.[3]

Kuypers published inventories of weapons maintained in castles and elsewhere in Holland and the Netherlands in the first half of the sixteenth century, but the cities of Holland were not included in his descriptions.[4] A recent study by De Jong reveals the growth of the early modern weapons industry in the Republic of the United Netherlands in the period 1585-1621 as part of a process of state

[1] This is a revision of part of the author's unpublished doctoral thesis *The Cities and States of Holland. A participative system of government under strain* (Leiden, 2001).

[2] *Ostendite modo bellum; pacem habebitis*, Livy, *Ab urbe condita*, 6. 18. 7.

[3] N. W. Posthumus, *Nederlandsche prijsgeschiedenis*, 2 Vols. (Leiden, 1943 and 1964), Vol. 1, p. 471, Tables 212 and 213 there.

[4] F. H. W. Kuypers, *Geschiedenis der Nederlandsche Artillerie van de vroegste tijden tot op heden*, 5 Vols. (Nijmegen, 1869-1871), Vol. 2, Appendix 4.

formation based on entrepreneurship, economic growth and military reform.[5]

As sources for the present investigation accounts of the Treasurer for North-Holland at The Hague, and of the city treasurers of Haarlem, Leiden, Dordrecht and Gouda were examined for expenditures on weapons and munitions. For Haarlem, Leiden and Gouda the minutes of the local councils (*vroedschappen*), and for Haarlem and Leiden the proclamation books (*aflezingboeken*) in which the texts of public announcements by the town criers were written were also studied.[6]

Despite a diversity of coins in circulation in sixteenth century Holland bookkeeping was made possible by a system of pounds, shillings and pence, based on known values of the individual coins. The coin most frequently named in the sources was the Rhine guilder which was equal to 40 groats Flemish, or 20 stuivers. According to Enno van Gelder the Rhine guilder was a coin weighing about 3.5 grams and having a silver content about 75 percent.[7] From contemporary sources in Holland it is known that 600 marks of silver in 1510 equated to 60,000 pounds of 40 groats.[8] Taking 1 mark equal to 244.753 grams,[9] this amount of silver should provide 60,000 coins containing 2.44753 grams of silver each. This calculation agrees (to 1%) with other data where 2.1 tons of pure silver was equated to 850,000 Rhine guilders, from which a silver content of 2.4705 grams per coin is calculated.[10]

[5] M. A. G. De Jong, *'Staet van Oorlog'. Wapenbedrijf en militaire hervormingen in de Republiek der Verenigde Nederlanden (1585-1621)*, (doctoral thesis, Leiden 2002), p. 9.

[6] Contractions used here are ARA: *Algemeen Rijksarchief* (National Archives), The Hague; Rek.Rek.: *Rekeningen Rekenkamer* (Accounts of the Chamber of Finances); GA: *Gemeente Archief* (City Archives); Tres.rek.: *Tresoriers Rekeningen* (Treasurers' Accounts); SA: Secretaries' Archives; Vroedschapsres.: minutes and resolutions of the *vroedschap*, the local council.

[7] H. Enno van Gelder, *De Nederlandse Munten* (Utrecht, 1966), Ch. III, pp. 46-75, but especially pp. 59-61, and p. 268.

[8] Margaret of Austria, Emperor Maximilian I's regent at Mechelen, requested 600 marks of silver, described as equal to 60,000 pounds of 40 groats; GA Haarlem, Vroedschapsres. 1501-1516, f. 58-58v, 21 Sept. 1510; Ward, *Cities and States of Holland*, p. 174, n. 381 there.

[9] For 1 mark of Troy equal to 244.753 grams in Flanders see J. Munro, 'A maze of medieval monetary metrology: Determining mint weights in Flanders, France and England from the economics of counterfeiting, 1388-1469', *The Journal of European Economic History* 29 (2000) 173-199; p. 178 (Table 1) and p. 198.

[10] The costs of Charles V's election to emperor, estimated at 850,000 Rhine guilders, equal to 2.1 tons of silver in: W. Blockmans, *Keizer Karel V 1500-1588. De Utopie van het Keizerschap* (Louvain, 2000), p. 76 and n. 54 there.

In passages cited verbatim from the sources money values are given in the original currency and units. But for purposes of comparison they have, where necessary, been converted to pounds of 40 groats Flemish. For Haarlem this required no change since the pound was equated to 40 groats. However, the treasurers at Leiden reckoned in pounds of 30 groats Flemish (15 stuivers), and so the figures in their accounts had frequently to be reduced by a factor of three quarters. This was simply a reversal in many instances of what the treasurers or their clerks had done in the sixteenth century, because many of the sums were first recorded in Rhine guilders and these had been converted to pounds of 30 groats by multiplying by four thirds. At Dordrecht and Gouda money values were noted in Flemish pounds based on 240 groats to the pound. Those data have been converted here to pounds of 40 groats by multiplying the figures by the factor 6.

The relationships, based on the (silver) penny d. or groat, are as follows:

1 pound = 20 st.	1 Rhine guilder = 20 st.
1 stuiver (st.) = 2 d.	1 groat = 1 d.

A duit was one quarter of a groat or one eigth of a stuiver.

2. The Guelders war and city defence in Holland

The Guelders war, which lasted from late in the fifteenth century until the surrender of Venlo to Emperor Charles V in 1543, was waged for nearly fifty years by Charles of Egmond, styled duke of Guelders, in his attempts to have his claim to the dukedom recognized by succesive Burgundian-Habsburg rulers Maximilian I, Philip I and Charles V. In the years reviewed here nearly 60 percent of the discussions held

[11] J. D. Tracy, *Holland under Habsburg rule 1506-1566. The formation of a body politic* (Berkely, 1990), Ch. 3, 'The Guelders wars', pp. 64-74; H. Wiesflecker, *Maximilian I. das Reich, Oesterreich und Europa an der Wende zur Neuzeit*, 5 Vols. (Munich, 1971-1986), Vol. 4, pp. 320-329, and pp. 606-609; Ward, *Cities and States*, p. 135..

[12] GA Leiden, SA I inv. no. 387, f. 29v-30, 6 Dec. 1511; GA Leiden, SA I inv. no. 383, loose page numbered '133v', 30 July 1512.

at diets of the cities and States of Holland were about the Guelders war.[11]

In 1511, at a time of fears of winter attacks by Charles of Guelders, the government of Holland at The Hague re-issued an earlier proclamation that every man in Holland should possess or acquire a suitable weapon for the defence of his town or city before the end of the year. The proclamation was read out at Leiden on 6 December 1511, and it is presumed to be a reflection of similar announcements in other cities and towns of Holland at that time. Bows and guns (*geschut*) and spears or pikes (*hantweer*) were stipulated, the later to be 'at least three feet longer than the bearer'. Short, unsuitable weapons were to be confiscated by the magistrates. This stipulation was not without reason for at times in Leiden men were coming to guard the city walls armed only with knives or even hammers. Two weeks later there was to be a weapons' inspection. Failure to comply with the law was punishable by a fine.[12]

It has been postulated that as a consequence of the Guelders war there was a growing military professionalism in defence matters among the magistrates of Holland which stood Holland in good stead then and a generation later at the time of the Dutch Revolt against Philip II.[13] At Leiden, where the account books were itemised to include the costs of defence and war materials, it is a simple matter to distinquish individual members of the local council (*vroedschap*) who were specialised in certain areas of military expertise, including the purchase of weapons. Hendrik van der Does, for example, was often named in connection with the purchase, inspection and transport of military supplies. The account books for the cities of Dordrecht, Haarlem, Leiden and Gouda contain items on the purchase of weapons and munitions during this phase of the war in Holland. It is of interest, therefore, in considering the many changes which occurred in Europe in the early sixteenth century in numbers of soldiers, military organization and materials of war which are reflected in the term 'Military Revolution',[14] to review here some of the types of weapons which were then in use.

[11] Ward, *Cities and States of Holland*, p. 264 and p. 367.
[14] C. J. Rogers (ed.), *The Military Revolution Debate* (Boulder, 1995); G. Parker, *The Military Revolution. Military Innovation and the Rise of the West 1500-1800* (Cambridge, 1988, 1992).

Not any weapon was considered suitable for the defenders of the city. When on watch the burghers of Leiden were ordered to be armed with crossbow (*stalen boog*, 'steel bow') complete with bolts or quarrels, or with a hand gun (*hantbosse*), halberd, pike or some similiar weapon.[15] Knives, hammers and axes as sole weapons were insufficient. Men coming on watch armed only with a hammer or an axe were to be fined 2 stuivers (4 groats). This was an appreciable sanction at a time when 3 to 4 stuivers (6-8 groats) was a day's wage for many men.[16]

The magistrates at Haarlem, Leiden and Gouda bought weapons in quantity. At Leiden the reason was explained as a service to the populace 'because the burgomasters had observed that the burghers were little inclined to arm themsleves with weapons'. Moreover, the magistrates and the experts whom they employed had more knowledge of the armaments market than the average citizen had. Weapons, including guns, pikes, bows, halberds and others were bought in Brabant and elsewhere, and they were then re-sold to the burghers.[17] The magistrates at Leiden sold the weapons almost at cost price without reckoning the overhead costs incurred in buying them at Antwerp or Mechelen, partly because they recognized that prices there had been inflated by high demand at the time.

The main extra cost to Leiden in one instance was for the wages of two soldiers whom they engaged to buy weapons at Antwerp and Mechelen. They were gone for 8 days at the generous fee of 12 stuivers per man per day, 'and these above-mentioned costs are not to be estimated on the aforesaid weapons because they were bought at a high price, since the whole world wants them, and the burghers would not have wanted to take them at a higher price'.[18] Nonetheless, most of the weapons were resold quickly. The prices and numbers of weapons bought and resold suggest the obvious: that the more expensive weapons (crossbows and handguns) were bought in smaller

[15] GA Leiden, SA I, inv. no. 387, f. 9, dated 13 Oct. 1507.
[16] L. Noordegraaf and J. T. Schoenmakers, *Daglonen in Holland 1450-1600* (Amsterdam, 1983).
[17] GA Leiden, SA I inv. no. 587, f. 75v, anno 1508.
[18] GA Leiden, SA I inv. no. 587, f. 76, anno 1508.

numbers and presumably sold to the better-off members of the city elites.

Weapons named in the city accounts can be divided into three categories: spearlike weapons; bows and handguns; heavier guns like artillery pieces. Each of these categories can be divided again into several kinds of weapons with different names. The easiest to identify are the spears, which included the combination of axe and spear called the halberd, and two different kinds of pike distinguished as 'short' (14 feet in length; approximately 4.3 metres) and 'long' (18 feet; approximately 5.5 metres). Pikes were viewed, and remained for a long time, as a kind of super-weapon from the time of the early shock tactics and successes of the Swiss against Charles the Bold in the 1470's, and '*by the first decade of the sixteenth century the pike reigned supreme as the queen of the battlefield*' after Emperor Maximilian I adopted the pike for his *landsknechts*.[19]

Pikes were much cheaper than halberds. Haarlem bought 300 pikes, each 18 feet long, at Antwerp in 1506, priced at 18 Rhine guilders per hundred, while Leiden bought 200 pikes at 20 Rhine guilders per hundred in 1508. The average price of a pike therefore was 3.5-4 stuivers each, about one day's wage for a workman. Following a serious riot at Leiden on 8 May 1513 which had long-lasting consequences Mr. Jan Steenhouer demanded a price of 6 stuivers each for 400 pikes which he sold to the magistrates who, with difficulty, were trying to restore order in the city. They finally gave him 5 stuivers for each 'in order to avoid more complaints'.[20]

But Leiden bought only 36 (3 dozen) halberds in 1507 at 14 stuivers each. They were made to order at Oudewater, and of these 34 were resold almost immediately to the citizens.[21] The halberd, a weapon combining the features of a pike and a battleaxe but three to four times more

[19] F. Tallet, *War and society in early modern Europe 1495-1715* (London and New York, 1992), p 21; H. Delbrück, *Geschichte der Kriegskunst im Rahmen der politischen Geschichte* (Berlin, 1920, repr. 1962), Vol. 4, pp. 4-8.
[20] GA Haarlem, Tres.rek. 1506-1507, f. 47-47v; GA Leiden, SA I inv. no. 587, f. 76, anno 1508; GA Leiden, SA I inv. no. 383, f. 179v, 5 April 1514.
[21] GA Leiden, SA I inv. no. 587, f. 76v, 20 Oct. 1507.

expensive than a pike, apparently remained popular with some people in Leiden although it was beginning to go out of use among professional soldiers. The halberd's length was insufficient to fend off pikes and lances. For that very reason the Swiss adopted the pike in preference to the halberd when they were defeated by Italian cavalry at Arbedo near Bellinzona in 1422.[22]

However, despite being more expensive than the simpler, cheaper and straight forward thrusting and stabbing instrument like the pike, 62 halberds were among the weapons bought in 1523 for the soldiers on fishery protection vessels in Holland and they were probably used to good effect in cutting grappling lines and in hand-to-hand fighting with freebooters, pirates and boarders. Two lots of 306 pikes of 17 feet length and 306 pikes of 14 feet were bought for an average price of 15 pounds of 40 groats per 100, that is 3 stuivers each on average. The 62 halberds cost 9 stuivers each. While these halberds were priced more cheaply than at Leiden in 1507 they still cost three times as much as pikes, the prices of which had remained unchanged.[23] The poor man's other weapon besides the pike was the longbow with its arrows. One hundred longbows cost Gouda 14 stuivers in 1508, the same price as one halberd at Leiden. Although arrows were bought in larger numbers (thousands) an arrow cost the same as a bow, calculated at 14 stuivers per hundred.[24] The work of cutting, shaping and stringing a bow must have been about the same as that of turning, feathering and tipping an arrow. It is sobering to recognize that one hundred longbowmen could be armed each with a bow and ten arrows for the price of eleven halberds. It is not surprising then that king Henry VIII of England was keen to encourage archery in England at the time when the longbow was being supplanted by firearms and becoming obsolete on the Continent. As a cheap offensive weapon the longbow still had some use in the open field, despite the opinion of

[22] G. Phillips, 'In the Shadow of Flodden: Tactics, Technology and Scottish Military Effectiveness, 1513-1550', *The Scottish Historical Review*, 77 (1998) 162-182; p. 169; M. L. Boscardin, 'Arbedo', *Lexikon des Mittelalters* (Munich and Zürich, 1980), Vol. 1, Column 869.
[23] ARA, Rek.Rek. inv. no. 4990, f. 27. The numbers 62 and twice 306 are presumably related to the numbers of men on the ships who were to be armed with the weapons.
[24] GA Gouda, Old Archive inv. no. 1169, f. 56, anno 1508.

the Leiden magistrates when they abolished it that it was 'of very little value and defence'.[25]

In 1508 Leiden bought eight steel crossbows for resale to the burghers, and a single windlass used in tensioning the string. All the crossbows were sold immediately but the price is not recorded. The windlass remained unsold, and so it stood to book at its value of 30 stuivers.[26] That suggests that the crossbows, each with a reserve steel bow, were themselves not cheaper than this. In that case they were comparable in price to a good firearm. Crossbows were harder hitting than the longbow, they had a longer range and they remained in use on board ships because they reduced the danger of fire and were free from problems associated with ignition and firing of firearms in wet weather and surroundings. Supplies in 1523 to the fishery protection vessels in Holland included 72 dozen darts or quarrels (*darden*) for use with crossbows, costing 5 stuivers per dozen. Calculated at approximately 42 stuivers per 100, therefore, they were three times more expensive than arrows for the longbow costing 14 stuivers per hundred.[27]

Firearms named in the account books of the cities of Holland are more difficult to identify exactly, but while a technical discussion would exceed the aims of this study some conclusions can be drawn from the data presented.[28] The first remark is that no complete identity should be

[25] GA Leiden, SA I inv. no. 383, f. 29v, 6 Dec. 1511.

[26] GA Leiden, SA I inv. no. 587, f. 76, anno 1508.

[27] ARA, Rek.Rek. inv. no. 4990, f. 27, anno 1523; V. Foley, G. Palmer and W. Soedel, 'The Crossbow', *Scientific American,* Vol. 252 (Jan. 1985) 80-86.

[28] For technical discussions and illustrations of early firearms: F. H. W. Kuypers, *Geschiedenis der Nederlandsche Artillerie van de vroegste tijden tot op heden* (5 Vols., Nijmegen, 1869 and 1871); R. C. Clephan, 'The military handgun', *Archeological Journal,* 67 (1910) 109-150; T. F. Tout, 'Firearms in England in the Fourteenth Century', *English Historical Rev.,* 26 (1911) 666-702; B. Rathgen, *Das Geschütz im Mittelalter: Quellenkritische Untersuchungen* (Berlin, 1928); A. R. Hall, *Ballistics in the Seventeenth Century* (Cambridge, 1952); A. N. Kennard, *Gunfounding and gunfounders* (London, 1986), reviewed in *Interdisciplinary Science Reviews,* 12 (1987) 371; B. S. Hall, *Weapons and Warfare in Renaissance Europe* (Johns Hopkins, 1997). For artists' impressions and illustrations of older weapons and firearms: J. R. Hale, *Armies, navies and the art of war* (Cambridge, 1990). Working full-sized copies of early firearms, handguns and wrought iron cannon were demonstrated by Prof. Richard Holmes of Cranfield University in a series of documentary programmes on historical battles fought in England which were shown on BBC Television (London and Bristol) in 1998 and later. An inexpensive and convenient source of photographs and artists' impressions of weapons and armour throughout the ages is the Men-At-Arms series published by Osprey, London.

assumed between the names given at the beginning of the XVIth century to the guns and firearms with the same names used later in the sixteenth century. Traditionally the names were derived from those of reptiles and birds of prey. Terms such as 'handgun' (*hantbus*, 'hand tube') and harquebus (*haakbus*, 'hooked tube') for the smaller hand-held weapons, and serpent, serpentine, falcon, falconet, culverin, quartan and their equivalents for the larger guns existed from the fifteenth century onwards and continued in use long afterwards. The only names of larger guns found in the accounts were large and small serpents or serpentines (*slangen*), quartan (*cortthals*) and leather guns (*lederen bossen*), the latter encased in leather, perhaps to protect the wrought iron barrel from rusting or to mitigate the effects of it exploding.[29] Although the older names were retained, the weapons themselves continued to evolve and generally increased in size throughout the whole of the sixteenth century and beyond.

Field guns, from at first being small enough to be carried several at a time on carts in the fourteenth century, grew to be huge bombards used as siege guns in the XVth century. Examples which still exist and are familiar to tourists are 'Dulle Griet' at Ghent and 'Mons Meg' at Edinburgh.[30] After that period guns became smaller and more mobile once more. They were provided with trunnions, projections on the gun barrel to hold it in place on its wooden understructure, and they were then mounted on wheeled carriages, an innovation which is attributed by some to Emperor Maximilian himself. During the sixteenth century guns then gradually increased again in size and weight.

Materials changed too from wrought iron to 'metal', that is to say bronze, and then later in the sixteenth century to cast iron, as techniques

[29] *'Cortthals'* in a letter from Cornelis Glasmaker to the magistrates of Dordrecht, printed in J. P. Ward, 'A selection of letters, 1507-1516, from the Guelders war', *Lias. Sources and Documents relating to the Early Modern History of Ideas*, 29 (2002) 125-151; *'lederen bossen'* in GA Leiden, SA I inv. no. 387, f. 24v, dated 3 Sept. 1509. For a photograph of leather guns see Parker, *The Military Revolution*, Figure 12, pp. 33-34, where it is said that an officer claimed to have invented leather guns in the 1620's.

[30] G. Parker, *The military revolution. Military Innovation and the Rise of the West 1500-1800* (Cambridge, 1988), Figure 2, p. 9; B. Rathgen, *Das Geschütz im Mittelalter. Quellenkritische Untersuchungen* (Berlin, 1928), pp. 517-518 and 523, and Plates 3-10 there.

of iron smelting improved. It should be noted, however, that methods of manufacturing cast metal cannon whether in bronze or iron changed very little from the fifteenth to the nineteenth centuries. The process of manufacturing cannon described by Biringuccio in 1540 is essentially the same as that shown in a large and detailed series of watercolour drawings made in the eighteenth century, illustrating the casting of cannon.[31]

In the older, more laborious method of manufacture of field guns wrought iron staves were bound around with iron rings or hoops to form literally a steel barrel. The barrel was closed off at one end with a detachable chamber of iron which was first filled with the charge of gunpowder, closed with a wooden plug and then held in place on the gun barrel by wedges or by being screwed on. The gun barrel was mounted in a box-like wooden structure called in the sources 'lade' ('box' or 'drawer'). This was the state of affairs at the beginning of the sixteenth century when the accounts of Haarlem, Leiden and Gouda show that large wrought iron guns of the older kind made by blacksmiths existed side by side with the newer, cast 'metal' guns made by artists like Hans Poppenruyter at Mechelen and by artisan bronze founders.

3. Handguns

The simplest type of hand-held gun in the fifteenth century was an iron or bronze tube about 40 cm. long, fixed with metal bands to a wooden pole resembling a broom handle. The tube had a touchhole bored into it, and as a gun it was in fact a miniature cannon. For aiming and firing, the pole could be wedged, held by one hand, under the elbow or otherwise on the shoulder, and a match was applied to the touchhole by the other hand. If some of these older guns were still in use at the beginning of the sixteenth century they may be included in the type of gun referred to in the sources as *hantbos* ('handtube').

[31] Vannuccio Biringuccio, *De la Pirotechnia* (Venice, 1558, first published 1540); M. H. Jackson and C. de Beer, *Eighteenth-century Gunfounding: The Verbruggens at the Royal Brass Foundry, a Chapter in the History of Technology* (Newton Abbot, 1973).

But by the beginning of the sixteenth century there were other more elaborate handguns, having a longer barrel fixed to a shaped wooden stock, and with a distinct, separate firing mechanism. The firing mechanism was an S-shaped metal lever ('serpentine') placed suitably near the butt of the gun and mounted above a metal pan on the side of the barrel adjacent to the touchhole. A glowing fuse was fitted into the upper limb of the S. When the gunner pulled on the lower limb of the S the fuse was depressed into the pan filled with fine gunpowder which ignited, the flame passed through the borehole and the gun fired.

There were several different kinds of hand-held firearms. Besides the term '*hantbos*' ('handgun') other terms found in the sources are '*kolf*', '*knipbos*' and '*haakbos*', none of which are described. From historical examples of guns which survive the most obvious difference is that the harquebus (*haakbos*) is a heavier weapon and it has a flat triangular or trapezoid piece of metal, the hook from which the gun derived its name, welded or soldered to the barrel near the muzzle. When a defender laid the gun against a wall or rampart the hook transferred the force of the recoil to the wall when the gun was fired. Apart from surviving historical specimens of harquebuses, other evidence that the harguebus was a heavier type of hand-held gun was found in an item for 1513 where captain Willem Turck was paid 24 stuivers which he had advanced for 6 supports or tresles (*scragen*) which he purchased for his mens' harquebuses.[32] Presumably the tresles were taken along with them when they were on the march. The other types of handgun named in the sources, *knipbus* and *kolf*, were lighter in construction and more suitable to be held freely in the hands of the marksman. Kuypers identified the users of the *knipbus* because of its lighter weight as city magistrates and infantrymen.[33] That included the better-off burghers in towns and cities generally.

'*What's in a name?*', a late sixteenth century poet-playwright asked. With respect to early firearms that is the question. According to a reference work, harquebuses were often termed 'calivers' in English, and this word

[32] ARA, Rek.Rek. inv. no. 2195, f. 24v, anno 1513.
[33] Kuypers, *Geschiedenis Nederlandsche Artillerie*, Vol. 1, pp. 177, 223, and 226.

in turn was described as a corruption of the word 'calibre.' English and French dictionaries relate the word 'calibre' to an Arabic word for 'mould'. That might perhaps be a reference to the form or mould in which metal was cast to make guns. Tallet wrote that arquebus (or harquebus) is the generic term for all sixteenth century hand firearms. Elsewhere Carasso-Kok and Levy-Van Halm implied that the type of gun called '*klover*' was also identical with the harquebus, but the word '*klover*', they claimed, is derived from Latin '*coluber*', meaning an adder.[34]

The implication that harquebuses (*haakbussen*) and calivers (*klovers*) were the same cannot be correct for the early sixteenth century. In the sources the two terms harquebus and caliver are used antithetically. There were social distinctions between the different guilds of men carrying bows and firearms. But there were also social or economic distinctions between the different guilds with firearms. This can be seen from a resolution of the council at Rotterdam in 1511 where in a reorganization of the shooters' guilds four guilds were recognized, to be armed with the crossbow, the longbow, the harquebus and the '*clover*'.[35] Therefore, two separate guilds were installed bearing firearms, one for men using the harquebus, and other guild for the '*clover*' or caliver. The sixteenth century Scottish antiquarian Robert Lindesay also wrote several times about longbows, crossbows and firearms in his chronicle. When he specifically mentioned handguns (which he described as small artillery) the terms 'hagbut' and 'collvering' were again used antithetically.[36]

The conclusion drawn here is that the harqebus with its hook was unmistakeably and unequivocally indentified by the term '*haackbos*', that the term '*knipbos*' refers to the lighter gun preferred by the city magistrates and infantrymen according to Kuypers, and by some members

[34] W. Shakespeare, *Romeo and Juliet*, Act II, Scene 2; R. E. Dupuy and T. N. Dupuy, (eds.), *The Collins Encyclopedia of Military History from 3500 B.C. to the present* (4th edn. Glasgow, 1993), p. 490; F. Tallet, *War and Society in Early Modern Europe 1495-1715* (London and New York, 1952), p. 22; M. Carasso-Kok and J. Levy-van Halm (eds), *Schutters in Holland. Kracht en Zenuwen van de Stad* (Haarlem, 1988), p. 18.
[35] GA Rotterdam, Old archive, inv. no. 43, p. 144, 7 Feb. 1511.
[36] A. J. G. Mackay (ed.), *The Historie and Cronicles of Scotland, etc., written and collected by Robert Lindesay of Pitscottie*, 3 Vols. (London and Edinburgh, 1899-1911), Vol. 1, p. 288.

of the urban shooters' guilds, and that other terms like '*hantbos*' (handgun) and '*clover*' (caliver) should be understood to be general terms indicating that they were handguns lacking the hook, and lighter in weight than the harquebus. Contemporary illustrations support this assertion. In illustrations of marching soldiers in Emperor Maximilian's triumphal train the men are clearly depicted with firearms lacking the triangular hook from which the harquebus derived its name.[37]

In this sense, therefore, the members of one of the shooters' guilds at Rotterdam were armed entirely with the heavier harquebuses, and the men of the other shooters' guild, the *kolveniers*, were armed possibly with a variety of lighter firearms and handguns. Within the context of urban military defence the harquebus, being a heavier weapon, was used strategically in defence, being fired perhaps mainly from the city walls. The other handguns, *knipbos* and *kolf*, being lighter could be more easily carried and used tactically when aimed and fired in open field.

The *knipbos* may have been a little less expensive on the average than the heavier harquebus, but the prices quoted for both these weapons are similar and fairly uniform and so it is presumed that they were essentially of the same quality. In 1508 Leiden bought four 'metal' or bronze guns under the former name (*knipbos*) at 24 stuivers, two at 30 stuivers and four at 21 stuivers each. About the same time Leiden also bought six harquebuses (*haakbos*) at 25 stuivers, and 12 at 27 stuivers each, while Gouda paid for 31 harquebuses a price of 25 stuivers each. In 1508 Leiden purchased forty seven *knipbossen*, each provided with 'powderhorn, priming powder, bottle and fuse etc.' for a price of 2 Rhine guilders 11 stuivers (51 stuivers) per complete set. In 1523 100 handguns (*handtbussen*) supplied to the fishery protection vessels cost 24 stuivers each.[38]

4. Standardization locally of handgun calibres

Exceptionally, in 1512 Leiden also ordered to be specially made at Rotterdam 100 harquebuses at the higher price of 32.5 stuivers each. This

[37] H. Wiesflecker, *Kaiser Maximilian I* (Munich, 1991), p. 343.
[38] GA Leiden, SA I inv. no. 587, f. 75v-76v, anno 1508; GA Gouda, Old archive inv. no. 1169, f. 61, anno 1508; ARA, Rek.Rek. inv no. 4990, f. 27, anno 1523.

particular set of firearms raises an important issue concerning norms and standards of calibre in firearms. From about 1520 and later in the 16th century Charles V took measures to introduce standardization of weapons in his armies, particulary in the sizes of cannon, and advances in standardizing artillery pieces were achieved later.[39] But the advantages of standardisation were understood and appreciated earlier. As examples, standardization in the coinage and in weights and measures, not internationally but regionally, can be cited. At Leiden and Haarlem weights and measures had to be submitted regularly to the city magistrates for control and calibration.[40]

Concerning firearms, first it can be asked whether there was a standard calibre, if only at local level, for handguns bought by the magistrates of Leiden at the beginning of the sixteenth century. It is, of course, so that if spherical lead bullets have a standard uniform weight then this implies a standard diameter for them and perhaps also a standard, or at least a minimum calibre for the guns from which they were fired. An early polemic between Kuypers and Favé concerned the calibres of fifteenth century Burgundian bullets and weapons, and it centred on the number of bullets to the pound weight of lead (which was taken as equal to 480 grams).[41]

As a condition of a petition which the gunners' guild made to the magistrates of Leiden in 1512 the guild stipulated that each man should have at home a reserve of half a pound of gunpowder and 25 bullets.[42] This ratio is assumed here to be a local standard. According to Leonhart Fronsperger writing on military matters in the sixteenth century in a loaded gun the weight ratio of gunpowder to bullet or cannon ball was as 1:2. This ratio remained unchanged until towards the end of the sixteenth century.[43] This implies, therefore, that 25 bullets at Leiden

[39] Kuypers, *Geschiedenis Nederlandsche Artillerie*, Vol 2, pp. 88f and 166f.
[40] GA Leiden, SA I inv. no. 387, f. 52, 16 Feb. 1516, and GA Haarlem, inv. no. Rood 63, f. 8v.
[41] Kuypers, *Geschiedenis Nederlandsche Artillerie*, Vol. 1, p. 229f.
[42] GA Leiden, SA I inv. no. 383, two loose pages, one numbered '130'; ibid. fo. 129-129v, 16 Sept. 1512.
[43] L. Fronsperger, *Von Kayserlichen Kriegsrechten* (Frankfurt am Main, improved edition 1571, first published 1555), p. 93f; A. R. Hall, *Ballistics in the Seventeenth Century. A study in the relations of science and war with reference principally to England* (Cambridge, 1952), pp. 166-168.

weighed one pound. With 480 grams to the pound weight, a spherical lead bullet of this size would weigh 19.2 grams and have a diameter of 14.8 mm. The specific gravity of lead is taken as 11.3.

When the magistrates of Leiden ordered 100 new harquebuses from Cornelis Geritszoon of Rotterdam in August 1512 the order was to make harquebuses *'van eenen loode'* or *'all op een loot'* ('all of one *lood*'). In the sources there is also an expression describing *'haekbossen die hij geboert heeft up een loot'* ('harquebuses which he bored all of one *lood*). The explanation for the expression *'op een loot'* or *'van een loot* is not that it refers specifically to the weight unit *'lood'*, which in modern terms is about 15 grams, but that the guns were to be made to the same bore size or calibre. It was recognized that they had to be bored to one uniform calibre in order to accomodate one uniform size of bullet. Although this is far from implying a standard size throughout Holland it does imply appreciation at local level for the advantages afforded by a uniform calibre for the guns used by the shooters' guilds in Leiden.

In December of the same year the magistrates announced publicly that persons who had received harquebuses from the city which were not newly bored should return them so that they could be replaced with re-bored guns. Then in two items for the same period of the year 1512-1513 Wouter Philipszoon, a locksmith, was paid for re-boring 54 and 66 harquebuses *'geboert op een loot'*, and for marking them with Leiden's coat of arms. It is proposed here that those 120 guns were re-bored to the size of the 100 new guns made by Cornelis Geritszoon.[44]

As corroboratory evidence, in February 1513 near the end of the refitting when almost all the hand guns, including the new ones, were ready at Leiden Sijmen Buytewech was paid for adapting (*vermaken*) the moulds in which the harquebus bullets were made, an operation which was obviously necessary if the new calibre differed from the earlier one. It required him to change or re-adjust the moulds 'two or three times'. His pay of 18 stuivers for this operation indicates that it took some time, at least two and perhaps three days or more. He then used the moulds to

[44] GA Leiden, SA I inv. no. 591, f. 37, 25 Aug. 1512; see also under 25 Oct. and 7 Dec. 1512; GA Leiden, SA I inv. no. 387, f. 33v, 21 Dec. 1512; GA Leiden, SA I inv. no. 592, f. 73; ibidem f. 73, 12 Jan. 1513.

cast and make bullets for which he was paid 54 stuivers.[45] It may be concluded that he adjusted the bullet moulds to the calibre of the new guns and the re-bored older guns in Leiden. By the reasoning given above they had a calibre of about 14.8 mm, requiring one pound of lead (480 grams) from which to cast twenty five bullets of 19.2 grams each.

The putative size of the bullets by the reasoning given above is only an indication of the final bore of the guns which the Rotterdam gunsmith made. The barrels were no doubt roomier than the approximately 15 mm. calculated, in order to allow an easy passage of the bullet with its wadding into the barrel during loading. The excess space is referred to as 'windage', and it was a feature of all early firearms. Two early harquebuses which survive have calibres of 27 and 34 mm.[46]

Of the 100 new harquebuses ordered by Leiden all can be traced. The price, 32.5 stuivers each, corresponded well with the quality of gun which the gunners' guild in their petition wished to have for its members. The guns were ordered on 25 August 1512 and were supplied in a period of about 22 weeks in numbers indicating that they were being made at the rate of four or five per week on average. The gunmaker's wife Alydt delivered them to Leiden and received payment for them.[47]

5. Artillery pieces

Problems of nomenclature of a different kind are encountered with the guns of larger calibre which were mounted on the walls of the cities. Most of them were simply called '*slangen*' or serpents, but at Leiden there is a reference to 'carriage guns' (*wagenbossen*). Haarlem purchased 70 new serpents at Antwerp in 1512, each costing 7 Rhine guilders 14

[45] GA Leiden, SA I inv. no. 592, f. 73v, before 2 March 1513 (f. 74).

[46] Carasso-Kok and Levy-van Halm, *Schutters in Holland*, p. 183; R. C. Clephan, 'The military handgun of the sixteenth century', *The Archaeological Journal*, 67 (1910) 109-150.

[47] GA Leiden, SA I inv. no. 591, f. 68, 15 Sept. 1512; GA Leiden, SA I inv. no. 592, f. 72v, 24 Nov. 1512, and f. 73v, 30 Jan. 1513. The harquebuses were ordered on 25 Aug. 1512; GA Leiden, inv. no. 591, f. 37, and delivered as follows: Numbers delivered; Date in accounts; Source: 6, 15 Sept., GA Leiden, inv. no. 591, f. 68; 24, 25 Oct., f. 68v; 12, 24 Nov., GA Leiden inv. 592, f. 72v; 12, 7 Dec. f. 72v; 18, 31 Dec., f. 73; 18, 26 Jan. 1513, f. 73v; 10, 11 Feb., f. 73v-74.

stuivers. The price included three chambers for each of the guns, and this indicates that they were wrought iron guns of the older type. An estimate of their weight based on figures given below (9 duits per pound weight of iron, including workmanship) suggests that the weight of each gun together with its three chambers was about 137 pounds, or about 65.8 kilograms (1 lb. taken as 480 grams). These pieces were meant probably to be mounted on and fired from the walls of the city. The guns were kept in store under the town hall, an indication that they were light and mobile enough to be brought out quickly. On a previous occasion in 1507 Haarlem bought and tested 38 serpents, probably of iron, made to order at Amsterdam in 1507, but the price was not specified.[48] A method used in Holland for testing guns was to place them in water and use compressed air to detect fissures, much as bicycle tyres are tested today for leaks.

Leiden possessed several large serpents which were also made of iron. Repairs carried out on one of them in 1515 were in the form of new rings requiring 483 pounds weight of iron. The complete gun must therefore have weighed several times this amount, perhaps two to three thousand pounds or so. The 483 pounds weight of iron which the blacksmith provided for repairing the gun was priced at 9 duits per pound weight. This included the costs of his work, because from the costs were deducted the current value of 258 pounds weight of iron which the magistrates provided at 3 duiten per pound weight or 37.5 stuivers per 100 pounds weight. These data were used to estimate the weight of the guns bought by Haarlem (above), assuming that they were made of iron. The wages for making and assembling a wooden mounting for the large serpent at Leiden were also considerable. A joiner and his assistant worked on it for eight days at a joint cost of 10 stuivers per day.[49]

The costs of the repairs to the Leiden cannon support the view that bronze guns were more expensive than iron guns. The final figure of 9 duits per pound weight of iron worked into the cannon by the

[48] GA Leiden, SA I inv. no. 589, f. 73, 25 April 1509; GA Haarlem, Tres.rek. 1511-1512, f. 91v; ibid. f. 92; GA Haarlem, Tres.rek. 1507-1508, f. 33v-34, 15 Dec. 1507. A. R. Hall, *Ballistics in the Seventeenth Century*, pp. 12-13.

[49] GA Leiden, *SA I inv. no. 594, f. 92-92v, 4 April 1515; ibidem, 12 April 1515.*

blacksmith, or 112.5 stuivers per 100 pounds weight, compares favourably with the costs of bronze cannons bought ready-made and complete by Gouda (see below). Confirmation of the cheapness of iron was found in figures from 1523 when a blacksmith at Zierikzee was paid almost the same price, 2.5 groats or 10 duits per pound weight (equal to 125 stuivers per 100 pounds weight), for two complete wrought iron cannon (*hoofstucken*, 'main guns') each with two chambers, weighing in total 1992 pounds weight, which he supplied to the fishery protection vessels for onboard ship. Each gun, therefore, with its two chambers weighed about 1000 pounds on average. Additional costs included iron fittings, wood made into two '*laden*', wooden mountings for the guns, and a tip for three of the workmen.[50] Cast iron cannon made later in the sixteenth century were cheaper still than wrought iron and much cheaper but less reliable than bronze cannon.[51]

Differences in the weights and prices of various guns becomes clear from the accounts of Gouda (1510-1511) where four bronze serpents were bought having a total mass of 3588 pounds weight, from which it is assumed that they averaged about 900 pounds each. Gouda also bought a gun described as a small serpent weighing 284 pounds, and another called a large serpent weighing 2047 pounds. All of those guns were priced at 12 pounds of 40 groats (240 stuivers) per 100 pounds weight of bronze, or in other words they were more than twice as expensive as iron guns, weight for weight. Wooden mounts or carriages for the two guns described as small and large cost together the considerable sum of 42 pounds (of 40 groats) and 15 stuivers. These two bronze guns, and probably the former four, were made for Gouda by a Master Simon of Mechelen. Kuypers identified a certain Master Simon at Brigdamme near Middelburg in Zeeland. However, a review of weapons' manufacturers at Mechelen which included those working

[50] ARA Rek.Rek. inv. no. 4990, f. 47v. For artillery and firearms on board ships see C. de la Roncière, *Histoire de la Marine Française*, Vol. 2 (2nd edn. Paris, 1914), pp. 490f; J. K. Oudendijk, *Een Bourgondisch Ridder over den oorlog ter zee. Philips van Kleef als leermeester van Karel V* (Amsterdam, 1941), pp. 72-74; L. H. J. Sicking, *Zeemacht en onmacht. Maritieme politiek in de Nederlanden 1488-1588* (Leiden and Amsterdam, 1996), pp. 272-276.

[51] T. A. Wertime, *The coming of the age of steel* (Leiden, 1961), p. 167.

there in the earlier part of the sixteenth century does not list a Master Simon.[52]

An impression of the sizes of the guns bought for Gouda can be got as follows. Firstly, something can be deduced about the calibres of guns in use at the time. Paulus Rodolphi, a monk and chronicle writer living in Friesland, described events there in the war of 1517 and jokingly compared the cannon balls flying around to 'apples and pears', adding for clarity's sake 'I mean of course the stone and lead cannonballs'. Elsewhere they were compared to tennis balls. This implies that the cannon balls may have had diameters about 6.5 to 7 cm., assuming a similarity to modern tennis balls and apples.[53] An iron ball or sphere of this size would weigh 1.38 kilograms or a little less than 3 pounds (2.88) of 480 grams, and a similar lead ball would weigh 2.03 kilograms or more than 4 pounds (4.23) of 480 grams. That these values are realistic is corroborated by other data below.

In order to estimate the sizes of the guns bronze cylinders were assumed as simple models for the serpent and the large serpent at Gouda, with the following results: for the serpent, a bronze cylinder length 200 cm., external diameter 20 cm., internal diameter 10 cm. would weigh about 414.7 kg. or 864 pounds of 480 grams; for the large serpent, a similar bronze cylinder length 200 cm., external diameter 30 cm., internal diameter 15 cm. would weigh about 933.1 kg. or 1944 pounds of 480 grams. The specific gravity of bronze is taken as 8.8. It will be noted, first, that the calibre (10.0 cm.) assumed for the model of the serpent does not deviate much from the size of a tennis ball or apple (about 7 cm.), especially since some room (windage) has to be left in the bore of the

[52] GA Gouda, Old Archive inv. no. 1170, f. 38, anno 1510, and inv. no. 1171, f. 20v, anno 1511; Kuypers, *Geschiedenis Nederlandsche Artellerie*, Vol. 1, p. 219; B. Roosens, 'Het arsenal van Mechelen ende de wapenhandel (1551-1567)', *Bijdragen tot de Geschiedenis*, 60 (1977) 175-247.

[53] J. G. Ottema (transl. and ed.), *Proeliarius of Strijdboek*, bevattende de jongste oorlogen in Friesland in het jaar 1518 etc. (Leeuwarden, 1855), p. 233; C. J. Rogers, 'The military revolutions of the Hundred Years War' in C. J. Rogers (ed.), *The Military Revolution Debate* (Boulder, 1995), pp. 65 and 87. The diameters of standard modern tennis balls are required to be minimally 6.35 and maximally 6.67 cm. A modern apple (Cox's Orange Pippin, 1998 harvest) chosen at random and bisected equatorially had a diameter of 7.0 cm.

cannon to allow the ball with its paper or cloth wadding to pass in easily, and, secondly, that the calculated weights of the two bronze cylinders approximate to the weights of the cannon listed in the Gouda account books.

If the Gouda serpents weighed about 900 lbs. each, the small serpent about 300 and the large serpent about 2000 pounds weight then the so-called serpent is modest in size when compared with later guns of the same name. Kuypers listed as serpentine or falconet a gun weighing 1000 pounds firing a lead ball of 6 pounds, and he named as a medium serpent a gun weighing 2500 pounds and firing an iron ball of 12 pounds.[54] The lead ball would have a diameter of about 7.87 cm. and the iron ball a diameter of about 11.26 cm. The specific gravity of iron is taken as 7.7, and of lead 11.3. Hall published data from English sources of about 1590 in which a serpentine cannon was described as weighing 5500 pounds. By that time smaller guns weighing from 500 to 1400 pounds weight were named after the falcon family, and they fired iron balls averaging about 3 pounds weight. Fronsperger described sixteenth century contemporary cannon together with the weights of their projectiles but not of the guns themselves. Serpents and falcons fired iron balls of 8 and 4 pounds weight respectively, with the charges of gunpowder 4 and 2 pounds weight.[55] For armies on the move cannon balls of this weight and size appear to have been the norm about the time that the monk Paulus was writing in 1517. It may be concluded, therefore, that the later falcons and falconets were the successors to the early sixteenth century serpents.

6. Munitions

Besides the weapons, the accounts list many other items needed for them, in particular lead for making shot, and saltpetre and other materials for making gunpowder. Lead bought for making cannon balls was often of scrap quality recovered from scenes of previous fighting and shooting (*'verloren schut'*, lost shot). This included lead recovered from the practice

[54] Kuypers, *Geschiedenis Nederlandsche Artillerie*, Vol. 2, p. 86.
[55] Fronsperger, *Von Keyserlichen Kriegsrechten*, Book IIII, p. 93f; Hall, *Ballistics in the seventeenth century*, pp. 166-168.

firing ranges. Lead, besides being used for domestic purposes, could be easily remelted and cast into new bullets and projectiles.

Quantities of lead noted (Table 1) range for different qualities from about 50 pounds weight to about 500 pounds. The prices are obscured a little because they refer sometimes to pounds weight of lead bought and sold and sometimes to the numbers of individual recovered bullets or cannonballs, but with no indications of their weights or sizes, so these latter items are not considered here. However, for old lead sold in bulk the price ranged from 42-52 stuivers/100 pounds weight:

If the limited number of items found are representative then newly cast lead ingots (*taerlingen*, dice or cubes) were considerably more expensive than the old, recovered lead. But the ingots would be free of dirt, stones and other extraneous material probably present in the unrefined lost shot. Similarly, lead shot (*hagelscut*) used for firing at close range was more expensive still since it had to be specially prepared in a shot tower.

In order to make harder cannon balls of more hitting power pieces of broken iron were sometimes mixed with the molten lead which was then poured into stone moulds. The moulds also appear in the accounts, but without any indication of their sizes and the calibres of the cannonballs made in them. Descriptions include moulds made of white stone, others of blue stone.[56] Some cannonballs were still made of stone

TABLE 1. Lead bought in bulk (1507-1512)

Quantity pounds	Quality	Price/100 lbs.wt. pounds of 40 groats	Price/lb. groats	Source#
206	old	2 lb. 10 st.*	1	GAL 586, f.54
478	old	2 lb. 12 st.*	1.04	GAL 586, f.54
300	old	2 lb. 2 st.*	0.84	GAL 591, f.68
152.5	old	2 lb. 2 st.*	0.84	GAD 443, f.115
90	ingots	3 lb. 15 st.	1.5*	GAL 590, f.76v
49	ingots	6 lb. 5 st.	2.5*	GAL 590, f.76v
139	hailshot	17 lb. 10 st.	7*	GAG 1170,f.38

GAL etc.: Gemeente Archief Leiden, Dordrecht, Gouda respectively.
* Price quoted in sources.

[56] GA Leiden, SA I inv. no. 586, f. 54, anno 1507, rubricized under Artillery; GA Leiden, SA I inv. no. 589, f. 72v, anno 1509; GA Gouda, Old Archive inv. no. 1171, f. 20v, anno 1511.

in the XVIth century. At Dordrecht in 1512 136 stone cannon balls were bought at 7 groats (3.5 stuivers) each, a day's wage. In 1523 54 stone balls of 5, 6 and 7 inches (approximately 12.7, 15.2 and 17.8 cm.) were bought for the fishery defence vessels at 4 stuivers each irrespective of their sizes, presumably because the work of chipping, chiseling and shaping them was not much related to the final size of the ball. In another purchase 150 stone balls of 5 inches and 300 of six inches were bought for the same price.

Iron cannonballs on the other hand were sold by weight and without reference to their sizes; 193 iron balls weighing 759 pounds were bought in 1523 at 66 stuivers per 100 pounds weight. The average weight per cannonball was therefore a little less than 4 pounds if it is assumed that they were all more or less identical and intended to be used in cannon of the same or similar calibres.[57] This size and weight is also in harmony with the monk Paul's remark about 'apples and pears'.

Finally, mention should be made of the 'fire arrows' or rockets which the master gunner Jan Krieckebeeck made at Leiden in 1512, perhaps by filling canvas forms with a combustible substance like gunpowder. For this he purchased four ells of canvas for 8 stuivers. The construction and purpose of the fire arrows is not described but probably they were meant for signalling purposes either shot from crossbows or launched from gun barrels or mortars in the way that rockets are still fired. Fronsperger's book of the mid-sixteenth century contains illustrations of fire arrows and rockets.[58]

Besides gunsmiths and metal workers employed on the manufacture and maintenance of the guns other tradesmen, in particular wood turners, joiners and coopers, were employed in making the bits and pieces needed to make the guns mobile and effective. The process of loading early cannon with detachable chambers is shown in illustrations.[59] The

[57] GA Dordrecht, Old Archive inv. no. 443, f. 113, anno 1513; ARA, Rek.Rek. inv. no. 4990, f. 27v, anno 1523.

[58] GA Leiden, SA I inv. no. 592, f. 72v; Fronsperger, *Von Kayserlichen Kriegsrechten*, p. 175v.

[59] C. J. Rogers, 'The military revolutions of the Hundred Years War' in C. J. Rogers (ed.), *The Military Revolution Debate* (Boulder, 1995), pp. 55-93.

use of separate, detachable chambers for the iron guns has been referred to above. Once the iron chambers were filled with gunpowder they were closed off with a wooden plug. A chamber was then screwed or clamped to the barrel of the gun, ready for firing. Large numbers of the wooden plugs made of willow were supplied to Leiden in times of crisis by joiners and wood turners. Wooden barrels, boxes and similar containers for gunpowder are also recorded, together with the costs of leather bags and other receptacles. Wood for making the 'drawers' or gun mountings in which the metal gun barrels were placed and the wheels on which they could be moved about were also accounted for. Other specific costs recorded for the artillery included a leather bag (at 6 stuivers) for keeping gunpowder in, and similarly 200 wooden tubs; 20 wooden boxes (at 3 stuivers each), buckets and barrels (at 3 stuivers each) for storing gunpowder; 300 wooden props for closing the gun chambers (at 4 stuivers per 100). Wheels (at 11 stuivers each) for the gun carriages were bought in sets of six, preserved with pitch which cost half a stuiver more per wheel; axles were less numerous and cost 3 stuivers each.[60]

But guns are not much use without gunpowder. In the section which follows quantities of gunpowder and materials for making it in the cities of Holland at the beginning of the sixteenth century are described.

7. Purchase and manufacture of saltpetre and gunpowder

Although there is still some discussion about whether firearms were invented in Europe or China there is consensus that saltpetre and gunpowder were first prepared and their properties investigated in China. The fact that from its earliest (thirteenth century) description in European sources the composition of gunpowder approximated to the ideal mixture has been accepted as an indication that gunpowder came to Europe from elsewhere. Three ingredients go into gunpowder: saltpetre, charcoal and sulphur.[61] By

[60] GA Leiden, SA I inv. no. 586, f. 52v; GA Leiden, SA I inv. no. 587, f. 77, f. 78-78v and f. 79; GA Leiden, SA I inv. no. 590, f. 77v and f. 78; GA Leiden, SA I inv. no. 591, f. 67 and f. 68v; GA Leiden, SA I inv. no. 592, f. 73v and 74.

[61] Biringuccio, *Pirotechnia*, p. 153.

1540 when Biringuccio published his treatis 'De Pirotechnia' the manufacture of gunpowder had reached a degree of sophistication which was scarcely improved on until the end of the eighteenth century.[62]

In the simplest method of manufacture the ingredients are finely ground and mixed intimately in certain proportions which depend on the use intended for the gunpowder. This is probably the process which the Leiden guild of gunners had in mind in 1512 when they requested an allowance of saltpetre in order to make their own gunpowder. However, in commercial processes better qualities of gunpowder which combust more reliably and uniformly are made by moistening the mixed and ground ingredients with a little water, extruding this paste through sieves to form grains of a desired size and then drying the grains in warm, airy buildings or sheds.

For different uses Biringuccio described four kinds of gunpowder which were made from saltpetre, charcoal and sulphur in parts by weight as in Table 2. He made clear the reasons for the different recipes by stating that they had to be suited to the 'instruments', the guns, in which they were intended to be used. As every gunner knows who uses them, he wrote, the gunpowders have to be chosen properly for each desired effect.[63] Mixture no. 1 was for the big artillery ('*artigliaria grossa*'), no. 2 for the medium-sized pieces ('*artigliarie mezzane*'), no. 3 for harquebuses and handguns ('*archibusi e schoppi*'), and no. 4 was

TABLE 2. Biringuccio's four gunpowder mixtures

	1		2		3		4	
	Parts	%	Parts	%	Parts	%	Parts	%
Saltpetre	3	50.0	5	66.7	10	83.3	13.5	79.4
Carbon	2	33.3	1.5	20.0	1	8.3	2	11.8
Sulphur	1	16.7	1	13.3	1	8.3	1.5	8.8
		100.0		100.0		99.9		100.0

[62] S. H. Mauskopf, 'Lavoisier and the improvements of gunpowder production', *Rev. d'Histoire des Sciences*, 48 (1995) 95-121; R. P. Multauf, 'The French crash program for saltpeter production 1776-1794', *Technology and Culture*, 12 (1971) 163-181, especially pp. 171-173.

[63] Biringuccio, *Pirotechnia*, p. 153; Hall, *Weapons and warfare*, pp. 82, 88-89 and 101.

preferred by people who wanted a rapidly burning gunpowder, thinking they were making it better that way, he remarked drily. Apart from this, it should be remarked that Biringuccio also distinquished between harquebuses (*archibusi*) and other handguns (*schoppi*), but that the same gunpowder mixture, no. 3, was used in each.

Mixture no. 3 approximates to the composition of gunpowder described in some chemistry handbooks: saltpetre 84.2%; carbon 7.9%; sulphur 7.9%, but descriptions from later dates simply reflect the empirical knowledge gained by artillerists and gunpowder makers in previous centuries.[64] Biringuccio's instructions for making gunpowder are short and to the point: the ingredients had to be well mixed, finely ground, engrained and then dried. The process was no doubt familiar to the readers of his first edition, but Biringuccio emphasized the precautions needed to ensure quality and uniformity of the product. The most important ingredient of gunpowder is saltpetre, 'on which differences and the whole strength of gunpowder depends' he wrote.[65]

Saltpetre is an anhydrous salt which is formed naturally in the soil or earth by bacterial action on organic materials, especially where large numbers of domestic animals and poultry are penned up, as in stables and hen coops. Saltpetre can be obtained from such soils by extracting with hot water, concentrating the extracts by evaporation, and crystallising dissolved substances to the desired degree of purity. This process is similar to the process which was used in Holland at that time to make refined table salt from crude, imported Bay salt. A reference to the manufacture of saltpetre was found for 1508 when Leiden repaid an advance of 10 stuivers for an undisclosed quantity of mineral earth (*specie*) to Master Willem Haver, a gunner, which was bought to make saltpetre from.[66]

But the production of saltpetre can be rationalized and improved on by mixing the preferred organic material, horse dung, with wood ash, moistening the pile frequently with urine, and leaving it to ferment in a

[64] W. F. Ehret (ed.), *Smith's General Chemistry for Colleges* (6th edn. London, 1946), pp. 498-499.
[65] Biringuccio, *Pirotechnia*, p. 153v.
[66] GA Leiden, SA I inv no. 587, f. 79, 15 Sept. 1508.

suitable room or cellar or covered space. The rest of the process is as above, by extraction and crystallisation. A. R. Williams reviewed the literature and examined the chemistry of saltpetre formation in a near-simulation of the historical production method, but using cow dung and a prescription of 1561. Urine was the key ingredient. Williams found that the dung provided bacteria and a substrate for converting urea in the urine to nitrate, while the wood ash provided potassium, thus forming potassium nitrate (saltpetre). Perhaps the most striking observation was how low the final yields of pure saltpetre were: about one percent.[67]

Williams' choice of cow instead of horse dung was perhaps the main reason for the depleted yield. The reportedly low yield is all the more remarkable in view of the large quantities of saltpetre recorded in the account books of the cities of Holland at the beginning of the sixteenth century. However, the raw materials were plentiful, the final product was costly and there was a good market for it. These factors probably determined that the arts of making saltpetre and gunpowder were widely distributed geographically. Gunpowder and saltpetre were bought and sold in Holland and the Low Countries in places as differing in size as Alkmaar and Antwerp, suggesting that they were made locally in proto-industrial settings. Table 3 gives an overview of the amounts and prices of saltpetre found in the accounts of Dordrecht, Leiden and Gouda. Prices there were quoted per 100 pounds weight. Where necessary they have been recalculated to pounds of 40 groats and stuivers per pound weight of saltpetre to allow comparison of the prices. An average price was found to be between about 2.5 and 3 stuivers (5-6 groats) per pound weight of saltpetre.

Differences in price probably reflect differences in quality more than anything else. There were a number of methods at that time for determining the purity of saltpetre, including its appearance, taste, ready solubility in water without leaving a residue, its behaviour on heating, and other similiar qualitative tests. Biringuccio judged it on taste: 'you

[67] A. R. Williams, 'Production of saltpetre in the Middle Ages', *Ambix*, 22 [2] (1975) 125-133; the article 'Saltpetre' in *Johann Heinrich Zedler, Grosses Vollständiges Universal-Lexikon*, (Leipzig and Halle, 1742, facsimile edn. Graz, 1961), columns 1128-1174, especially columns 1142-1146.

TABLE 3. Saltpetre bought for Dordrecht, Leiden and Gouda (1506-1512)

Quantity lbs wt.	Price per 100 lbs wt. In pounds of 40 groats	Price/lb.wt. calcd (st.)	Source#
850	12 lb. 0 st.	2.4	GAD 442, f.129
2010	17 lb. 0 st.	3.4	GAD 443, f.114v.
1100	13 lb. 12.5 st.	2.73	GAL 587, f.79v.
500	20 lb. 0 st.	4.0	GAL 591, f.67v.
969	15 lb. 8 st.	3.08	GAL 592, f.73.
582	12 lb. 15 st.	2.55	GAL 592, f.75v.
288	15 lb. 0 st.	3.0	GAG 1168, f.31
257	12 lb. 10 st.	2.5	GAG 1168, f.31.
600	9 lb. 1 st.	1.81	GAG 1170, f.30v.
496	10 lb. 0 st.	2.0	GAG 1170, f.37

GAD etc.: Gemeente Archief Dordrecht, Leiden, Gouda respectively.

can taste if it is good with your tongue'.[68] The most reliable way to test saltpetre, however, was to prepare gunpowder from it, then load and fire a gun.

Charcoal for making gunpowder is found in quantity in the accounts, but the weights were not specified. Charcoal was and still is a commodity used in a number of applications, the most common one being as fuel for heating and cooking. The accounts contain a separate rubric (under the heading 'Turf') for the fuels bought, for example, in order to heat the town halls. In the items found under 'Artillery' at Leiden the term '*tonne*' means a barrel of charcoal, the quantity which was bought for making gunpowder. Even if the Leiden standard barrel for measuring peat (*torf*) is assumed to have a volume of 227 litres[69] it is difficult to convert this to a weight of charcoal or carbon.

One of the suppliers of charcoal to the gunpowder manufactory at Leiden was a baker who made charcoal and was paid 8 stuivers for 2.5 barrels. Curiously, this was the price which was also paid to another man, Joris Pieterszoon, for one barrel of charcoal.[70] Perhaps the baker was able

[68] Biringuccio, *Pirotechnia*, p. 150.
[69] J. M. Verhoeff, *De oude Nederlandse maten en gewichten* (Amsterdam, 1983), p. 47.
[70] GA Leiden, SA I inv. no. 587, f. 79v, 10 Nov. 1508; GA Leiden, SA I inv. no. 587, f. 79, 26 Aug. 1508.

to use his spare oven capacity to make charcoal and to sell it cheaply since he had to keep his oven burning at times of the day when there was no bread in it. But the art of making charcoal was not restricted to charcoal burners and bakers. In another case the gunpowder master Huyge Joestzoon himself may have made or supervised the manufacture of charcoal from willow wood when he bought willow to the value of 21 stuivers to convert to charcoal for making gunpowder. Willow was one of the preferred woods because of its light, porous structure. Biringuccio named willow and hazelnut wood as suitable for making charcoal for gunpowder: 'to make charcoal there are some people who besides willow use hazelnut wood'.[71]

Saltpetre and charcoal figure prominently enough in the city accounts of Holland. But a minor mystery presents itself. Where is the sulphur required to make gunpowder? There is no mystery about its production, which was simple. In volcanic regions of Italy and Sicily crude sulphur (brimstone) was piled up, set alight and the molten sulphur which ran out was collected and purified by sublimation in a heated oven to give the beautiful yellow crystals called 'Flowers of Sulphur'. The process was described by Biringuccio.[72]

For the total 3151 pounds weight of saltpetre accounted for at Leiden in the years 1507-1513 (Table 3) about ten percent of this weight was needed as sulphur to make gunpowder. But no purchase of sulphur was found. In two other instances unspecified amounts of sulfur were bought by Gouda in 1507, and by the authorities at Zutphen in Guelders in 1510. The Gouda entry records the costs but not the quantity of sulphur other than to say that it was one barrel. In the entry noted at Zutphen the price of saltpetre which was brought from Cologne by Andrew Artsack and his son John were recorded; 10 guilders or pounds per 100 pounds weight is in the range of prices in Table 3. But there is no quantitative information about the sulphur which was also in the load.[73]

[71] GA Leiden, SA I inv. no. 587, f. 78v; GA Leiden, SA I inv. no. 591, f. 68v; Biringuccio, *Pirotechnia*, p. 153v.

[72] Biringuccio, *Pirotechnia*, Chapter II, 'Del solfo e sua minera', with illustrations on pp. 26v and 27.

[73] GA Gouda, Old Archive inv. no. 1168, f. 31v; GA Zuthphen, Old Archive inv. no. 933, f. 50.

The fact is, however, that apart from gunpowder bought on the open market, considerable quantities of gunpowder were made by order of the magistrates at Leiden in the crisis years of the early sixteenth century, and so presumably there was sulphur available at the time. Three types of gunpowder are listed in the accounts; coarse, harquebus and fine, but the differences between them in composition and grain size are not made clear. By comparison with the mixtures and compositions which Biringuccio described (Table 2) it may be concluded however that the cheaper kinds (*grof*, coarse) either contained less saltpetre or required less work done on them and were intended for use with artillery pieces and perhaps in the harquebuses if necessity required it. The more expensive kinds (*knip*) were to be used in the lighter firearm, the *knipbus* preferred by the magistrates. The kind of gunpowder classified as small or fine (*clien*) was probably used in order to fill the priming pans and the firing mechanisms of the guns, but may also have been used to load the ligher firearms. The various names, however, and the specific reference in a number of cases to fine corned gunpowder for use in handguns are evidence that the differences in quality and texture of gunpowders were recognized and understood by experts.

In 1513 Jan Beelen made a total of about six hundred pounds weight of gunpowder of two different qualities at Leiden. There were 102 pounds of '*cloever*', probably intended for use in harquebuses and hand guns generally, and 496 pounds of '*knip*' for the lighter weapon preferred by infantrymen and magistrates or as primer in the firing pans of the guns. Materials were provided by the magistrates, and Jan Beelen was paid different wages for the two kinds of gunpowder which he made, reflecting differences in the time and work needed in grinding, sieving and mixing the ingredients. For making '*cloeverkruit*' he was paid five and a half Rhine guilders per hundred pounds weight. At 6 pounds of 40 groats per 100 pounds weight he was paid about 9% more for making gunpowder of the '*knip*' quality. Elsewhere, Jan Pieters was paid 6 pounds and 7 pounds of 40 groats for making 40 pounds weight and 20 pounds weight respectively of gunpowder for which the stadholder provided the saltpetre.[74] By

[74] GA Leiden, SA I inv. no. 592, f. 75, 21 June 1513; ibidem f. 75v; ARA, Rek.Rek. inv. no. 3411, f. 20v.

implication these gunpowders were of different qualities or fineness, and a simple calculation suggests that one quality of gunpowder took about twice as much work or time to make as the other. That seems not unreasonable in view of the rather small amounts involved. It is also apparent that making gunpowder in bulk was a more economical process.

The difference in qualities of gunpowder is reflected even more

TABLE 4. Gunpowder and types bought or made (1509-1523)

Quantity lbs wt.	Type	Price/100 lbs wt. pounds of 40 groats	Price/lb.wt. Stuivers	Source#
300	-	12 lb.*	2.4	GAG 1170. f.37
396	'coarse'	15 lb.	3*	ARA 3404, f.27v
2516	'coarse'	15 lb.*	3	ARA 4990, f.28
3527	-	15 lb. 18 st.*	3.2	ARA 4990, f.28
306	harquebus	10 lb.*	2	GAG 1175, f.40v
307	harquebus	10 lb.*	2	GAG 1175, f.40v
308	harquebus	17 lb. 10 st.	3.5*	ARA 4990, f.29
195	harquebus	17 lb. 10 st.	3.5*	ARA 3404, f.27v
102	'cloever'	-	n.d.	GAL 592, f.75
496	'knip'	-	n.d.	GAL 592, f.75v
106.5	-	15 lb.	3*	GAD 442, f.129
181	-	15 lb.	3*	GAD 442, f.129
203	-	15 lb.	3*	GAD 442, f.129
429.5	-	20 lb.	4*	GAH 1512, f.92
28	'knip'	25 lb.	5*	GAG 1170, f.38
1	'knip'	30 lb.	6*	GAG 1170, f.38
45.5	'knip'	30 lb.	6*	ARA 3404, f.27v
25	'knip'	37 lb. 10 st.	7.5*	ARA 2195, f.24v
12	'knip'	40 lb.	8*	ARA 3411, f.20
59	-	40 lb.	8*	ARA 3404, f.27v
204	'fijn knip'	16 lb.*	3.2	GAD 443, f.113v
425	'small'	20 lb.*	4	GAG 1175, f.40v
70	'fine corned'	17 lb. 10 st.	3.5*	ARA 4990, f.29
176	ditto	20 lb.	4*	ARA 4990, f.29v
42	ditto	22 lb. 10 st.	4.5*	ARA 4990, f.29
68	ditto	27 lb. 10 st.	5.5*	ARA 4990, f.29v

ARA: Algemeen Rijksarchief; GAG etc.: Gemeente Archief Gouda, Dordrecht, Leiden.
* Price/weight quoted in the accounts, converted where necessary to pounds of 40 groats.
- Under 'Type', type not indicated.
n.d.: no data; the accounts contain only wages paid for making these quantities; see text above.

markedly in the prices paid at Gouda for powder expressly bought for use in harquebuses and in '*knip*' guns. Small amounts of '*knip*' quality gunpowder were relatively expensive and are unrepresentative. The smallest amounts bought (1 pound weight and 28 pounds weight) are totally unrepresentative, but the larger amount (425 pounds weight) described as '*clien*', that is small or fine, is probably of the same quality and for use in the same kind of '*knip*' gun, and its price equivalent to 4 stuivers (8 groats) per pound weight for large quantities may therefore be accepted as representative. Gunpowder described as 'fine corned gunpowder for handguns' was delivered to the fishery protection vessels in 1523. Bulk gunpowder described as coarse (*grof*) was the cheaper kind as the entries in Table 4 with data from 1523 show.

The largest single bill for munitions, gunpowder and shot found is not listed in the tables above. The materials were supplied by the artist and artisan Hans Poppenruyter to the stadholder of Holland during the first siege of Poederoijen in 1507. The bills submitted by Poppenruyter were not well specified. There is a summary of munitions supplied, and an explanation concerning the lack of written receipts. Direct authorization by the stadholder was needed for the money to be paid, and the second half of the large sum, which amounted to 1936 pounds and 2 stuivers in total, was not paid out by the Treasurer for North Holland until 1510. Even this was only part of previous costs incurred by Holland for the supply of munitions by Poppenruyter.[75]

Poppenruyter was described as a master gun founder (*meester bussgieter*), but he is beter known perhaps as a creative artist in bronze, and a friend of Albrecht Dürer. It is known that Poppenruyter later supplied bronze cannon made at his foundry in Mechelen to the armies of Emperor Charles V and King Henry VIII of England and others, but from this bill it is apparent that he furnished gunpowder and other munitions at an early date. Poppenruyter (who died before 24 January 1534) was probably earning large sums of money from the wars at this time, for in 1508, 1512 and 1514 he expanded and enlarged considerably his foundry at Mechelen, and he bought several properties

[75] ARA, Rek.Rek. inv. no. 3406, f. 74.

and dwellings there and elsewhere at that time and in the following years.[76]

Finally, a word can be said about the economics of gunpowder making as practised at Leiden and elsewhere. With labour costs at about 6 pounds of 40 groats per hundred pounds weight of gunpowder, and materials' costs amounting to more than 12 pounds of 40 groats per hundred pounds weight of gunpowder (assumed, 80 pounds weight of saltpetre at 3 stuivers per pound weight; the costs of charcoal and sulphur neglected) then the cost of locally made gunpowder had to exceed 18 pounds of 40 groats per hundred pounds weight. From the relative cheapness of the bulk, coarse (*grof*) gunpowder at about 15 pounds of 40 groats per hundred pounds weight it made sense to buy saltpetre and to employ the expertise and manpower available to specialize in making the finer grades of gunpowder needed for the city's handguns like harquebuses and '*knipbos*' guns.

This is borne out by data in Table 4. It also appears that the central authorities at The Hague in the first two decades paid appreciably more per pound weight for the gunpowder which they bought than the costs which the cities incurred for the gunpowder which they made themselves. By purchasing weapons and producing in part their own war materials, the economic and technical controls of the magistrates of Holland and of the technical experts whom they employed were guarantees of cost effectiveness, quality and reliability. This and other factors contributed to an increase in military expertise which the magistrates acquired from their experiences in the Guelders war.

[76] O. Schottenloher, 'Erasmus, Johann Poppenruyter und die Entstehung des Enchiridion militis Christiani', *Archiv für Reformationsgesch.*, 45 (1954) 109-116. This article contains (pp. 113-116) valuable biographical information derived from an earlier publication (1910) by G. van Doorslaer. According to Kuypers, *Geschiedenis Nederlandsche Artillerie*, Vol. 2, pp. 98 and 165, Poppenruyter was appointed master gun founder on 12 Jan. 1520. But according to Schottenloher (Van Doorslaer) Poppenruyter had this function in 1515 already, with a salary of 200 pounds Flemish per annum, loc. cit. p. 115; B. Roosens, 'Het arsenaal van Mechelen en de wapenhandel (1551-1567)', *Bijdragen tot de Geschiedenis*, 60 (1977) 175-247, p. 187 and footnote 55 there.

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