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THE LIGHT FIELD CANNON FROM KURZĘTNIK – A UNIQUE EXAMPLE OF MEDIEVAL ARTILLERY (AGAINST THE BACKGROUND OF DEVELOPMENT OF FIREARMS IN THE TEUTONIC ORDER'S STATE IN PRUSSIA)

Abstract:

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The paper deals with the find of an early 15th c. light field cannon from the castle of Kurzętnik in the territory of the former state of the Teutonic Order in Prussia. The find is discussed against the background of development of firearms in the Order's state, including gun types, organisation of manufacture, prices etc. Based on technological examinations, the cannon was cast of copper, which matches data on such guns from contemporary Teutonic records.

Key words: Teutonic Order, Middle Ages, 14th-15th c., military, artillery, archaeometallurgy, copper guns

Introduction

The cannon in question (Fig. 1) was discovered in 1941 during archaeological excavations in the ruins of the castle in Kurzętnik (then Kauernick) in Western Prussia (now in north-eastern Poland). It was found in the castle's cellar. After the discovery, the find was stored at the Museum in Marienwerder (Kwidzyn). In the face of the oncoming Russian front in 1944, it was evacuated and concealed in the village of Alt Rosengart (now Różany near Malbork). Having been rediscovered in 1950, it is now part of the collection of the Museum in Kwidzyn, Branch of the Castle Museum in Malbork (inv. No. MZM/MK/M/46) (Grodzicka 1960, 358; 1963, 7, 12; Woźniak 1990, 70; Chodyński 2003, 80, 88; 2007, 389; 2010, 126; see also Szymczak 2004, 104-105).

Kurzętnik was originally a property of the bishops of Chełmno (Culm), within the state of the Teutonic Order. Since 1291 it belonged to the cathedral chapter. The castle had a considerable strategic significance, as it secured nearby fords on the River Drwęca. The army of King Władysław Jagiełło approached the castle during the Grunwald (Tannenberg) campaign on 10th July 1410 in order to continue their march towards the centre of the Order's state. King Władysław did not decide to cross the river, as both the castle and the fords' defences were additionally reinforced by the Order. This implies that the artillery at the castle may have been composed both of cannons belonging to the chapter and the Order. After the battle of Grunwald (Tannenberg) King Władysław granted the castle to a nobleman Jan of Kretkow. Kurzętnik was, however, lost by the Poles already in Autumn 1410, as the main part of the Royal troops withdrew from Prussia. During the next war with the Order the castle surrendered to the Polish troops in 1414. Both the castle and the town of Kurzętnik were then burnt to the ground. Based on this, M. Grodzicka proposed 1414 as a *terminus ante quem* for the cannon; she stated, however, that it was impossible to say whether it originally belonged to the chapter or the Order itself. The relief of the Holy Virgin with Child (the saint patron of the Teutonic Order) on the muzzle could speak in favour of the latter (Grodzicka 1960, 369; 1963, 8-10; Goździelewski 1970, 39-40; Głosek 1990, 159; Woźniak 1990, 70; Biskup 1993, 104; Chodyński 2003, 76, 88; 2010, 126).

On the other hand, the castle of Kurzętnik is known to have been a seat of a burgrave in 1416-1426. In 1454 the castle was seized by the troops of the Prussian Union allied with Poland against the

Fig. 1. Kurzętnik cannon – a general view. *Photo by G. Żabiński*.

Ryc. 1. Puszka z Kurzętnika – widok ogólny. *Fot. G. Żabiński.*

Teutonic Order. In late October 1454 it was re-captured by the Teutonic troops which pulled the castle down and it was never rebuilt again (Biskup 1967, 278-288; Nadolski 1990, 116-120). Therefore, the cannon could find its way into the ground both in 1414 and 1454. This, however, does not oppose to the dating of the find to the early 15th c.

Description of the cannon

The cannon barrel consists of two clearly distinct parts, i.e., the chase and the powder chamber, with the latter being narrower in its external diameter (according to V. Schmidtchen, it was a typical feature of early stone ball cannons: Schmidtchen 1977a, 13; see also Müller 1968b, 17). The transition between both parts is additionally marked by three step-like faults. The entire barrel is encircled by six rings (three on the chase and three on the powder chamber), which are homogeneous part of the cast. The lowest ring near the bottom of the powder chamber forms a low semi-oval guard (or pan) of the touch hole. There are also two cross-shaped ornaments on both sides of the touch hole (Fig. 2:1). Interestingly, there is an iron or steel pipe in the touch hole (Fig. 2:2). This seems to match contemporary data from the Order's account books on purchases of steel touch-holes (e.g., AMH, 24, 28, 62, 143). The bottom of the chase is notably rounded, no doubt in order to better accommodate the cannonball (Fig. 3:1). There is a holder in the ornamental form of a twisted rope in the central part of the barrel, between the chase and the powder chamber (Fig. 4). It was originally used to lift the barrel with a crane in order to mount it on the stand or carriage. Based on a pre-1945 drawing and a photo (Figs. 3:1-2), the holder was provided with a ring. It did not survive until present. A similar feature is notable on a stone ball cannon as shown in a ca. 1400 German manuscript (*Anleitung, Schießpulver zu bereiten, Büchsen zu laden und zu beschießen*, Bayerische Staatsbibliothek, München, Cgm 600; see Schmidtchen 1977a, 15-17, Figs. 4-6; see also Możejko 2000, 173, Fig. 1). The muzzle is ornamented with a cast relief of the Holy Virgin with Child (Fig. 5). There is a notable chip on the muzzle (Fig. 6) and at the bottom of the cannon there is a lump of metal in its central part (Fig. 7). Both are in all probability traces of lost-wax (cire-perdue) casting. Based on these traces, it could be assumed that the cannon was cast muzzle-up. Traces of gas-holes are notable on the entire surface of the cannon (Fig. 8) (for a general description see also Grodzicka 1963, 7-8; Szymczak 2004, 104-105)[1].

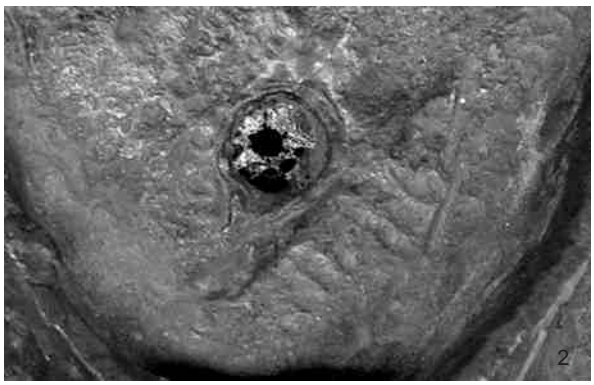
General metrical data of the cannon are the following:

– total weight – 42 kg 280 g; total length – 507 mm; chase's internal length – 225 mm; muzzle's external diameter – 171 mm; muzzle's internal diameter (calibre) – 135 mm; muzzle's thickness – 18 mm; powder chamber's internal

[1] It should be stressed that art historians, such as M. Woźniak and A. R. Chodyński, also date the cannon to the early 15th c. (Woźniak 1990, 70; Chodyński 2007, 388-389; 2010, 126).

Fig. 2. Kurzętnik cannon: 1 – the touch hole with its ornament; 2 – the iron or steel pipe in the touch hole. *Photo by G. Żabiński*.

Ryc. 2. Puszka z Kurzętnika: 1 – otwór zapłonowy z ornamentem; 2 – żelazna lub stalowa rurka w otworze zapłonowym. *Fot. G. Żabiński.*



length – 230 mm; powder chamber's external diameter – 131 mm; powder chamber's internal diameter – ca. 40 mm (see also Fig. 9); holder's length – 96 mm; holder's height – 61 mm; holder's thickness – 21 mm; touch hole's diameter – 5 mm; relief's dimensions – 98 x 58 mm;

– putative weight of the cannonball (granite) – ca. 3.5 kg (or ca. 2.5-2.6 kg, according to J. Szymczak 2004, 148, 163; see also Świętosławski 1993, 27-28);

– putative weight of the propellant charge: ca. 0.2 kg (based on a 1:19 proportion between the weight of the charge and the ball; Schmidtchen 1977a, 14; Szymczak 2004, 163). J. Szymczak says with right that the weight of the charge depended on the type of firearms and sort of gunpowder. E.g., the charge for the "Mons Meg" which launched 340 kg balls, was 38 kg, i.e., the proportion was ca. 1:10 (Szymczak 2004, 134-135, 143; 163-164, Tab. 10).

Classification of the cannon

The cannon can be classified as a *Steinbüchse*, i.e., a stone ball cannon. M. Grodzicka says that small stone ball cannons had a calibre of ca. 10-15 cm and medium stone ball cannons – ca. 25 cm. The Kurzętnik cannon would therefore fit into the former group. Concerning the relation of the calibre to the barrel length, this researcher says that the chase length was usually ca. 1 calibre and the powder chamber length was ca. 2.5 calibre. These proportions are ca. 1.5 and ca. 2.2 for the Kurzętnik cannon (using rough estimates of the external length of both parts) (Grodzicka 1963, 10). Similar data were also mentioned by V. Schmidtchen, based on cannonball diameters. He said that light stone ball cannons fired balls of ca. 12-20 cm in diameter, heavy cannons – of ca. 25-45 cm, while "gigantic" cannons (literally *Riesengeschütze*) fired projectiles of ca. 50-80 cm in diameter (Schmidtchen 1977a, 12; Głosek 1990, 157; Szymczak 2004, 144; Dąbrowska 2009, 39). Furthermore, he stated usual length proportions between the calibre, the chase and the powder chamber for early stone ball cannons as ca. 1:1-1.5 (calibre-chase) and ca. 1:2 (calibre-powder chamber) (Schmidtchen 1977a, 14).

The Kurzętnik cannon was often referred to as a bombard in previous scholarship. Obviously, the lack of preciseness of medieval sources' terminology must be borne in mind. K. Górski says

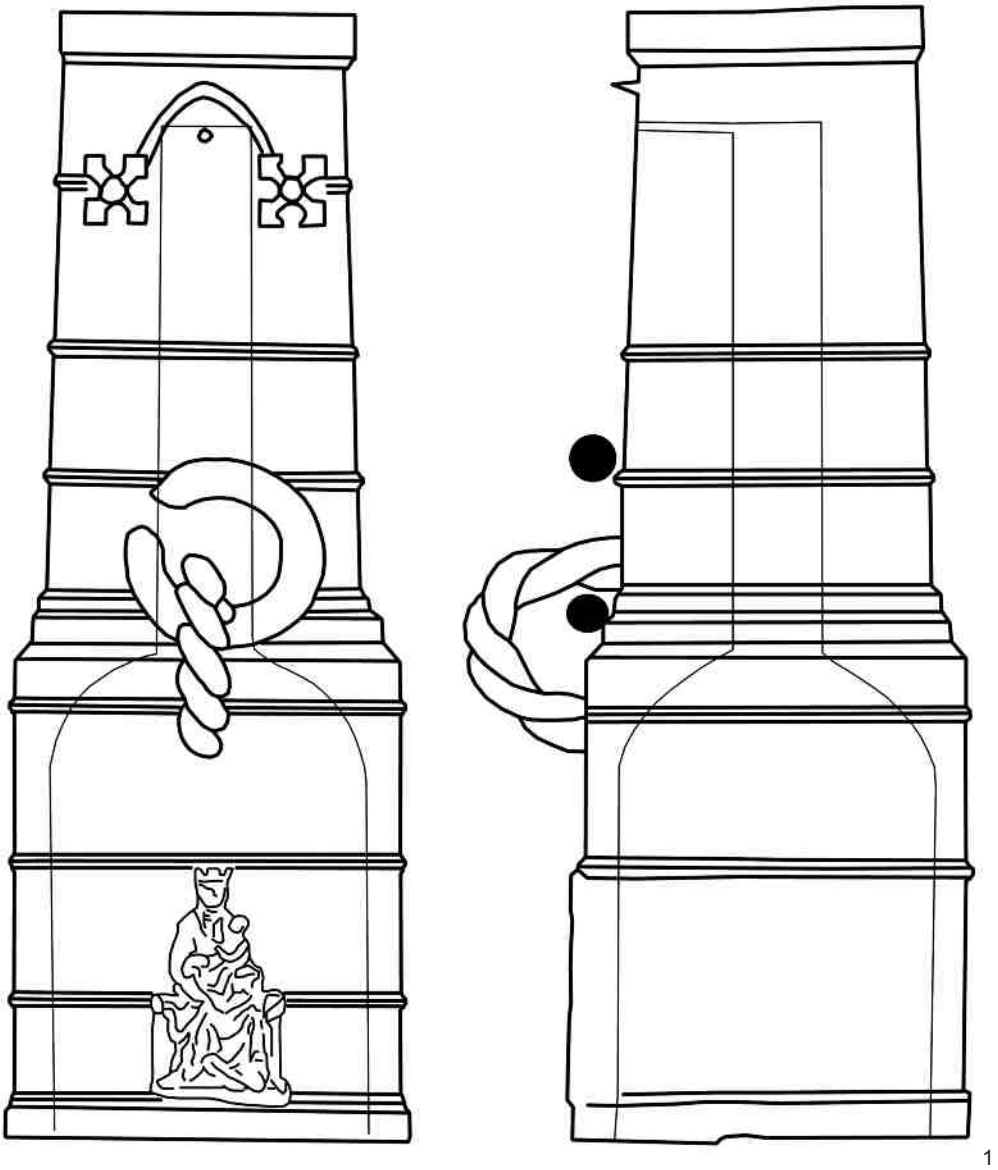


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Fig. 3. Kurzętnik cannon: 1 – a pre-1945 drawing; 2 – a pre-1945 photo (1 – *adapted by G. Żabiński*; 2 – after *Chodyński 2007, 388*).

Ryc. 3. Puszka z Kurzętnika: 1 – rysunek sprzed 1945 r.; 2 – fotografia sprzed 1945 r. (1 – *oprac. G. Żabiński*; 2 – wg *Chodyński 2007, 388*).

Fig. 4. Kurzętnik cannon – the holder in the central part. *Photo by G. Żabiński*.

Ryc. 4. Puszka z Kurzętnika – uchwyt w części środkowej. *Fot. G. Żabiński.*

Fig. 5. Kurzętnik cannon – the relief with the Holy Virgin on the muzzle. *Photo by G. Żabiński*.

Ryc. 5. Puszka z Kurzętnika – płaskorzeźba z wyobrażeniem Matki Boskiej przy wylocie lufy. *Fot. G. Żabiński.*

that the term bombard usually referred to siege artillery or wall-breaking cannons. He stresses, however, that early bombards resembled later mortars, with their broad muzzles, short chases and narrow powder chambers (Fig. 10) (Górski 1902, 22-23; see also Mielczarek 1998, 67).

As stressed with right by J. Szymczak, "bombard" could refer to many types of firearms, also including small handgonnes (Szymczak 2004, 31-34, 62-63). Interestingly, K. Górski maintained that the narrowness of the powder chamber was aimed at achieving a proper condensation in order to secure better explosive properties (Górski 1902, 23; see also Müller 1968b, 17). A similar feature is also notable for the Kurzętnik cannon. As V. Schmidtchen says, it was a common trait of early stone cannonballs. It facilitated a concentration of the impact of the explosion on the gravity centre of the ball and secured a better compression of the propellant (Schmidtchen 1977a, 14). Another type of early cannon was a terrace-gun (*Tarrasbüchse*), referring to small cannons deployed in castles' terraces. Originally, terrace-guns were placed on wooden trestles, which were equipped with "aiming brackets" (sort of a gunner's quadrant) or split-trail elevation devices in order to change the angle elevation if needed. At some point such cannons started to be equipped with wheeled carriages, which enabled their use in the field. J. Szymczak says that terrace-guns were not particularly heavy (he mentions examples of Wrocław (Breslau) barrels from 1427, which weighted ca. 143 kg) (Górski 1902, 16-19; Schmidtchen 1977a, 19, 21, Fig. 13; Mielczarek 1998, 69; Szymczak 2004, 53-55).

Another type of medieval cannon was *hufnica*. The term comes from Czech *houfnice*, and it literally meant a field cannon which was to accompany a *houf*, or a detachment of combatants. K. Górski says that it refers to cannons which fire projectiles at higher trajectories and at shorter distances. Such cannons, with muzzle diameters being broader than in the case of terrace guns and narrow powder chambers, were designed for firing at targets behind fortifications (Górski, 1902, 20; see also Głosek 1990, 157 and Mielczarek 1998, 70). It seems, however, that the definition by K. Górski is strongly influenced by a modern term *howitzer*, which etymologically derives from *houfnice*. On the other hand, he says with right that a wide-scale application of field artillery is to be attributed to Czech Hussites. They placed short barrel cannons on the carts of their wagon forts (Górski, 1902, 20-22; on some earlier examples of using firearms in open field battles in Western Europe see, e.g., McLachlan 2010, 14-18). J. Szymczak says that *houfnice* were light fields cannons, with the calibre up to 230 mm, with distinct chases and powder chambers. The former was usually ca. 1.5 calibre long and the entire barrel was usually 3.5-4 calibres long (it is worth noting that both proportions perfectly fit the Kurzętnik cannon). Such cannons

Fig. 6. Kurzętnik cannon – the chip on the muzzle. *Photo by G. Żabiński.*

Ryc. 6. Puszka z Kurzętnika – szczerba u wylotu lufy. *Fot. G. Żabiński.*

Fig. 7. Kurzętnik cannon – the lump of metal at the bottom. *Photo by G. Żabiński.*

Ryc. 7. Puszka z Kurzętnika – zbrylenie metalu w części dolnej. *Fot. G. Żabiński.*

were usually equipped with "aiming brackets" (split-trail elevation) and their powder chambers were considerably narrower than chases, in order to allow the combustion of the entire gunpowder load. *Houfnice* were originally transported on carts, but soon they were provided with wheeled carriages (Szymczak 2004, 60-61).

Bearing it all in mind, with particular reference to a relatively small size of the cannon, it seems justified to classify the Kurzętnik specimen as a light field cannon, close to the original meaning of *houfnice*. It would fit into the early 16th c. classification of cannons by Emperor Maximilian I, with light field cannons firing projectiles of over 5 lbs (see e.g. Chodyński 1996b, 57; for a similar classification from the 1530s see Górski 1902, 34).

Possible analogies

Based on the shape of the barrel and the proportions between the breech and the chase, some possible analogies to the Kurzętnik cannon may be proposed.

The Museum für Deutsche Geschichte in Berlin stores a cannon barrel of possibly Bosnian origin (inv. No. W 347; Fig. 16). It is clearly divided into the breech part and the chase part, although with no prominent difference in their external diameters. There are three rings along each part of the barrel, with the last one in the chase part being a double one. There are vertical holders on both parts. Interestingly, the bottom of the barrel was clearly broken during the explosion of the propellant while using the cannon. Based on this, it can be said that due to inaccuracies in the process of casting, a large air bubble originated in the bottom part. This clearly indicates that the cannon was cast muzzle-up, analogously to the Kurzętnik cannon. The total length of the cannon is 65 cm, with the chase being 28 cm long, the breech being 25 cm long and the bottom being 12 cm thick. The calibre is 14 cm, with the powder chamber diameter being 5.2 cm. The present weight of the cannon is 80.3 kg, which is twice as much as in the case of the Kurzętnik cannon, although the dimensions of both items are very similar. The Bosnian cannon can be dated to the turn of the 14th and the 15th c. (Müller 1968a, 12-13; id. 1968b, 37; *Burg* 2010a, 259, Fig. 14:33).

Another interesting item is stored in the collection of the Zeughaus in Berlin (Fig. 2). This cannon was made of iron bars, with a holder and an iron ring in its central part. The total length of the barrel is 80.5 cm, with the chase being 30.5 cm long. The calibre is 18.0 cm and the diameter of the powder chamber is 5.0 cm. The barrel rests on a two-wheeled carriage, which is provided with a simple split-trail elevation ("aiming bracket"). The cannon is dated to the 2nd half of the 15th c.

Fig. 8. Kurzętnik cannon – traces of gas-holes. *Photo by G. Żabiński*.

Ryc. 8. Puszka z Kurzętnika – ślady otworów po ulatnianiu się gazów. *Fot. G. Żabiński.*

(Smith, DeVries 2005, 310-311, No. 25 – with further reference).

Before World War I the Museum at the Schwarzburg Castle in Germany stored another cannon which is of interest as an analogy for the Kurzętnik find. It was a 60 cm long barrel, with the powder chamber being 24 cm long. The outer diameter of the barrel was 23 cm and of the powder chamber – 18 cm. The barrel was provided with two holders and a hook at the bottom. The total weight of the specimen was 157 lbs, i.e., ca. 65 kg (Diener-Schönberg 1907/1909, 347, Fig. 850). Regrettably, no data concerning the raw material or the calibre are known.

Fig. 9. Kurzętnik cannon – a frontal view. *Photo by G. Żabiński*.

Ryc. 9. Puszka z Kurzętnika – widok od przodu. *Fot. G. Żabiński.*

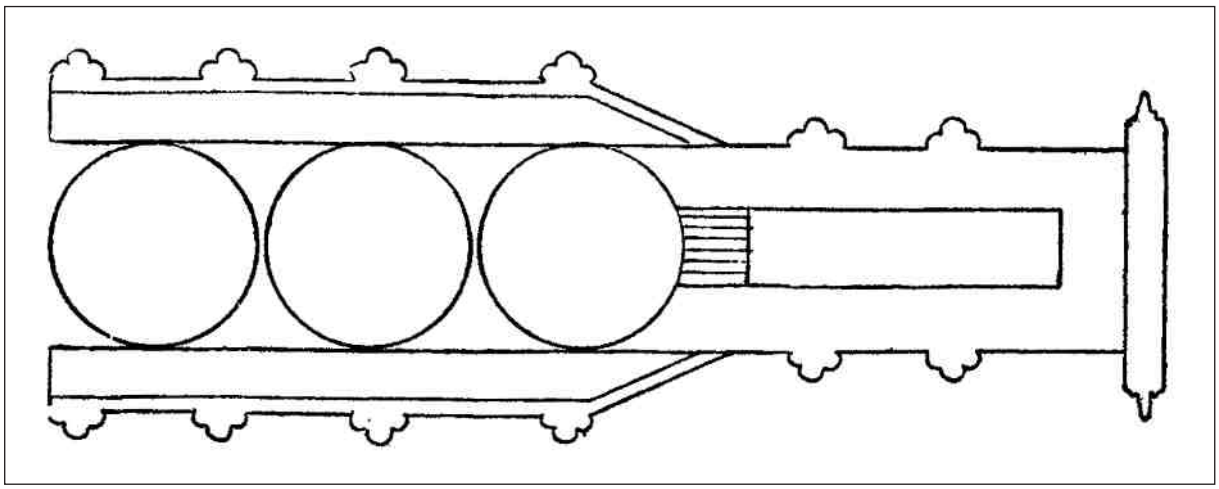


Fig. 10. Bombard (after *Górski 1902, 24, Fig. 6*).

Ryc. 10. Bombarda (wg *Górski 1902, 24, Fig. 6*).

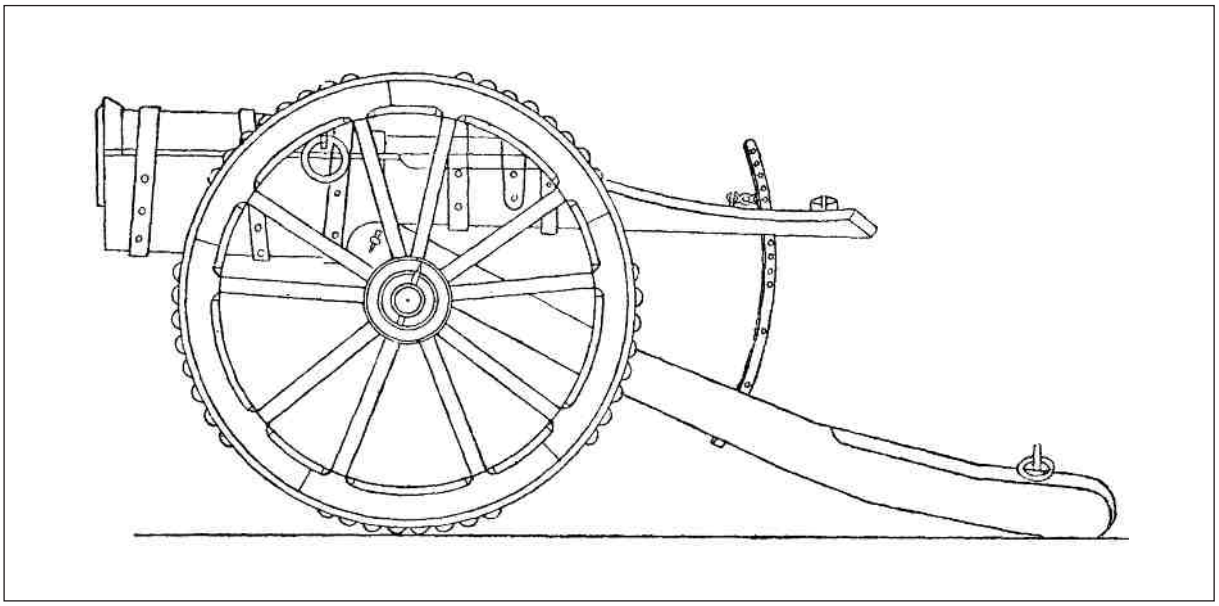


Fig. 11. Terrace-gun on a wheeled carriage with a split-trail elevation, the 15th c. (after *Górski 1902, 18, Fig. 2*).

Ryc. 11. Taraśnica na łożu kołowym z łukowym podnośnikiem celowniczym, XV w. (wg *Górski 1902, 18, Fig. 2*).

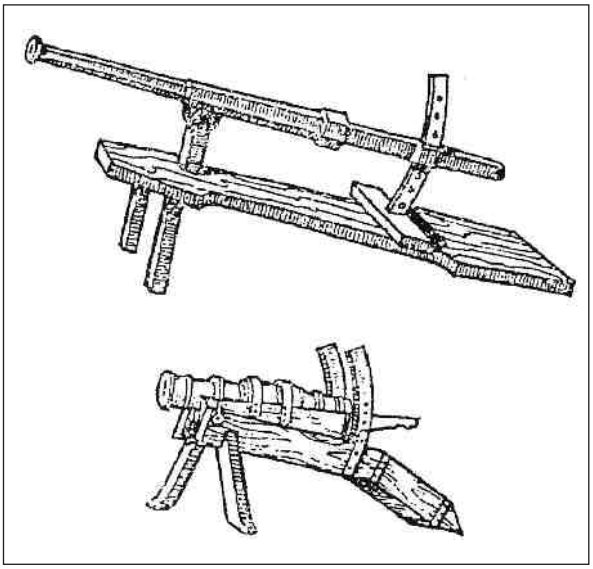


Fig. 12. Terrace-guns on trestles with split-trail elevations, the 15th c. (after *Szymczak 2004, 54, Fig. 12*).

Ryc. 12. Taraśnice na kozłach z łukowymi podnośnikami celowniczymi, XV w. (wg *Szymczak 2004, 54, Fig. 12*).

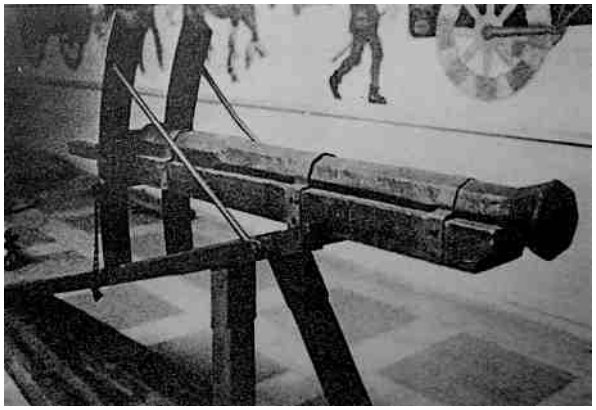


Fig. 13. Terrace-gun on a trestle with a split-trail elevation, the 15th c. (after *Schmidtchen 1977a, 21, Fig. 13*).

Ryc. 13. Taraśnica na koźle z łukowym podnośnikiem celowniczym, XV w. (wg *Schmidtchen 1977a, 21, Fig. 13*).

An iron cannon barrel (referred to as a *houfnice*) is stored in the collection of the Museum in Nový Bydžov in the Czech Republic (Fig. 17). The barrel is 54.5 cm long, with the calibre being 11 cm. Also in this case the chase (31 cm long) is broader than the breech (23.5 cm, with the diameter of the powder chamber being 7.0 cm). The entire cannon is additionally reinforced with iron bands. The bottom is 7.4 cm thick and there were two trapezoid hooks that were attached to the barrel. Their function was to strengthen the connection between the barrel and the base. The find is dated to the 1st quarter of the 15th c. (Drobná, Durdík 1975, 54, cat. No. 281).

Reconstruction of the carriage and the cannon's use

Carriage

It cannot be said with any reasonable certainty what kind of carriage was used for the Kurzętnik cannon. It may have been both a stationary trestle or a wheeled carriage (cf. Schmidtchen 1977a, 18-19; Szymczak 2004, 54, 61). The earliest cannons were either simply placed on the ground on small artificial mounds with their barrels being

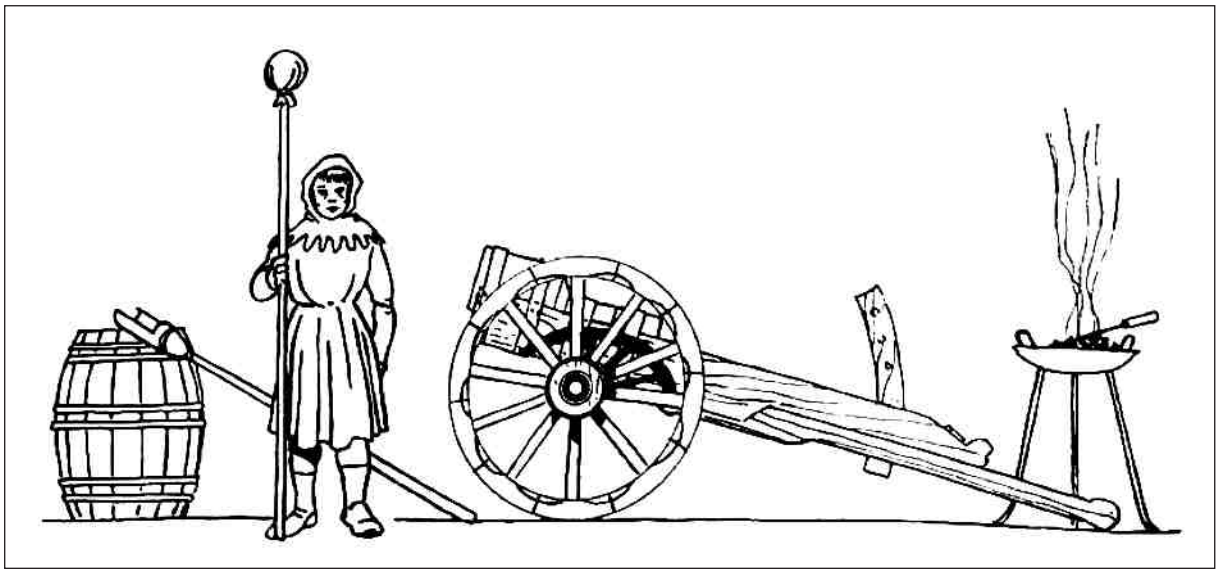


Fig. 14. *Houfnice*, late 14th – early 15th c. (after *Nowakowski 1988, 158*).

Ryc. 14. Hufnica, koniec XIV – początek XV w. (wg *Nowakowski 1988, 158*).

elevated at a proper angle, or were mounted on immobile stands, made of rectangular beams of timber (Figs. 18-19). In the early 15th c. such stands started to be provided with wheels, thus becoming carriages (Figs. 20-22).

In order to facilitate aiming, barrels started to be mounted on a beam which rested on another beam (trail). The barrel could be elevated using the "aiming bracket" (split-trail elevation) which was permanently attached to the lower beam and went through a slot in the upper one. The lower beam rested on a two-wheeled axis. Another device used for this purpose was a so-called screw elevation (Fig. 22). In the 1460s, a limber started to be attached with a pintle and a chain to the carriage. Due to this, a two-wheeled carriage became a four-wheeled transport cart, which essentially improved the cannon's maneuverability (Müller 1968b, 19, 33; Schmidtchen 1977a, 18-19; Goetz 1985, 37; Szymczak 2004, 61, 69-71; Smith, DeVries 2005, 310; *Burg* 2010a, 273).

With regard to the afore-mentioned holder with the now lost ring that can be seen on the pre-1945 photo of the Kurzętnik cannon, some words should also be said on lifting the cannon barrels. The simplest form was a tripod or a tetrapod stand with a system of compound pulleys (Schmidtchen 1977b, 68-69, Figs. 95-96). Another device was a lift in the shape of a large table, provided with a screw elevation. The barrel was hooked at the lower part of the screw and lifted by turning it (Schmidtchen 1977b, 69, Fig. 98; von Lindgren 2001, Fig. 1) (Fig. 24).

Use

Based on the afore-mentioned ca. 1400 German manuscript, V. Schmidtchen attempted at reconstructing the process of charging a stone ball cannon. He said that a wooden stopper had usually been placed in the powder chamber between the powder charge and the stone ball. Furthermore, the ball was additionally fastened in the chase with wooden wedges, and potential empty space in the case may have been filled with moist clay or sand. All this was to secure proper tightness and thus the most effective use of the explosion impact (Schmidtchen 1977a, 15-18; Szymczak 2004, 73-74; see also Müller 1968b, 19). Thereafter, ignition powder was poured into the touch hole and the cannon was ignited using a hot wire, a slow match or a linstock with a slow match (Szymczak 2004, 75) (Fig. 25).

Concerning the financial aspect of the use of the Kurzętnik cannon, it was assessed in the following way:

– stone cannonball (assuming a 2.6 kg ball) – 30 Denars
– propellant charge – ca. 26 Denars
– wooden stopper – ca. 4 Denars

Althogether ca. 60 Denars or 1/12 Mark (Świętosławski 1993, 28; Szymczak 2004, 163).

Firearms in the state of the Teutonic Order in Prussia to ca. 1410

The main bulk of data concerning the stores of firearms in the Teutonic Order's castles is contained in the Order's inventory books. It must

Fig. 15. Cannon barrel from Bosnia, late 14th – early 15thc. (1 – after *Burg 2010a, Fig. 14.33*; 2 – after *Müller 1968b, 37*).

Ryc. 15. Lufa działa z Bośni, koniec XIV – początek XV w. (1 – wg *Burg 2010a, Fig. 14.33*; 2 – wg *Müller 1968b, 37*).

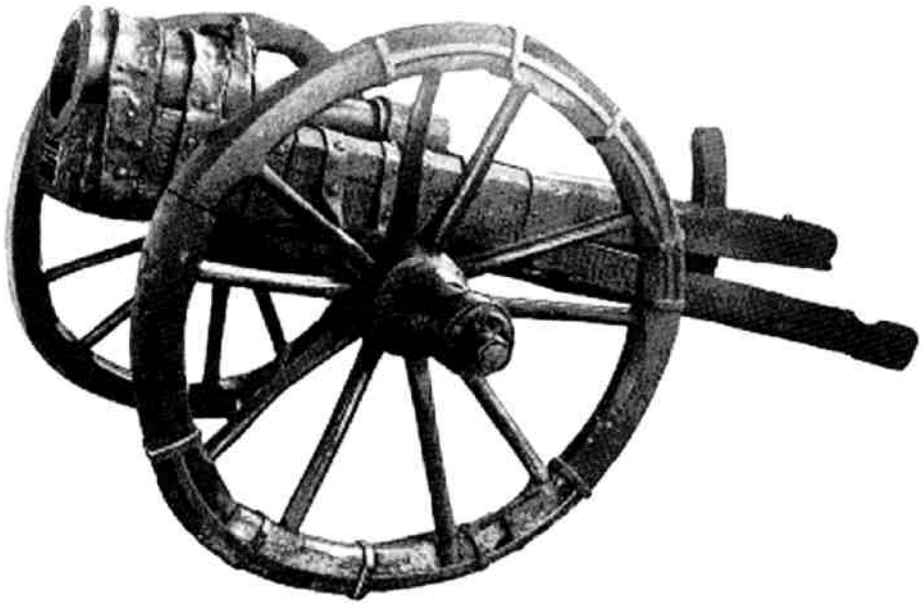


Fig. 16. *Houfnice* from the Zeughaus in Berlin, 2nd half of the 15th c. (after *Smith, DeVries 2005, No. 25*).

Ryc. 16. Hufnica ze zbiorów Zeughaus w Berlinie, 2. połowa XV w. (wg *Smith, DeVries 2005, No. 25*).

Fig. 17. *Houfnice* from the Museum in Nový Bydžov, c. 1400-1425: 1 – view from above; 2 – bottom part; 3 – muzzle part. *Photo by P. Strzyż* (not to scale).

Ryc. 17. Hufnica ze zbiorów muzeum w Novým Bydžovie, ok. 1400-1425 r.: 1 – widok z góry; 2 – część denna; 3 – wylot lufy. *Fot. P. Strzyż* (bez skali).

be said, however, that these sources also have their limitations. There were no steady patterns of recording the stores, although later inventories were usually organised along the principle of a given room with its resources. The terminology was often incoherent. Changes in the structure and contents could both reflect actual rearrangements and different attitudes of scribes. Sometimes the inventories may have been based on other records and not on the eyewitness' inspection. All in all, it seems that the inventories were strongly influenced by personal attitudes and preferences of their authors (see, e.g., GÄDO, XVIII, editorial remarks by W. Ziesemer; Schmidtchen 1977a, 24, 30, 32-34, 40; Chodyński 1978, 8; Nowakowski 1986, 74-75, 90; 1991, 75; Żabiński 2011; forthcoming).

The first mention of firearms in the Order's inventory books comes from 1374, when three *buchsen* were mentioned at Lipienek (Leipe) (GÄDO, 558; Schmidtchen 1977a, 26; Nowakowski 1991, 84). Mentions in narrative sources are somewhat earlier. The early 15th c. chronicle of Johann Posilge mentions the use of firearms in Spring 1362, during the siege of Kaunas (Kowno) by the Teutonic troops. He says that these guns were not *groszin steynbuchszen*, but *lothebuchszen* only (Posilge 1866, 81-82; Schmidtchen 1977a, 24; Głosek 1990, 156). Mentions in the late 14th c. chronicle of Wigand of Marburg concern military expeditions to Lithuania in the 1380s and 1390s and record the use of firearms (*bombardae*, *pixides*) in siege warfare both by the Order and the Lithuanians (Wigand of Marburg 1863, 599, 601, 613, 618-619, 622, 627, 632, 646-649, 654-660; see also 719; *Franciscani Thorunensis Annales* 1866, 115, 126-127). Wigand sometimes offers more details: e.g., under 1383 he says of destroying the walls of the Trakai (Troki) castle with *sagittis* projected with bombards; *sagittae bombardarum* were also used by Duke Švitrigaila (Świdrygiełło) when defending Old Kaunas (Stare Kowno) in 1385 against the Order (Wigand of Marburg 1863, 622, 632). The verb *sagittare* is also used in relation to a Teutonic great bombard (*magna bombarda*) used during the siege of Marienwerder by the Lithuanians in 1384. This verb was also used in

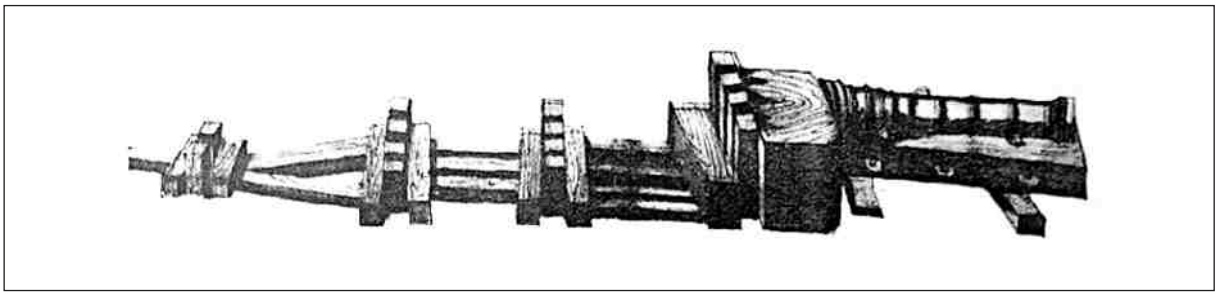


Fig. 18. Heavy bombard on an immobile stand (after *Schmidtchen 1977a, 19, Fig. 8*).

Ryc. 18. Ciężkie działo na nieruchomym łożu (wg *Schmidtchen 1977a, 19, Fig. 8*).

Fig. 19. Heavy bombard on an immobile stand, Wigand Gerstenberg, *Landeschronik von Thuringen und Hessen*, Kassel, Ms Hass 115, late 15th c. (after *Burg 2010a, 273*).

Ryc. 19. Ciężkie działo na nieruchomym łożu, Wigand Gerstenberg, *Landeschronik von Thuringen und Hessen*, Kassel, Ms Hass 115, koniec XV w. (wg *Burg 2010a, 273*).

Fig. 20. Cannon on a wheeled stand, the 15th c. (after *Szymczak 2004, 70, Fig. 17*).

Ryc. 20. Działo na łożu kołowym, XV w. (wg *Szymczak 2004, 70, Fig. 17*).

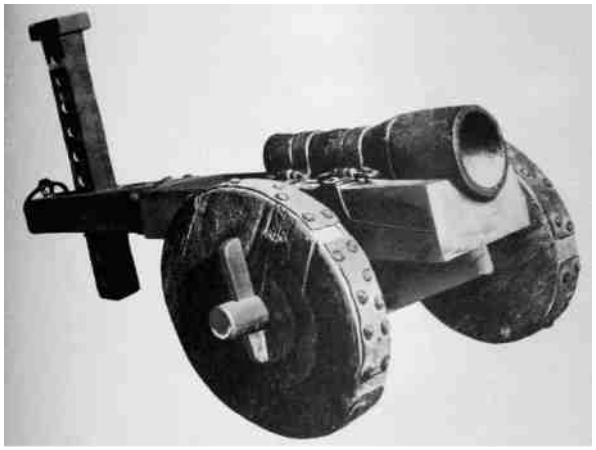


Fig. 21. Cannon on a wheeled stand with elevation, Italy, the 15th c. (after *Goetz 1983, 37*).

Ryc. 21. Działo na łożu kołowym z podnośnikiem celowniczym, Włochy, XV w. (wg *Goetz 1983, 37*).

a relation of the siege of Old Grodno by Duke Vytautas in 1392, as well as under 1394 during the siege of Vilnius (Wilno) (*ibidem*, 629, 648, 660; see also *Franciscani Thorunensis Annales*, 135). This attracts special attention, as it may imply that the term *sagitta* stood for a gun projectile in general. This issue is dealt with below, when discussing the use of bolts for guns. *Lapides bombardarum* are mentioned under 1393 during the siege of Grodno by the Teutonic army and under 1394 during the Teutonic siege of Vilnius (Wilno) (Wigand of Marbug 1863, 649, 659-660; see also *Franciscani Thorunensis Annales* 1866, 127). Shutters (*protecticula*, *propugnacula*) protecting siege cannons are also mentioned concerning the latter siege (Wigand of Marburg 1863, 659-600) (Fig. 26).

According to the continuator of the chronicle of Johann von Posilge, a large cannon was cast at Marienburg in Summer 1408 (Teutonic account

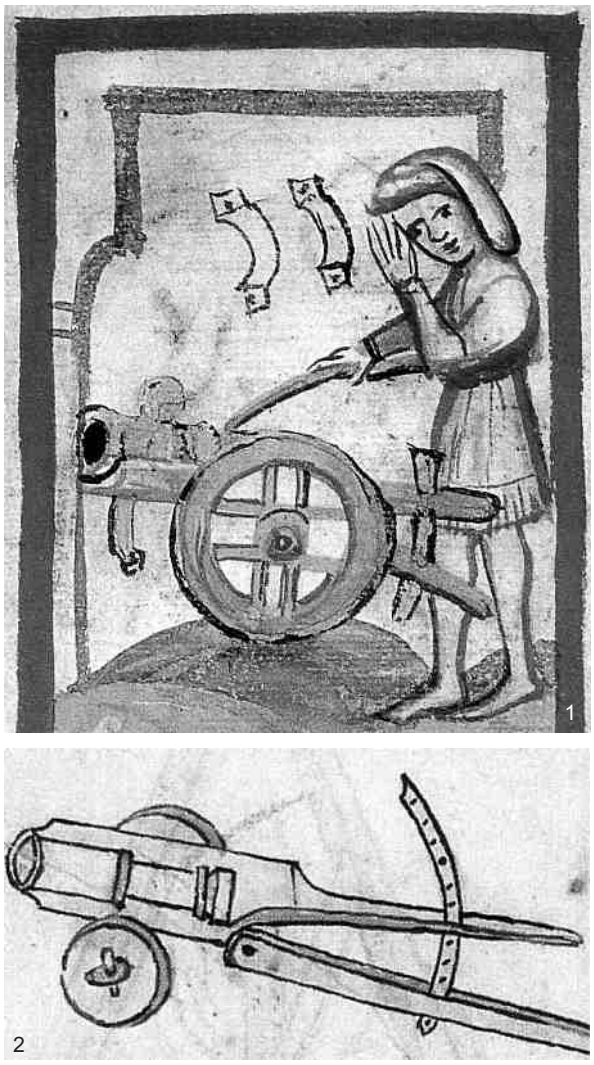


Fig. 22. Cannons on wheeled carriages with split-trail elevations: 1 – Cgm 600, f. 6v, Bayerische Staatsbibliothek, München, 1410/1420; 2 – Anonymous, *Das Buch von der Büchsenmeisterei*, Germanisches Nationalmuseum, Nürnberg, Hs 719, 1462/1463 (1 – after *Tittmann 2001, Fig. 15*; 2 – after *Burg 2010b, Fig. 6.42.a*).

Ryc. 22. Działa na łożach kołowych z łukowymi podnośnikami celowniczymi: 1 – Cgm 600, f. 6v, Bayerische Staatsbibliothek, Monachium, l. 1410/1420; 2 – anonim, *Das Buch von der Büchsenmeisterei*, Hs 719, Germanisches Nationalmuseum, Norymberga, 1462/1463 r. (1 – wg *Tittmann 2001, Fig. 15*; 2 – wg *Burg 2010b, Fig. 6.42.a*).

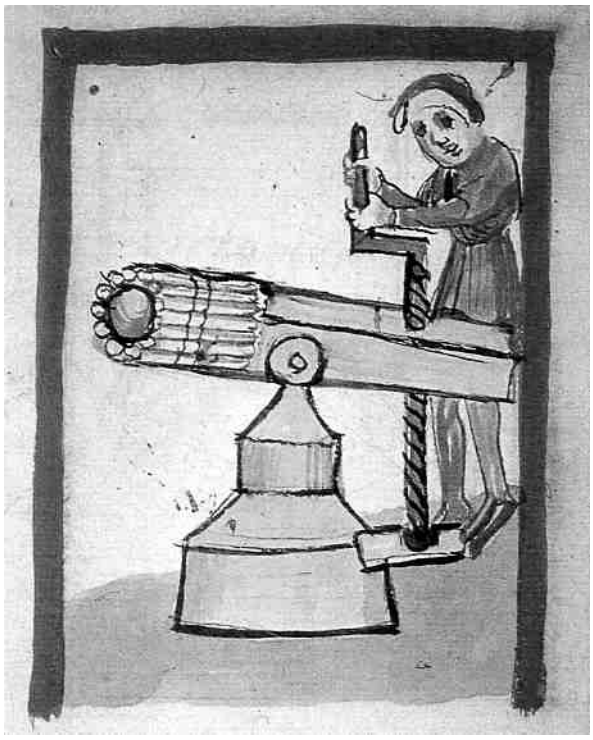


Fig. 23. Screw elevation device. Cgm 600, f. 16v, Bayerische Staatsbibliothek, München, 1410/1420 (after *Tittmann 2001, Fig. 10*).

Ryc. 23. Śrubowy podnośnik celowniczy. Cgm 600, f. 16v, Bayerische Staatsbibliothek, Monachium, l. 1410/1420 (wg *Tittmann 2001, Fig. 10*).

books record casting of huge cannons under 1408 and 1409). The chronicle says that it consisted of two parts and it was so huge that no parallel one could be found in Germany, Poland or Hungary (Posilge 1866, 292; Schmidtchen 1977a, 46; Świętosławski 1993, 28; Nowakowski 1994b, 334; Szymczak 2004, 185; Chodyński 2007, 389).

This cannon was possibly comparable in size to Europe's largest guns (Figs. 27-29), such as the "Dulle Griet" of Ghent (calibre 640 mm; length over 5 m; weight 16.4 t; cannonball weight 340 kg), the "Swine" of Świdnica (Schweidnitz) from ca. 1467 (calibre ca. 500 mm; weight ca. 8.5 t); the "Mons Meg" of Edinburgh from 1449 (weight ca. 6 t) (Müller 1968b, 28; Goetz 1985, 26, 48; Szymczak 2004, 63, 81, 108); the early 15th c. Austrian "Großer Pumhart von Steyr" (Schmidtchen 1977a, 10, Fig. 1); the "Feule Mette zu Braunschweig" from 1411 (weight ca. 8.75 t) (Müller 1968b, 28; Schmidtchen 1977a, 13, Fig. 3). This issue is discussed below, based on available account sources.

Data from Teutonic account books for the period in question (i.e., *Das Marienburger Tresslerbuch der Jahre 1399-1409*, henceforth as: MTB) may roughly be divided into four groups:

– personnel – mostly expenses on salaries of master gunners and their assistants; costs of their travels; gifts for them and the like

– guns – expenses related to casting, forging, purchase and repair of firearms, including gun stocks, trestles, carriages and wagons; purchase of raw materials and necessary tools; transportation costs of raw materials and ready guns; manufacture-related salaries,

– projectiles – analogously to guns

– gunpowder – as above

– other – transportation costs not directly related to manufacture (e.g., during military

Year	Aim	Cost Mark	Cost Ferto	Cost Scot	Cost Den	Cost Mark	Cost Ferto	Cost Scot	Cost Den	MTB
1399	Personnel	40								14
	Total					**40**				
1400	Personnel	5								74
	Total					**5**				
1401	Personnel	6.5	1							99, 116, 117, 119, 121, 127
	Guns (20)	60.5	0.5		12					99, 119, 120, 140
	Projectiles	47		2	24					116, 117, 119-120, 127
	Gunpowder	419	1	1						118-119, 126-127
	Other	4	1							99, 127
	Total					**538**		**1**	**6**	
1402	Personel	22	1	2						158, 171-172, 181, 190-190, 198, 202, 215
	Guns (2)	9	1							201, 217
	Projectiles	9	1							183, 194
	Gunpowder	10								172, 217
	Other	6		23	20					193
	Total					**57**	**3**		**20**	199
1403	Personel	65			4					225, 229, 233, 239, 245, 248, 250, 252, 257, 259, 269, 270, 273, 283
	Guns (2)	21.5		11.5						217, 247
	Projectiles	36.5	8.5							212, 232, 246-248
	Gunpowder									
	Other	2.5		7	10					239, 247
	Total					**128.5**		**0.5**	**14**	
1404	Personnel	51								299, 303, 305, 308, 310, 311, 315, 317, 324, 336
	Guns (1)	9								309
	Projectiles		0.5							326
	Gunpowder	190.5		9.5						287, 307, 321
	Other	13								311
	Total					**264**		**0.5**		
1405	Personnel	10								341, 365
	Guns (4)	9.5			72					339
	Projectiles			13	12					364
	Gunpowder	172.5		15	66					345, 348, 352
	Other	4	1	1	12					364
	Total					**196**	**1**	**29**	**162**	
1406	Personnel	104								384-385, 401, 408
	Guns									
	Projectiles									
	Gunpowder	54.5	1	1	24					381, 383
	Other									
	Total					**158.5**	**1**	**1**	**24**	
1407	Personnel	23								430, 439-440
	Guns									

	Projectiles	0.5			5					446
	Gunpowder	6.5		1	24					446
	Other		5							428
	Total					**31**	**1**	**1**	**29**	
1408	Personnel	45.5								470, 474, 478-479, 483, 487-488, 495, 500, 510, 514
	Guns									
	Large cannon (*grose bochse*) (1)	784								480, 483, 496, 501-502, 506-507
	Other (3)	94.5		3	25					502, 511, 515
	Total guns					878.5		3	25	
	Projectiles	7	4.5	12						495, 497, 511
	Gunpowder	835		22	1					480, 482, 497, 507, 514
	Other	22								464, 493, 511
	Total					**1791**		**4**	**26**	
1409	Personel	104.5		7						524, 536, 546, 553-554, 562, 574, 576-579, 579-580, 582, 584-585, 587-588, 597
	Guns									
	Second largest cannon (*bochse nest der grosen*) (1)	288		10.5	9					557-558, 574, 577, 597
	Long cannon (*lange bochse*) (1)	121.5	1	3	24					554, 573, 590, 591
	Small long cannon (*cleyne lange bochse*) (1)	69		10	8					559
	Other (4)	52		1						525, 544, 547, 558, 573-574, 579, 583, 597
	Total guns					531.5	1	1.5	11	
	Projectiles	108.5		6	8					523, 532, 556, 559, 571-572, 584, 596-597
	Gunpowder	1807.5		2	28					525, 573-574, 583, 587, 596-597
	Other	101	3	3	26					555, 559, 572-574, 579-580, 582, 588-591, 596-597
	Total					**2550**		**2.5**	**13**	
	TOTAL	**5866.5**	**1**		**9**					

Tab. 1. Expenses on firearms in *Das Marienburger Tresslerbuch der Jahre 1399-1409*.[2]

Tab. 1. Wydatki na broń palną w *Das Marienburger Tresslerbuch der Jahre 1399-1409*.

expeditions); manufacture and purchase of other equipment and tools for firearms, such as caissons, ladles, gunpowder measures, etc.

The expenses in the period of 1399-1409 are presented in table (tab. 1). The total expenses per year may be calculated in various ways, as some works contracted in one year were paid for in the following year. Furthermore, it is difficult to precisely establish the number of manufactured guns, as in some cases only the amount of raw material was stated. Therefore, in some cases there is no simple relation of the number of manufactured guns and the total expenses on guns (including raw materials, repairs, fitting, etc.). For a similar reason, quantities of gunpowder and projectiles are not presented in the table.

[2] Mark = 4 Ferto = 24 Scot = 720 Denars (see also Rathgen 1922, 22-34 for an extract from the *Tresslerbuch*).

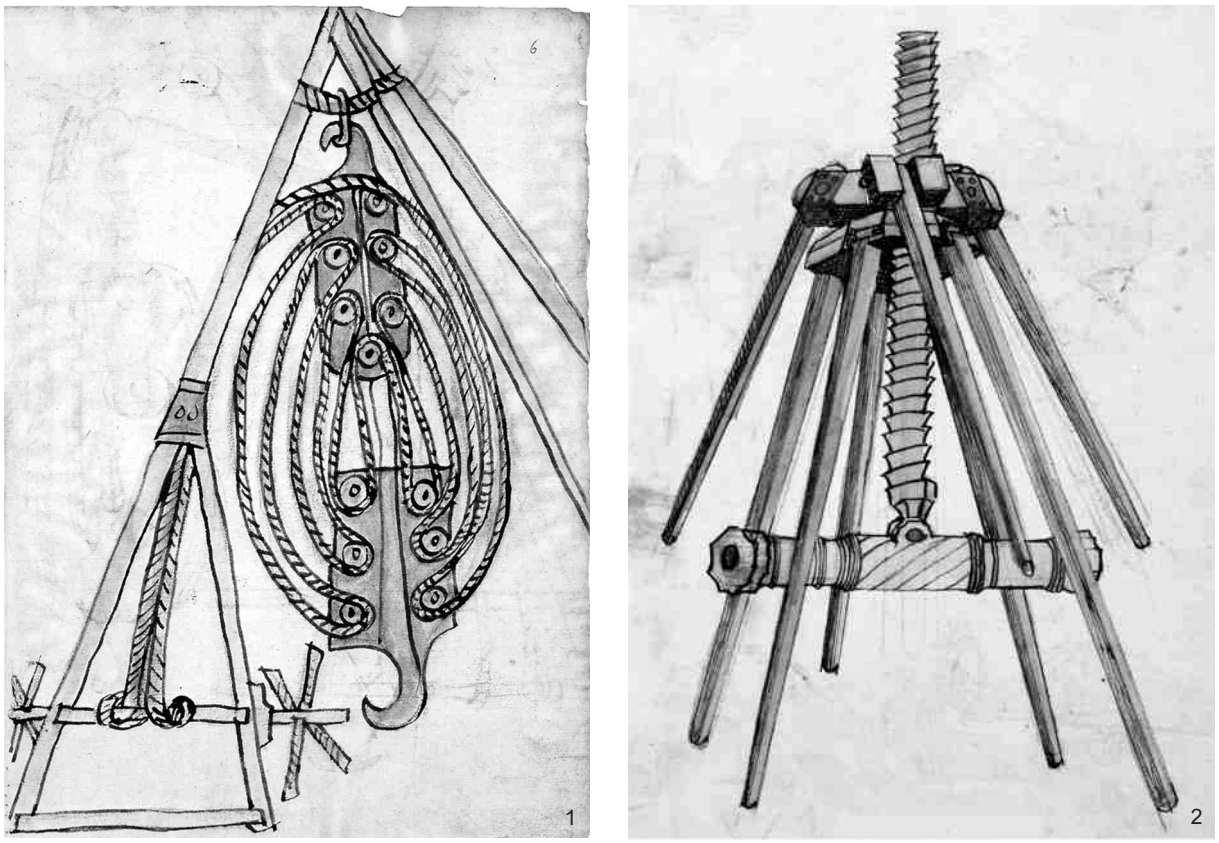


Fig. 24. Devices for lifting the cannon barrels: 1 – Clm 197, Bayerische Staatsbibliothek, München, c. 1440; 2 – Philip Mönch, *Kriegsbuch*, 1496, Cod. Pal. Germ. 126, f. 22r. Universitätsbibliothek, Heildelberg.

Ryc. 24. Urządzenia do podnoszenia luf działowych: 1 – Clm 197, Bayerische Staatsbibliothek, Monachium, ok. 1440 r.; 2 – Philip Mönch, *Kriegsbuch*, 1496, Cod. Pal. Germ. 126, f. 22r. Universitätsbibliothek, Heildelberg.

An enormous increase of the expenses before the Great War (1409-1411) is striking (cf. Schmidtchen 1977a, 18-27; Nowakowski 1988, 94; id. 1994b, 335; Szymczak 2004, 185). In 1408, the structure of expenses was clearly dominated by costs of casting of the large cannon and manufacture of gunpowder. In 1409, however, costs of gunpowder came to the foreground, which is not surprising as the war broke out in August of that year.

A detailed discussion of the structure of expenses is beyond the scope of the present paper. It is worth, however, making some brief comments on selected issues. First, the expenses on firearms can be compared with the rough sum of total expenses of the Order's treasurer in a given year:

– 1400: total expenses – 24000 Marks (MTB, 89); firearms – 5 Marks (0.02%);

– 1401: total expenses – 18500 Marks (MTB, 130); firearms – 538 Marks (2.9%);

– 1402: total expenses – 33900 Marks (MTB, 203); firearms – 58 Marks (0.17%);

– 1403: total expenses – 39600 Marks (MTB, 278); firearms – 128.5 Marks (0.39%);

– 1404: total expenses – 37700 Marks (MTB, 328); firearms – 264 Marks (0.7%);

– 1405: total expenses – 12300 Marks (MTB, 369); firearms – 196 Marks (1.59%);

– 1406: total expenses – 17400 Marks (MTB, 410; firearms – 158.5 Marks (0.91%);

– 1408: total expenses – 25800 Marks (MTB, 515); firearms – 1791 Marks (6.94%);

– 1409: total expenses – 62100 Marks (MTB, 598); firearms – 2550 Marks (4.1%).

Concerning some more interesting examples, the following ones could be mentioned (see also Schmidtchen 1977a, 75-77):

– the salary of 40 Marks for Engilhard the master gunner in 1399 (MTB, 14) was comparable to 30 Marks paid to a painter for two paintings (MTB, 5) or 38 Marks paid for six horses for the Grand Master (MTB, 27);

– 24 Marks were paid in 1401 for 12 iron guns (MTB, 119; Schmidtchen 1977a, 62; Świętosławski 1993, 22). More than 26 Marks were spent on building and repair works in Stuhm (Sztum) (MTB, 94-95); 21.5 Marks were paid to

a painter for painting seven banners and some other works (MTB, 103); 29.5 Marks were spent on six horses, given to the Samogitians (MTB, 105); 20 Marks were paid for one horse for the Grand Hospitaller (MTB, 109);

– 5 Marks were paid in 1402 for making 40 stones (ca. 550.8 kg) of gunpowder in Marienburg (Malbork) (MTB, 172). More than 4.5 Marks were spend on five mail coifs (*hundiskogeln*) (MTB, 147) and 4 Marks were paid for Klaus the veterinary surgeon for his service (MTB, 165);

– 13 Scot were paid in 1405 for 100 gun stoppers (*pfroppen*) (MTB, 364; Świętosławski 1993, 26). The same sum was spent on two saddles for the Grand Master (MTB, 335);

– the total cost of manufacture of the large cannon of 1408 can be estimated at 784 Marks (MTB, 480, 483, 496, 501-502, 506-507). A comparable sum of almost 991 Marks was spent on sending a detachment of 2 brethren-knights and 100 armed men to Livonia (MTB, 492).

Concerning the personnel, with special reference to master gunners, it can be said with reasonable certainty that most of them were burghers from the Teutonic Order's state (MTB, 588: Nicolaus and Peter Balen from Elbing (Elbląg), Andris from Marienburg (Malbork); MTB, 554, 583, 578, 587: Peter Werderer, Werner von Berge and Sweczer from Gdańsk (Danzig); see also Schmidtchen 1977a, 47). Some of them may have been foreigners, such as Hannus Missener (MTB, 245, 248, 250, 259, 384), an unnamed master gunner from Neumark (MTB, 311), or Hermann Hutter from Braunschweig (MTB, 588-589). Most interestingly, some members of the Order possessed enough technological skills to act as master gunners, as the brethren-knight Johann of Christburg (Dzierzgoń), who inspected the casting of the large cannon in 1408 (MTB, 479, 483, 510; Schmidtchen 1977a, 53) and was also mentioned in 1409 (MTB, 587: *her Johann dem herren von Cristburg, der mit der bochsen schuwest*; ibid., 574; Schmidtchen 1977a, 46, assumes that he may have been identical with Johann von Rumpenheym, Commander of Elbing (Elbląg) in 1339-1404; see also Nowakowski 1994b, 334). Another brethren-knight Kulman was mentioned in 1409 with regard to gunpowder manufacture (MTB, 587). The most prominent master gunner was no doubt Heinrich Dumechen (also referred to as bell-founder), who was mentioned on several occasions related to casting of guns, gunpowder manufacture and military campaigns (MTB, 511, 553, 558, 572-574, 576, 588, 591; Schmidtchen 1977a, 58, 60-61). At one occasion in 1409 the account book recorded

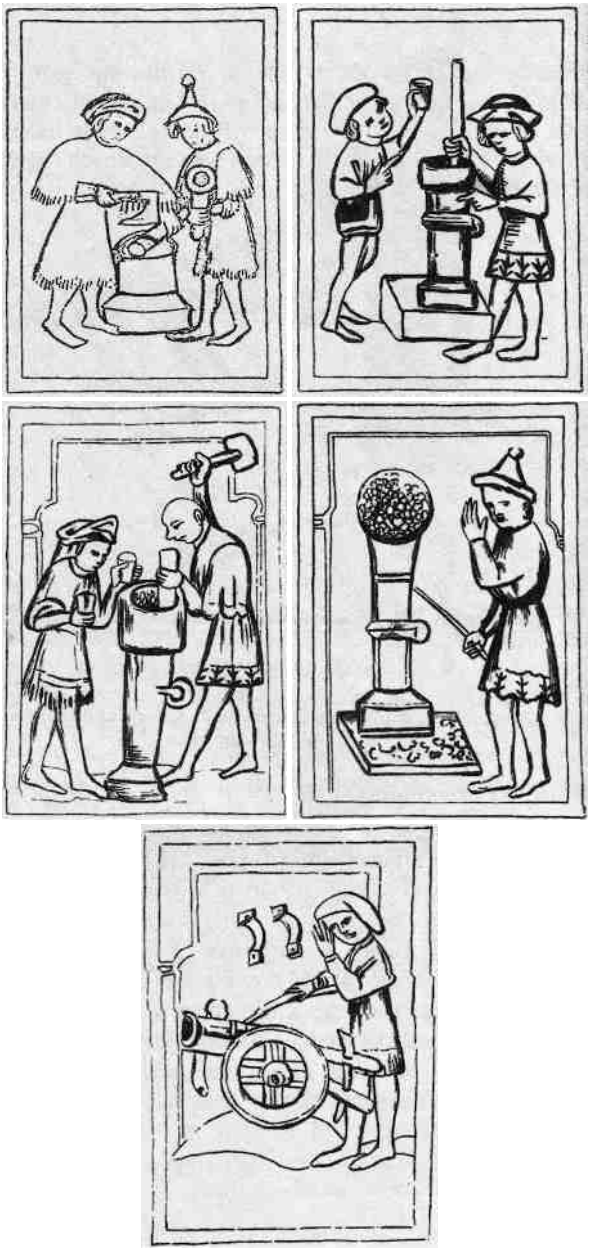


Fig. 25. Charging the cannon. Cgm 600, Bayerische Staatsbibliotke, München (after *Szymczak 2004, 74, Fig. 20*).

Ryc. 25. Ładowanie działa. Cgm 600, Bayerische Staatsbibliotke, Monachium (wg *Szymczak 2004, 74, Fig. 20*).

the participation of his wife in gunpowder manufacture in Elbing (Elbląg) (MTB, 587; Schmidtchen 1977a, 48; Nowakowski 1988, 94; id. 1994b, 335; Szymczak 2004, 140). The fact that many master gunners were also bell-founders is not surprising, based on technological relation between both trades (e.g., MTB, 215, 217, 269, 305, 547; Schmidtchen 1977a, 56).

Furthermore, attention is drawn to a variety of tasks they performed: direct participation in military activities (e.g., MTB, 172, 562, 574,

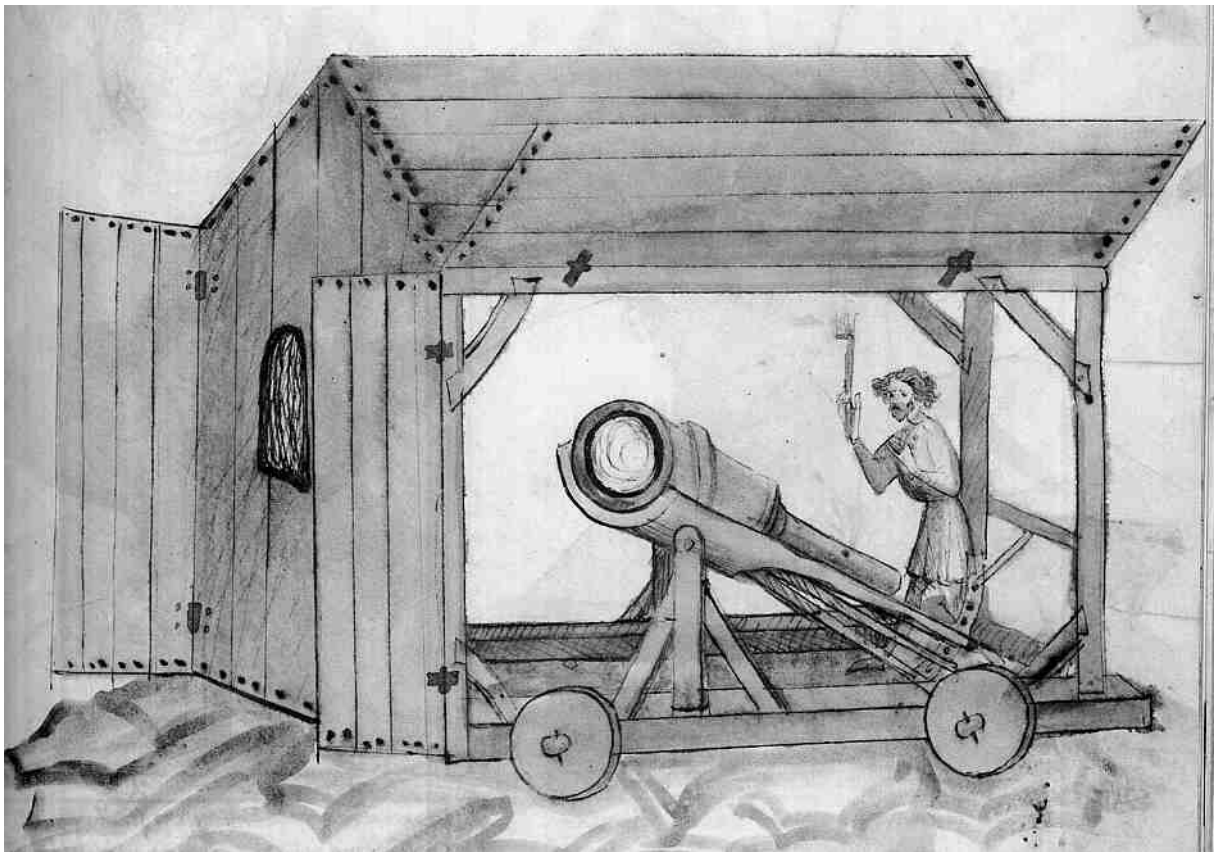


Fig. 26. Cannon in a shutter (after *Kyeser c. 1405, f. 108r*).

Ryc. 26. Działo w osłonie (wg *Kyeser c. 1405, f. 108r*).

576-579, 588-589), casting of alloy guns (e.g., MTB, 217, 479, 483, 502, 510, 547, 554, 559, 590-591; Schmidtchen 1977a, 53-54, 56, 60, 61) (as iron guns were made by smiths, e.g., MTB, 119, 502, 574; Schmidtchen 1977a, 62; Nowakowski 1988, 94; Szymczak 2004, 80, 105, 185), manufacture of gunpowder (e.g., MTB, 172, 217, 587; Schmidtchen 1977a, 47), casting of lead bullets and manufacture of incendiary bolts (MTB, 466, 587), or securing gun utensils (MTB, 572).

As it can be seen based on Teutonic registers of stores of weaponry until 1410, the terminology concerning firearms and other pertinent resources (gunpowder and ammunition, utensils) is not very precise (see Appendix 1; cf. Schmidtchen 1977a, 43-46). Guns are usually referred to as *steynbuchsen* or *lotbuchsen* only, occasionally with some general mention on their size (great – medium – small). It is only in exceptional cases that more precise data are given. These, however, can be completed with more detailed data from the account books:

– bolt guns (*pflilbuchsen*) (Appendix 1:3);

– gun bolts (*bochsenpfile*) (Appendix 1:17, 1:22; on such guns see, e.g., Szymczak 2004, 31, Fig. 1; ibid., 144, 301, Fig. 43);

– a small cannon which launches stone balls of a fist's size (*buchse dy schuest eynen steyn eyner fuest gros*) (Appendix 1:3; Rathgen 1922, 10);

– stone ball cannons which launch balls of a man's head size (*buchse die eynen steyn schut zo gros als eyn heupt*) (Appendix 1:13; see also Rathgen 1922, 9; Szymczak 2004, 147; Nowakowski 1988, 94)

– iron guns (*yserynne buchsen*) (Appendix 1:13; on such guns, made of bars of wrought iron that were assembled together using vertical hoops and bands, see, e.g. Smith 2000; Szymczak 2004, 79-83). In 1401, 24 Marks were paid to Molner the smith for making 12 such guns in Marienburg (Malbork) (MTB, 119; Schmidtchen 1977a, 62; Nowakowski 1988, 94; id. 1994b, 334; Świętosławski 1993, 22; Szymczak 2004, 80, 185). In 1404, 9 Marks were paid form one gun with three powder chambers. As the money was paid upon the request of the smithing master, it can be assumed that it was an iron gun. The cannon was used in the military expedition to Gotland (MTB, 309; Schmidtchen 1977a, 63; Świętosławski 1993, 22; Nowakowski 1994b, 335; Szymczak 2004, 107, 286). In 1408, 8 Marks were paid for the manufacture of *eyne*

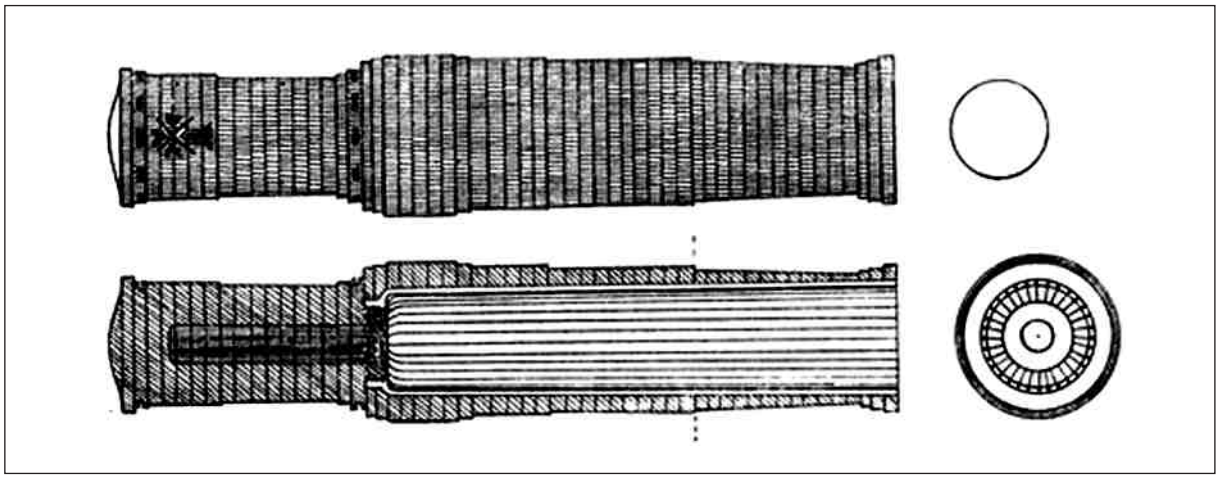


Fig. 27. Dulle Griet (after *Żygulski jun. 1975, 123, Fig. 65a-b*).

Ryc. 27. Dulle Griet (wg *Żygulski jun. 1975, 123, Fig. 65a-b*).

yserynne steynbochse in Marienburg (Malbork) (MTB, 502; Schmidtchen 1977a, 62; Świętosławski 1993, 22; Szymczak 2004, 80, 105);

– iron lead bullet guns (*yserynne lotbuchsen*) (Appendix 1:9, 1:20);

– small red brass lead bullet guns (*cleyne erynne lotbuchszen*) (Appendix 1:20).

With regard to cast alloy guns, the matter is more complex, as it is not always possible to precisely reconstruct the content of alloy. Such a detailed analysis is anyway beyond the scope of this paper. Some selected examples would include:

– six guns with a total weight of 15 Zenteners (ca. 729 kg, i.e., ca. 121.5 kg each, assuming their equal weight), cast in Marienburg (Malbork) in 1401, with a total cost of raw materials being 15 Marks (MTB, 120; Schmidtchen 1977a, 54);

– in 1402, 2 Marks and 3 Ferto were paid for re-casting of two alloy guns in Marienburg (Malbork) (*vor 2 buchsen von nuwes wider zu gyssen*) (MTB, 201; Schmidtchen 1977a, 55; Świętosławski 1993, 21);

– in 1403, 4 Marks were paid for casting of two guns in Marienburg (Malbork). Each consisted of four parts (i.e., these were veuglaires) and their total weight was 4 Zenteners 20 lbs (ca. 202.5 kg) (MTB, 217; Schmidtchen 1977a, 55-56; Świętosławski 1993, 22; Szymczak 2004, 107; on veuglaires see also Goetz 1985, 28-29, Mielczarek 1998, 69);

– in 1405, 9.5 Marks and 6 Schillings (i.e., 2 Scot and 12 Denars) were paid for four lead bullet copper guns (*kopperyne lodtbuchsen*) of a total weight of 8 stones and 2 lbs (ca. 110.97 kg) (MTB, 339, Schmidtchen 1977a, 63; Świętosławski 1993, 21);

– in 1408 the foundry master Dumechen cast 2 *mittelbochsen*, which weighed 9.5 Zenteners (ca. 461.7 kg) each and their total cost was 85.5 Mark (MTB, 511; Schmidtchen 1977a, 58; Świętosławski 1993, 22, Szymczak 2004, 109; Dąbrowska 2009, 39);

– in 1409 the foundry master Dumechen was paid 9 Marks for two small veuglaires (*cleyne steynbochsen*). The one had one powder chamber only and was referred to as *geschruwete*, i.e., with the powder chamber and the barrel being screwed together, while the other was *nicht geschruwet mit 3 polferhusen* (MTB, 558; Schmidtchen 1977a, 60; Świętosławski 1993, 22; Szymczak 2004, 56-57, 107; see also id. 1998, 284) (Fig. 30); in the same year, he received 22 Marks for casting of two medium-sized cannons (MTB, 558; Schmidtchen 1977a, 60; Świętosławski 1993, 22).

Most naturally, one's attention is especially attracted to the afore-mentioned large cannon, cast at Marienburg (Malbork) in 1408. Its total weight can be roughly estimated at even over 13 tons, although the actual figure could be lower, as part of the raw material may have been lost in the course of manufacture process. V. Schmidtchen says with right that it must have been a fairly complicated process as the source mentions a repeated casting of the cannon chase. This also implies that the cannon had a detachable gunpowder chamber (MTB, 480, 501, 506-507, 511; Rathgen 1922, 37-38, 43-48; Schmidtchen 1977a, 56-59, 64; Szymczak 2004, 108). Interestingly, a similar feature can be seen in the case of the large bronze cast cannon (the so-called Bombard of Muhammad, a Turkish cannon dated to 1464) from the collection of the Tower of London. The cannon

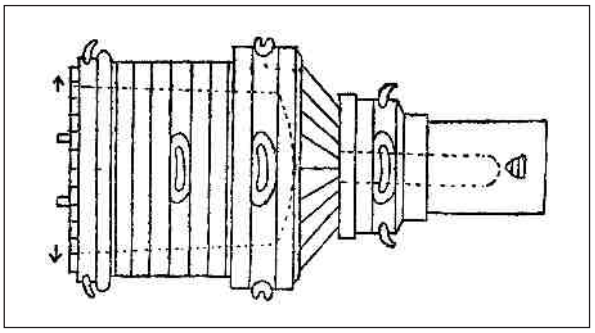


Fig. 28. Pumhart von Steyr (after *Górski 1902, 23, Fig. 5*).

Ryc. 28. Pumhart von Steyr (wg *Górski 1902, 23, Fig. 5*).

is 5.2 m long, its bore diameter is 63 cm and an approximate weight of its projectile is ca. 300 kg. The cannon's weight is more than 17 tons (Fig. 31) (Żygulski jr 1975, 123, Fig. 65:e-f; Williams, Paterson 1986; Mielczarek 1998, 68).

Furthermore, a cannon referred to as *Vellemuwer* (Wall-Breaker) was mentioned in November 1409, with regard to hostilities against Poland. The record concerns the purchase of cannon stoppers for the largest cannon (*grose bochse*), the second largest cannon (*bochse nehest der grosten*), the *Vellemuwer* and some other cannons (MTB, 589). The Wall-Breaker was mentioned in the third place and its stoppers were two times cheaper than those for the two largest guns (4 Denars versus 8 Denars). It could therefore be supposed that the *Vellemuwer* may have been identical with the long cannon (*lange bochse*), cast in 1409 at the cost of almost 122 Marks (MTB, 554, 573, 590, 591). Most interestingly, a cannon with the same name (*Felmawer*) was mentioned in the Teutonic Order's state as late as 1455, on the occasion of the Thirteen Years War (1454-1466) (*Ältere Hochmeisterchronik*, 699). Obviously, it cannot be said whether it was physically the same gun.

Concerning projectiles, more interesting examples would include:

– 60 large stone cannonballs (*grose buchsensteyne*), 122 medium-sized stone cannonballs (*mittelsteyne*) and 121 small stone cannonballs (*cleyne steyne*), manufactured in Marienburg (Malbork) in 1401 at a total cost of 14 Marks and 7 Schillings. The prices were the following: 2 Scot per large cannonball, 1 Scot per medium-sized one and 24 Denars per small one (MTB, 119-120). The terms: large, medium-sized and small were not used consistently as in the same year 100 *grose buchsensteyne* were paid for, with a price of 3 Schillings each (MTB, 127). As 2 Scot = 5 Schillings, these cannonballs were considerably smaller than those mentioned previously. Interestingly, in 1403 the price of 1 Scot was given for a stone cannonball as large as a head (*also gros als eyn houpt*) and 24 Denars were paid for a stone cannonball as large as a bowls ball (*als gros als die boskulen*) (MTB, 212; for such cannonballs in 1409 see also MTB, 572; Schmidtchen 1977a, 65; Świętosławski 1993, 25; for prices of cannonballs see also Rathgen 1922, 41);

– in 1401, 3 Marks and 0.5 Ferto were paid for 12500 lead bullets and shots (*vor 12500 gelote und hailgeschis*) (MTB, 127);

– in 1403, 3 Marks and 3 Ferto were paid for 60 stone cannonballs for large medium-sized cannons (*zur groszen mittelbuchsen*), i.e., 45 Denars per item (MTB, 212);

– in 1407, 0.5 Mark and 5 Denars were paid for casting of 3 Zenteners (ca. 145.8 kg) of lead bullets (*gelote*) in Marienburg (Malbork) (MTB, 446; Świętosławski 1993, 25);

– in 1408, 2 Marks 8 Scot were paid for making one large cannonball (*vor den grossen bochsensteyn zu hauwen*) (MTB, 497); in the same year a stone-cutter (*steynhauwer*) Hannos was paid 4.5 Ferto for one large stone cannonball (*vor eynen steyn zu grossen bochse*) (MTB, 511; Świętosławski 1993, 25; Szymczak 2004, 150). In 1409, 18 Marks were paid for 16 large stone cannonballs, with the same price of 4.5 Ferto per item (MTB, 532). Interestingly, sometimes large cannonballs were diminished in order to fit smaller guns (MTB, 556);

– in the same year, 1 Mark was spent on casting of 6 Zenteners (ca. 291.6 kg) of lead bullets (MTB, 511; Świętosławski 1993, 25);

– in 1409, small stone cannonballs of a fist's size were mentioned (*cleyne steyne als dy fuste gros*), with the price of 18 Denars per item (MTB, 572).

When dealing with ammunition, it is also worth mentioning numerous finds of artillery projectiles from the territory of the Teutonic Order's state. Among them, there is an assemblage of 37 stone cannonballs that match the calibre of the Kurzętnik cannon (see Appendix 2 and Fig. 32). A stone cannonball of 13.4 cm in diameter and of the weight of 3.1 kg was discovered at the castle of Sehesten (Szestno). As there are no data on a siege of the castle with the use of firearms (Biskup 1967, 136-137, 374-377, 416-421), it can be tentatively assumed that it came from the castle's stores. On the other hand, stone cannonballs from the area of Chojnice (Konitz) are to be rather related to sieges of this castle by Polish troops, be it in 1433, 1454 or 1466 (Biskup 1967, 180, 252,

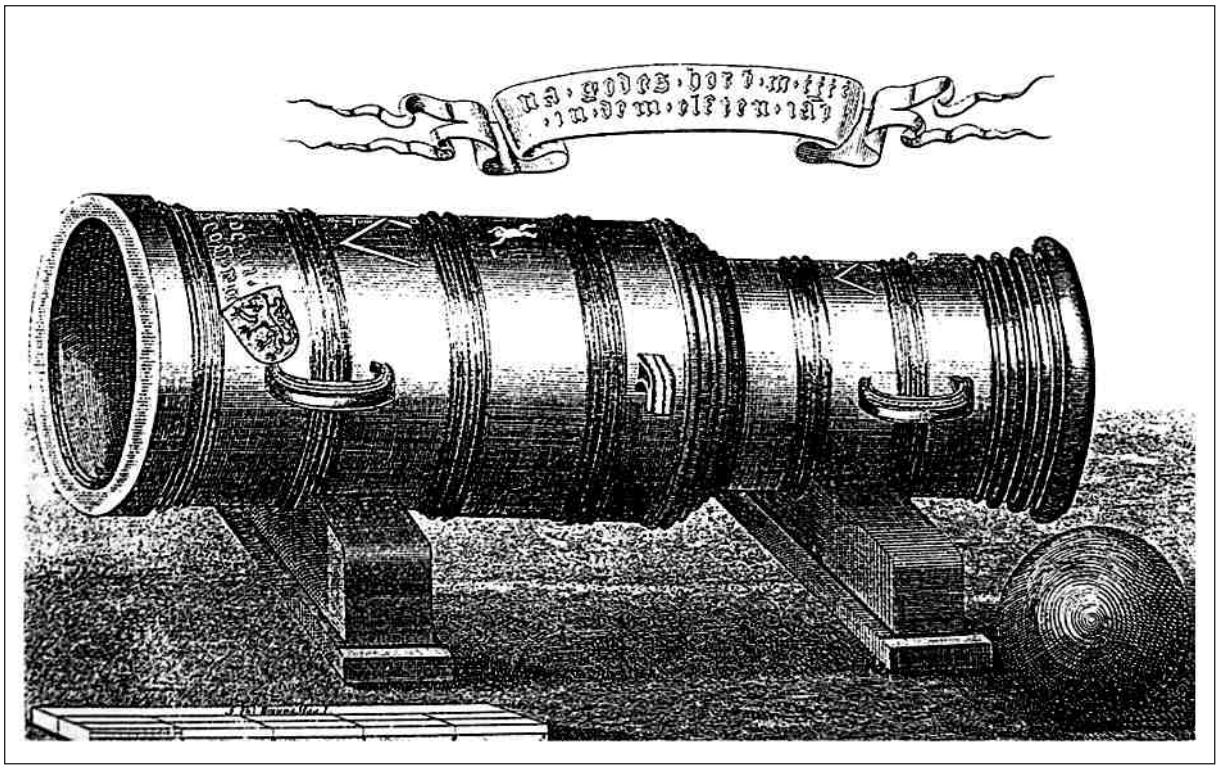


Fig. 29. Feule Mette (after *Schmidtchen 1977a, 13, Fig. 3*).

Ryc. 29. Feule Mette (wg *Schmidtchen 1977a, 13, Fig. 3*).

256-266, 693-694; Szymczak 2004, 244-245, 252-253, 262; Strzyż 2011, 96-100, Figs. 20: 1-4 and 21:1-2). Stone cannonballs from the castle of Człuchów (Schlochau) come perhaps from the castle's arsenal, although it is difficult to determine whether they may be related to the Teutonic or the Polish period (Strzyż 2011, 117-118, Figs. 22-23; on stone cannonballs from the territory of the Teutonic Order's state see also Arszyński, Sikorska-Ulfik 1990; Wasilewski 2004; Strzyż 2007; 2009).

With regard to gunpowder, the following records from the account books are especially worth mentioning (see also Rathgen 1922, 83-86):

– in 1402, 5 Marks were paid for the manufacture of 40 stones (ca. 550.8 kg) of gunpowder in Marienburg (Malbork) (MTB, 172);

– in 1404, 34.5 Marks were spent on 2 barrels (*tonnen*) of gunpowder (MTB, 287);

– in 1407, 6.5 Marks and 54 Denars were spend on 33 stones (ca. 454.41 kg) of gunpowder. Such a price (higher than that in 1402), was in all probability related to the fact that additional cleaning of saltpetre was needed (MTB, 446).

Among utensils, the following items were recorded (see also Rathgen 1922, 87-91):

– picks for making stone balls (*bicken* or *bicken do man buchsensteyne mitte howt*) (Appendix 1.1, 1.12; MTB, 497, 523);

– pairs of callipers for making large stone cannonballs (*vor kromme holzer zu machen noch zirkelmose, do man dy grosen bochsensteyne noch gehawen hat*) (MTB, 497);

– gun hammers (*hamer czu den buchsen*) (Appendix 1:8, 1:25; MTB, 573);

– ramrods for lead bullets (*stempel do man gelote mitte trybet*) (Appendix 1:12);

– ladles for charging guns (*ladeleffel*) (MTB, 573, 597);

– wedges for fastening projectiles in gun barrels (*kyle zu buchsen*) (MTB, 364);

– gun stoppers (*pfroppen zu den buchsen*) (MTB, 364, 587); these were sometimes fitted with iron (MTB, 573, 597; Rathgen 1922, 41; Schmidtchen 1977a, 72; Świętosławski 1993, 26; Szymczak 2004, 120);

– gunpowder measures and gunpowder sieves (*polvermoes* and *polffersyb*) (MTB, 364, 572);

– gunpowder bags (*polfersecke*) (MTB, 573);

– pipes for carrying fire by master gunners (*roren, do der bochsenschocze fuwer mag inne tragen*) (MTB, 572);

– caissons for utensils (*kommen*) (MTB, 574);

– gun trestles (*bocken* and *stonungen*) (MTB, 515, 525, 597);

– ropes and straps for guns (*lynen* and *stroppen*) (MTB, 511, 525, 574);

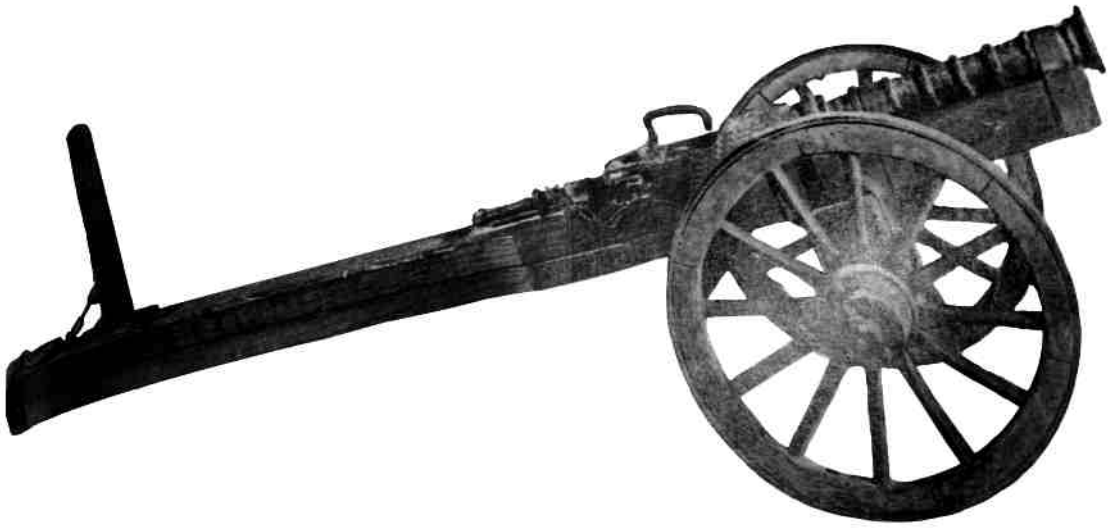


Fig. 30. Veuglaire, the 15th c. (after *Goetz 1983, 39*).

Ryc. 30. Foglerz, XV w. (wg *Goetz 1983, 39*).

– gun wagons with utensils (*buchsenwayn mit allem gerete*) (Appendix 1:25; see also, e.g, MTB, 555, 562, 573, 577, 579, 597; interestingly, special iron fitted chests for gun utensils were mentioned in Elbing (Elbląg), e.g., NKRSME 2, No. 1460, 87);

– gun carriages (*karren* or *bochsenkarren*) (MTB, 559, 562, 573, 579-580).

In the period between 1410 and ca. 1450 the data become sometimes more detailed. Concerning gun types (apart from the most common division into *steynbuchsen* and *lotbuchsen*), sizes, and ammunition, they mention the following examples:

– terrace guns (*tarrasbuchsen*; for this type of guns see, e.g., Szymczak 2004, 53-55): in 1413 at Toruń (Thorn) (GÄDO, 434). Two years thereafter, these were referred to as *steyn tarrasbuchsen*, i.e., stone ball terrace guns (GÄDO, 434). In 1418, these guns were recored as *cleyne steynbochsen* (GÄDO, 436). Terrace guns were also mentioned at Toruń in 1433, 1436, 1437, 1440, 1441 and 1446 (GÄDO, 445, 447-448, 450, 453, 456, 460); at Kowalewo Pomorskie (Schönsee) in 1446 (GÄDO, 424; Visitationen, 211, No. 116); at Königsberg (Królewiec, now Kaliningrad in Russia) in 1431 and 1446 (GÄDO, 30, 45; Visitationen, 260, No. 122); at Elbing (Elbląg) in 1440, 1446 (GÄDO, 92, 104); at Memel (Klaipeda) in 1416, 1434 and 1447 (GÄDO, 306, 309, 312-313); at Brandenburg (Pokarmin, now Ušakovo in Russia) in 1441 (GÄDO, 221); at Ragnit (Ragneta, now Neman in Russia) in 1425, 1432 and 1437 (GÄDO, 281, 285, 287-288); at Brodnica (Strassburg) in 1435 and 1437 (these were stone ball guns – GÄDO, 390-391; Visitationen, 110, No. 90); at Sehesten (Szestno) in 1437 (GÄDO, 187); at Osterode (Ostróda) and Neidenburg (Nidzica) in 1446 and 1449 (GÄDO, 335, 338-339; Visitationen, 261-262, No. 123); at Papowo (Papau) in 1413, 1414, 1416, 1419, 1435, 1437 and 1440 (GÄDO, 519, 521-523, 531-533); at Grudziądz (Graudenz) in 1414, 1434, 1437, 1440 and 1447 (GÄDO, 600-601, 603, 605, 608, 610); at Świecie (Schwetz) in 1411 (GÄDO, 616); at Tuchola (Tuchel) in 1420, 1431 and 1437 (GÄDO, 640, 643-644); at Gdańsk (Danzig) in 1416, 1418, 1420, 1421, 1422, 1428, 1434 and 1446 (GÄDO, 694, 697, 701, 703, 705, 706, 710; Visitationen, 278-279, No. 125).

In some cases, the inventories mention lead bullet terrace guns:

– 13 *gros gelote czur tarrasbuchsen* were recorded at Nieszawa (Nessau) in April 1432 (GÄDO, 484). The terrace gun itself was mentioned in September 1432 and in 1434 (GÄDO, 485). Based on the record from 1435, it was made of copper (*kopperyne tharresbochse*) (GÄDO, 485-486). Analogously, 2 *tharrasbuchsen* mentioned at Stara Kiszewa (Alt Kischau) in 1437-1439 were lead bullet guns (GÄDO, 729-730, 732, 734). The same can be said about three *tarrasbuchsen* at Gniew (Mewe) in 1416, which were referred to as *grose lotbuchsen* (GÄDO, 742, 744);

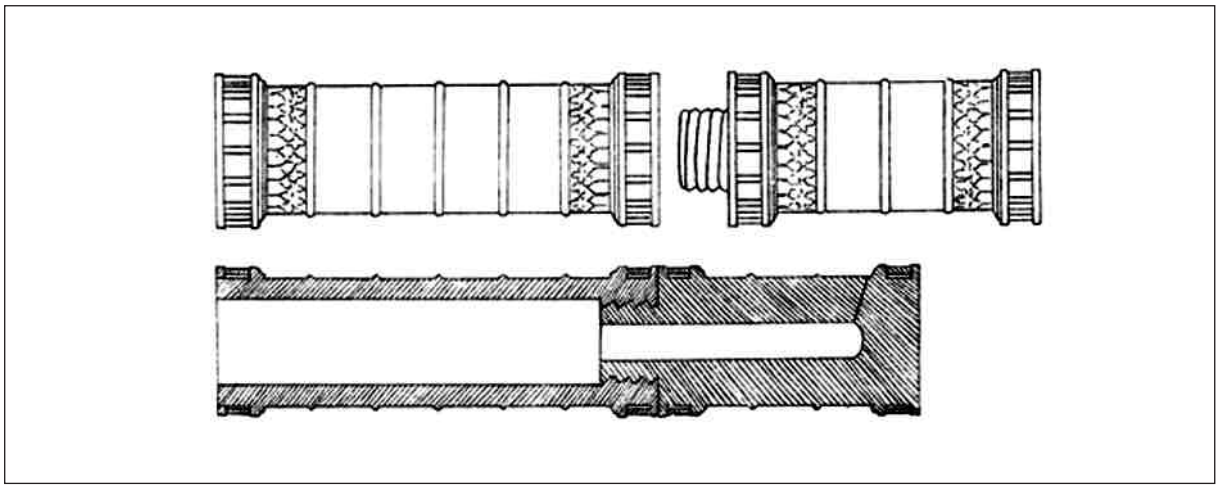


Fig. 31. Bombard from the Tower of London, the so-called Bombard of Muhammad, 1464 (after *Żygulski jun. 1975, 123, Fig. 65e-f*).

Ryc. 31. Bombarda ze zbiorów Tower of London, tzw. Bombarda Mahometa, 1464 r. (wg *Żygulski jun. 1975, 123, Fig. 65e-f*).

– veuglaires (*bochsen mit camern*, *kamerbuchsen*; see, e.g., Rathgen 1922, 12-14, Szymczak 2004, 55-56, id. 1998, 294): in 1418 at Toruń (Thorn) (GÄDO, 436). In 1422, it was additionally said that the gun had four chambers and in all probability it was a stone ball cannon (GÄDO, 438, see also the 1428 inventory, GÄDO, 443). Furthermore, a *steynbuchse von dreyn stocken* was recorded in 1428 at the Bierzgłowo (Birglau) procurator's castle (GÄDO, 443). In 1437, this gun was referred to as *kamerbuchse mit dreyen kamern* (GÄDO, 451), while in 1440 *2 kammerbochsen mit 2 kammern* were mentioned (GÄDO, 455). In 1447 *1 steynbochse mit 3 kamern* was recored at Memel (Klaipeda) (GÄDO, 312-313). A *steynbochse* with 3 chambers was also mentioned at Człuchów (Schlochau) in 1413 (GÄDO, 652). In 1415 it was only generally said that among 13 stone ball cannons there were also veuglaires (*under den die haben kamern*) (GÄDO, 653). In 1420 there were three *steynbochsen* with nine chambers altogether at that castle (GÄDO, 656). Ca. 1440 nine *steynbochsen* and eight *camern zcu buchsen* were recorded there (GÄDO, 671). A *steynbochse mit 5 kamern* was recorded in 1416 at Gniew (Mewe) (GÄDO, 744). As many as 105 *kamerstugke* were recorded at Gniew (Mewe) in November 1422. The entire artillery park encompassed 36 *lotbuchsen* and 10 *steynbuchsen* but it was not said to which guns the afore-mentioned chambers were used (GÄDO, 747). On the other hand, 11 *steynbuchsen* with nine *camern dorczu* were recorded there in 1431 (GÄDO, 748).

On the other hand, some records mention lead bullet veuglaires:

– *5 lotbuchsen mit 22 kamern* were recorded at Holland (Pasłęk) in 1451 (GÄDO, 106);

– breech-loading guns (*hinderende*), perhaps some sort of veuglaires: in 1432 at Balga (Bałga, now Veseloe in Russia) (GÄDO, 165);

– guns in wooden stocks, stands or carriages (*bochsen in holczen laden*; cf. Szymczak 2004, 69-71): in 1440, 1441 at Bierzgłowo (Birglau) (GÄDO, 455, 457); in 1441 at Starogród (Althausen) (GÄDO, 506); in 1431, 1433, 1435, 1437 and 1438 in Człuchów (Schlochau) (GÄDO, 658, 660, 663, 665, 668, 669) – these were *steybochsen in laden beslagen* or *in wolbeslagen laden*, which may imply carriages with iron-rimmed wheels;

– lead bullet guns on trestles (*lotbuchsen czu gestellen*; cf. Szymczak 2004, 53, 58-59): in 1416 at Nieszawa (Nessau) (GÄDO, 481). Two years thereafter, seven *lotbochsen* and three *gestellen* were mentioned (GÄDO, 482);

– iron guns (*yseryn buchsen*): in 1414 and 1424 at Königsberg (Królewiec, now Kaliningrad in Russia) (GÄDO, 14, 26); in 1440 at Ortelsburg (Szczytno) (GÄDO, 100); at Memel (Klaipeda) in 1434 (GÄDO, 309); at Nieszawa (Nessau) in 1431 (GÄDO, 483); at Ragnit (Ragneta, now Neman in Russia) in 1437 (GÄDO, 287-288); at Golub (Gollub) in 1421 (GÄDO, 404); at Komorsk (Kommerau) in 1440 (GÄDO, 630, 632). More precise data were sometimes given: in 1431 and in April 1432 at Nieszawa (Nessau) eight (nine) *eyserene lotbuchsen* were recorded (GÄDO, 483, 484; see also GÄDO, 485). In September 1432, in 1434 and 1435 three *iseren steynbuchsen* were mentioned there (GÄDO, 485, 486). Two *yserynne lothbochsen* were mentioned in 1418 at Kreuzburg (Krzyżpork) (GÄDO, 221); four *eyseryn*

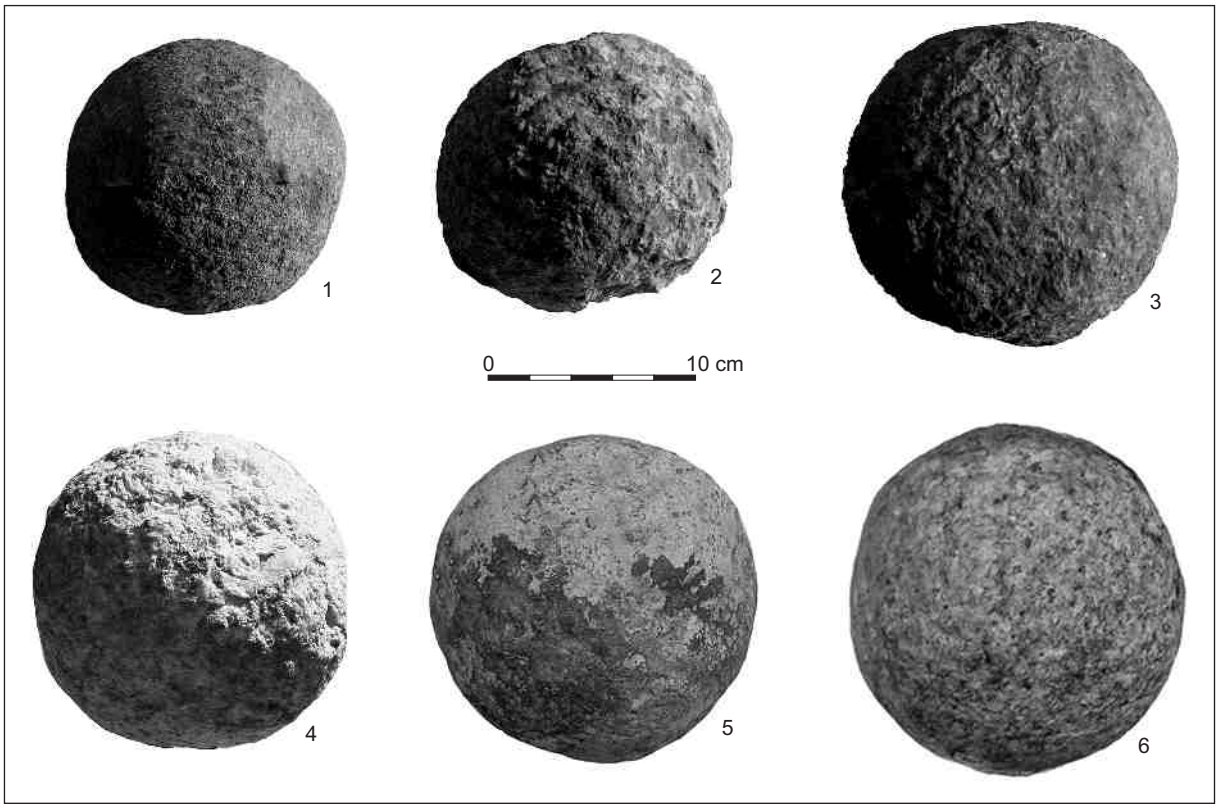


Fig. 32. Stone cannonballs. 1-3 – Chojnice, Market Square, 15th c.; 4 – Szestno, castle, 15th c.; 5-6 – Człuchów, castle, 15th c. *Photo by P. Strzyż*.

Ryc. 32. Kamienne kule armatnie. 1-3 – Chojnice, Rynek, XV w.; 4 – Szestno, zamek, XV w.; 5-6 – Człuchów, zamek, XV w. *Fot. P. Strzyż*.

lodbuchsen were recorded in 1434 at Starogród (GÄDO, 506); five *ysern lodbuchsen* were recorded at Drezdenko (Driesen) in 1428 (GÄDO, 771). One *yserinne steynbuchse* was recorded in 1411 at Świecie (Schwetz) – two *grosze steynbuchsen* were mentioned immediately before this gun (GÄDO, 616);

– copper guns (*kopperyne bochsen*): one *kopperen tarrasbochse* and one *kopperene lotbuchse* at Nieszawa (Nessau) in 1431 (GÄDO, 483). In April 1432 and in 1434 nine (eight) *copperne lotbuchsen* were mentioned at Nieszawa (Nessau) (GÄDO, 484, 485). In 1435 there were four *kopperyne steynbochsen* and one *kopperyne tharresbochse* at that castle (GÄDO, 485-486). 13 *coppern lotbuchsen* were recorded in 1434 at Starygród (Althausen) (GÄDO, 506). Two *cleyne kopperinne steynbuchsen* were mentioned in 1411 at Świecie (Schwetz);

– red brass guns (*eren buchsen*): in 1440 at Ortelsburg (Szczytno) (GÄDO, 100); in April 1432 at Nieszawa (GÄDO, 484). In September 1432, three *eren steynbuchsen* and one *mit 2 kamern* were mentioned there (GÄDO, 485). An *eryne lothbochse* was recorded in 1418 at Kreuzburg (Krzyżpork) (GÄDO, 221). 42 *lotbuchsen* were recorded in 1437 at Gniew (Mewe) and in the following year the inventory mentioned 42 *eren buchsen* (GÄDO, 750-751). The same was stated for 1440, while in 1441 their number decreased to 40 (GÄDO, 753-754). Interestingly, the records from 1444, 1446 and after 1446 mention 42 *lotbuchsen* again (GÄDO, 756, 758, 760)

– handgonnes (*hantbuchsen*; for various kinds of handgonnes see, e.g., Szymczak 2004, 36-41): at Holland (Pasłęk) in 1416, 1428, 1432, 1440 and 1446 (GÄDO, 87, 88, 91, 97, 105; Visitationen, 250, No. 120); at Nieszawa (Nessau) in 1416 (GÄDO, 481); at Brandenburg (Pokarmin, now Ušakovo in Russia) in 1441 (GÄDO, 234); at Brodnica (Strassburg) in 1438, 1446 and 1447 (GÄDO, 392-395; Visitationen, 276, No. 124, 322, No. 134); at Osterode (Ostróda) in 1446 and 1449 and at Soldau (Działdowo) in 1449 (GÄDO, 335, 338-339; Visitationen, 261-262, No. 123); at Papowo (Papau) in the 15th c. (GÄDO, 523, with no precise date); in 1438, 1442, 1443 and 1448 at Rogóźno (Roggenhusen), with a mention in 1438 that these guns were *lothbuchsen* (GÄDO, 548-549, 551-552, 554, 556); in 1437, 1438 and 1446 at Radzyń Chełmiński (Rehden), with mentions in 1438 and 1446 that these guns were

Fig. 33. Handgonne from the Curonian Spit, early 15th c. (after *Szymczak 2004, 38, Fig. 4*).

Ryc. 33. Rusznica z Zalewu Kurońskiego, wczesny XV w. (wg *Szymczak 2004, 38, Fig. 4*).

lotbuchsen (GÄDO, 578, 580; Visitationen, 221, No. 118); in 1411 at Świecie (Schwetz) (GÄDO, 616) (Figs. 33-34);

– hackbuts (*hockenbuchsen*; for such firearms see, e.g, Nowakowski 1994a, 103; Szymczak 2004, 41-45), obviously handgonnes equipped with hooks: at Osterode (Ostróda) and Soldau (Działdowo) in 1449 (GÄDO, 338-339). Interestingly, two *steynbochsen*, 10 *tharrasbochzen* and 10 *hantbochszen* were recorded in 1446 at Ostróda (GÄDO, 335; Visitationen 261-262, No. 123), while four *steynbochsen* and 15 *hockebuchsen* were mentioned in 1449. This could imply that the term *hockenbuchse* could also refer to terrace guns, perhaps in case the latter were deployed in castle terraces.

Interestingly, seven *handbochsen* and 12 *steynbochsen* were recorded at Brodnica (Strasburg) in 1435, while two years thereafter 19 *hantbuchsen* were mentioned (GÄDO, 390-391; Visitationen, 110, No. 90). This means that 12 handgonnes were projecting stone ammunition.

Furthermore, the following mentions were particularly interesting, due to their singularity:

– iron bullets (*yserynne gelote*): in 1411 at Bratian (Brathean) (GÄDO, 366; on iron balls see Szymczak 2004, 152-154; see also Rathgen 1922, 81-82);

– small short guns (*cleyne kurcze buchsen*), possibly some sort of handgonnes: at Christburg (Dzierzgoń) in 1434 (GÄDO, 141);

– gun bolts (*bochsenpfeile* or *pfeylen, die man mit bochsen scheust*): in 1418 and 1420 at Tuchola (Tuchel) (GÄDO, 639-640); in 1449 at Osterode (Ostróda) (GÄDO, 338-339). Such bolts were also recorded at Radzyń Chełmiński (Rehden) in 1411 and 1412 as *lotbuchsenpfile* (GÄDO, 565, 567). This may imply that these were used interchangeably with lead bullets. It could also be supposed that *bochsenpfeile* was another term for lead bullets (see Rathgen 1922, 20-21). This can be proposed based on the 1415 record of Człuchów (Schlochau) – *an pfeylen: 510 gelote cleyn und gros* (GÄDO, 653). On the other hand, the 1420 record of that castle stated – *an pfylen: 540 grose pfyle czu rogarmbrost und ouch czu den bochsen* (GÄDO, 656). This strongly suggests that the same projectiles could be used both for crossbows and for firearms. The question of use of bolts for firearms has long been discussed in scholarship, and such a possibility was accepted. It anyway concerns the very beginning of firearms in Europe and the well-known depiction of a pot-de-fer with an arrow in the manuscript by Walter de Milemete of 1326. A vase-shaped barrel (dated to ca. 1330-1340, calibre 3.6 cm, weight 9 kg) was found in Loshut in Sweden (Smith 1999; Tittmann 2001, 222-226, Figs. 6-7; Szymczak 2004, 31, Fig. 1, 144; *Burg* 2010b, 267, Fig. 6:19). Furthermore, J. Szymczak reproduces a drawing from a ca. 1420-1430 manuscript, which shows identical bolts being used for crossbows and handgonnes (Szymczak 2004, 301, Fig. 43; see also Rathgen 1922, 17-21) (Fig. 35).

With regard to utensils (for a list with extensive comments see also Szymczak 2004, 72-77), there were:

– ramrods (*stempil czu den buchsen*): in 1412 at Bratian (Brathean) (GÄDO, 367); in 1419 and 1425 at Tilsit (Tylża, now Sovetsk in Russia) (GÄDO, 278, 282); in 1415, 1420 1431, 1433, 1435, 1437 and 1438 at Człuchów (Schlochau) (GÄDO, 653, 656, 658, 660, 663, 665, 668). These were perhaps also referred to as *ladeysen*, as in 1434 at Christburg (Dzierzgoń) (GÄDO, 141). It could tentatively be proposed that the term "iron rod" (*eyszern stange*) referred to a similar utensil (in 1446 and 1449 at Osterode (Ostróda), GÄDO, 335, 338-339; Visitationen, 262, No. 123). The same must rather obviously be said about iron ramrods (*eysern stempel*): at Grudziądz (Graudenz) in 1434 (GÄDO, 603);

– hammers (*hamer*): in 1412 at Bratian (Brathean) (GÄDO, 367); in 1419 and 1425 at Tilsit (Tylża, now Sovetsk in Russia) (GÄDO, 278, 282);

Fig. 34. Handgonne, early 15th c. (after *Kyeser c. 1405, f. 103v*).

Ryc. 34. Rusznica, wczesny XV w. (wg *Kyeser c. 1405, f. 103v*).

– logs or wedges (*0,5 tonne clotcze zcu bochsen*): in 1452 at Brandenburg (Pokarmin, now Ušakovo in Russia) (GÄDO, 224);

– founding cauldrons (*giszkessel*): in 1452 at Brandenburg (Pokarmin, now Ušakovo in Russia) (GÄDO, 244);

– ignition hooks or lintstocks (*czundehoken*): in 1419 and 1425 at Tilsit (Tylża, now Sovetsk in Russia) (GÄDO, 278, 282);

– gunpowder ladles (*pulverschuffeln*): in 1434 at Christburg (Dzierzgoń) (GÄDO, 141). In all probability the same utensil was recorded as *pulverladen* in 1417 at Osiek (Mossig) (GÄDO, 544). Another name for this utensil was *ladeschuffel*: in 1423 and 1424 at Świecie (GÄDO, 620, 622);

– priming pans (*tegel czu der buchse*): in 1414 two such deviced were mentioned at Pokrzywno (Engelsberg). They belonged to a *steynbuchse* which was sent to Toruń (Thorun) in order to be re-cast (*1 steynbuchse die ist czu Thorun, die sal ma weder gisen*) (GÄDO, 589);

– gun stoppers (*propfeysen* or *proppen*): in 1423 and 1424 at Świecie (Schwetz) (GÄDO, 620, 622); in 1420 at Człuchów (Schlochau) (GÄDO, 656);

– gun wagons (*buchsenwayn*): one was recorded at Świecie (Schwetz) in 1423 and 1424 (GÄDO, 620, 622).

Considerable resources of firearms were also stored in Prussian towns. In 1404, stores of firearms in the Town Hall of the Old Town of Elbing (Elbląg) were mentioned (NKRSME 1, No. 75, 21). The same occurred in 1410 and 1411 (NKRSME 1, Nos. 1044 and 1046, 227; NKRSME 2, Nos. 1250 and 1251, 31; see also Chodyński 1996a, 17-18). Interestingly, an inventory of military equipment of the Old Town Hall of Elbląg from 1413 recorded 21 *kopperyne steinbuchsen*, which were interpreted by A. R. Chodyński as small calibre red brass stone ball guns (Chodyński 1996a, 20, 22; see also Rathgen 1922, 71-73).

Place of manufacture

M. Grodzicka says that mentions of founders in Teutonic account books date back to 1401. In 1403 a foundry at the Marienburg (Malbork) castle was mentioned; in 1409 a foundry was recorded in Gdańsk (Danzig) (Grodzicka 1963, 10; Chodyński 2003, 79; Szymczak 2004, 185). An assumption that the cannon in question may have

been manufactured at Marienburg (Malbork) has also been made by A. R. Chodyński (Chodyński 2003, 88; 2007, 388; 2010, 126; see also Ekdahl 2002, 234).

Based on the account books, it can be said that Marienburg (Malbork) was in fact the most significant manufacture centre (MTB, 99, 119-120, 140, 172, 201, 212, 217, 307, 321, 326, 348, 352, 364, 381, 446, 479-480, 482, 495, 497, 501-502, 506-507, 511, 514, 523, 544-545, 547, 556-558, 562, 571-574, 579-580, 590-591; Rathgen 1922, 52-60; Schmidtchen 1977a, 53-54, 56-60, 62, 64; Świętosławski 1993, 20; Nowakowski 1994b, 334-335). In some cases, damaged guns from other castles were sent to Marienburg (Malbork) to be repaired, as it was the case with a *mittelbochse* from Grudziądz (Graudenz) in 1409, whose touch hole was burnt through (MTB, 574; Schmidtchen 1977a, 64). In the same year, a damaged gun from Balga (Veseloe) was sent to the capital castle (MTB, 583; Schmidtchen 1977a, 64). The same occurred with two damaged *steynbochsen* from Ragnit (Ragneta) in 1419 (GÄDO, 276).

Manufacture of firearms and stone cannonballs at the Fore-Castle (Low Castle) at Marienburg

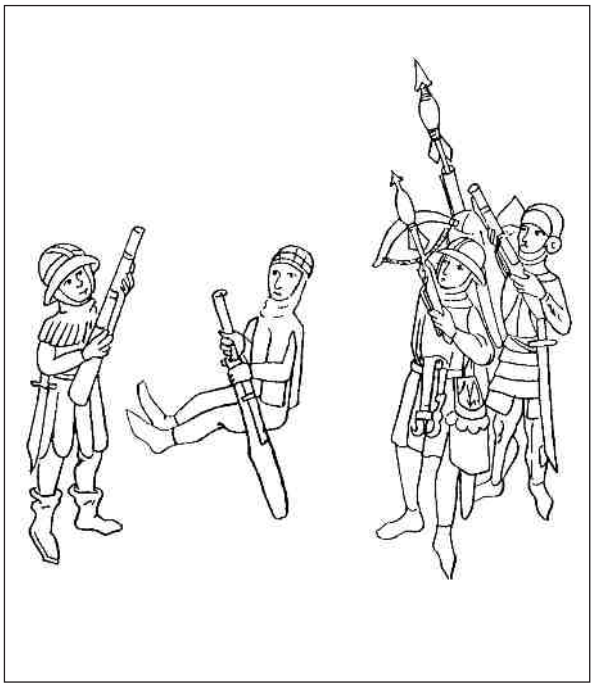


Fig. 35. Gun and crossbow bolts, c. 1420-1430 (after *Szymczak 2004, 301, Fig. 43*).

Ryc. 35. Broń palna i bełty, ok. 1420-1430 (wg *Szymczak 2004, 301, Fig. 43*).

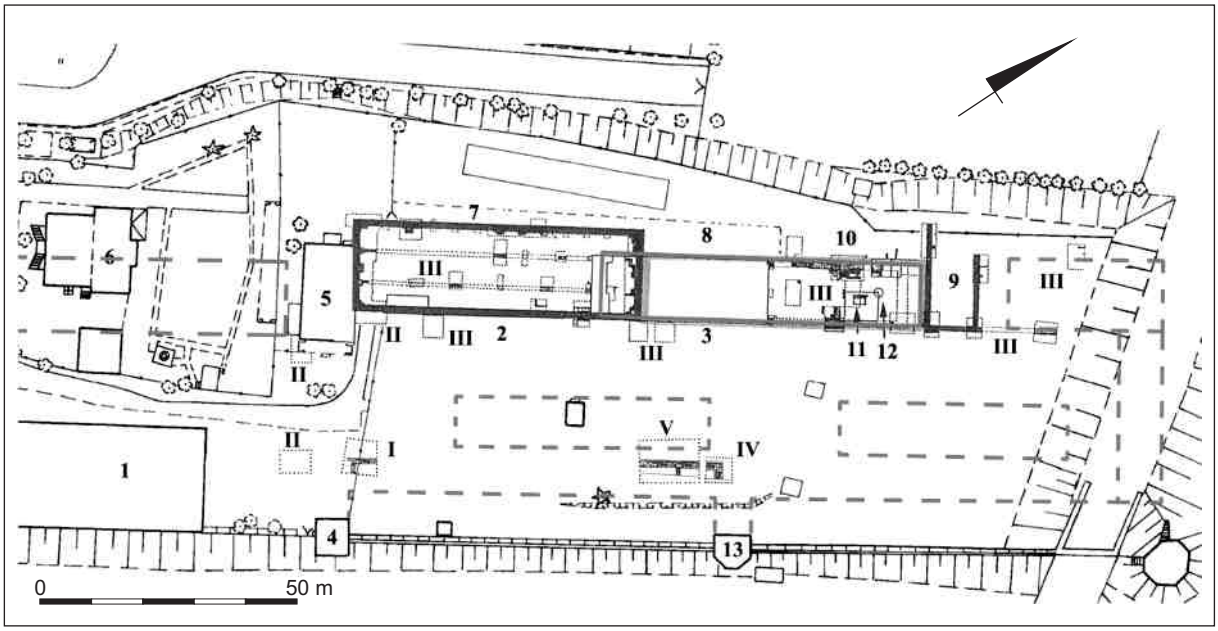


Fig. 36. Marienburg (Malbork) Castle, the north-eastern part of the Fore-Castle, Site 1: 1 – Karwan (artillery and wagon depot); 2 – division wall; 3 – foundry; 4 – Gunpowder Tower; 5 – shed house; 6 – office of the Castle Reconstruction Administration; 7 – arcade house; 8 – medieval foundry; 9 – residential building; 10 – malt-drying kiln; 11 – oak wood chest; 12 – well; 13 – Three-Walled Tower. I – examinations by K. Pospieszny and M. Dąbrowska, 1995-1996; II – examinations by M. Dąbrowska, 1997; III – examinations by M. Dąbrowska, 1998-2004; IV – examinations by E. Fudzińska, 2008; V – examinations by E. Fudzińska and G. Żabiński, 2010 (drawing by G. Żabiński – adapted from Steinbrecht 1911; Dąbrowska 2007, 306, Fig. 3).

Ryc. 36. Zamek w Malborku, północno-wschodnia część Przedzamcza, stan. 1: 1 – Karwan (magazyn artylerii i wozów); 2 – ściana działowa; 3 – odlewnia; 4 – Wieża Prochowa; 5 – dom podcieniowy; 6 – siedziba Zarządu Odbudowy Zamku; 7 – dom arkadowy; 8 – średniowieczna odlewnia; 9 – budynek rezydencjonalny; 10 – piec do suszenia słodu; 11 – skrzynia dębowa; 12 – studnia; 13 – Wieża Trójścienna. I – badania K. Pospiesznego i M. Dąbrowskiej, l. 1995-1996; II – badania M. Dąbrowskiej, 1997 r.; III – badania M. Dąbrowskiej, l. 1998-2004; IV – badania E. Fudzińskiej, 2008 r.; V – badania E. Fudzińskiej i G. Żabińskiego, 2010 r. (oprac. G. Żabiński – wg Steinbrecht 1911; Dąbrowska 2007, 306, Fig. 3).

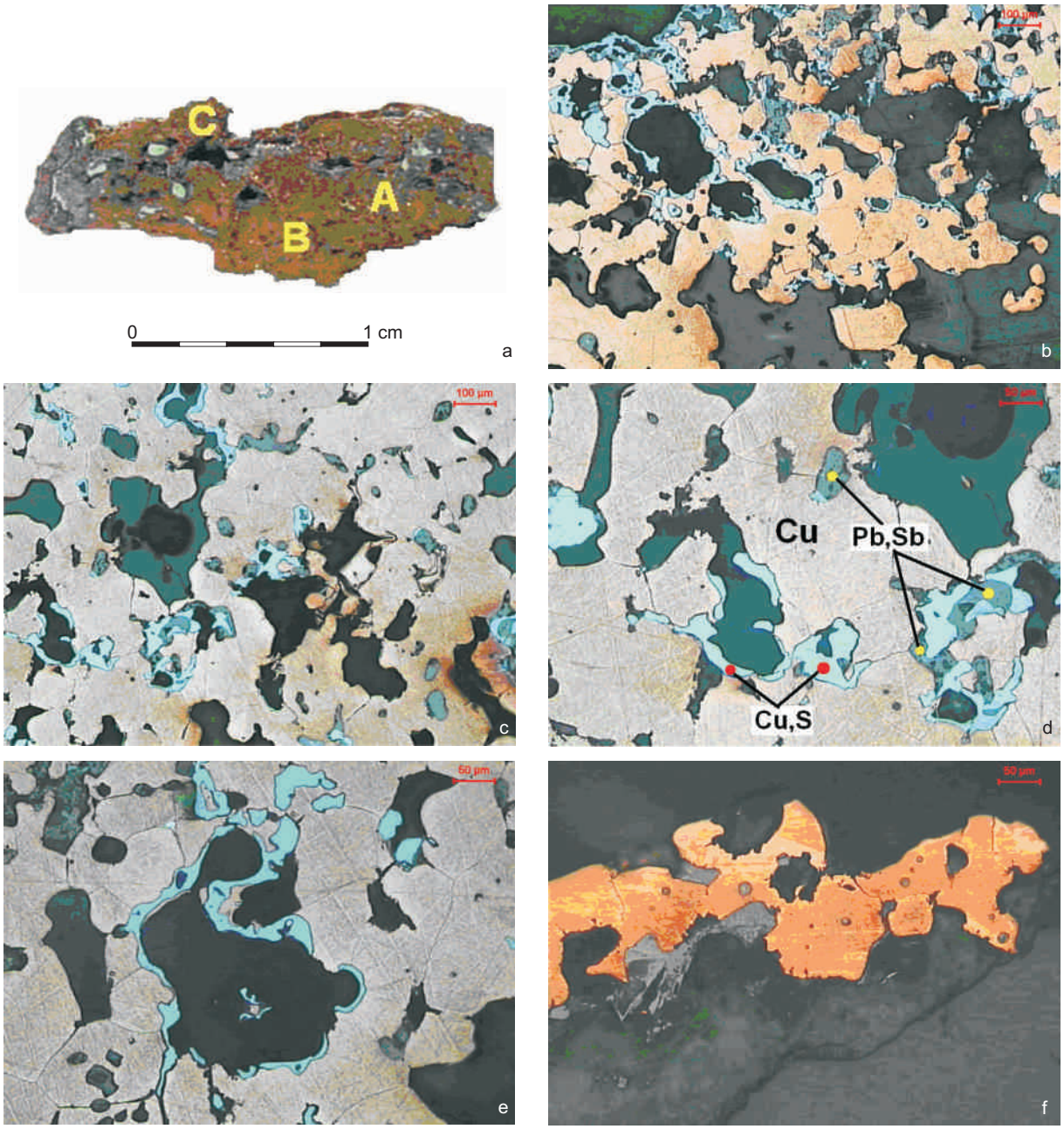


Fig. 37. Microstructure of the cannon from Kurzętnik, Castle Museum in Malbork, No. MZM/MK/M/46: a – general view of the sample with spots of detailed observations (A-C); b – microstructure of the sample in Spot A. Numerous pores filled with corrosion products can be seen; c-e – microstructure of the sample in Spot B; f – microstructure of the sample in Spot C.

Ryc. 37. Mikrostruktura puszki z Kurzętnika, Muzeum Zamkowe w Malborku, nr inw. MZM/MK/M/46: a – widok ogólny próbki z miejscami obserwacji szczegółowych (A-C); b – mikrostruktura próbki w miejscu A. Widoczne liczne pory wypełnione produktami korozji; c-e – mikrostruktura próbki w miejscu B; f – mikrostruktura próbki w miejscu C.

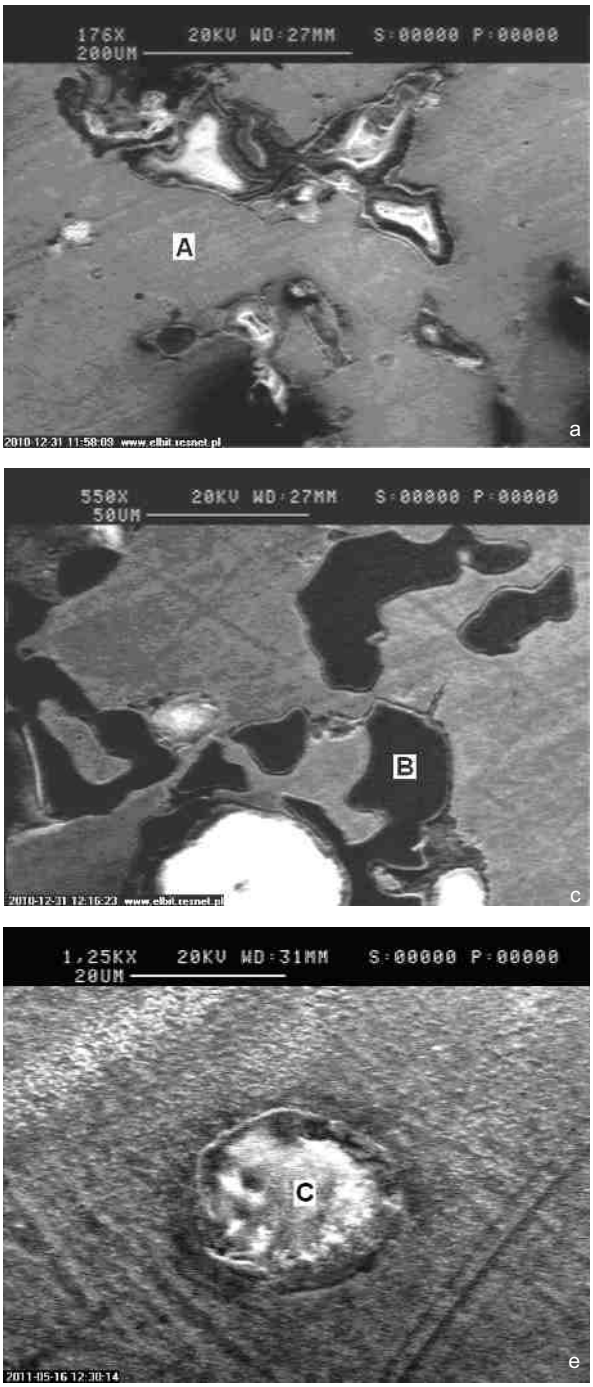
(Malbork) has been confirmed by archaeological excavations. In the 2nd half of the 19th c. foundations of a building with a significant amount of charcoal and slag were discovered. Based on it, it was assumed that a "foundry house" (*gissehus*) was situated there (AMH, 451; Jóźwiak, Trupinda 2007, 412). Research by M. Dąbrowska in 1998-2004, carried out in the area of the present-day Foundry, yielded remains of three medieval buildings. The first of them (56.5 x 18 m) was identified as the "stone-cutting house" (*steynhof*), while the second one (53 x 12.5 m) was though to be the afore-mentioned "foudry house". To the north of it, the third building (10,5 x at least 20 m) was found. Based on numerous finds of crossbow bolts, it was interpreted as a workshop of a bolt-

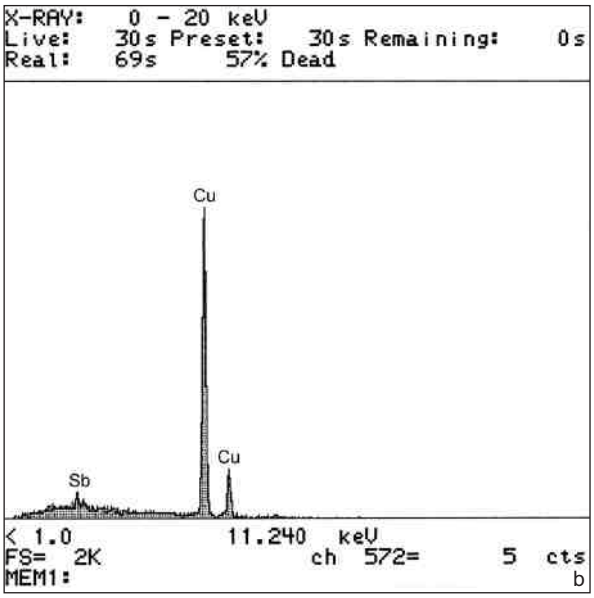
maker (Dąbrowska 2007, 308-311; Jóźwiak, Trupinda 2007, 412-413). With regard to the "foundry house," finds of more than 300 fragments of casting moulds are of special significance. Based on their size, it was assumed that they served for casting of cannons with diameters of ca. 33-43 cm. Interestingly, some sherds with internal layers of metal (copper oxide alloys) were interpreted as putative remains of moulds for repeated casting (Dąbrowska 2009, 21-28) (Fig. 36).

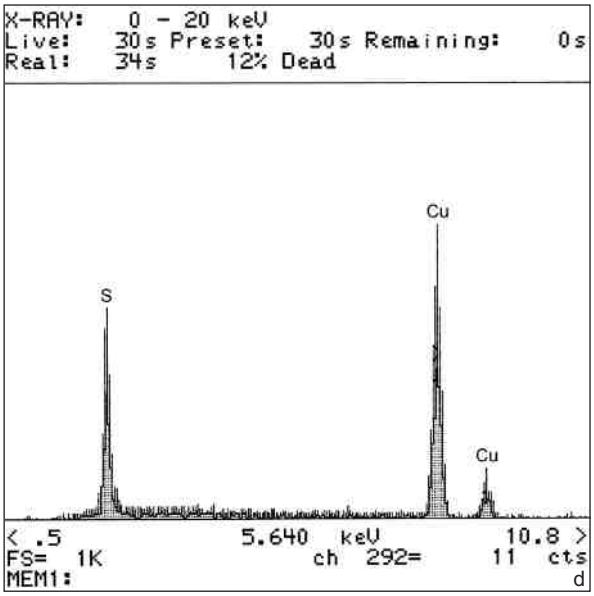
Other centres seem to have played an auxiliary role, just to mention the most significant examples:

– in Gdańsk (Danzig), almost 230 stone cannonballs were made in 1402 and 1403. These were to be transported to Marienburg (Malbork) (MTB, 183, 232). The small long cannon (*cleyne lange bochse*), being a veuglaire with three powder chambers, was cast in 1409 in Gdańsk (Danzig). Its weight was 11.5 Zenteners (ca. 558.9 kg) and it cost 65 Marks 1 Vierd 4 Scot and 1 Denar. It was also transported to the Order's capital (MTB, 554, 559, 573; Schmidtchen 1977a, 61-62; Świętosławski 1993, 23; Szymczak 2004, 107, 109-110). V. Schmidtchen assumes that the Marienburg (Malbork) foundry was too busy at that time, so the casting had to take place somewhere else (Schmidtchen 1977a, 62). In 1409, 69 large stone cannonballs were bought in Gdańsk (Danzig) (MTB, 584). Furthermore, there are mentions of purchases of guns and ammunition in Gdańsk (Danzig) by the municipal authorities of the Old Town of Elbing (Elbląg). In 1410, the town spent 100 Marks on guns (*bussen*) bought in Gdańsk (Danzig) (NKRSME 1, No. 1004, 217; see also No. 1016, 221; Świętosławski 1993, 21). In 1414 the Old Town of Elbląg (Elbing) purchased a huge siege cannon in Gdańsk (Danzig) for 78 Marks. Its total weight was 12.5 Zenteners or ca. 607.5 kg. Apart from that, the town also bought seven stone ball cannons, 10 large lead bullet guns and 13 small lead bullet guns of a total weight of 12.5 Zenteners and 13 lbs (ca. 612.76 kg) for a total price of 69 Marks 8 Scot and 9 Denars (NKRSME 2, No. 1429, 78-79; Świętosławski 1993, 21; Szymczak 2004, 109). Furthermore, 41 stone balls for the large cannon from Gdańsk (Danzig) were bought for 2 Marks 9 Scot and 24 Denars (i.e., 3.5 Scot for each), as well as a significant amount of ammunition for other guns (NKRSME 2, No. 1431, 79; Szymczak 2004, 150);

– in Elbing (Elbląg), acquisitions of firearms and utensils are frequently mentioned, although it is not always explicitly stated that these were made locally. In 1404, 4 Scot were paid for one new *lotbusse*, 3.5 Scot for three ignition rods (*entczundeysen*) and 15 Scot for two stones and 6 lbs of lead (NKRSME 1, No. 67, 16; Świętosławski 1993, 21). In 1406, a purchase of eight iron bars (*schenen*) for guns was mentioned (NKRSME 1, No. 357, 67), which implies a local manufacture. A significant amount of gunpowder was made in 1409 (MTB, 587). In the same year, 14 stone cannonballs for the afore-mentioned largest cannon were transported from that town (or the Teutonic castle) to Brodnica (Strassburg) (MTB, 591). 1 Mark 8 Scot was spent on the manufacture of one *lothbusse* and 1 Mark 10 sc – for the purchase of one *lotbusse* in 1410 (NKRSME 1, No. 1004, 217). Furthermore, there are other mentions on expenses related to firearms, also including the manufacture of guns and ammunition (NKRSME 1, No. 1011, 218-219; Nos. 1049 and 1050, 229; No. 1124, 246; Świętosławski 1993, 24, 26-27). In 1410, the town spent 7 Marks 8 Scot spent for stone ball cannons and 3 lead bullet guns. The money was paid to a bell-founder from Heilsberg (Lidzbark Warmiński) (NKRSME 1, No. 1005, 217). This bell-founder was in all probability Master Herman of Heilsberg (Lidzbark Warmiński), who cast five small cannons for the town of Elbing (Elbląg) in 1410. Their total weight was 5.5 Zenteners 15 lbs (ca. 273.37 kg) and the total cost was 17 Marks 14 Schillings (NKRSME 1, No. 1050, 229; Świętosławski 1993, 21; Szymczak 2004, 109, 186). Assuming that they were of equal weight, their size would be very similar to the Kurzętnik cannon. In the same year 5 Scot were paid for 240 gun stoppers (*proppen*) and 43 Marks 19.5 Scot were spent on 1320 stone cannonballs. Furthermore, the manufacture of gun trestles (*bussenstelle*), ladles (*laden*) and gunpowder was also mentioned (NKRSME 1, No. 1051, 229-230; Świętosławski 1993, 24-25; Szymczak 2004, 119, 149; for gunpowder see also NKRSME 1, No. 1070, 233; Świętosławski 1993, 26). In October 1410, supplies of guns and stone cannonballs for the King of Poland were recorded (NMRSME 1, No. 1105, 241). In 1411 the municipal authorities paid 58 Marks 18 Scot for casting a *grosse buchse*. Apart from that, 3 Marks and 6 Scot were paid for 14 lead bullet guns (NKRSME 2, No. 1171, 10; Świętosławski 1993, 21; Szymczak 2004, 109). In the same year 1.5 Marks were paid for two oak beams for *bussenstellen*, i.e., some sort of stands or trestles (NKRSME 2, No. 1251, 31; Świętosławski 1993, 24; Szymczak 2004, 115). In 1413, expenses on sulphur were recorded (NKRSME 2, No. 1327, 56). Another series of expenses on guns, utensils, cannon wagons and gunpowder (including its manufacture) was recorded in 1414 (NKRSME 2,







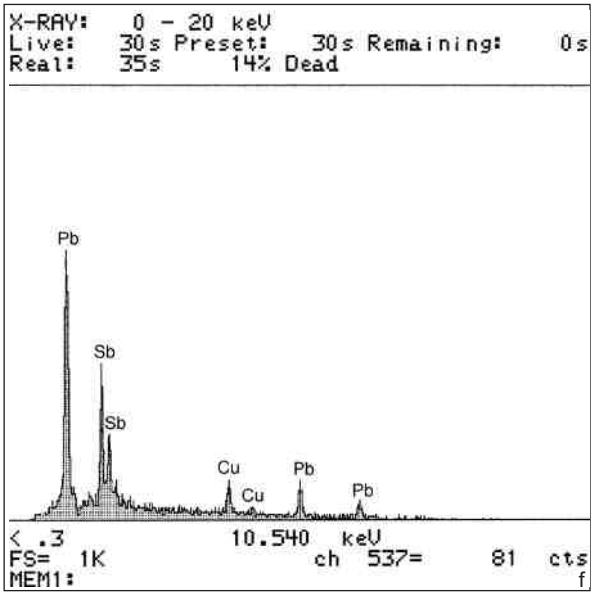


Fig. 38. EDS analysis of the cannon from Kurzętnik, Castle Museum in Malbork, No. MZM/MK/M/46: a – analysis of the framework of the sample in Spot A; b – EDS spectrum in Spot A, peaks of Cu and traces of Sb are visible; c – analysis of dark separations (SEM) in Spot B (light-blue in light microscope); d – EDS spectrum in Spot B, peaks of Cu and S are visible; e – analysis of light separations (SEM) in Spot C (dark-grey in light microscope); f – EDS spectrum in Spot C, peaks of Pb and Sb and the framework of Cu are visible.

Ryc. 38. Analiza EDS puszki z Kurzętnika, Muzeum Zamkowe w Malborku, nr inw. MZM/MK/M/46: a – analiza osnowy próbki w miejscu A; b – spektrum EDS z miejsca A, widoczne piki od miedzi oraz śladów antymonu; c – analiza wydzieleń ciemnych (SEM) w miejscu B (jasnoniebieskich w mikroskopie świetlnym); d – spektrum EDS z miejsca B, widoczne piki od miedzi i siarki; e – analiza wydzieleń jasnych (SEM) w miejscu C (ciemnopopielatych w mikroskopie świetlnym); d – spektrum EDS z miejsca C, widoczne piki od ołowiu i antymonu oraz miedzianej osnowy.

No. 1425, 77; Nos. 1430 and 1435, 79; No. 1449, 84; No. 1488, 95; Świętosławski 1993, 24; on municipal expenses on firearms see also Rathgen 1922, 66-75);

– in Königsberg (Królewiec, now Kaliningrad in Russia) there are data on stone cannonball manufacture in 1403 (MTB, 246-247). In the same year, 17 guns were fitted with iron there. These were supposed to be sent to Ragnit (Ragneta) (MTB, 247).

Manufacture of the cannon and technological examinations

V. Schmidtchen says that smaller stone ball cannons were usually made of iron rods or were sporadically cast of iron since the end of the 14th c. Heavier stone ball cannons, which were used in siege warfare, were either forge-welded of iron rods or made of cast bronze (Schmidtchen 1977a, 13; on the other hand, R. D. Smith says that iron rods were carefully assembled together, but not forge-welded, Smith 2000). Among heavy cannons made of iron bars and hoops and bands, worth mentioning are the "Mons Meg" (1449), a huge bombard of Rennes (before 1456), or the "Pumhart von Steyr" (early 15th c.). It is assumed that cast bronze barrels started to dominate in the 2nd half of the 15th c., due to improvements in casting technology (Szymczak 2004, 80-82; on the "Mons Meg" see also Smith 2000, 75-76).

J. Szymczak describes a technique of barrel casting of a so-called "slow forming," based on a 1842 military manual. It basically consisted in preparing a clay model of the barrel (a so-called false or counterfeit model). Models of holders, ornaments and inscriptions were made of wax, fat and charcoal, and then were place in proper places on the false model. Then, a mould was formed around the false model. The mould was made of layers of clay mixed with horse dung and cow fur, and it was additionally reinforced with rims and metal sheets. The mould was then fired and the clay of the false model was removed from inside. An iron rod (a core) was then placed and fixed inside of the mould in order to ensure a precisely vertical direction of casting. It was wrapped with a rope, so that it did not melt together with the barrel. Hot bronze was then poured into the mould. After the cast had cooled down, the mould was broken into pieces and the iron rod was removed. The barrel was then drilled to receive a bore of desired diameter. Eventually, it was cleaned and polished, and the touch hole was drilled (Szymczak 2004, 89-91; see also Müller 1968b, 21-23). The process was described in a similar way by M. Dąbrowska, based on the 18th c. "Teaching of Artillery" manual by J. Jakubowski (Dąbrowska 2009, 28-32; see Jakubowski 1781-1783).

It seems, however, that another techonology was applied for the Kurzętnik cannon. It has rightfully been defined by A. R. Chodyński as lost-wax (cire-perdue) casting (Chodyński 2010, 126). V. Schmidtchen defines the following steps in this technique:

– preparation of a core – a round wooden shaft was wrapped with hemp ropes and then it was covered with a mixture of clay, ash, fur and chaff. The surface was then covered with wax and tallow;

– wax models of holders, ornaments, etc. were attached to the core;

– a spillway was attached to the future muzzle part of the cannon. Its role consisted in securing a proper thickness of the muzzle and in removing air bubbles from the cast. Eventually, after the cannon had been cast, the spillway was cut away with a saw;

– a mould was made by putting layers of clay on the core. The mould was then rotated on the shaft over a hearth in order to dry the clay and melt the wax away;

– the core was removed and the mould was additionally reinforced with iron rims and bars;

– the mould was vertically placed in a ditch and it was additionally reinforced with sand;

– a chase and breech core, made of a clay-covered iron rod was driven into the mould. It was properly fixed on both ends, in order to ensure its central position;

– hot bronze (with a proportion of ca. 90% Cu and 10% Sn) was cast into the mould;

– after the bronze had cooled down, the mould was broken into pieces and the barrel was polished (Schmidtchen 1977a, 52-53; Dąbrowska 2009, 33, also assumes that the cire-perdue technique may have been used for gun casting in the early 15th c., based on significant amounts of wax purchased for gun casting, see MTB, 483, 496, 502, 545, 547, 558).

The cost of casting of the Kurzętnik cannon was estimated at ca. 2.5-3 Marks (Świętosławski 1993, 27; Szymczak 2004, 105). This estimation, however, was made for the assumed weight of ca. 25-30 kg, while the actual one is more than 42 kg (i.e., ca. 3.5 stones). In 1401, the cost of purchase and transport of 5 Zenteners of copper from Gdańsk (Danzig) to Marienburg (Malbork) was calculated at 14 Marks 3 Ferto and 12 Schillings, i.e., less than 3 Marks per Zentener. In the same year, the casting cost of six guns with a total weight of 15 Zenteners was calculated at

1 Mark per Zentener (MTB, 120; Schmidtchen 1977a, 54; Świętosławski 1993, 21). The total cost of casting of the Kurzętnik cannon could therefore be estimated at ca. 4 Marks.

In previous scholarship the cannon was usually referred to as made of bronze (Cu, Sn) or gunmetal (red brass: Cu, Sn, Zn) (e.g., Grodzicka 1963, 7; Świętosławski 1993, 27; Chodyński 2003, 76, 80, 88; 2007, 388-389; 2010, 126). M. Dąbrowska assumed that the chemical content of metal used in medieval cannon casting was ca. 90% Cu and ca. 10% Sn (Dąbrowska 2009, 36). On the other hand, B. Rathgen assumed that most Teutonic guns may have been made of pure copper (Rathgen 1922, 11).

A sample was taken from the lump of metal in the central part of the bottom of the cannon (Fig. 7). The sample was then sunk in epoxy resin and polished using diamond pastes. The surface of the sample was then etched with a reagent for copper alloys ($K_2Cr_2O_7$ – 2 g, H_2SO_4 – 8 ml, saturated solution of NaCl – 4 ml and H_2O – 100 ml) in order to reveal the microstructure of the sample. Observations of the macro- and microstructure of the sample were carried out using a Leica DMLM optical microscope. A qualitative analysis of metal and visible impurities was also carried out, using a Stereoscan 120 scanning microscope with an EDS X-ray microanalyser.

Microstructure and analysis

A microscopic image of a vertical cross-section of the sample with spots of microscopic observations (A, B and C) is offered in Fig. 37:a. The microstructure in the examined cross-section of the sample in Spot A can be seen in Fig. 37:b, in Spot B – in Fig. 37:c-e, and in Spot C – in Fig. 37:f. Images of the microstructure come from various spots of the sample and they clearly demonstrate that the metal is very porous and it contains numerous impurities resulting from the process of smelting.

An EDS analysis of the sample (Fig. 38:a-b) demonstrated that the cannon was made of copper with trace impurities of antimony. On the other hand, impurities (Fig. 37:d) are of two-fold nature: light-blue ones are copper sulphides (Fig. 38:c-d), while dark-grey ones are eutectic separations of Pb-Sb alloy. Based on the analyses and examinations of the microstructure, it can be said that the gun was cast of copper.

Conclusions

The Kurzętnik cannon is truly a unique specimen as regards the earliest examples of medieval firearms in present-day Polish collections. It possibly dates from the early 15th c. and in all probability it was cast at the Marienburg (Malbork) Castle foundry. Although nothing certain can be said about the carriage of this cannon, it can safely be classified as a *houfnice*, i.e., a light field cannon. Based on inspection of its external features, it can be assumed that cire-perdue technology was used for its manufacture. Thanks to technological examinations, it was possible to find out that the cannon was cast of copper and not of bronze or brass. This seems to be of particular significance, as the existence of copper cannons was often questioned in previous scholarship. Furthermore, it confirms the evidence of Teutonic written sources, which clearly mention the existence of such weapons. Eventually, archaeological research yielded stone cannonballs which were used for cannons of a similar size.

Appendix 1. Stores of firearms in the Teutonic Order's castles to 1410 (for a chronological review see also Rathgen 1922).

1. KÖNIGSBERG (KRÓLEWIEC, now Kaliningrad in Russia), COMMANDERY, GRAND MARSHALL'S OFFICE			
Stores	**Year / Room**		
	1374	1404	1407
	crossbow maker's workshop (*sniczhus*)		
saltpetre, barrels (*tonnen salpetri*)	6		0,5
saltpetre, stones (*steine salpetri*)	84		
ready gunpowder, lb (*pfunt bereiter pulver*)	1900		
gunpowder, barrels (*tonne pulver / buchzenpulfer*)		7,5	7
stone ball cannons (*steynbochzen*)			
small stone ball cannons (*cleyne steynbochsen*)	5		3

lead bullet guns (*lotebuchsen*)	12	3	15
great (stone ball) cannons (*grosse buchsen*)	2		
picks (*bicken*)			24
Source: GÄDO, 7, 9, 11 Scholarship: Schmidtchen 1977a, 28			

2. ELBING (ELBLĄG), COMMANDERY						
Stores	**Year / Room**					
	1396	1402	1404, February		1404, September	
	house commander's residence (*des huskompthurs gemach*)		crossbow maker's workshop (*sniczhus*)	not specified	crossbow maker's workshop	not specified
saltpetre, barrels (*vas salpetri*)	1	not mentioned			61	
saltpetre, stones (*steyne salpeter*)	61		61			
sulphur, barrels (*tonnen swebil*)	3	„			1	
great (stone ball) cannons (*grosse bochse*)				1		1
medium cannons (*mittelbuchse*)	1*	„		1		1
small stone ball cannons (*cleyne steynbochsen*)	3	„		2 (1 damaged)		1
lead bullet guns (*lotbochse*)				1		1
stone balls for great cannons (*steyne czur grossen buchsen*)	303	„				
stone balls for medium cannons (*steyne czur mittelbochsen*)	120	„				
stone balls for small cannons (*steyne czu den cleynen buchsen*)	400	„				
Source: GÄDO, 79, 83-85 Scholarship: Schmidtchen 1977a, 28-30 (this author draws attention to the fact that the great cannon was first mentioned in 1404, while great cannon balls were already recorded in 1396)						
Remarks: * this cannon was leased to the burghers of Elbing						

3. CHRISTBURG (DZIERZGOŃ), COMMANDERY						
Stores	**Year / Room**					
	1385	1390	1392	1399	1404	1410
	crossbow maker's workshop (*sniczhus*)		crossbow maker's workshop	not specified	crossbow maker's workshop	crossbow maker's workshop
saltpetre, lb (*pfunt salpetri*)		7500				

saltpetre, barrels (*tonne salpetri*)			1			
saltpetre, stones (*steyne salpetri*)				53		
sulphur, barrels (*tonne sweybel*)						1
gunpowder, barrels (*tonne pulvers*)			5,5		6	21
gunpowder, stones (*steyne pulver*)				37		
bolt guns (*pfilbuchsen*)	2					
great (stone ball) cannons (*grosse (steyn) buchse*)	1	1	1	1	1	1
small stone ball cannons (*cleyne steynbuchse*)	1	3	1			1
small stone ball cannons which launch balls of a fist's size (*buchse dy schuest eynen steyn eyner fuest gros*)						1
lead bullet guns (*lothebuchsen*)		5	5			5
stone balls for great cannons (*steyne*)			125			
stone balls for small cannons (*steyne*)			100			
Source: GÄDO, 125-128, 130, 132 Scholarship: Schmidtchen 1977a, 30-31						

4. BALGA (BAŁGA, now Vesoloe in Russia), COMMANDERY			
Stores	**Year / Room**		
	1392	1395	1410
	not specified	armoury (*harnuschkamer*)	not specified
gunpowder, barrels (*tonne (buchsen)pulvers*)	6	2	8,5
stone ball cannons (*steynbuchsen*)		2	
Source: GÄDO, 152-154 Scholarship: Schmidtchen 1977a, 31; Nowakowski 1986, 90			

5. BRANDENBURG (POKARMIN, now Ušakovo in Russia), COMMANDERY		
Stores	**Year / Room**	
	1399	
	crossbow maker's workshop (*sniczhus*)	treasury (*tresil*)
gunpowder, sacks (*secke pulvers*)	10	
corned saltpetre, barrels (*tonnen geluttert salpetri*)	2	
sulphur, barrels (*tonne swebil*)		1
great (stone ball) guns (*grosse buchse*)		1
lead bullet guns (*lothebuchse*)		1
Source: GÄDO, 217 Scholarship: Schmidtchen 1977a, 31		

6. RAGNIT (RAGNETA, now Němaп in Russia), COMMANDERY							
Stores	**Year / Room**						
	1379, no exact date	1379, December	1392	1396	1402	1407	
	Crossbow maker's workshop (*sniczhus*)					Ragnit castle, room not specified	Labiau (Labiawa, now Polesk in Russia), room not specified
gunpowder, barrels (*tonne buchsenpulver*)			1	2	2	5 and 5 sacks	
great stone ball cannons (*grosse steynbuchsen*)			2				
small stone ball cannons (*cleyne steynbuchsen*)			3				
stone balls for small stone ball cannons (*steyne doczu*)			number not given				
stone ball cannons (*steynbuchsen*)						11	
great and small stone ball cannons (*steynbuchsen gros und cleyne*)				6	6		
lead bullets (*gelote*)						180	
lead bullet guns (*lothbochsen*)			16	14	14	18	2
guns (*bochsen*)	6	7					
Source: GÄDO, 258 - 260, 262, 264, 267 Scholarship: Schmidtchen 1977a, 31-32; Nowakowski 1986, 90							

7. MEMEL (now Klaipeda in Lithuania), COMMANDERY					
Stores	**Year / Room**				
	1389	1389	1402	1404	
	not specified			kitchen (*kochen*)	
gunpowder, barrels (*tonne pulvers* / *buchsenpulver*)		1	0,5	3	
great stone ball cannons (*grosze steinbochse*)					1
small stone ball cannons (*cleyne steynbochsen*)			2		5
stone balls for stone ball cannons (*steyne czu bochsen* / *buchsensteyne*)		60	40		
stone ball cannons (*steynbuchsen*)	2	2			
lead bullet guns (*lothbuchsen*)	4	5	3		
damaged guns (*czubrachene buchse*)		1			
Source: GÄDO, 301-303 Scholarship: Schmidtchen 1977a, 32-33; Nowakowski 1986, 90					

8. OSTERODE (OSTRÓDA), COMMANDERY						
Stores	**Year / Room**					
	1391	1392	1397		1407	1410
	not specified		armoury (*harnaschkamer*)	Wildenberg (Wielbark) near Ortelsburg (Szczytno)	not specified	
gunpowder, barrels (*tonne pulvers*)		10				2 (1 in Osterode, 1 divided between other castles)
gunpowder, stones (*steyne polvers*)	10					
saltpetre, barrels (*tonnen salpetir*)						4
guns / cannons (*buchsen*)						23 (in the entire commandery)
made gunpowder, barrels (*gemachter pulver, tonnen*)			3			
gunpowder for lead bullet guns (*polver*)		amount not given				
great (stone ball) cannons (*grosse buchse*)	1	1			1	
medium (stone ball) cannons (*messige (bochze)*)					1	
small (stone ball) cannons (*cleyne bochsen*)	3	3		1	1	
hammers for small (stone ball) cannons (*hamer doczu*)				1		
stone balls for great stone ball cannons (*mit steynen*)	30	30				
stone balls for small stone ball cannons (*steyne doczu*)	60	60				
lead bullet guns (*lothebuchsen*)	2	2			2	
lead bullets for lead bullet guns (*gelote doczu*)	300	180				
Source: GÄDO, 317-319, 322, 326 Scholarship: Schmidtchen 1977a, 33-34						

9. BRATHEAN (BRATIAN), REEVESHIP	
Stores	**Year / Room**
	1405
	not specified
iron lead bullet guns (*yserynne lothbuchsen*)	2
Source: GÄDO, 365	

10. BRODNICA (STRASSBURG), COMMANDERY				
Stores	**Year / Room**			
	1396	1404	1406	1409
	not specified			
great (stone ball) cannons (*grosse buchse*)	1	1	1	1
Source: GÄDO, 378-381 Scholarship: Schmidtchen 1977a, 34				

11. GOLUB (GOLLUB), COMMAN DERY	
Stores	**Year / Room**
	1410
	not specified
lead bullet guns (*lotbuchsen*)	2
Source: GÄDO, 401	

12. KOWALEWO POMORSKIE (SCHÖNSEE), COMMANDERY			
Stores	**Year / Room**		
	1392	1399	1410
	not specified		crossbow maker's workshop (*sniczhus*)
gunpowder, stones (*steyne polvers*)			4
gunpowder, barrels (*tonne polvers*)			0,5
stone ball cannons (*steynbuchsen*)	1	1	
small stone ball cannons (*cleyne steynbuchsen*)			2
lead bullet guns (*lotbuchsen*)	2	2	3
ramrods for lead bullets (*stempel do man gelote mitte trybet*)			3
picks for making stone balls (*bicken do man buchsensteyne mitte howt*)			2
Source: GÄDO, 411-412 Scholarship: Schmidtchen 1977a, 34-36			

13. TORUŃ (THORN), COMMANDERY				
Stores	**Year / Room**			
	1392	1397	1407	1410
	chamber at the castle (*kamer off dem huse*)	not specified	not specified	not specified
gunpowder, barrels (*loge mit pulver*)	1			
gunpowder, sacks (*secke mit pulver*)		3		
great (stone ball) cannons (*grosse buchsen*)	1	1		

stone ball cannons which launch balls of a man's head size (*buchse die eynen steyn schut zo gros als eyn heupt*)			1	2
iron guns (*yserynne buchsen*)	6	6		
stone balls (*buchsensteyne*)	60			
Source: GÄDO, 429-431, 433 Scholarship: Schmidtchen 1977a, 36-37; Nowakowski 2004, 227-228				

14. BOBROWNIKI (BIBERERN), REEVESHIP			
Stores	**Year / Room**		
	1392	1404	1405
	not specified	not specified	not specified
gunpowder, barrels (*thunne pulvirs*)		2,25 (1,25 in Dobrzyń)	2
gunpowder, sacks (*secke*)		2	2
stone ball cannons (*steynbuchsen*)	1 (in Dobrzyń)	8 (3 in Dobrzyń)	7
stone balls (*steynen*)	15 (in Dobrzyń)		
lead bullet guns (*lothbuchsen*)	2 (1 in Dobrzyń)	4 (2 in Dobrzyń)	10
lead bullets (*gelote*)	60 in Dobrzyń, other bullets in Bobrowniki		
damaged guns (*czubrochne bochse*)		1 (in Dobrzyń)	
Source: GÄDO, 466-468, 470 Scholarship: Schmidtchen 1977a, 37			

15. NIESZAWA (NESSAU), COMMANDERY			
Stores	**Year / Room**		
	1388	1402	1407
	not specified	not specified	not specified
guns (*buchsen*)	1	1	1
Source: GÄDO, 477-479 Scholarship: Schmidtchen 1977a, 37-38			

16. LIPIENEK (LEIPE), REEVESHIP								
Stores	**Year / Room**							
	1374	1381	1387	1391	1398	1399	1404	1409
	not specified	not specified	not specified	not specified	not specified	not specified	not specified	not specified
guns (*buchsen*)	3	3	-	3	3	3	3	3
Source: GÄDO, 524-529 Scholarship: Schmidtchen 1977a, 38								

17. RADZYŃ CHEŁMIŃSKI (REHDEN), COMMANDERY		
Stores	**Year / Room**	
	1377	1382, 1389, 1390, 1391, 1402, 1404, 1409
	not specified	
guns (*buchsen*)	1	not mentioned
gun bolts (*bochsenpfile*)	540	not mentioned
Source: GÄDO, 558-563 Scholarship: Schmidtchen 1977a, 38		

18. GRUDZIĄDZ (GRAUDENZ), COMMANDERY		
Stores	**Year / Room**	
	1398	1404
	not specified	not specified
gunpowder, stones (*steyne gemachtes pulvers*)	19	19
great stone ball cannons (*grosse steynbochse*)	1	1
small stone ball cannons (*cleyne steynbochse*)	1	1
stone balls (*steyne doczu* / *mit steynen*)	97	19
lead bullet guns (*lotebuchsen*)	6	6
lead bullets (*und gnug gelote doczu*)	number not given	number not given
Source: GÄDO, 597-598 Scholarship: Schmidtchen 1977a, 38-39		

19. ŚWIECIE (SCHWETZ), COMMANDERY					
Stores	**Year / Room**				
	1377	1382	1392	1394	1407
	not specified		not specified		
gunpowder, sacks (*lederynne secke mit pulver*)			13	4	not mentioned
great (stone ball) cannons (*grosse buchsen*)			2	2	,,
stone balls for the greatest cannon (*czur grosten steyne*)			48	48	,,
stone balls for the other cannon (*czur andern steyne*)			120	120	,,
guns (*buchsen*)	2	not mentioned	not mentioned	not mentioned	,,
lead bullet guns (*lothebuchsen*)			5	5	,,
lead bullets (*gelote*)			400	400	,,
Source: GÄDO, 613-615 Scholarship: Schmidtchen 1977a, 39-40					

20. CZŁUCHÓW (SCHLOCHAU), COMMANDERY			
Stores	**Year / Room**		
	1392	1402	1410
	not specified	not specified	not specified
gunpowder, barrels (*vas pulvers*)	1	1	more than 0,5
great (stone ball) cannons (*grosse bochsen* / *steynbuchsen*)	2	2	2
small stone ball cannons (*cleyne steynbuchsen*)			3
Stone balls (*steyne*)	200	200	200
lead bullet guns (*lotbochsen*)		2	2
iron lead bullet guns (*yserynne lotbuchszen*)			2
small red brass lead bullet guns (*cleyne erynne lotbuchszen*)			2
Source: GÄDO, 649-650 Scholarship: Schmidtchen 1977a, 40			

21. ŚWIDWIN (SCHIVELBEIN), REEVESHIP				
Stores	**Year / Room**			
	1385	1386	1389	1402
	not specified	not specified	not specified	not specified
gunpowder, barrels (*tonne polvers*)				1,5
saltpetre, barrels (*tonne salpetri*)	1			
saltpetre, barrels (*veschin salpetri*)		2		
saltpetre, stones (*steyn salpeter*)				1
sulphur, barrels (*tonne swebel*)		less than 1		
great (stone ball) cannons (*grosse buchse*)	1			
small guns (*cleyne bochsen*)	2			
guns (*bochsen*)		3	4	
Source: GÄDO, 672-673 Scholarship: Schmidtchen 1977a, 40				

22. GDAŃSK (DANZIG), COMMANDERY							
Stores	**Year / Room**						
	1384	1385	1389	1391	1396	1407	
	crossbow maker's workshop (*sniczhus*)					crossbow maker's workshop	Lauenburg (Lębork) castle
gunpowder, lb (*pfunt pulvers*)			600	600**			
gunpowder, sacks (*secke mit buchsenpulver*)					6		
saltpetre, barrels (*tonnen salpetri*)			1	1**	1,5	1,5	
sulphur, barrels (*tonne swebil*)			0,5	0,5**		1	
great (stone ball) cannons (*grosse buchsen*)	3	3	1*	1	1	1	
stone ball guns (*steynbochse*)				1			
stone balls (*buchsensteyne*)					90		
small guns (*cleyne bochsen*)	8	8	6				
guns (*buchsen*)							1
gun bolts (*buchsenpfeyle*)							60
lead bullet guns (*lotebuchsen*)				4	4		
Source: GÄDO, 682, 684-686, 688, 690 Scholarship: Schmidtchen 1977a, 42							
Remarks: * the cannon was kept at Marienburg at that time; ** the 1389 record gives the quantities of particular resources and then mentions their price being 80 Marks; the 1391 record mentions this price only							

23. GNIEW (MEWE), COMMANDERY						
Stores	**Year / Room**					
	1396	1399	1402	1404, February	1404, August	1407
	not specified	crossbow maker's workshop (*sniczhus*)				
great stone ball cannons (*grosse steynbochse* / *grosze bochse*)	1	1	1			
lead bullet guns (*lothebuchsen*)	9	9	9	8	68	8
Source: GÄDO, 737-741 Scholarship: Schmidtchen 1977a, 42-43						

24. GOTLAND, REEVESHIP		
Stores	**Year / Room**	
	1404	1407
	not specified	tower (*turm*)
gunpowder, barrels (*tonne pulvers*)	2	15
small stone ball cannons (*kleine steinbuchsen* / *cleyne buchsen*)	2	2
stone ball cannons (*steynbuchsen*)		4
stone balls (*buchsensteyne*)		300
lead bullet guns (*lothbuchse*)	1	1
Source: GÄDO, 762-764 Scholarship: Schmidtchen 1977a, 43		

25. NEUMARK (NOWA MARCHIA), REEVESHIP					
Stores	**Year / Room**				
	1408		1410		
	Świdwin (Schivelbein) castle	Drezdenko (Driesen) castle	Świdwin (Schivelbein) castle	Drezdenko (Driesen) castle	Kostrzyń (Küstrin) castle
gunpowder, barrels (*tonne pulver*)	0,5	4	1		0,5
gunpowder, sacks (*secke*)		3	1		
gunpowder, stones (*steyn pulvers*)			1		
saltpetre, stones (*steyn salpeters*)	1				
gun wagons with utensils (*buchsenwayn mit allem gerete*)		1		1	
great (stone ball) cannons (*grose buchsen*)				2	
stone ball cannons (*steynbuchsen*)		3		2	
lead bullet guns (*lotbuchsen*)		6		6	4
gun hammers (*hamer czu den buchsen*)		2		2	
lead bullets, barrels (*tyne mit loten czu den buchsen*)		1		1	
Source: GÄDO, 765-767					

Appendix 2. Finds of stone cannonballs matching the calibre of the Kurzętnik cannon from the territory of the Teutonic Order's state in Prussia.

Site	Context	Metrical data		Publication	Collection	Chronology	Raw material/Remarks
		Calibre (cm)	Weight (kg)				
Chełmno	Stray	12,9	2,9	Strzyż 2011, Cat. No. 74	MZCh, inv. No. MZCH/H/20	15th c.	Granite
Chełmno	Stray	12,7	2,8	Strzyż 2011, Cat. No. 76	MZCh, inv. No. MZCH/H/19	15th c.	Granite
Chojnice	Old Market Square (Stary Rynek), Trench 1	13,3	1,8	Strzyż 2011, Cat. No. 90	Archaeological Station of the IA UŁ in Białe Błota, inv. No. CHR/1097/00/2	15th c. (1431 or 1454 ?)	Granite, ½ missing
Chojnice	As above	12,7	1,6	Strzyż 2011, Cat. No. 91	Archaeological Station of the IA UŁ in Białe Błota, inv. No. CHR/1097/00/3	As above	Granite, ½ missing
Chojnice	As above	13,5	3,0	Strzyż 2011, Cat. No. 97	Archaeological Station of the IA UŁ in Białe Błota, inv. No. CHR/1097/00/9	As above	Granite
Chojnice	As above	13,3	2,3	Strzyż 2011, Cat. No. 99	Archaeological Station of the IA UŁ in Białe Błota, inv. No. CHR/1097/00/1	As above	Granite, ½ missing
Człuchów	Castle, Trench 15B	13,4	3,32	Strzyż 2011, Cat. No. 108	IA UW, inv. No. Cz. Z.15B.54	15th c.	Limestone
Człuchów	Castle, Trench 15B	12,4	1,57	Strzyż 2011, Cat. No. 110	IA UW, inv. No. Cz. Z.15B.34	15th c.	Granite, ½ missing
Człuchów	Castle, Trench 15B	13,3	3,16	Strzyż 2011, Cat. No. 115	IA UW, inv. No. Cz. Z.15B.56	15th c.	Granite
Człuchów	Castle, Trench 16	11,3	2,07	Strzyż 2011, Cat. No. 116	IA UW, inv. No. Cz. Z.16.56	15th c.	Granite
Człuchów	Castle, Trench 18	11,4	1,81	Strzyż 2011, Cat. No. 117	IA UW, inv. No. Cz. Z.18.65	15th c.	Granite, damaged, 1/6 missing
Człuchów	Castle, Trench 19B	11,8	2,21	Strzyż 2011, Cat. No. 142	IA UW, inv. No. Cz. Z.19B.12/21	15th c.	Granite
Człuchów	Castle, Trench 19B	13,5	3,23	Strzyż 2011, Cat. No. 144	IA UW, inv. No. Cz. Z.19B.12/3	15th c.	Granite
Elbląg	?	12,0	2,2	Strzyż 2011, Cat. No. 173	MAHE, inv. No. ME/43/HM	15th c.	Granite
Elbląg	?	13,5	5,3	Strzyż 2011, Cat. No. 174	MAHE, inv. No. ME/45/HM	15th c.	Granite
Elbląg	Cellar, ul. Wigilijna 11/12	13,0	3,7	Strzyż 2011, Cat. No. 191	MAHE, inv. No. ME/66/HM	15th c.	Granite, ¼ missing
Elbląg	Town armoury, Old Market Square (Stary Rynek)/Rzeźnicka	13,0	3,2	Strzyż 2011, Cat. No. 252	MAHE, inv. No. ME XXIII/260	15th c.	Granite
Golub Dobrzyń	Castle?	13,0	2,9	Strzyż 2011, Cat. No. 298	ZG	15th c.	Granite
Grudziądz	Castle?	13,3	3,2	Strzyż 2011, Cat. No. 304	MG, inv. No. MG/ML/245	15th c.	Granite
Grudziądz	Castle?	13,0	3,1	Strzyż 2011, Cat. No. 306	MG, inv. No. MG/ML/243	15th c.	Granite
Grunwald?	Battlefield?	13,0	2,5	Strzyż 2011, Cat. No. 326	MO, inv. No. 1727; 284	1410?	Granite
Kwidzyn	Stray	13,0	-	Strzyż 2011, Cat. No. 404	MK, inv. No. MK/M/110	15th c.	Granite
Kwidzyn	Stray	12,7	-	Strzyż 2011, Cat. No. 406	MK, inv. No. MK/M/112	15th c.	Granite
Kwidzyn	Stray	12,1	-	Strzyż 2011, Cat. No. 407	MK, inv. No. MK/M/113	15th c.	Granite
Kwidzyn	Stray	12,7	-	Strzyż 2011, Cat. No. 408	MK, inv. No. MK/M/114	15th c.	Granite
Mała Nieszawka	Castle, Trench 5	12,8	2,9	Strzyż 2011, Cat. No. 600	MOTDE, inv. No. MT/A/Ś/21/145/ 78	1350-1425 (1422?)	Granite
Puck	Castle, western gate	13,5	3,5	Strzyż 2011, Cat. No. 814	MZP, inv. No. Pk.Z.05-c.01	1450-1500 (1464?)	Granite
Reszel	Castle, tower cellar	13,5	3,5	Strzyż 2011, Cat. No. 853	MWMO	Late 14th-15th c.	Granite

Szestno	Castle	13,4	3,1	Strzyż 2011, Cat. No. 949	IAE PAN Łódź, inv. No. Sz.48/86	15th c.	Granite, slightly damaged
Toruń	Castle?	11,9	2,4	Strzyż 2011, Cat. No. 959	MOTR, inv. No. Dz./H/498	1350-1450	Granite, damaged
Toruń	Castle?	12,7	2,4	Strzyż 2011, Cat. No. 960	MOTR, inv. No. Dz./H/157	As above	Granite, damaged
Toruń	Castle?	12,9	2,7	Strzyż 2011, Cat. No. 961	MOTR, inv. No. Dz./H/134	As above	Granite, damaged
Toruń	Castle?	12,9	2,9	Strzyż 2011, Cat. No. 962	MOTR, inv. No. Dz./H/150	As above	Granite, damaged
Toruń	Castle?	13,0	2,9	Strzyż 2011, Cat. No. 963	MOTR, inv. No. Dz./H/493	As above	Granite
Toruń	Castle?	13,2	3,2	Strzyż 2011, Cat. No. 964	MOTR, inv. No. Dz./H/154	As above	Granite, with a hole
Toruń	Castle	13,2	-	Strzyż 2011, Cat. No. 965	MOTDE, inv. No. MT/ZK-922	Mid-15th c.	Granite, ½ missing
Toruń	Castle	13,5	4,1	Strzyż 2011, Cat. No. 966	MOTDE, inv. No. MT/ZK-920	Mid-15th c.	Granite

IAE PAN – Instytut Archeologii i Etnologii Polskiej Akademii Nauk (Institute of Archaeology and Ethnology of the Polish Academy of Sciences)
IA UŁ – Instytut Archeologii Uniwersytetu Łódzkiego (Institute of Archaeology of the University of Łódź)
IA UW – Instytut Archeologii Uniwersytetu Warszawskiego (Institute of Archaeology of the University of Warszawa)
MAHE – Muzeum Archeologiczno-Historyczne w Elblągu (Archaeological-Historical Museum in Elbląg)
MHECh – Muzeum Historyczno-Etnologiczne w Chojnicach (Historical-Ethnological Museum in Chojnice)
MK – Muzeum w Kwidzynie (Museum in Kwidzyn)
MOTR – Muzeum Okręgowe w Toruniu, Ratusz (District Museum in Toruń, Town Hall)
MOTDE – Muzeum Okręgowe w Toruniu, Dom Eskenów (District Museum in Toruń, Eskens House)
MWMO – Muzeum Warmii i Mazur w Olsztynie (Museum of Warmia and Masuria in Olsztyn)
MWLW – Muzeum Warmińskie w Lidzbarku Warmińskim (Warmia Museum in Lidzbark Warmiński)
MZCH – Muzeum Ziemi Chełmińskiej w Chełmnie (Museum of the Land of Chełmno in Chełmno)
MZP – Muzeum Ziemi Puckiej (Museum of the Land of Puck)
ZG – Zamek w Golubiu Dobrzyniu (Castle in Golub Dobrzyń)
ZRe – Zamek w Reszlu (Castle in Reszel)

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PUSZKA Z KURZĘTNIKA – UNIKALNY OKAZ ŚREDNIOWIECZNEGO DZIAŁA (NA TLE ROZWOJU BRONI PALNEJ NA TERENIE PAŃSTWA ZAKONU NIEMIECKIEGO W PRUSACH)

Streszczenie

Artykuł niniejszy poświęcony jest najstarszemu zabytkowi artylerii w obecnych zbiorach polskich – puszce z zamku w Kurzętniku na terenie dawnego państwa Zakonu Niemieckiego w Prusach. Zabytek omówiony został na szerszym tle rozwoju broni palnej w państwie zakonnym do ok. 1410 r. Na podstawie analizy bronioznawczej zabytek ten datować można na początek XV w., acz stwierdzić należy (wbrew dawniejszej literaturze), iż w ruinach zamku mógł on zostać zdeponowany zarówno w 1414 r., podczas tzw. wojny głodowej, jak i w 1454 r.

Zabytek ten mierzy 50,7 cm długości, ma kaliber 135 mm i waży 42,28 kg. Strzelano zeń kulami kamiennymi o masie ok. 3 kg, zaś masę ładunku prochowego szacować można na ok. 0,2 kg. Budowa puszki, z wyraźnie wyodrębnioną szerszą częścią wylotową i węższą komorą prochową, jest dość typowa dla wczesnych armat strzelających kulami kamiennymi (*steynbuchsen*). W dawniejszej literaturze puszka z Kurzętnika często określana była jako bombarda. Wydaje się jednak, iż lepiej byłoby określić ją jako hufnicę (lekkie działo polowe). Na podstawie kształtu lufy i proporcji między częścią wylotową a komorą prochową wskazać można na kilka analogii do tego zabytku: działo prawdopodobnie pochodzenia bośniackiego z przełomu XIV i XV w. (zbiory Museum für Deutsche Geschichte w Berlinie), hufnicę z 2. połowy XV w. (zbiory Zeughausu w Berlinie), działo z dawnych zbiorów zamku Schwarzburg w Niemczech czy hufnicę z 1. ćwierci XV w. ze zbiorów Muzeum w Novým Bydžove w Czechach.

W dalszej części artykułu omówione zostały początki broni palnej w państwie zakonnym. Pierwsze wzmianki pochodzą z 2. połowy XIV w. (1362 r. – kronika Posilgego; 1374 r. – inwentarze zamkowe), acz bardziej dokładne dane w źródłach inwentarzowych i rachunkowych to dopiero koniec XIV i początek XV w. Na podstawie danych rachunkowych oszacowano wydatki centralnej kasy Zakonu na broń palną w okresie poprzedzającym Wielką Wojnę, gdzie wyraźny wzrost widoczny jest w l. 1408 i 1409, a związany był on zarówno z produkcją kilku wielkich dział, jak i wydatkami na proch i amunicję. Skrótowo omówione zostały także prace puszkarzy i innych specjalistów działających na rzec Zakonu, obejmujące zarówno wyrób broni, prochu i amunicji, jak i szereg innych zadań. Na podstawie zachowanych źródeł pisanych omówiono typy broni palnej, amunicji i osprzętu, używane w państwie zakonnym. Głównym centrum produkcji broni palnej i amunicji do niej był niewątpliwie sam zamek w Malborku (gdzie na produkcję dział wskazują też dane archeologiczne). Informacje o produkcji broni palnej i amunicji pochodzą też z Gdańska, Elbląga i Królewca.

Ostatnia część artykułu zawiera badania technologiczne puszki z Kurzętnika. Na podstawie obserwacji mikroskopowych oraz analizy za pomocą mikroskopu skaningowego stwierdzono, iż zabytek został wykonany z miedzi, śladowo zanieczyszczonej antymonem. Puszki miedziane (*kopperyne bochsen*) znane są z zakonnych źródeł inwentarzowych i rachunkowych, tak więc przedwojenna literatura przedmiotu wskazywała, iż znaczna część zakonnych zasobów artyleryjskich mogła być wykonana właśnie z tego surowca. Z drugiej strony, badacze powojenni, aż do czasów współczesnych, niemal jednogłośnie twierdzili, iż zabytek kurzętnicki wykonano z brązu lub spiżu. Badania technologiczne pozwoliły na skorygowanie tego poglądu.

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