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The revolutionary cannon of the 15th century

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The 15th century saw the most important period of European fortress development. [1] This was driven by artillery's own development: bombards became reliable wall breakers, about 1420 [2]; small-arms had separated from artillery proper, about 1440. [3] Further, the early propellant, serpentine [4], was replaced by the easier to handle corned powder; it was corned small, for small-arms and large, for artillery. [5] Guns were either, forged from iron hoops and staves, or, cast in bronze; there were even hybrids. [6] After an initial move towards gigantism, Mons Meg [7] and the Dardanelles gun, [8] the potential of more modest pieces was recognized. It is generally acknowledged that, about 1450, the strength of bronze guns was enhanced by their being cast breech down. This and other modest developments, like trunnions, led to the first appearance of a revolutionary cannon. [9] Less well known is the important step of reaming their bores.

Breech down casting

It is logical to suggest that bronze guns were first cast by bell founders, they used the same materials and techniques. So, after the practice with bells, guns were cast muzzle down. [10] Unfortunately, this left them with slag inclusions that weakened the breech. Slag is the unavoidable side product of using a flux in the melting process. [11] Slag floats in the liquid metal and, unless drawn off, solidifies within the cast to give weak zones at the top, the breech. Casting the gun breech down and somewhat longer than needed, probably from about 1440, left the slag inclusions at the gun's muzzle end. When cold, the gun could be trimmed to length and the impurities discarded. This practice was not universally adopted for some time and bronze guns continued to be cast muzzle down well into the 16th century. [10]

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Porosity

Like most metals, liquid bronze is less dense than its solid and, as it cools against the walls of the mould, the remaining liquid core becomes even less dense. At some point during the cooling the bronze looses fluidity and the core solidifies to normal density. The space that would have been filled, had the metal been sufficiently fluid, is left empty as pores. Porosity weakens the gun and is more likely in large volumes of cast metal, like the breech. The problem of porosity is reduced if the gun is cast longer than needed. This provides a head of liquid metal, putting the base of the cast, the breech end, under greater pressure and helping the molten metal to flow and so fill nascent pores. Even so, porosity is not always avoided, as can be seen in the case of a cast iron 13" mortar. [12]

Reaming the bore

All castings, when fresh from the mould, appear in a rough state and their surfaces need to be cleared of materials adhering from the moulds. This cleaning process, chasing, results in an acceptably smooth surface finish. Hand chasing was straightforward on the larger bombards where the bore to length ratio was reasonable but was particularly difficult in the case of long guns of narrow calibre. Cast bronze small-arms were finished by reaming the bore. [13, 14] This technique began to be applied to artillery pieces after about 1450. [15] A fortuitous, but probably unforeseen, consequence of reaming was that cast artillery now had a more uniform calibre and a straighter bore. They were well placed to take advantage of the consistently sized cast iron shot found in Europe from 1414 (and commonly available by 1480). [16, 17]

These guns had their own ball moulds [18] and, so, a reproducible windage. The size of the windage is unknown but was probably about 1/20 of the ball's diameter. [19] As the windage is reduced, three advantages accrue: first the shot is better collimated; second, for a given propellant charge, the shot's velocity increases, [20] and; third, wear due to balloting is reduced. [21] Accordingly, both range and accuracy were improved and the gun's useful life is extended.

Also, about 1470, we find the first appearance of trunnions cast directly onto guns, which simplifies the design of their carriages and reduces the problems encountered with targeting. [22] Although these guns were individually much lighter than bombards and could be mounted on carriages this only improved their manoeuvrability, not their overall transport. [23] The advantage of the trail carriage was somewhat offset, however, by the need to accommodate the gun's recoil, some 10 – 15m (50'). [24]

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Cannon

These new bronze guns, cast breech down, with a reamed bore, and firing consistently sized projectiles, would become the most effective cannon of their day. [9] After about 1470, the besieger was able to deliver a devastatingly more powerful shot, fired more frequently, from further away and hitting more accurately; about this time we see bombards appearing less frequently in arsenal inventories. [25] France was probably the first early modern state to have sufficiently evolved to organise the casting, logistical support and efficient exploitation of whole batteries of cannon. [26] What is certain is that during the French invasion of Italy, 1494, they fully exploited their new batteries.

Consequences

Prior to the appearance of these cannon, late medieval poliorcetics was biased towards the besieger. The bombard, though not very accurate, was still effective against large targets like castle walls. The besieged, on the other hand, had few targets worthy of such monsters and relied on small-arms or wall guns to keep the bombards at a respectful distance and to defend against the inevitable assault. Strangely, after the unchallengeable success of the cannon's initial appearance, its improved accuracy marked it as a suitable weapon for the distant defence of fortresses – these cannon fathered bastions.

References

[1] Tomkinson, 2018.

[2] Rogers, 1993, pg266

[3] de Crouy-Chanel, 2011.

[4] Tomkinson, 2020.

[5] Hall, 1997, pg 101 ff.

[6] Mallet, 1856, pg 188.

[7] Smith and Brown, 1989.

[8] Lefroy, 1868.

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[9] The reader should be aware that we use the term 'cannon' as a definition for the bronze guns described herein. Although this type of gun would become the cannon of the future, in the 15th century it was a term applied to almost any type of gun.

[10] López-Martín, 2007, pg 271 ff.

[11] Flux suppresses excessive oxidation, and thus waste, of the molten metal.

[12] Mallet, 1856, Plate III, Fig. 1, pg 22.

[13] Biringuccio, 1990, pg 307.

[14] López-Martín, 2007, pg 263 ff.

[15] von Essenwein, 1877; Vol II, Plate XXXVIII] These are exclusively cast bronze cannon, the technological problems involved in boring iron guns were not overcome until the late 1700's.

[16] Awty, 2007.

[17] López-Martín, 2007, pg 195.

[18] The Burgundian 16-pdr, *Gouvernante*, had 127 iron shot cast for it in 1478, [Smith and DeVries, 2005, pg 254.] The fact that this gun, a 'grosse coulverine', was given a name implies it ranked in status alongside the castle breakers of previous decades, the named bombards.

[19] Galili & Rosen, 2014.

[20] Benton, 1867, pg 124 ff.

[21] Mallet, 1856, pg 162 ff.

[22] Most of the variation in a gun's range results from irregularities in the propellant; increasing the projectile's initial velocity flattens its trajectory and counteracts the effects of this variation. This enables gunners to look along the gun (the 'line of metal') and see just where the shot should strike.

[23] Smith and DeVries, 2005, pg 208ff. Whilst bombards were certainly unwieldy to transport, they still made about 12 – 15 km a day, not much slower than that of an army,

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about 20 km a day. It is worth remembering how 'delicate' gun carriages can be, even in Wellington's time moving artillery along poor roads could wreck the carriages.

[24] Ufano, 1621, pg 43. Within a siege battery, a gun's recoil needs to be managed. Fan shaped wooden beds, sloping gently up towards their rear quickly brought the gun to rest and eased its return to the embrasure after reloading. By varying the rearward slope, guns of different calibre were accommodated in roughly equal distances, about 30' but the need to have fairly free access behind guns increased this space requirement to about 50' (15m).

[25] Smith and DeVries, 2005, pg 205.

[26] Contamine, 1964, pg 266. In 1489 Charles VIII of France had trains including 58 cannon, 33 large culverins, 13 medium culverines and 45 Falcons.

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