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Military Engineers and Artillery Production in Milan Under the Sforza (1450–1535)
Institutions, Professionalism, Techniques

Summary: The late 15th-century Milanese army boasted an impressive artillery park of several heavy bombards and a multitude of light field artillery pieces. Such war machines were manufactured and operated by the specialised personnel of the 'ducal munitions and public works office', i.e., engineers recruited among both Lombards and foreigners, supervised by a general commissar. Unfortunately, the study of Milanese firearms production and its political and diplomatic implications remain practically uninvestigated among contemporary historians, except for a few important studies from the 19th and 20th centuries.

Thanks to the epistolary documentation contained in the archival series *Ingegneri e architetti*, conserved in the State Archive of Milan, this contribution will focus on providing an overview of the activities of the ammunition office, the professional backgrounds of its engineers and their skill sets, as well as gunmaking processes, production sites, and techniques. Finally, this contribution will stress the impact of artillery production on the Italian and broader European political culture of the time: even in times of peace, the art of gunmaking and its products shaped the diplomatic and economic relations between Italian and other European states, via the constant exchange of specialised gunsmiths and the diffusion of innovative military technology.

Keywords: Milan, Sforza, engineers, firearms, gunpowder, technology, warfare

Introduction

Milanese 15th-century artillery production is a complex topic, since it embraces the history of technology, warfare, political institutions, and economy, encompassing the milieu of the duchy of Milan as a whole. It is useful, therefore, to take a quick, preliminary

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glimpse of the sources and the studies available on the matter. The most important nucleus of documents regarding these topics is preserved in the State Archive of Milan, in the fund *Autografi* and in the series *Uomini Celebri dell'Arte*, sub-series *Ingegneri e architetti*, which gathers missives, contracts, estimations, and provisions written or received by Milanese engineers and architects from 1387 to 1882. The majority of this documentation, however, comes from the second half of the 15th century, encompassing the entirety of the Sforza rule.[1] Pertinent documentation is also scattered across the fund *Registri delle Missive*, which contains letters sent and received by the dukes and by ducal officials from 1447 to 1538,[2] as well as in the subseries *Fabbriche di armi, armature e artiglierie* of the aforementioned *Autografi* fund, which contains several interesting documents about weapon manufacture workshops, techniques and strategic material purchases.[3] Unfortunately, however, subsequent archival reorganisations and bombings during WWII disrupted the original order of the Sforza archives.[4] Moreover, there is an absolute lack of material sources: not a single Milanese artillery piece has survived the test of time.

These seem to be the main reasons why Milanese firearm production has been left at the margins of the most recent historiographical enquiries about 15th-century Lombardy. The only extensive works available on this specific topic are those written by Angelo Angelucci and Luca Beltrami between the second half of the 19th century and the second decade of the 20th century.[5] These works, thanks to a wide array of documentary sources, cover topics such as Milanese handgunners (*schioppettieri*) corps, Milanese gunmaking, and the different types of artillery available to the ducal army; however, they suffer from a strong nationalistic bias that sometimes lead to very inaccurate reconstructions, e.g. Angelucci boasts that the arquebus was undoubtedly an Italian invention, while its real origin is unclear.[6]

Most recent historiography, however, can only partially correct these views, since it focuses on the more institutional, less technical aspects of the Milanese military organisation. Nonetheless, works like those by Maria Nadia Covini and Giorgio Chittolini are fundamental in understanding the framework in which the Milanese artillerymen operated: key topics like the structure and financing of the ducal army and the cultural background and the professional behaviour of the ducal officials are deeply discussed in these studies.[7] In 2007, the publication of a biographical dictionary

1 ASMi.A.UCdA.bb. 81–88.

2 ASMi.V-S.RdM.

3 ASMi.A.A.C.M.

4 For a quick resume of these events, see this page on the website of the State Archive of Milan: https://archiviodistatomilano.cultura.gov.it/as-milano

5 Angelucci A. 1865; Angelucci A. 1869; Beltrami L. 1916.

6 Angelucci A. 1865, 27–28. The words *archibugio* and *arquebus* seem to derive from the German *Hackenbüchse*, see: Hall B.S. 1997, 100.

7 Covini M.N. 1998; Covini M.N. 1993, 60–75; Chittolini G. 1988, 101–133.

dedicated to Milanese engineers contributed to reorganise all the information available about these professionals; but again, this work does not delve into the concrete aspects of weapons production, but instead references back to the classic 19th century works on these matters.[8] There are, however, a few studies that try to focus more on the concrete side of the matter: the studies respectively on Genoese, Venetian, and Ferrarese artillery written by Renato Gianni Ridella,[9] Carlo Beltrame,[10] and Manlio Calegari,[11] as well as the informative papers written by Fabrizio Ansani about the traveling gunmakers active in Florence and Italy.[12] Although these works shed some light on production techniques, the Milanese milieu is left on the margin of their discussions.

The typical profile of a ducal engineer

The production of artillery for the Milanese army was managed by a specialised group of technicians, ducal engineers, who did not focus exclusively on it, but were employed in a plethora of tasks and projects. This social group was made up of people with very diverse professional backgrounds that, thanks to their previously acquired knowledge and their first-hand experience in the field, ended up serving the duke both for military and civilian purposes. From their professional profiles, they can be divided into three groups: the designers of machines for civilian or military purposes (i.e. cranes for construction works, siege machines, etc.), expert managers of construction sites (organising workers, estimating costs, supplying materials and tools, etc.) and, finally, artists (painters, sculptors, chisellers, etc.) who, thanks to their drawing ability and their understanding of mathematics and proportions, became involved in architectural projects (what nowadays we would call civil engineers).[13] The gunmakers themselves had backgrounds in various types of metalworking, such as blacksmithing, tinsmithing, boilermaking, bellfounding, or clockmaking – all these craftsmen would have the right skills and the necessary experience to start a career in the production of heavy, light, and portable firearms.[14]

These pre-acquired skills, however, represented only a starting point: before serving in the Milanese military, these engineers had to endure a period of training in the

8 Bossi P., Repishti F., Langé S. 2007.

9 Ridella R.G. 2005, 77–134.

10 Beltrame C. 2011, 12–22.

11 Calegari M. 2005, 55–76.

12 Ansani F. 2017a, 148–187; Ansani F. 2021, 3–92; Ansani F. 2017b, 749–789. There is another paper which is more focused on Milan, see: Ansani F. 2019.

13 Covini M.N. 1993, 65–66.

14 Ansani F. 2017a, 155, 161.

field. The reason behind the need of a practical apprenticeship period resided in the fact that gunmaking and the firing of effective artillery volleys were a conglomeration of empirical knowledge achieved through trial and error: these masters did not have a precise or scientific understanding 'of the numerous, complex, critical variables involved in the casting of their guns. Sometimes, failures followed successes. The production of a French cannon, like the casting of a statue or the fabrication of any machinery, required multiple attempts, observation, intuition, and reflection'.[15] Examples of this practice can be found in Milanese sources. For instance, one of the most skilled Milanese engineers, Danese Maineri (†1482), started his career at some time in the 1450s with a training period under his father Zuchino, who served as a military engineer under the duke Filippo Maria Visconti and was confirmed in his position by the new duke Francesco Sforza in 1451.[16] When Zuchino died in 1462, his son replaced him in his service in the 'Office of the Como Canal' (Officium Navigii Cumarum):[17] at this point, D. Maineri had probably already acquired a vast hands-on engineering experience.[18]

Itinerancy was a key characteristic of the Milanese engineers. Their main activities incuded the inspection of ducal fortresses, the estimation of the necessary reparation works and their costs, they were constantly travelling across the duchy; as soon as they finished their job on one site, they could be quickly dispatched to another location and to a different type of work. See, for example, a letter written by Bartolomeo Gadio da Cremona (chief of the ducal engineers) to the duke Galeazzo Maria Sforza, on November 7, 1467:[19] we read that Gadio has been sent to Sesto Calende in order to supervise the construction of a pontoon bridge on the Ticino river and the loading of an ammunition shipment on boats bound for Pavia. He entrusts the first job to three engineers, who estimate to finish the bridge in a little more than a day; in the meantime, the ammunition carriages arrive from Milan and the ammunition – some bombards, stones, wood, and other unmentioned equipment – is unloaded on the banks of the Ticino, near a wharf that Gadio has managed to build while supervising the work of the other three engineers. When the boats arrive, he loads the ammunition on them, and on November 8, 1467, Gadio sails to Pavia, where the shipment is awaited. All this happens while Gadio is ill with fever and aching joints, but he cannot rest – soon after the ammunition is delivered to Pavia, he goes back to his office in Milan to do some paperwork and inform the duke.[20]

15 Ansani F. 2017b, 779.

16 Covini M.N. 1993, 67; Mancini F. 1975,163; ASMi.V-S.CI. b. 853 (Pavia). August 17, 1472.

17 Engineers can be seen as jacks-of-all-trades: even if they specialised in one or more fields, they had to be able to work on very diverse projects. Being a skilled artilleryman and siege engineer did not prevent D. Maineri from taking care of the hydraulic works on the Como canal.

18 Mancini F. 1975, 163.

19 ASMi.A.A.C.M. b. 88. fasc. 5. November 7, 1467.

20 ASMi.A.A.C.M. b. 88. fasc. 5. November 7, 1467.

Being skilled technicians, but also full-fledged ducal officials, these professionals, in addition to engineering skills, had to possess a certain diplomatic aptitude, to interface efficiently with local communities throughout the dominion. The support of the locals was vital for the duke, especially in remote areas: the horse tax (*tassa dei cavalli*) for the housing of Milanese troops, the provision of workforce and carriages for public works, and the security of the Milanese borders depended on how well the duke – via his officials – managed to gain the favour of these communities by granting them benefits (e.g. tax exemptions) and supporting them in their claims and disputes against local landlords.[21] Regarding public construction works, these communities were not only fundamental in providing workforce and equipment, but also often tried to bend the original planning to their advantage. One such instance happened in Valtellina during the construction of the bridge of Ganda, near Morbegno, between 1488 and 1490. The engineer Giovanni Antonio Amadeo, sent by the duke to define a suitable location for the bridge along the banks of the Adda river, found himself involved in a harsh dispute between the local communities, each vying to have the bridge bulit closest to themselves, in order to take advantage of it for commercial purposes and for the collection of transit duties. Amadeo managed to remain neutral, avoiding any favouritism, without compromising the esteem the locals had for the duke;[22] exhausted by these negotiations, however, Amadeo wrote to his chief Ambrogio Ferrari that 'it took more effort to influence the mind of the men than to lay down the pillars of said bridge'.[23]

Officium munitionum et laboreriorum

As soon as he became duke of Milan, during the first months of 1450, F. Sforza started a massive reorganisation of the Milanese institutions. Mimicking the structure of the companies of adventure he was so familiar with, each task was delegated to faithful officials – chosen among his closest friends and supporters – who could count on a network of collaborators, had large margins of initiative, and had to report periodically to Cicco Simonetta, the personal secretary of the duke.[24] Gabriele and

21 A military mobilisation plan compiled in 1472 gives an idea of the contribution of local communities to military logistics. The ducal army is said to have been able to field eight heavy bombards, four medium bombards, eight light artillery (*spingarde*), and 100 hand cannons (*schioppetti*), all with their ammunition, powders, and various equipment. To achieve this, the communities of the dominion had to supply 227 carts, 522 pairs of oxen, and 600 herdsmen. See: Covini M.N. 1998, 380–381. For the importance of the collaboration between ducal officials and local communities, see: Chittolini G. 1988, 105–108.

22 Covini M.N. 1993, 63.

23 'Li volle più ingenio a condure la mente deli homine che nonne a mettere zoxo quisti pilloni del dicto ponte'. Schofield R.V., Shells J., Sironi G. 1989,178, n. 200, April 9, 1490.

24 Covini M.N. 1998, 144.

Giovanni da Cernusco, who supervised the activity of the engineers under the Visconti, were confirmed in their ammunition office (*officium munitionum*).[25] However, in 1455, the assignments of this office began to overlap with the work of the new general commissioner of public works (*commissarius generalis super laboreriis*), B. Gadio, who supervised the construction of the Castello di Porta Giovia in Milan; while B. Gadio managed the work and the salaries of the engineers and labourers in his specific construction site, the *officium munitionum* did the same thing with the rest of the personnel dispersed throughout the duchy.[26] By the end of the 1460s, the two offices had completely merged together, coalescing into the *Officium munitionum et laboreriorum*, which was in charge of both the supervision of public works and the management of all the engineers under Milanese service. In 1472, the *officialis munitionum* Filippo Corio, helped by the network of ammunition officials who kept track of the necessities of all the ducal fortresses, handled ammunition purchases and other provisions; B. Gadio, both in person and by correspondance, coordinated the activities of the engineers in accordance with the will of the duke. In addition the office had its own accountant, Francesco Pandolfo, and a partnership with the wheat merchant Gabriele della Croce, who supplied each ducal castle in the dominion with food provisions.[27]

The *officium* was also responsible for the purchase of saltpetre, sulphur, coal, copper, lead, tin, and iron, i.e. key raw materials for gunmaking. In two letters written to the duke between February 1474 and March 1474, B. Gadio tells that F. Corio was sent to Venice, together with a master of saltpetre (*magistro dal salnitrio*),[28] to negotiate with a local merchant the purchase of 2000 *cantari*[29] of saltpetre and a 300-ducats-worth batch of lead suitable for making bullets;[30] we do not know the outcome of these negotiations, but the fact that F. Corio was assisted by Leonardo Botta, one of the Milanese ambassadors in Venice, gives us an idea of the importance of the matters handled by the *officium.*[31] Saltpetre and powder were also regularly bought from Genoa, Asti, Naples, and the Empire: in all these transactions, either B. Gadio or F. Corio was

25 Covini M.N. 1998, 144.

26 Covini M.N. 1998, 144.

27 Covini M.N. 1998, 144. For the organogram of the *officium* in 1472, *see:* Santoro C. 1948, 119–122.

28 Saltpetre purchases were usually carried out only after the mineral had been tested for its purity and quality. The saltpetre master mentioned here was sent with F. Corio specifically for this purpose. ASMi.A.UcdA. b. 88. fasc. 10. February 28 and March 17, 1474.

29 A *cantaro* was a measurement of weight common throughout the 15th century Italian peninsula. In Milan, one *cantaro* was equivalent to 100 Milanese *libbre sottili* (thin pounds), for a total of circa 32,6793 kg. The 2000 *cantari* of saltpetre bought by F. Corio in Venice were therefore equal to 65 358,6 kg, *see:* Frangioni L. 1993, 46–49.

30 ASMi.A.UcdA. b. 88. fasc. 10. February 28 and March 17, 1474.

31 ASMi.A.UcdA. b. 88. fasc. 10. February 28 and March 17, 1474. *See:* Zapperi R. 1971.

involved, either in person or by means of delegated engineers, from whom they constantly required detailed updates on the negotiations, the quality of the mineral, its price, and the shipments status.[32]

Castles as manufacturing and storing centres

All these materials were safely stored in castles, along with artillery pieces, portable firearms, and various kinds of weaponry and tools. The castles of Milan, Pavia and Cremona were the major ammunition storing centres of the duchy: from their warehouses, necessary goods were supplied to other fortifications.[33] Artillery pieces were stored in dedicated rooms called *bombardere*. For example, in a letter dated May 9, 1472, B. Gadio tells the duke that he made some transportation tests with the disassembled one-year-old bombard *Galeazesca Victoriosa*, which was held in the Castle of Porta Giovia in Milan. Thanks to a decent number of workmen, securing each piece to a sturdy wooden pole mounted on cartwheels, B. Gadio managed to take the *Galeazesca* out of the *bombardera* and moved it to the vast castle gardens, where it underwent maintenance, i.e. the cleaning of the threaded joint between the barrel and the ignition chamber.[34]

As evidenced above, castle gardens were used as testing and shooting grounds. Their size, proximity to the facilities in which artillery was stored, and the fact that they were under the strict control of the duke made castle gardens the ideal place to conduct tests on newly made firearms. In one example, a mortar was put to test in Genoa in the 1470s: the mortar was placed on a proper base in the castle of Luccoli and fired a projectile that, thanks to its parabolic trajectory, fell into the gardens of the nearby fortress of Castelletto.[35] We also have evidence of job interviews conducted by Gadio and other expert Milanese engineers in the garden of the Castle of Porta Giovia in Milan, to hire various foreign engineers into Milanese service.[36]

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32 For Genoa, Asti and the Empire, see: ASMi.A.UcdA. b. 88. fasc. 8. December 21, 1471; fasc. 9. February 1, March 31, April 3, October 9, October 20, 1473; fasc. 10. March 21, 1474 and June 14, 1476; fasc. 11. March 27, 1476. For Naples, see: Bianchessi S. 1998, 541–582.

33 Covini M.N. 1998, 149. For example, on December 21, 1471, B. Gadio entrusted F. Corio with the delivery of two mortars, 10 *spingarde*, some *schioppetti*, and a few heavy crossbows – with their respective ammunition and powders – to the fortresses of Genoa: these goods were taken from the Castle of Porta Giovia in Milan and from the castle of Pavia. ASMi.A.UcdA. b. 88. fasc. 8. December 21, 1471.

34 ASMi.A.UcdA. b. 88. fasc. 8. May 9, 1472.

35 ASMi.A.A.C.M. b. 231. fasc. 5, *Adoardus da Curte ducallis Lucolli castelani* to the duke, date unknown. The castle of Luccoli was situated on the site of the current Villetta Di Negro, while the Castelletto was situated on the current Spianata di Castelletto. For visual reference, *see:* the map by Brusco G. 1789, markers 45 and 59. The shot covered a distance of 0.5 Milanese mile, i.e. 892,405 m.

36 E.g., the job interview of the French artilleryman *Jacomo de Paris*. See: ASMi.A.UcdA. b. 88. fasc. 9. April 1, 1473.

Most importantly, however, it was in castles that Milanese artillery pieces were produced. This should not surprise the reader, since it should appear perfectly logical to have production facilities, storing warehouses, and testing grounds all close together. The sources offer multiple attestations of the casting of different artillery pieces; while the most extensively recorded casting is the one of the *Galeazesca Victoriosa* in the castle of Porta Giovia in Milan in 1469–1471, we also have other mentions, e.g. that of a mortar cast and tested in the castle of Luccoli in Genoa, and of a bombard tailpiece made in the castle of Imola.[37]

Manufacturing processes: established theory and fallible praxis

It is vital to stress that 15th-century technological manufacturing was always a compromise between a somewhat established theoretical (but gained through practical trial-and-error processes) base of knowledge and a fallible and not-so-accurate crafting practice.

Practically acquired theory suggested that, compared to iron-forging, bronze-casting was certainly more expensive in the short term[38] but more economically efficient in the long term: unlike iron-forged guns, bronze heavy artillery could be melted down and recast, making it easier and cheaper to repair;[39] bronze artillery was also safer to use and could withstand more powerful powder charges, providing an increased offensive potential.[40] Another advantage was that bronze guns could be made into two, three, or four separate pieces connected by threaded joints, making them easy to disassemble for transportation via oxen carriages or ships.[41] For these reasons, already from the mid-15th century, iron was relegated to the making of lighter artillery pieces, such as *spingarde*, *passavolanti*, and *carbuctane* and portable firearms like *schioppetti* – being smaller, these pieces could maintain a relatively low weight even when fabricated in cast iron, making them cheaper but still easily manageable.[42] All these artillery pieces were tested before firing: three hammer strikes ensured the solidity of the piece.[43] Regarding mathematics and proportions observed during the design of these pieces, the calibre determined the length of the barrel, the necessary amount of powder, and, therefore, the dimensions of the ignition chamber. Small calibre weapons required lead ammunition to obtain a certain offensive power, while larger calibres used stone

37 For the *Galezesca*, see: ASMi.A.A.C.M. b. 231. fasc. 5. August 27, 1469 and December 18, June 27, August 25, 1471; ASMi.A.UcdA. b. 88. fasc. 8. July 1, 1471. For the bombard of Imola, see: ASMi.A.A.C.M. fasc. 5. July 10, 1472.

38 Hall B.S 1997, 92–93.

39 Ansani F. 2017a, 156–157.

40 Hall B.S 1997, 93.

41 Ansani F. 2017a, 155–157.

42 Ansani F. 2017a, 155–157.

43 ASMi.A.UcdA. b. 88. fasc. 8. May 22, 1472.

projectiles instead; cast iron shot was a later innovation.[44] Finally, when it comes to gunpowder chemistry, it was assumed – thanks to empirical experiments – that fine powders with a high saltpetre percentage were suitable for light artillery and portable firearms, while coarser, low-saltpetre powders were ideal for heavy bombards.[45]

Real-life praxis, however, was a totally different beast. First, the practical application of theoretical principles depended entirely on the first-hand experience of the individual masters. The fact that each master applied his own practical solutions, techniques, and procedures resulted in a general lack of standardisation both in the manufacturing processes and in the finished artillery pieces: for a Renaissance Italian state, it was common to have several heavy bombards (*bombarde grosse*) of different lengths, calibres, and weights that required different amounts of powder, because their creators followed their own plans, instead of a set, common standard.[46] In the 1470s, the artillery park of the dukes of Milan included heavy bombards of different calibres: two *Ferline* which fired 200-pound stone projectiles, the *Corona* (400-pound projectiles), the *Bissona* and *Liona* (300-pound projectiles), and the enormous *Galeazesca Victoriosa* (570-pound projectiles).[47] This lack of standardisation was not limited to gunmaking but concerned every other aspect of artillery management as well. In June 1472, B. Gadio and Benedetto Ferrini (a Florentine engineer serving the dukes of Milan) had a harsh dispute on the making of artillery carriages: B. Gadio held in high regard the traditional Lombard way of making them with medium-sized wheels – a compromise between ease of unloading and efficiency on difficult terrain – while B. Ferrini insisted that the bigger the wheels, the better; each master believed in his own method, based on practical experience.[48] The empiricism of the methods used in gunmaking often led to unsuccessful results. The calculation of the percentages of tin and copper to achieve a strong bronze alloy, how much material should be put in the furnace, and the evaluation of whether the metal was ready to be cast or not – everything was done by eye and by hands-on experience. But sometimes the eye and experience can be misleading: the casting of the barrel (*tromba*) of the *Galeazesca Victoriosa* required two attempts, due to a disastrous mistake made by the engineer Francesco da Mantova, who misjudged the melting point of the bronze alloy and started pouring it in the mould when it was not yet completely molten.[49] Moreover, there were also important technological limitations that influenced the design and the offensive potential of these weapons, such as the

44 ASMi.A.UcdA. b. 88. fasc. 8. May 22, 1472; Hall B.S. 1997, 93–95.

45 Hall B.S 1997, 42–43.

46 Ansani F. 2017a, 157–160.

47 Ansani F. 2017a, 171–172.

48 ASMi.A.UcdA. b. 88. fasc. 8. June 7, 1472.

49 ASMi.A.UcdA. b. 88. fasc. 8. July 1, 1471.

unreliability of iron casting. In fact, until almost the end of the 15th century, Italian gunmakers had not mastered the knowledge and the techniques used to build furnaces strong enough to efficiently produce cast iron of strength and quality suitable for the making of artillery.[50] But in some areas of the Italian peninsula, such as the Lombard alpine valleys under Milanese and Venetian control, experiments were carried out, thanks to the availability of local craftsmen skilled in the making of suitable blast furnaces and the casting of complex iron works.[51] At the end of the 1480s, Venice tried to standardise artillery pieces made in the foundries of the Brescian valleys and started to make cast-iron cannonballs for the light artillery pieces of the Serenissima.[52] Similarly, in the 1490s, Ludovico Sforza set up foundries in Val d'Ossola to enhance the production of armour pieces and cast-iron artillery.[53] Others tried to pursue these achievements, but ultimately failed because, apart from highly skilled personnel, it was fundamental to work with iron ores of great purity: the duke Ercole d'Este did manage to begin manufacturing cast-iron cannonballs and light artillery in Ferrara, but, even if he hired specialised Lombard personnel, the production was mediocre and discontinuous, since the mineral used was of inferior quality compared to Lombard iron.[54]

Milan, after all, was one of the leading European centres for steelworks, and therefore became a major centre of iron-cast artillery production as well: Milanese masters could count on not only decades of technical know-how thanks to an excellent armour and arms making industry,[55] but also on a constant supply of quality iron ores from the Lombard alpine valleys and copper, tin, and lead from Northern and Central Europe, thanks to the commercial intermediation operated by the Swiss confederation.[56] This is why cast-iron light artillery pieces were ubiquitous in Milan. The industry was so prolific that it not only supportted the internal demand of the ducal army, but also was able to reserve a portion of the production for commercial purposes. Between 1460 and 1479, the marquis of Mantua bought several batches of iron-cast *spingarde* and *schioppetti* (along with armour sets, lances, and other weaponry),[57] while, in 1492, Ferrante of Aragon, king of Naples, bought a significant batch of 1000 iron *spingarde* from the Milanese arsenals.[58] To conclude this

50 Ansani F. 2017a, 156.

51 Ansani F. 2017a, 156, 178, 180; Ansani F. 2017b, 751, 761, 773.

52 Ansani F. 2021, 288–289.

53 Motta E. 2014, 223.

54 Ansani F. 2021, 289.

55 Montandon G. et al. 1929; Motta E. 1914, 187–232.

56 Soldi Rondinini G. 1978, 426–427.

57 Ansani F. 2019, 2–8.

58 Ansani F. 2017a, 168.

array of Milanese industriousness, the heavy bombard *Liona*, made by Francesco Bianco, was a true exception in the panorama of the heavy artillery of the first half of the 15th century, since it was entirely made of cast iron.[59]

Foreign masters in Milan: international circulation of craftsmen and techniques

In 15th-century Italy, artillery production and gunsmithing were not subject to any sort of military secret, mainly because it would have been practically impossible to prevent the diffusion of knowledge and practical know-how. Like painters, sculptors and mercenary captains, military engineers were always searching for a better patron, a better salary, and lucrative benefits for themselves and their families. This caused intense competition between states, where each power tried to lure expert artillery masters into their service, offering them good salaries, free tools, workshops, accommodation, and so on.[60] In March 1474, B. Gadio sent F. Corio to Venice to convince an artillery master named Francesco (who had served in Milan years before) to return to Milanese service; since the man was absent, F. Corio explained to his wife all the benefits he would obtain: she said her husband would surely accept this good offer as soon as he got home.[61]

The circulation of specialised personnel across the peninsula was intense. The Piedmontese Ferlino da Chieri, before settling in Venice in the 1450s, worked in Savoy and Milan, where he made two heavy bombards, named *Ferline* after himself.[62] The Bolognese Aristotele Fioravanti (†1486), after serving the dukes of Milan and other Italian states, moved to Russia, where he worked as military architect and artillery expert for the tsars.[63]

European masters were active in Italy at the time as well. Guglielmo dello Monaco, a Frenchman, after serving Milan in the 1440s, moved to Naples, where he cast the imponent bombard *Neapolitana* and crafted the bronze doors of the Castel Nuovo, becoming the most prestigious artillery master of the entire Neapolitan kingdom.[64] In the 1490s, L. Sforza hired many German and Swiss mercenary companies, which brought in Lombardy *schioppettieri* and artillery masters from the same regions,

59 Ansani F. 2017a, 172.

60 Ansani F. 2017a, 166–168.

61 ASMi.A.UcdA. b. 88. fasc. 10. March 17, 1474. Unfortunately, the missive does not report the contract offered by F. Corio.

62 Ansani F. 2017a, 172.

63 Ghisetti Giavarina A. 1997.

64 Ansani F. 2017a, 169–170, 177.

thus generating a productive technological exchange with Milanese engineers.[65] Finally, temporary loans were also possible. In 1496, Maximilian King of the Romans loaned his master artilleryman Zohanne Openzeler to L. Sforza: Openzeler stayed in Milan for a few weeks and cast at least four artillery pieces.[66]

Technological exchange between Milan and France is attested by a missive dated 1 April 1473 in which B. Gadio recounts to the duke the exam of a French artilleryman, Jacomo de Paris, who requested to be accepted into Milanese service. Under the keen eye of B. Gadio and other expert engineers, Jacomo was required to hit a 100-foot-distant target with an artillery piece of his own construction. Although he fails, he gets close enough; B. Gadio suggests the duke should hire him and grant him an apprenticeship under an expert master.[67] This document, however, provides other valuable information: the bombard used is a single-piece (and, therefore, muzzle-loading), probably bronze unit, fires a stone projectile of 57 pounds and uses a 7-pound powder charge. Compared with other Milanese bombards, with ammunition poundage ranging from 300 to 570 pounds, this piece seems more akin to the French-style, mobile artillery that would become popular a few years later, first during the Burgundian wars and later during the Italian expedition of Charles VIII.[68] This is just a hypothesis, but it seems very plausible, given the constant commercial and diplomatic connections between Milan and France; in the 1460s, the political relationship between the Sforza and the French crown was so amicable that a Milanese contingent fought for King Louis XI in the War of the Public Weal using the French-style light artillery pieces previously mentioned.[69]

Conclusion: artillery production as a state-run business

We have seen how artillery was produced, stored, and tested in castles under the control of the duke, overseen by expert engineers who learnt the craft after practical apprenticeships, working under the supervision of the directors of the *officium munitionum et laboreriorum*. The *officium* represented a solid institutional frame, but was quite informal in its management, granting these professionals ample margins of initiative. This informal but solid organisation encouraged experimentation and the pursuit of new techniques and technologies, such as 'alpine-style' iron casting. This constant technological research was also carried out thanks to foreign engineers from both Italy and elsewhere in Europe, who could be hired with long-term contracts or as

65 Ronchi M. 2021, 257–284.

66 ASMi.A.A.C.M. fasc. 5. November 27, 1496.

67 ASMi.A.UcdA. b. 88. fasc. 9. April 1, 1473.

68 Ansani F. 2021, 271–295.

69 Ansani F. 2021, 277.

short-term loans between allied powers. In fact, a strong diplomatic relationship with foreign powers was necessary to have access to skilled professionals and the necessary raw resources (saltpetre, copper, tin, etc.) for gunmaking.

Therefore we can see that the production of artillery in the 15th-century duchy of Milan was a state-run, state-controlled business, since these manufacturing processes were enclosed in the thick network of the ducal political and administrative institutions. Moreover, enormous financial resources were needed to cast and field these artillery pieces, costs that only the duke could afford, thus preventing private actors from taking part in this industry.

Although this conclusion applies to heavy artillery, we have evidence of light artillery escaping the ducal monopoly, thanks to it being cheaper and easier to make: in 1476 Genoa, a ducal artilleryman heard rumours about some bronze *spingarde* being made clandestinely by certain tinsmiths for anti-Milanese rebels.[70]

There is a lot more to research and to say on these topics, but for now we must settle for these few pages, which I hope have provided a quick but satisfying picture of Milanese firearm production in the 15th century.

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