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THE INFLUENCE OF TECHNICAL AND TECHNOLOGICAL DEVELOPMENT ON CANNON MANUFACTURING IN HUNGARY

(A MŰSZAKI-TECHNIKAI FEJLŐDÉS HATÁSA A HAZAI LÖVEGGYÁRTÁSRA)

Throughout history, the characteristics of artillery pieces primarily determined the possibilities of artillery development. The development of artillery pieces was not a process in itself but a part of general scientific, technical and technological development. It is evident that artillery weapons and their state of technical development reflected the state of technical and technological development of the society that created them. However, there are historical examples that do not prove this seeming evidence. In certain cases, methods invented in the field of artillery production were ahead of their time and significantly contributed to general industrial development. This article, however, also presents a case when industrial capacities were not exploited in the interest of cannon production.

Keywords: *artillery, cannon manufacturing, cannon barrel, arms industry*

A történelem folyamán a tüzérség fejlődésének lehetőségeit alapvetően a lövegek jellemzői határozták meg. Ezeknek az eszközöknek a fejlődése nem egy magában álló folyamat, hanem az általános tudományos, műszaki és technikai haladás része. Magától értetődik, hogy a tüzérség eszközparkja, annak műszaki fejlettsége tükrözi az azt létrehozó társadalom műszaki-technikai fejlettségét. Mégis, feltűnnek olyan történelmi példák, amikor ez a látszólagos evidencia nem valósul meg. Néhány esetben a löveggyártás érdekében kifejlesztett eljárások megelőzték korukat, és jelentősen hozzájárultak az általános ipari fejlődéshez. Egy olyan esetet is bemutat az alábbi cikk, amikor az ipar lehetőségeit nem aknázták ki a löveggyártás érdekében.

Kulcsszavak: *tüzérség, löveggyártás, lövegcső, hadiipar*

Technical and technological development always contributed to the modernisation of artillery weapons. In the early days, modernisation simply meant the development of barrels. Later, the possibilities provided by barrel improvement were utilised in the field of developing carriages, as well as the instruments and methods of cannon operation, then projectiles and gunpowder, and finally (to date) the instruments and methods of cannon operation again.

It needs to be added, however, that traditional artillery tasks have partially been taken over by units equipped with mortars and rocket artillery. Weapons had been specialised and categories transformed: until the First World War, (land) artillery pieces were classified as field, fortress and siege weapons, while afterwards the categories were field, anti-tank and anti-aircraft guns.

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Conventional guns have traditionally been the most traditional, most common and most characteristic artillery weapons from their early introduction to date. Although there was a period when the Hungarian armed forces had significant rocket artillery, it may be stated that conventional artillery pieces have predominantly and traditionally comprised Hungarian artillery throughout its history. Conventional guns are categorised based on the barrel's specifications (measurements and other characteristics). Gun barrels are central parts that can be specified in the case of early artillery pieces, too, and therefore can be examined throughout the entire history of artillery.

It is obvious that all developments apart from those aiming at the improvement of the specifications of the barrel targeted the most complete utilisation of the characteristics of this most crucial cannon part. In the case of traditional artillery, the barrel has remained a decisive element, and all the above listed components were and are to make the operation of this crucial gun part as effective as possible. This means that developments may be divided into those of the barrel and those others targeting the improvement of barrel operation. The first type of innovation should be examined first, as these developments also define the frames of the second type of improvement.

The manufacturing of guns and barrels had gone through huge technological development since their appearance. The influence of general technological development can be well demonstrated throughout the entire history of weapons. With outstanding cases the development line diverges, and therefore those cases are worthy of studying.

When analysing the influence of general technical and technological development the examination of production methods proves to be most important, as these define the specifications of gun barrels. Not only were each period's top technologies utilised when manufacturing barrels, but historical examples also prove that those technologies sometimes were even surpassed, making important and sudden technological headway possible for the civilian industry. At other times, when barrels were not manufactured in compliance with the industrial standard of the period, outdated artillery pieces were produced. Studying such cases, however, is made difficult by the lack of a comprehensive volume discussing the manufacturing of artillery weapons from the beginnings to date.

Figure 1. A hooped gun of the Hungarian Museum of Military History[2]

[2] Photographer: Péter Szikits

The casting of the first mortar-like guns reflected the scientific experience of the casting of bells, which had the same proportions. The manufacturing of moulds, made of clay and dried above live coals, required great professional knowledge and experience, and took a long time. Casting too was a complicated task requiring technological discipline. Finally, bronze (tin bronze), the raw material of gun barrels, was costly. The need for cheaper manufacturing brought the profession of blacksmiths (and coopers) to the field of gun manufacture, but they needed the hammer mills' wrought iron as well. This way, "wrought iron cannon" of hoops and staves were born, which could be used similarly to previous guns, but their production required less advanced technology and cheaper raw materials. The barrels of such guns consisted of lengthy wrought iron rods of rectangular section, held together by hoops. As staves hold the head of a wine barrel, claws at the end of the rods fasten the powder chamber.

In Hungary, the use of cannon became widespread after the Angevin period, during the reign of Sigismund, at the turn of the 14th and 15th centuries.[3] This did not only mean the Royal artillery, towns also had cannon. There was mention of artillery in several towns in account books from the 1420s.[4] Castles had considerably strong artillery pieces.[5] From the appearance of the first cannon to the Ottoman occupation, Royal Hungary had a great quantity of modern guns. The inflow of technology was very strong in the period, owing to Western European craftsmen whose settling in Hungary was consciously organised.[6] "It is a little-known fact that during the first period of the rapid development of firearms, Hungary proved to be successful as a country of reception, technological modernisation being traceable both in the battlefields and in libraries." [7]

To produce longer bronze cannon new improvements were needed such as casting the barrel with the muzzle facing upwards, using a large feeder to recover the shrinking metal and the partial pre-heating of the mould.[8] In the new technology's development, sometime in the middle of the 15th century, several unknown "polyhistors" had a prominent part, such as Vanoccio Biringuccio who studied the creation of bells, statues, water conduits and several other products and wrote a book in the early 16th century.[9] They were not afraid to use experiments and use the gathered experience to produce cannon. Certainly, it was essential to have access to the raw materials of bronze, i.e. copper and tin, the worldwide trade of which unquestionably existed by then.

To decrease costs, i.e. to replace the expensive bronze in the process of manufacturing modern muzzle-loading weapons brought about the development of cast iron cannon. This was to satisfy the expanding fleets' artillery needs. Its fundamental condition was the spread of more efficient blast furnaces from the 14th century. The topic needs further research, but it is most possible that a key to the new development was the widening use of reverberatories

[3] Iványi, Béla: A magyar tüzérség fejlődésének vázlata a XV. és a XVI. században. Debrecen, 1916. p. 6.
[4] Veszprémy, László: Lovagvilág Magyarországon. Budapest, 2008. p. 200.
[5] Iványi, Béla: A magyar tüzérség fejlődésének vázlata a XV. és a XVI. Században. Debrecen, 1916. p. 7.
[6] Veszprémy, László: Lovagvilág Magyarországon. Budapest, 2008. p. 198.
[7] Ib. p. 202.
[8] Bán, Attila: Középkori és újkori bronzágyúk öntéstechnológiájának vizsgálata. In: Bányászati és Kohászati Lapok. Kohászat. Vol. 142, Issue 1. Budapest, 2009. pp. 6-12.
[9] Smith, C. S. – Gnudi, M. T.: The Pirotechnia of Vanoccio Biringuccio. New York, 2005.

(basin furnaces where the metal does not touch the combustible), which had been widely used to melt non-ferrous metal by the 16th century, when the first guns of this type appeared.

Such guns were widely used throughout Europe by the early 17th century. In Hungary, however, bronze cannon were employed more extensively.[10]

During the skirmishes along the Habsburg–Ottoman border, founders always were Germans, although customers mostly were Hungarians.[11] Thus, border castles generally were well equipped, even if older guns too remained in service and, more extensively than in Western Europe, they relied on field cannon rather than fortress guns in fortress defence,[12] obviously due to transportation and financial issues.

The artillery of the Habsburg Empire was considered to be modern. The system of light 3, 6 and 12-pounder field guns used during the Seven-Year War proved to be so successful that other European great powers practically copied it.[13] From the middle of the 18th century to the middle of the 19th century, the Imperial Artillery had enough good-quality cannon, surmounting its Prussian rival in the quantity of guns and its Russian opponent in the greater proportion of mobile (mounted) units. During the Napoleonic Wars "Austria had the best artillery of the continental allies, but it could not compare to that of the French"[14]

By that time, gun boring machines that made it possible to produce barrels by drilling seamless, solid bronze bars were already available.[15] In 1774, John Wilkinson petitioned a patent for a horizontal tool specifically developed to drill cast iron cannon barrels.[16] Wilkinson soon found a new customer: his method was accurate enough to facilitate the serial production of the cast iron cylinders of the Watt steam engine,[17] and the spread of the new technology.

In 1848, the troops of the Hungarian revolution had to confront the effective and well-equipped Austrian artillery. In November, the besieged region of Háromszék in Transylvania faced a seemingly hopeless situation, due to the lack of artillery. Founder Áron Gábor then reached back to an ancient and simple barrel casting method, fitted to local circumstances. The number of guns produced with his method matched the strength of opposing forces in the region, making resistance possible.[18]

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[10] Domonkos, György: Inventáriumok a Királyi Magyarországon és az Erdélyi Fejedelemségben a 16-17. században: váraink fegyverzete és hadfelszerelése. PhD Thesis, Loránd Eötvös University of Sciences, Budapest, 2004. p. 36.
[11] Domonkos, György: Rákóczi taraszkjai. I. In: Örökség, 2006. 11. pp. 4-5.
[12] Domonkos, György: A magyar tüzérség a XVI-XVII. században. In: Gyula, Enzsöl (Ed.): A magyar tüzérség kialakulása és fejlődése. Budapest, ZMKA, 1992. p. 34.
[13] Wise, Terence – Hook, Richard: Artillery Equipments of the Napoleonic Wars. London, 1985. p. 3.
[14] McNab, Chris: Armies of the Napoleonic Wars. Oxford, 2009. p. 168.
[15] McNeil, Ian: An Encyclopaedia of the History of Technology. Routledge, London, 1990. p. 396.
[16] Weigley, Russell Frank: The Age of Battles: The Quest for Decisive Warfare from Breitenfeld to Waterloo. Indiana University Press, 2004. p. 18; McNeil, Ian: An Encyclopaedia of the History of Technology. Routledge, London, 1990. pp. 396-397.
[17] Wille, Hermann Heinz: A szakócától a dinamóig. Budapest, 1988. p. 194.
[18] Bán, Attila: Az ágyúöntés technikája a Székelyföldön 1848–1849-ben. In: Hermann Róbert, Benkő Levente (Eds.): Ágyúba öntött harangok: Tanulmányok Gábor Áron születésének 200. évfordulójára. Sepsiszentgyörgy, 2014. pp. 100-120.

The need for breech-loading rifled guns set new requirements concerning raw materials. In the transitional period leading up to the widespread use of cast steel, various barrel-producing methods and various raw materials were in use in many states. The choice of the Austro-Hungarian Monarchy was bronze, the specifications of which were improved by the Uchatius method: work-hardening the gun after casting it. However, while other great powers immediately changed to the use of cast steel barrels as soon as steel industry met the needed requirements, Austria-Hungary stuck with bronze barrels and did not employ modern construction methods when manufacturing guns either.

In the 1870s, Austro-Hungarian industry was not yet capable of manufacturing artillery pieces similar to Krupp-type steel cannon. Regulation "steel bronze" guns introduced in 1875 were up to their rivals made of steel, and could be produced by domestic industry.[19] The essence of Major General Franz Ritter von Uchatius' invention was strengthening the material by deformation after casting his guns. "Cannon bronze" (tin bronze containing 8% of tin) would otherwise have proved to be a poor material for manufacturing rifled, breech-loading gun barrels. This smart and progressive method, which is called autofrettage today, has been employed to date. The hydraulic version of the technique became widespread during the Second World War.

Type	**Quick breech mechanism**	**Recoil mechanism**	**Gun shield**	**Cast steel barrel**	**Weight (kg)**	**Projectile (kg)**	**Range (km)**
M1875 8cm field gun					742	4.3	4.5
M1875 9cm field gun					1005	6.3	4.5
M1875/96 9cm field gun					?	6.7	6
M1905 8cm field gun	+	+	+		1020	6.7	7
M1905/8 8cm field gun	+	+	+	+	1020	6.7	7
M1899 10cm field howitzer	+				1000	14.7	6
M1899 15cm heavy field howitzer	+				?	38.5	6.2
M1875 7cm mountain gun					?	?	?
M1899 7cm mountain gun	+				318	4.7	5.2
M1908 7cm mountain gun	+	+			402	4.8	5.3
M1909 7cm mountain gun	+	+			467	4.8	5.3
M1899 10cm mountain howitzer	+				?	14.7	6
M1902 10cm mountain howitzer	+	+			?	14.7	6
M1908 10cm mountain howitzer	+	+			1233	14.7	6
M1910 10cm mountain howitzer	+	+			1210	14.7	6

Table 1. Austro-Hungarian (mostly "steel bronze" barrelled) field cannon introduced before the First World War[20]

[19] Ortner, M Christian: The Austro-Hungarian Artillery from 1867 to1918: Technology, Organization and Tactics. Wien, 2007. pp. 74-75.

[20] DeVries, Kelly - France, John - Neiberg, Michael S – Schneid, Frederick (Eds.): King of Battle: Artillery of World War I. p. 145, p. 161. (Google Books. Download: 30 04 2016); Kinard, Jeff: Artillery: An Illustrated History of Its Impact. Santa Barbara, 2007. p. 115; Kováts-Lugosi-Nagy-Sárhidai: Tábori tüzérség. Zrínyi Kiadó, Budapest, 1988. pp. 223-228; Csesznák, Benő: Az Uchatius-ágyúk leírása és hatása. Budapest, 1877. pp. 79-81.

The invention of rifled, and then rifled and breech-loading guns in the 19th century motivated experimenting to find more durable materials for barrels. Wrought iron refined through Cort's puddling procedure, which aimed at reducing the carbon content of iron and producing solid steel, was used. Krupp re-melted steel and manufactured cannon from alloy steel melted in clay or graphite crucibles. His invention was to employ several crucibles simultaneously. The British introduced Armstrong's built-up guns, constructed of "a series of concentric wrought-iron tubes made from spiral coils."[21] The Parrott Gun, a cast iron cannon reinforced by a wrought iron band on the breech, invented by British Captain Blakeley, was first used by Americans.

It became clear that cannon manufacturing needed cheap cast steel. Henry Bessemer solved this problem with such a success that the entire steel industry was revolutionised, and the cost of steel radically decreased.[22] The Siemens-Martin method, which appeared not much later and made more sophisticated and precise alloying possible, however, was "taken back" by the arms industry, suddenly making cast iron and bronze cannon permanently outdated. Siemens' heating method (which was used for the Siemens-Martin furnace) then revolutionised crucible steel production, which had been little productive so far.

Annealed steel barrels with a nickel compound also paid off. Later chrome also became an alloy, and by the beginning of the Second World War the compound used to date had been created: besides 0.3% of carbon content the main alloys are nickel (cca. 3%) and chrome (cca. 1%).[23]

To decrease weight, built-up barrels were started to be used where the undersized outer barrel compressed the inner barrel. This facilitated that the pressure pliantly expanding the barrel when firing first dissolved this pressure so the peak of the pressure would be less in the most stressed layers near the bore. Later the same effect was achieved by directionally deforming the barrel made from one piece, the name of this process employed to date being autofrettage.

In the 1880s, modern steel production methods spread in the Austro-Hungarian Monarchy, as well.[24] The Siemens-Martin furnaces made the accurate setting of carbon content possible, as well as the alloying of the raw material to some extent. However, while other great powers took advantage of the capabilities of steel industry and introduced steel gun barrels as well as barrels of steel alloyed with nickel, Austria-Hungary stuck with Uchatius' "steel bronze."

The Austro-Hungarian Monarchy's metallurgy routinely used the Bessemer converters and the Siemens-Martin furnaces by the turn of the 19th and 20th centuries. The Skoda Factory delivered modern cast steel barrelled, so-called "rapid-fire" naval guns to its customers.[25] Despite this the Monarchy's artillery entered the First World War mostly with the "steel

[21] Holley, Alexander L: A Treatise on Ordnance and Armor. New York, London, 1865. p. 2.
[22] Flavell-While, Claudia: Man of steel. In: Chemical Engineer, November 2010. Issue 68. www. tcetoday.com. (Download: 05 05 2016)
[23] A löveggyártásnál felhasznált anyag ismertetése. Kohászat. Manuscript. Library of the Hungarian Institute of Military Technology 6892. Diósgyőri Új Gyár, 1931. p. 13, p. 16.
[24] Remport, Zoltán: Magyarország vaskohászata a dualizmus korában. Budapest, 2005. pp. 64-73.
[25] History. Skoda. http://www.skoda.cz/en/skoda-holding/key-information/company-history (Download: 30 06 2015); Skoda Works. Globalsecurity.org. http://www.globalsecurity.org/military/world/europe /at-kuk-skoda.htm (Download: 30 06 2015)

bronze" barrelled Uchatius-type cannon which, being mechanically hardened, may have been outstanding when they were introduced, but had become outdated by 1914.

Nevertheless, as the industrial capacity and the scientific background were available, the Monarchy was still able to introduce modern guns during the First World War and produce them in large quantities.

When entering the First World War, the Austro-Hungarian artillery, equipped with outdated artillery pieces, hardly met the requirements of its age. This outdatedness was obvious already in 1914. In comparison with Russian artillery weapons, Austro-Hungarian guns were inferior concerning both technical specifications and performance. New, modern guns equipped with steel barrels were introduced to the Austro-Hungarian arsenal during the First World War. Constructional improvement clearly showed in the performance of artillery pieces: the new guns were equal to their Russian counterparts.

Type	Quick breech mechanism	Recoil mechanism	Gun shield	Cast steel barrel	Weight (kg)	Projectile (kg)	Range (km)
76mm quick-firing light gun	+	+		+	1040	6.6	8.8
76mm quick-firing horse gun	+	+		+	975	6.6	8.8
76mm quick-firing mountain gun	+	+	+	+	626	6.4	7.1
Quick-firing horse mountain gun	+	+	+	+	?	6.4	7.1
Horse mountain gun of the Trans-Amurian border guards	+	?	?	+	?	?	?
122mm light field howitzer	+	+	+	+	1225	21	6.7
152mm heavy field howitzer	+	+	+	+	2750	41	8.7
107mm heavy field gun	+	+	+	+	2180	18.1	9.8

Table 2. Russian First World War field cannon[26]

Type	Quick breech mechanism	Recoil mechanism	Gun shield	Cast steel barrel	Weight (kg)	Projectile (kg)	Range (km)
M1915 10.4cm field gun	+	+	+	+	3300	17.5	12.8
M1917 8cm field gun	+	+	+	+	1386	8	9.9
M1918 8cm field gun	+	+	+	+	1330	8	10.5
M1914 10cm field howitzer	+	+	+	+	1430	16	8
M1914 15cm field howitzer	+	+	+	+	2770	42	8
M1915 7.5cm mountain gun	+	+	+	+	612	6.5	7
M1916 10cm mountain howitzer	+	+	+	+	1235	16	8

Table 3. Austro-Hungarian field cannon introduced during the First World War[27]

[26] DeVries, Kelly - France, John - Neiberg, Michael S – Schneid, Frederick (Eds.): King of Battle: Artillery of World War I. p. 257.(Google Books. Download: 30 04 2016); Kováts-Lugosi-Nagy-Sárhidai: Tábori tüzérség. Zrínyi Kiadó, Budapest, 1988. pp. 328-335.

During the First War more than 15,500 gun barrels and 10,300 carriages were produced by war factories of the Monarchy.[28] As First World War veteran, Director of the Hungarian Institute of Military Technology Gusztáv Czeigler wrote: "In 1918, the artillery arsenal was modern regarding both quality and quantity, gun development and production not being hindered by the Austro-Hungarian parliament. At the Piave offensive, there was a gun every 28 metres, at the key frontline section every 16 metres. Had we had such artillery equipment in 1914, who knows where we would be today?"[29]

With the Trianon Peace Treaty the country lost its artillery arsenal and its armament producing capacities. Starting gun manufacturing at Diósgyőr was crucial and successful already by 1924.[30] Any yet, by the time of the Second World War, an awkward situation had arisen: although modern Hungarian, Italian and Swedish armour was manufactured, production capacity proved to be insufficient to supply enough guns and to replace losses. The Diósgyőr Gun Factory (MÁVAG-D) reached its production peak by 1943, with 1,260 artillery pieces a year. At the same time, there was a pending order for 2,160 guns from the Ministry of Defence[31] that the factory was unable to execute despite the well-organised and extensive cooperation with other companies.

After the Second World War, the Hungarian Defence Forces, and then the Hungarian People's Army were well equipped with artillery weapons regarding both quantity and quality. Borrowing modern Soviet technologies secured top-level weapons. Hungarian gun production reached its peak by 1953, with 1,287 pieces manufactured that year,[32] which was followed by a drawback and almost complete termination, due to the reduction of the strength of the armed forces. Gradual modernisation from the 1960s meant the extensive involvement of foreign sources, providing the Hungarian People's Army with sufficient modern artillery weapons.

The introduction of rotary forging of barrels in Warsaw Pact countries helped the modernisation of gun production. The Austrian GFM company provided its top technology to the Soviet Union from 1967.[33]

Developed states always utilised the latest industrial achievements for the purposes of gun and gun barrel production, and in certain cases, by recognising the needs, they even realised technological leaps and surpassed the general technical and technological standards of each period. Examples include the inventing of casting muzzle-loading iron cannon, high-precision gun drilling (Wilkinson), mass production of steel with air processes (Bessemer) or the

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[27] Felszeghy, Ferenc (Ed.): Magyar Tüzér. Budapest, 1938. pp. 146-148; Horváth, Csaba (Ed.): A magyar tüzérség 100 éve. Budapest, 2014. pp. 115-119; Kováts-Lugosi-Nagy-Sárhidai: Tábori tüzérség. Zrínyi Kiadó, Budapest, 1988. pp. 229-238.

[28] Horváth, Csaba (Ed.): A magyar tüzérség 100 éve. Budapest, 2014. pp. 114-115.

[29] Felszeghy, Ferenc (Ed.): Magyar Tüzér. Budapest, 1938. p. 153.

[30] Farkas, Lajos: A magyar hadiipar kialakulásának, tevékenységének történeti feldolgozása a Diósgyőri Gépgyárnál. Manuscript. Diósgyőr, 1984. Military History Archives, Budapest, Separate Collection of the Hungarian People's Army. IV/B-61. p. 2.

[31] Perlaki, Gyula: a hazai löveggyártás története. Manuscript. Military History Archives, Budapest, 1985. Separate Collection of the Hungarian People's Army IV/B-57. pp. 4-6.

[32] Germuska, Pál: A magyar középgépipar. Budapest, 2014. p. 547.

[33] Transfer of Austrian Gun-barrell Forging Technology to the USSR. Intelligence Memorandum, 1982. CIA. http://www.foia.cia.gov/sites/default/files/document_conversions/89801/DOC_0000496800.pdf (Download: 17 04 2016)

technique of autofrettage using enormous pressure. Wilkinson's invention solved the accurate fitting of steam engines' cylinders and pistons, thus making the spread of modern Watt steam engines possible. Henry Bessemer's creation facilitated the production of cast steel, in great quantities. The method reduced the price of steel significantly and increased production quantities considerably. It contributed to the expansion of railways, the building of skyscrapers and the extension or establishment of new industries such as steel casting or sheet metal manufacturing. Only one example has been found where a gun or a gun barrel was manufactured at a level significantly lower than the general industrial development of the state, and that illustrated the industry of the Austro-Hungarian Monarchy prior to the First World War.

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