Chapter 23

The Evolution of Firearms Technology from the Sixteenth Century to the Twenty-First Century

This is online Chapter 23 of the third edition of the law school textbook Firearms Law and the Second Amendment: Regulation, Rights, and Policy *(3d ed. 2021), by Nicholas J. Johnson, David B. Kopel, George A. Mocsary, E. Gregory Wallace, and Donald Kilmer.*

All of the online chapters are available at no charge from either https://www.AspenPublishing.com/Johnson-SecondAmendment3 or from the book's separate website, firearmsregulation.org. These chapters are:

17. *Firearms Policy and Status. Including race, gender, age, disability, and sexual orientation.*

18. *International Law. Global and regional treaties, self-defense in classical international law, modern human rights issues.*

19. *Comparative Law. National constitutions, comparative studies of arms issues, and case studies of individual nations.*

20. *In-Depth Explanation of Firearms and Ammunition. The different types of firearms and ammunition. How they work. Intended to be helpful for readers who have little or no prior experience, and to provide a brief overview of more complicated topics.*

21. *Antecedents of the Second Amendment. Self-defense and arms in global historical context. Confucianism, Taoism, Greece, Rome, Judaism, Christianity, European political philosophy.*

22. *Detailed coverage of arms rights and arms control in the United Kingdom from the ninth century to the early twentieth century. A more in-depth examination of the English history from Chapter 2.*

23. *This chapter.*

This Chapter describes how the technology of firearms, accessories, and other personal arms developed from early modern England to the present. While technological history was covered in Chapters 2 through 16 of the textbook, this Chapter provides more detail and context, including how the invention of mass production techniques for firearms led to dramatic changes in the American economy.

A. FIREARMS TECHNOLOGY IN GREAT BRITAIN FROM EARLY TIMES

Understanding arms rights and arms control requires understanding arms. As with the First Amendment freedom of the press, knowledge of past technological developments provides perspective on present technology issues and those that might arise in the future.

Accordingly, Chapters 2 through 16 contain parts describing how arms changed (or did not) during their relevant time periods. Continuing themes are developments in reliability, accuracy, durability, and affordability of various arms. These developments have changed the types of arms that people keep and bear.

Some of the most important technology issues for firearms are:

- Ignition: How does a user fire the gun? How reliable is the ignition system?
- Loading: How does the user load the gun—from the front of the gun (the *muzzle*) or from the back of the barrel (the *breech*)? The latter is much faster and more convenient.
- Repeating: After the gun has been fired once, can the user fire one or more additional shots? Or does the user have to reload all over again? This is the difference between a *repeater* and a *single-shot* firearm.

The above issues have been influenced by advances in manufacturing technology, and the availability of inputs in different times and places. From the sixteenth through eighteenth centuries, firearms manufacture was primarily artisanal; a craftsman's only helper would be an apprentice. During the nineteenth century, most production shifted to factories that used machine tools. They could produce high-quality arms in large quantities. Even so, artisanal firearms manufacture in home workshops continues to the present.

It is possible that the pendulum might swing back toward home manufacture. Today, home manufacturers of firearms can use machine tools with computer numerical control (CNC) to make tasks such as cutting metal much more precise. Hobbyists are experimenting with 3-D printing (computer-aided manufacturing [CAM]) to manufacture firearms components. Mark A. Tallman, Ghost Guns: Hobbyists, Hackers, and the Homemade Weapons Revolution (2020).

Short List of Sources

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1. *Matchlocks and Wheellocks*

The first firearms in the Western world are known as *hand cannons*. The user poured gunpowder down the muzzle, and then dropped in projectiles, such as stones or nails. To ignite the hand cannon, the user moved a heat source, such as a live coal held by tongs, to the *touch hole*, a small opening near the powder charge. The barrel of the hand cannon was attached to a long stick to keep the user several feet away from the touch hole; the erupting powder charge not only burned in the barrel, it also sent a large flame out the touchhole.[1]

A hand cannon from circa 1350.

When the first British king from the Tudor family, Henry VII, took power in 1485, firearms had been of little military significance in England. By the end of the reign of the last Tudor, Henry's granddaughter Elizabeth I, in 1603, firearms had much advanced; the most sophisticated handgun could automatically fire 16 shots with a single press of the trigger. By the middle of the seventeenth century, the best rifles could fire 30 shots, one at a time, without reloading. However, such firearms were quite expensive, and therefore out of reach of the average consumer.

The most important improvement in firearms technology before 1800 was in the ignition system. The ignition change made firearms more reliable, faster to reload, and much better suited for carrying for an extended time while loaded.

The *matchlock* firearm was invented in the second quarter of fifteenth century, and by Tudor times it had made the hand cannon obsolete.[2] The matchlock's trigger is connected to an S-shaped device, the *serpentine*, which holds a slow-burning cord. By pulling the trigger, the user lowers the lit cord down to a small pan of gunpowder, the *flash pan* or *firing pan*. The cord ignites the gunpowder, and the flame travels

1. Robert Held, The Age of Firearms: A Pictorial History 24 (1956).
2. *Id.* at 26-27.

along a small channel, passes through a small circular opening (the *touch hole*), and enters the *breech* (at the rear of the barrel).[3] There, the flame ignites the main charge of gunpowder. The expanding gas from the burning gunpowder pushes the spherical bullet through the barrel, and out the *muzzle* (the front of the barrel).

Today, "a flash in the pan" is a metaphor for that something briefly seemed important but soon proved to be useless. The phrase comes from a flash in the pan that failed to ignite the main charge.

Matchlocks were a big improvement from the ignition system for hand cannons. But the matchlock still had several disadvantages: the burning cord drew attention to the user—a problem in hunting and some other situations. To be ready to shoot, the user had to keep the cord lit. This was not practical for routine carriage for immediate self-defense. Nor could a matchlock be stored so that it was instantly ready for self-defense. Matchlocks usually did not work at all in the rain, or sometimes in the damp. The safety problem of burning cords near gunpowder is apparent.

What are today called "matches"—paper or wooden sticks with chemical tips that are ignited by friction—did not exist until the mid-nineteenth century.[4] So lighting the slow-burning matchlock cord required an external source of flame, such as burning coal that had been ignited in a campfire.

Spanish matchlock musket, manufactured around 1530. Usually fired while resting on a forked stick. Matchlock muskets were the standard arm for the Spanish conquest of Florida.

3. The rope was usually made from flax tow or hemp tow. George C. Neumann, Battle Weapons of the American Revolution 6-7 (2011). It was soaked in saltpeter (a gunpowder ingredient). Tow is a loose ball of coarse and unspun waste fibers from hemp or linen production. It is used for gun cleaning, for wadding, and for tinder. George C. Neumann & Frank J. Kravic, Collector's Illustrated Encyclopedia of the American Revolution 161, 262, 269 (1975); Jim Mullins, Of Sorts for Provincials: American Weapons of the French and Indian War 48 (2008).

4. What we call "matches" in the twenty-first century are paper or wood sticks with sesquisulfide of phosphorus attached to the tip. As common consumer items, they were preceded in the nineteenth century by matchsticks with white phosphorus tips. The principle was discovered in 1669, but it was not practical to apply due to the difficulty in obtaining phosphorus. *See* Anne Marie Helmenstine, *History of Chemical Matches*, ThoughtCo. (Jan. 3, 2018).

Around 1500, Leonardo da Vinci invented the *wheellock*.[5] Rather than using a burning cord, the wheellock is self-igniting. In a wheellock, the user turns a key to wind up a steel wheel under spring tension. When the tension is released by the trigger pull, the serrated wheel strikes a piece of iron pyrite. The resulting shower of sparks ignites the powder in the flash pan. The flash pan powder fire then travels through the touch hole to ignite the main powder charge. The wheellock's sparking mechanism is similar to the ignition system used in today's disposable cigarette lighters.

The wheellock weighed less and could be carried so that it was ready to shoot, like all modern firearms. In a self-defense emergency, the defender would not need to light a cord before being able to use the firearm. "Double-barreled wheellocks were nowhere unusual," so the user could fire two shots without reloading.[6] A study by Professor Carlisle Moody suggests that the growing availability of always available defensive firearms in the centuries after 1500 may have contributed to the sharp decline in European homicide rates.*See* online Ch. 19.D.1.

With no burning cord, wheellocks were much better for hunting. Compared to matchlocks, wheellocks had more intricate parts, were more likely to malfunction,

A wheellock carbine (short rifle) from the home of John Alden, one of the *Mayflower* Pilgrims. Alden shared a cabin with the Pilgrims' military captain, Miles Standish. The story of their competing courtship of Priscilla Mullins is told by Henry Wadsworth Longfellow, an Alden-Mullins descendant, in the epic poem The Courtship of Miles Standish.

5. Vernard Foley, *Leonardo and the Invention of the Wheellock*, Scientific Am., Jan. 1998, at 96.
6. Held, at 52

and were nearly four times as expensive. Wheellocks worked somewhat better in rain or damp, but still had many problems in bad weather.[7]

Henry VIII (reigned 1509-47) and his successors did integrate some wheellocks into their military forces, especially cavalry, for which the matchlock was too clumsy. But they continued to rely mainly on matchlocks until nearly the end of the seventeenth century because matchlocks cost so much less. Except for soldiers on guard duty, military personnel rarely need to be able to fire at a moment's notice. European battles were almost never a surprise event. "Wheellocks remained essentially private weapons."[8]

The wheellock was well-suited for a European gentleman or lady who could afford to carry one for protection. Wheellocks were also apparently available to members of the working class who were sufficiently motivated to scrimp and save to buy one — as apparently was the Pilgrim John Alden. He was a cooper (a barrel-maker) — not a highly lucrative calling. His possession of the relatively expensive wheellock exemplifies the importance that the English emigrants to America placed on quality firearms.

But the wheellock proved too delicate for the rough conditions of use in American forests.[9] A frontiersman on a weeks-long hunting expedition needed to be able to repair gun parts using only a campfire for heat and a rock as an anvil; wheellock parts, like clock parts, were too intricate for such repair.[10] Based on experience, Americans and American Indians instead chose a different firearm, which made its appearance just as the European-American settlement of North American was getting underway: the flintlock.

2. The Flintlock, the Brown Bess Musket, and Fowlers

Early in the seventeenth century, a much-improved version of the wheellock was invented: the *flintlock*. In the flintlock, the gunpowder is ignited by flint striking a piece of steel and producing sparks. A matchlock took 43 steps to reload, but a flintlock needed only 26. Flintlocks were mechanically simpler than wheellocks, and so could be manufactured more affordably. Flintlocks reduced *misfires* (failure to ignite)

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7. M.L. Brown, Firearms in Colonial America: The Impact of History and Technology, 1492-1792, at 57-58 (1980); W.W. Greener, The Gun and Its Development 65-66 (9th ed. 1910). A wheellock required "weeks of labor of the most expert craftsmen, for every screw, must, bolt, wheel, sear, lockplate and others of the thirty-five to fifty components — all of which had to be fitted with watchlike precision — entered the gunmaker's shop as bars of pig iron and scraps of steel which could take shape only by patient and skillful application of the smelting furnace and of a hundred different tools through a thousand stages of gradual, hand-wrought process." Held, at 50. "No experienced master gunsmith worked cheaply — by 1580 that trade being universally among the most lucrative," matched in Germany by making watches, clocks, and armor, in Italy by "landscape gardening and mosaic in-laying, "and in England, where there were still few gunsmiths," by "shipwrighting, printing, and bookbinding." *Id.* at 57.

8. *Id.* at 58.

9. David B. Silverman, Thundersticks: Firearms and Violent Transformation of Native America 27 (2016).

10. Held, at 142.

by 40 percent. A well-trained user could fire up to five shots per minute, depending on the gun.[11]

Collectively, the wheellock, the flintlock, and intermediate types (latter sixteenth-century proto-flintlocks such as the *snaphaunce*) were called *firelocks.*[12] Unlike a matchlock, a firelock is capable of igniting gunpowder by itself, with no need for an external source of fire. Whereas a long gun matchlock is held against the user's chest, a firelock's buttstock can be brought to the shoulder. Shouldering improves the gun's stability and puts the user's sight line on the same line as the barrel, thus improving accuracy. The disadvantage of firelocks compared to matchlocks is their greater number of small internal parts, making them less

This snaphaunce pistol is an early type of flintlock. It was manufactured in northern Italy in the sixteenth century by Beretta, perhaps the world's oldest continuously operating business enterprise, established in 1526. Note the folding stock on the pistol, allowing for concealed carry under a cloak. Today, a gun with a barrel under 16 inches and stock is classified as a short-barreled rifle (SBR), and subject to special restrictions pursuant to the National Firearms Act of 1934. Ch. 8.E.2.d.

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11. W.W. Greener, The Gun and Its Development 66-67 (9th ed. 1910); Charles C. Carlton, This Seat of Mars: War and the British Isles 1585-1746, at 171-73 (2011).

12. "The true snaphaunce, rarely used in New England" differs from the "true" flintlock in how the cover of the flash pan (a/k/a firing pan) is connected to the rest of the gun lock. Patrick A. Malone, The Skulking Way of War: Technology and Tactics among the New England Indians 34 (1991). American sources often do not use the different terms with precision.

Because of simpler mechanics, a snaphaunce was about half of the price of a comparable quality wheellock, which is to say about double the cost of a matchlock. Unlike the wheellock, the snaphaunce did not have a wheel housing or chain drive that could become clogged. Moreover, the snaphaunce flint, unlike the wheellock pyrite, was not friable (easily crumbled). A sharpened flint could reliably produce sparks for about 20 shots before needing to be resharpened. Because of cost, most military stuck with matchlocks (except for snaphaunce handguns), making the snaphaunce mainly a civilian gun. Held, at 72.

durable under hard use.[13] As seen in Chapters 3 through 5, the word "firelock" often appears in American colonial and Early Republic firearms legislation.

For either firelocks or matchlocks, once the powder and ammunition have been loaded, the user might tap on the gun's exterior, so that a few grains of powder in the flash pan fall into the touch hole. This is the origin of "knock on wood" for good luck.

Until the Glorious Revolution in 1688, the British government had been relatively slow in adopting flintlocks, compared to the Continent. Afterward, new King William III began to make the flintlock the main military arm in England. In the early eighteenth century, General John Churchill was responsible for the adoption of what became the standard military flintlock musket: the .75 caliber Brown Bess.[14]

Due to the necessities of hunting and Indian-fighting, Americans made the transition from matchlocks to flintlocks much sooner than the British did.[15] In Great Britain, only the upper class could legally hunt, but in America anyone could. Chs. 2-3.

Like its predecessor the arquebus, the musket is a long gun that has a smooth *bore* (the interior of the barrel). If the bore is not smooth, but instead has spiral grooves, *rifling*, the firearm is a *rifle*, not a classic musket. The rifling makes the bullet spin on its horizontal access, and thereby improves aerodynamic stability. Especially at a distance, a gun with rifling is much more accurate than a smoothbore. Today, most modern shotguns have smooth bores, whereas rifles and handguns have rifled barrels.

The smoothbore Brown Bess was not accurate, but it did not need to be. The standard European fighting method of the time involved massed lines of infantry, so a high rate of fire in the enemy's general direction was sufficient. The Brown Bess remained the main service firearm of the British army and militia until well into the nineteenth century.[16]

This Brown Bess musket was captured and used by Americans during the American Revolution.

13. Ernest Marsh Lloyd, A Review of the History of Infantry 133-34 (1908).
14. John Nigel George, English Guns and Rifles 80-81 (1947).
15. *Id.* at 85.
16. *See generally* Stuart Reid, The Flintlock Musket: Brown Bess and Charleville 1715-1865 (2016); Erik Goldstein & Stuart Mowbray, The Brown Bess (2010).

A close-up of the lock of a Brown Bess flintlock. The sharpened piece of flint is held in the jaws of the hammer, which are tightened by a screw. When the trigger is pulled, the hammer falls forward to strike the frizzen (the L-shaped piece of steel on the right, also known as the battery). The sparks fall onto the flash pan to ignite the gunpowder. The flame then travels inside the gun, via the touch hole, and ignites the main powder charge.

Another very common firearm was the fowling piece, for bird hunting. Like the Brown Bess, it was a smoothbore long gun. The difference was that the fowling piece barrel was lighter and its muzzle was slightly flared to increase the velocity of the birdshot.[17] As the American fowler evolved, influenced by the English and by immigrant French Huguenot gunsmiths, "[t]he result was the development of a unique variety of American long fowler. These American long guns served as an all-purpose firearm. When loaded with shot, they were suited to hunt birds and small game, and when loaded with a ball, they could provide venison for the table. In times of emergency, they were needed for militia, and more than a few saw service in the early colonial wars as well as the Revolution."[18] The modified Dutch fowlers were the first distinctively American firearms.[19]

17. George, at 85.
18. *Id.*
19. Bill Ahearn, Muskets of the Revolution and the French & Indian Wars 101 (2005).

This Dutch fowler from about 1680 is typical of the long guns that were first introduced to the Hudson Valley when it was part of New Netherland.

In the period before the Revolution, most American gunsmiths used imported locks.[20] The *lock*, or *action*, is the mechanism that contains the trigger and other components that fire the gun. The use of recycled parts was also common.[21] So, for example, a damaged fowling piece might be repaired with some lock parts scavenged from a musket. Thus, the musket versus fowler categories should not be viewed as rigidly divided in America. There were many hybrids.[22] The variety of American firearms and edged weapons was further increased because America at all times, including after the Revolution, was a major export market for older, surplus European arms—not only from the United Kingdom, but also from Germany, France, Spain, and the low countries; to these would be added firearms scavenged from the various European armies that fought in colonial wars or the American Revolution.[23] During the Revolution, many fowling pieces were employed as militia arms. Ideally, although not always in practice, they would be retrofitted to allow for the attachment of a bayonet.[24] As a British officer noted after the battles of

20. Tom Grinslade, Flintlock Fowlers: The First Guns Made in America 1, 5, 15, 23-25 (2005).

21. *Id.*

22. Goldstein & Mowbray, at 40-41; Grinslade, at 5, 23 ("The distinction between fowlers and muskets in the eighteenth century was not always clear-cut. Those manufactured from existing parts shared a common appearance, often combining aspects of both fowler and musket."). For example, the locks from French muskets that were captured during France's various wars in North America were often recycled into use on American fowlers.

23. George G. Neumann, Swords & Blades of the American Revolution 7, 53 (3d ed. 1991).

24. Grinslade, at 5, 54, 63 ("In times of Indian raids or war, the family fowling-piece served the need for a fighting gun."); Mullins, at 49 (The classic fowling piece lacked the musket's swivels for attachment of a sling).

Lexington and Concord in 1775, "These fellows were generally good marksmen, and many of them used long guns made for Duck-Shooting."[25]

Whatever the specifics of any state or colony's arms requirements, Americans went to war with a very wide variety of personal arms, not always necessarily in precise compliance with the narrowest definitions of arms that might appear in a militia equipment statute. At Valley Forge in 1777, Baron von Steuben was encamped with the Continental Army, most of whose members had brought their personal firearms to service. Von Steuben observed that "muskets, carbines, fowling pieces, and rifles were found in the same company."[26]

Before pulling the trigger on a flintlock or wheellock, the user must use his or her thumb to pull the hammer all the way to a back position. A hammer that is ready to fire is *cocked*.[27] Dutch guns made for the Indian trade were among the first to allow for a *half-cock* position, which could be maintained indefinitely. Having the gun half-cocked made it faster to fire in an emergency.[28] The *sear* is a ratcheted device that holds the hammer in either fully cocked or half-cocked position. "Going off half-cocked" literally indicates a defective or worn-out sear, and metaphorically describes rash action without proper preparation.

All of the guns pictured above are smoothbores, except for John Alden's carbine rifle. Rifled arms were insignificant in England during the eighteenth century, but very important in America, as described below.

3. The Blunderbuss and Other Handguns

Especially common in the seventeenth and eighteenth centuries was the flintlock blunderbuss. Recall that Sir John Knight was prosecuted for carrying one in 1685 but was acquitted. *See* Ch. 22.F.3.[29] It could be loaded with a single very large bullet, but the more common load was 20 large pellets, or even up to 50.[30] It was devastating at short range.[31] The name seems to be an adaptation of the Dutch "donder-buse" or "thunder gun." A blunderbuss could be a large handgun, or it could have a short stock attached and be used as a shoulder arm.

Excellent for self-defense at close quarters, the blunderbuss was of little use for anything else, having an effective range of about 20 yards. Travel increased

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25. Frederick MacKenzie, A British Fusilier in Revolutionary Boston, Being the Diary of Lieutenant Frederick Mackenzie, Adjutant of the Royal Welch Fusiliers, January 5-April 30, 1775, at 67 (Allen French ed., 1926; rprnt. ed. 1969) (quoting an unnamed officer).

26. Friedrich Kapp, The Life of Frederick William Von Steuben 117 (2d ed. 1859).

27. The hammer was sometimes called the "cock," because its motion "resembled the pecking motion of a bird." Ahearn, at 98.

28. Silverman, at 28.

29. The case reports do not indicate what type of firearm Knight carried, but contemporary accounts indicate that Knight had at least one blunderbuss.

30. George, at 92-93.

31. Brown, at 143.

greatly in the eighteenth century, but even the main English highways were not safe after dark. Stagecoach guards and travelers carried blunderbusses, or other short guns, such as traveling or coaching carbines, or (most often) a pair of ordinary pistols.[32] The muzzle of the blunderbuss flared outward slightly, like a bell. This made it easier to load while bouncing in stagecoach, or on a swaying ship.[33] One military use was by sailors to repel boarders.[34] In the American Revolution, Americans found it most useful for "street control, sentry duty and as personal officer weapons."[35]

For centuries England had been a backwater for firearms manufacture, and most firearms, other than basic military matchlocks, were imported. By the early eighteenth century, that had changed, and far more handguns were manufactured in England than anywhere else.[36]

British navy blunderbuss made about 1760.

4. Breechloaders and Repeaters

The blunderbuss, the Brown Bess, fowlers, and the vast majority of other firearms were *muzzleloaders*. To load or reload the gun, the user would pour a

32. George, at 80, 91, 98.
33. Brown, at 143.
34. George, at 59.
35. Neumann, at 20.
36. Harold L. Peterson, Arms and Armor in Colonial America 1526-1783, at 212 (Dover 2000) (1956) (handguns); Held, at 51 (no one in England could make a good matchlock before 1660, or repair one before 1600; before 1620, only "crude military matchlocks" and cannons were manufactured in England).

premeasured quantity of gunpowder into the muzzle.[37] Next, the user would insert the ball(s) of ammunition into the muzzle.[38] With a ramrod, the user then pushed the ball and the powder all the way to the back of the barrel, the breech. Breechloaders replaced muzzleloaders during the nineteenth century.

Most firearms in the eighteenth century were *single-shot*. To fire a second shot, the user had to repeat the process of ramming the powder and the bullet down the muzzle. Today, most firearms can fire more than one shot without having to be reloaded. *Repeating* arms carry their supply of ammunition internally. For example, a *revolver* usually has five or six units of ammunition in a revolving *cylinder*.

Some shotguns and rifles have two barrels, either side-by-side, or over-and-under. They can fire two shots, and then have to be reloaded. The double-barreled shotgun was firmly on stage by the end of the eighteenth century, for hunting and for self-defense.[39]

In firearms parlance, to "regulate" a gun is to adjust the two barrels so they both fire at the same point of aim. Likewise, to regulate a mechanical clock is to adjust the moving parts so they keep proper time. A "well-regulated" militia can shoot accurately, and move in proper formation, such as by keeping in a straight line as it turns to meet an oncoming foe. More broadly, a well-regulated militia is the opposite of a disorderly rabble or mob.

Breechloading and repeating arms would become predominant in the nineteenth century, but they had been around for centuries before. The first breechloaders were invented in the late fifteenth century.[40] Some breechloading wheellocks were made for Henry VIII in 1535 and 1537.[41] Some single shot breechloading rifles invented during the reign of Henry VIII, "with some minor difference in details, were found to be veritable Snider rifles."[42] The Snider was the main firearm of the British army from 1866 to 1874. By the seventeenth and eighteenth centuries, breechloaders had become numerous, but were still far outnumbered by muzzleloaders.[43] As for repeaters, they appeared no later than the early sixteenth century.[44]

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37. The premeasured gunpowder might be applied with a *charger*, a cylinder that would receive powder poured from the gunpowder carried in a powder horn. Or the premeasured gunpowder might be contained in paper cartridges, which would be torn open and poured down the muzzle.

38. One ball for any shot at distance. Multiple small balls for bird hunting, and sometimes for close-quarters defense. For gun with rifling, only a single ball, under all circumstances.

39. George, at 228-38.

40. Brown, at 103.

41. *Id.* at 80.

42. Charles B. Norton, American Breech-loading Small Arms 10 (1872).

43. Greener, at 103-110.

44. Brown, at 50 (German breechloading matchlock arquebus from around 1490-1530 with a ten-shot revolving cylinder); Greener, at 81-82 (Henry VIII's revolving cylinder matchlock arquebus); David B. Kopel, *The History of Firearms Magazines and of Magazine Prohibition*, 88 Albany L. Rev. 849, 852 (2015) (16-round wheellock from about 1580). Such guns were also made in the seventeenth century. *See, e.g.*, Brown, at 105-06 (seventeenth-century four-barreled wheellock pistol could fire 15 shots in a few seconds).

This German wheellock from the late sixteenth century fired 16 rounds with a single trigger pull. The ammunition is superposed—one round is stacked atop another.

For repeating arms, "Successful systems definitely had developed by 1640, and within the next twenty years they had spread throughout most of Western Europe and even to Moscow."[45] The leading magazine-fed repeaters starting in the mid-seventeenth century were "the Kalthoff and the Lorenzoni. These were the first guns of their kind to achieve success."[46]

The former "had two magazines, one for powder and one for balls. The earliest datable specimens which survive are two wheel-lock rifles made by Peter Kalthoff in Denmark in 1645 and 1646."[47] "[T]he number of charges in the magazines ran all the way from six or seven to thirty."[48]

Kalthoff repeaters "were undoubtedly the first magazine repeaters to be adopted for military purposes. About a hundred flintlock rifles of their pattern were issued to picked marksmen of the [Danish] Royal Foot Guards and are believed to have seen active service during the siege of Copenhagen in 1658, 1659, and again in the Scanian War of 1675-1679."[49]

Kalthoff-type repeaters "spread throughout Europe wherever there were gunsmiths with sufficient skill and knowledge to make them, and patrons wealthy enough to pay the cost. . . . [A]t least nineteen gunsmiths are known to have made such arms in an area stretching from London on the west to Moscow on the east, and from Copenhagen south to Salzburg. There may well have been even more."[50]

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45. Harold L. Peterson, The Treasury of the Gun 229 (1962).
46. *Id.*
47. *Id.*
48. *Id.* at 230.
49. *Id.*
50. *Id.*

As with a lever-action rifle, the next shot was made ready by a simple two-step motion of the trigger guard.[51]

The Lorenzoni pistol also "was developed during the first half of the Seventeenth Century."[52] It was a magazine-fed Italian repeating handgun that "used gravity to self-reload."[53] In being able to self-reload, Lorenzonis are similar to modern semi-automatic firearms, which are also known as *self-loading* arms. The Lorenzonis' ammunition capacity was typically around seven shots. The gun's repeating mechanism quickly spread throughout Europe and to the colonies, and the mechanism was soon applied to rifles as well.[54]

On July 3, 1662, famed London diarist Samuel Pepys observed "a gun to discharge seven times, the best of all devices that ever I saw, and very serviceable, and not a bawble; for it is much approved of, and many thereof made."[55] Abraham Hill patented the Lorenzoni repeating mechanism in London on March 3, 1664.[56] On March 4, 1664, Pepys wrote about "several people" who were "trying a new-fashion gun" that could "shoot off often, one after another, without trouble or danger, very pretty."[57]

Despite Hill's patent, "[m]any other English gunsmiths also made guns with the Lorenzoni action during the next two or three decades."[58] Most notably, famous English gunsmiths John Cookson and John Shaw adopted the Lorenzoni action for their firearms. So did "a host of others throughout the 18th century."[59]

"The Kalthoff and Lorenzoni actions . . . were probably the first and certainly the most popular of the early magazine repeaters. But there were many others. Another version, also attributed to the Lorenzoni family, boasted brass tubular magazines beneath the forestock . . . Guns of this type seem to have been made in several parts of Europe during the Eighteenth Century and apparently functioned well."[60] "The Lorenzoni system even found its way to America where records indicate that at least two New England gunsmiths actually manufactured such guns."[61]

England's Prince Rupert — nephew of King Charles I, and a leading military commander of the mid-seventeenth century — owned two types of advanced repeating guns, which would not become common until two centuries later. One was a breech-loading lever-action repeater. The other was a revolver.[62] As of the mid-eighteenth century, German-made revolving pistols and rifles "were not rare."[63]

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51. Brown, at 106-07.

52. Peterson, Treasury, at 230.

53. Martin Dougherty, Small Arms Visual Encyclopedia 34 (2011).

54. Peterson, Treasury, at 232.

55. 4 The Diary of Samuel Pepys 258 (Henry Wheatley ed., 1893).

56. The patent was for a "gun or pistol for small shot carrying seven or eight charges of the same in the stock of the gun. . . ." Clifford Walton, History of the British Standing Army. A.D. 1660 to 1700, at 337 (1894).

57. 7 Pepys, at 61.

58. Peterson, Treasury, at 232.

59. Peterson, Arms and Armor, at 215.

60. Peterson, Treasury, at 233.

61. *Id.* at 232.

62. George, at 55-58 (both guns made in England no later than the British Civil Wars (Ch. 22.H.2) by an English gunmaker).

63. Held, at 153.

London's gunmakers in the latter half of the eighteenth century sold a wide variety of single-shot and repeating handguns. They were as small as five inches for pocket carry, or as large as "horse pistols" with detachable shoulder stocks, to be carried by travelers in saddlebags.[64] Repeaters' ammunition capacity was up to six.[65]

If gunmakers knew how to make breechloaders and repeaters, why did it take until the nineteenth century for such guns to become the main type of firearms? Why didn't the English army have Snider rifles when Henry VIII was king, rather than over three hundred years later? Why didn't the 30-shot Danish flintlocks become standard, instead of the one-shot Brown Bess?

Breechloaders and repeaters require much closer fittings among their parts than do single-shot or muzzle-loading guns. Until the invention of machine tools to make uniform parts, the quantity of labor required to build a breechloader or repeater made such guns very expensive.[66] (Machine tools are discussed in Part C.) Thus, British gunsmiths concentrated on building affordable, single-shot, muzzle-loading flintlocks. The breechloader or repeater would be a special order for a customer who could afford to pay for a great deal of labor.

The issues for telescopic sights were similar. They were first produced no later than 1702 but did not become common until the mid-nineteenth century.[67] The knowledge existed, but not the means of high-volume affordable production.

During the eighteenth century, British firearms development was mainly the refinement of flintlocks, rather than innovation.[68] One novelty was replacement of wooden ramrods with iron ones, starting in 1740.[69] In the third quarter of the eighteenth century, English gunsmiths invented the *tumbler swivel* and the *roller-bearing feather-spring*. The combination created the *frictionless lock*. (That is, the lock moved with almost no friction; the lock still produced desired friction by striking flint against the steel frizzen.) The frictionless lock fired faster and misfired much less.[70] The "waterproof" flash pan from the same time made the flintlock less vulnerable to moisture.[71] Finally, the *patent breech* much improved the efficiency of the gunpowder explosion.[72]

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64. *Id.* at 162.

65. *Id.* at 162-63.

66. Additionally, until improvements in the latter part of the eighteenth century, it was "prohibitively expensive" to make a breechloader whose breech could be sealed tightly enough to always prevent gas seepage (which reduced the power propelling the bullet) or in the worst case that might cause a backfire and seriously injure the user. *Id.* at 61. Also, rifles are well-suited for deer hunting, but the Tudor English aristocracy preferred to chase deer to exhaustion with horses and hounds, rather than take them by shooting. *Id.*

68. George, at 101-04.

69. J.F.C. Fuller, Armament and History 100 (Da Capo Pr. 1998) (1945).

67. Brown, at 148.

70. Held, at 136.

71. *Id.*

72. In the early flintlocks, the touch hole connected to an edge of the main powder charge. Thus, part of the powder would start burning before other parts. With the patent breech, the touch hole does not directly connect to the main charge. Instead, the touch hole follows a channel to an *antechamber* centered behind the main charge. The fire from the touch hole ignites the powder in the antechamber, which then instantly ignites the main charge. *Id.* at 137.

The patent breech made "the gun shot so hard and so fast that the very possibility of such performance had not hitherto been imaginable."[73] Previously, to get the full propellant benefit of the relatively long time it took for all the powder to burn, barrels had to be long. By 1795 in England, "the old thirty-nine to forty-eight inch barrels were obsolete," replaced by 26 to 32-inch barrels, and sometimes as short as 22 inches. The lower barrel weight made double-barreled guns so much easier to carry and aim that by 1810 double-barreled guns outsold single-barreled guns.[74] So the high-quality flintlock of 1800 was much superior to its ancestor of 1700.

Likewise, American firearms development in the twentieth century was primarily about improving the types of guns. Part E. Even in the twenty-first century, the archetypical "modern" gun is something that a consumer could have bought in the late nineteenth century: a breech-loading semi-automatic pistol using a detachable magazine to fire metal-cased ammunition with smokeless powder. Part D.

B. COLONIAL AMERICA'S GROWING DIVERGENCE FROM GREAT BRITAIN

1. Flintlocks

As described in Section A.2, in seventeenth-century England the predominant ignition system for firearms was the matchlock, with the shift to flintlocks beginning late in the century. Americans made the transition much earlier. The matchlock was inexpensive, and served well enough for European-type battles, in which large masses of infantry shot in each other's general direction. Nobody bothered to take careful aim, because the objective was volleys of fire at the closely packed troops of the enemy.

But Indians did not fight that way. They preferred quick raids and ambushes. Because a matchlock is ignited by a slow-burning cord, it was impractical to keep in a constant state of readiness against surprise attack. The burning cord also revealed the location of the matchlock's user. Concealment did not matter in European infantry battles, but it was a fatal flaw in America, where fighting often took place in the woods, with both sides hiding behind natural cover. Concealment problems also made the matchlock inferior for hunting, so Americans in the seventeenth century replaced their matchlocks with flintlocks as soon as they could. For the same reasons, Indians who were buying arms from the colonists strongly preferred flintlocks to matchlocks.[75] Captain Miles (or Myles) Standish, a former professional soldier who was a military leader of Plymouth Colony, was the first famous New England user of a proto-flintlock (a snaphaunce), in 1620.[76] As discussed in Section A.1,

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73. *Id.*

74. *Id.*

75. Harold L. Peterson, Arms and Armor in Colonial America 1526-1783, at 18-49 (Dover 2000) (1956).

76. Patrick A. Malone, The Skulking Way of War: Technology and Tactics among the New England Indians 33 (1991).

Standish's cabinmate, John Alden, owned a wheellock rifle, a firearm that was much more advanced than a matchlock, although less sturdy than Standish's flintlock.

2. *The Pennsylvania-Kentucky Rifle*

The most common arms in the United Kingdom in the eighteenth century were *smoothbores*. That is, the *bore*, the interior of the barrel, was smooth. Smoothbores are well-suited for bird-hunting. They are not very accurate beyond 50 yards. Today, the most common smoothbores are shotguns.

In a rifle, spiral grooves (*rifling*) are cut in the bore. The grooves make the bullet spin on its horizontal axis, so the bullet's flight is more aerodynamically stable.[77] Rifles are superior for long-range shooting. Since the late fifteenth century, rifles had been well established in the mountainous regions of southern Germany and northern Switzerland.[78] Rifled arms were originally created for target shooting and sport. "In the latter part of the seventeenth century some of the German princes employed mountaineers as sharpshooters, who brought their rifles with them."[79] But rifles had not caught on in Great Britain.

Early in the eighteenth century, rifle makers from Germany and Switzerland began settling in Pennsylvania, in the Lancaster area. America was attracting skilled craftsmen immigrants, who could set up their own business and prosper, free of the extensive controls of guilds and government in the homeland. Pennsylvania, with its complete religious freedom, was especially attractive for craftsmen who also sought the free exercise of religion. When George Hanover, a German, became King George I of Great Britain in 1714 (Ch. 22.J.1), many German-speaking gunsmiths decided that the time was right to emigrate to America.[80]

Over the century, knowledge of rifle-making spread nationally, as apprentices who trained in Pennsylvania moved throughout the colonies. The Pennsylvania gunmakers initially produced the Jaeger model, which they had made in central Europe. But it was very heavy to carry; the bullets were large and slow; and it required adjusting the rear sight to shoot at different distances.[81] "What Americans demanded of their gunsmiths seemed impossible": a rifle that weighed ten pounds or less, for which a month of ammunition would weigh one to three pounds, "with proportionately small quantities of powder, be easy to load," and "with such velocity and flat trajectories that *one* fixed rear sight would serve as well at fifty yards as at three hundred, the necessary but slight difference in elevation being supplied by the user's experience."[82]

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77. It had long been recognized that rifling made bullets more accurate, but the reason why was not understood until 1747, when Newtonian mathematician and gun enthusiast Benjamin Robins presented his paper *Observations on the Nature and Advantages of Rifled Barrel Pieces*. Held, at 36.

78. M.L. Brown, Firearms in Colonial America: The Impact of History and Technology, 1492-1792, at 28 (1980).

79. Lloyd, at 235.

80. George, at 144-47.

81. Held, at 141.

82. *Id.* at 142

"By about 1735 the impossible had taken shape" with the creation of a new type of rifle, the iconic early American gun: the Pennsylvania-Kentucky Rifle.[83] Pennsylvania was the primary place where it was made, and Kentuckians became the most famous users.[84]

The Pennsylvania-Kentucky rifle was longer than the European Jaeger. The longer barrel improved the balance, and helped the user obtain a more accurate sight of the distant target.[85] While European rifles generally had a *caliber* (the interior bore diameter) of .60 or .75 inches, Americans preferred a smaller caliber, usually somewhere from .40 to .46, and sometimes as low as .32.[86] A smaller caliber meant smaller bullets. One pound of lead will make 16 bullets for a .70 caliber gun, but 46 bullets for a .45 caliber. With the smaller caliber, a person on a hunting expedition that might last for weeks or months could carry a greater quantity of ammunition.

Riflemen were careful to learn the exact quantity of powder their rifle needed, so that none was wasted.[87] They could then adjust the quantity as appropriate, such as adding more powder for an especially long shot. Among America's riflemen, there was "a cult of accuracy."[88] Long-distance shooting contests were major events in rural communities. Everyone was expected to be a master of precision

Kentucky rifle. Manufactured in Lancaster, Penn., sometime in 1780-1810.

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83. *Id.*

84. John G.W. Dillin, The Kentucky Rifle (1924). Originally, "Kentucky" referred to an area extending from southern Ohio and Indiana all the way to northern Tennessee. Charles Edward Chapel, Guns of the Old West 20-21 (1961).

85. A common sighting system was a small blade above the top of the muzzle, and a U-shaped notch atop the breech. The user aligned the gun so that the view of the front blade fit inside the U of the back notch. This showed where the barrel was pointed. If the barrel is longer, then so is the *sight radius*—the distance between the front and rear sights. A longer sight radius is more accurate. Brown, at 268.

86. *Id.* at 267.

87. *Id.* at 268.

88. Alexander Rose, American Rifle: A Biography 18-19 (2008).

shooting — not just for prestige, but for dinner. For example, in squirrel shooting, a shot to the center of the body would ruin much of the meat. So Americans could "bark" a squirrel: a shot just under the tail would knock the squirrel off a tree branch, and the squirrel would fall to the ground, intact.

Until around 1840, the Pennsylvania-Kentucky rifle was the most accurate long-distance firearm in the world.[89] It was ideal for hunting mammals and for the irregular tactics of Indian-fighting. Indians preferred them for the same reasons. It fit the forest.

Rifles were important on the frontier and other areas west of the Hudson River. Until the American Revolution, they were rarely seen in New England, where smoothbore muskets continued to predominate. New Englanders and others also had many fowling pieces — a bird-hunting gun similar to a shotgun. *See* Part A.2. Although fowling pieces were lighter than muskets, a musket could be used for bird hunting, and a fowling piece could be used for infantry combat.[90]

For European-style fighting, rifles had several disadvantages compared to muskets. First, they needed more labor to produce, and were consequently more expensive. Second, they took longer to reload, in part because pushing a spherical bullet past the rifling grooves was difficult. Under optimal conditions with expert use, the maximum rate of rifle fire was about three shots per minute, compared to four or five with a musket. Third, they were too delicate to use with a bayonet.[91]

A bayonet is a dagger or other straight knife that is attached to the front of a gun. (The word comes from Bayonne, France, the bayonet-manufacturing capital.[92]) The standard *socket bayonet* of the eighteenth century was attached to the side of the muzzle by a lug. In a typical European battle, fought with linear tactics, the musket-armed infantry on each side would be lined up three deep in rows. Without bothering to aim at a particular target, the first row would fire a volley at the opposing army. The first row would then step to the rear and begin reloading. The second row would step forward and fire its volley. The three-row cycle made it possible to fire a volley every several seconds.

Eventually, one army would march quickly toward the enemy ranks, absorbing some volleys on the way. Then, the battle would be decided by hand-to-hand

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89. Held, at 144. The barrels and stocks of the Kentucky rifles were as good as those of the best European guns. The locks were of much lesser quality compared to Europe's best. *Id.* at 145.

90. Brown. at 85.

91. Peterson, Arms and Armor, at 198-203; Lloyd, at 234.

92. Bayonne had long been a manufacturing center for cutlery and weapons. While it is generally agreed that bayonets were invented around 1640, there are several stories about how the invention happened. Thompson, at 61-62. According to one version, "Some peasants of the Basque provinces, whilst on an expedition against a company of bandits, having used all their ammunition, were driven to the desperate necessity of inserting their long knives into the mouths of their arquebuses, by which means they routed their adversaries." Greener, at 626.

combat. The soldiers would stab and slash each other with the bayonets at the end of their muskets. They would also use their muskets as clubs. The rifleman was at a huge disadvantage. All riflemen had a tomahawk, a hatchet, or some other edged weapon. But their opponents who had a bayonet at the end of their muskets had a much longer reach.[93]

Accordingly, when Americans had to fight European armies—such as the French from 1744-45 and from 1754-63, or the British from 1775-83—the musket was the more important arm. The American Revolution was won mainly with muskets, not rifles. During the Revolution, rifles did play a decisive role in the West. There, Americans and their Indian allies defeated the British and their Indian allies, securing American claims to the vast lands between the Appalachian Mountains and the Mississippi River. The Pennsylvania-Kentucky rifle was a leading firearm of the 1815 Battle of New Orleans, when Americans led by General Andrew Jackson routed the best forces in the British army. *See* Ch. 6.A.6. The Pennsylvania-Kentucky rifle would become the first iconic American firearm. To Americans, the Pennsylvania-Kentucky rifle showed that Americans were free because they were excellent marksmen.

Many people needed a firearm that met militia requirements and was also useful for hunting. In America, "civil and military uses of firearms dovetailed as they had not generally done in Europe."[94] "Thus the distinction between military and sporting arms is almost lost."[95] Americans developed what collectors call the "semi-military" firearm. It was usually .70 to .75 caliber, and similar to a musket, but with variations that made it better for hunting.[96] The short blunderbuss, ubiquitous in England (Section A.3), became popular in America in the eighteenth century, mainly for self-defense in urban areas, and for naval use.[97]

Handguns were used for self-defense, and in the militia, army, or navy by officers, cavalry, and sailors. Depending on size and purpose, handguns were carried in saddle holsters ("horse pistols"), on belts, in trouser pockets, in vests, or "in the big outer pockets of the greatcoat."[98] A variety of multishot pistols from the late eighteenth century have been preserved, holding two to four rounds.[99]

3. Breechloaders and Repeaters

As in Great Britain during the seventeenth and eighteenth centuries, the very large majority of firearms in America were single-shot muzzleloaders. Firearms that load from the back (*breechloaders*) or that can fire several shots without reloading (*repeaters*) did not become mass-market consumer items until the nineteenth

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93. Peterson, Arms and Armor, at 294-303.

94. Lee Kennett & James LaVerne Anderson, The Gun in America: The Origins of National Dilemma 41 (1975).

95. Peterson, Arms and Armor, at 179.

96. *Id.*

97. *Id.* at 204-05.

98. *Id.* at 208-11; Charles Winthrop Sawyer, Firearms in American History: 1600 to 1800, at 165 (1910).

99. *Id.* at 194-98, 215-16.

century. Large-scale production of such arms at affordable prices required the prior invention of machine tools. Part C.

Nevertheless, breechloaders and repeaters were available in colonial America for persons who could afford them. In September 1722, Boston gunsmith John Pim entertained some Indians by demonstrating a firearm he had made. Although "loaded but once," it "was discharged eleven times following, with bullets in the space of two minutes each which went through a double door at fifty yards' distance."[100] Pim's gun may have been a type of the repeating flintlock that became "popular in England from the third quarter of the 17th century," and was manufactured in Massachusetts starting in the early eighteenth century.[101] Pim also owned a .52 caliber six-shot flintlock revolver, similar to the revolvers that had been made in England since the turn of the century.[102]

The most common American repeaters of the early eighteenth century were probably Cooksons—originally named after English gunsmith John Cookson.[103] A ten-round Cookson later displayed in a museum "found its way into Maryland with one of the early English colonists."[104] A Boston gunsmith also named John Cookson (perhaps related to the eponymous Englishman) manufactured repeaters in the eighteenth century. The American Cookson advertised a repeater in the *Boston Gazette* on April 12 and 26, 1756, explaining that the rifle was "to be sold at his house in Boston . . . the said gun will fire 9 Times distinctly, as quick, or as slow as you please."[105] "Thus this type of repeating flintlock popular in England from the

Cookson flintlock repeating rifle. The powder and ammunition magazines were in the buttstock; they were brought into the firing chamber by rotating the side lever.

100. Samuel Niles, *A Summary Historical Narrative of the Wars in New England*, *in* Massachusetts Historical Society Collections, 4th ser., vol. 5, at 347 (1837).

101. Peterson, Arms and Armor, at 215-17.

102. Brown, at 255.

103. Harold L. Peterson, The Treasury of the Gun 230 (1962).

104. *The Cookson Gun and the Mortimer Pistols*, Am. Rifleman, Sept. 29, 1917, at 3, 4.

105. Peterson, Arms and Armor, at 215.

third quarter of the 17th century, was known and manufactured in Massachusetts early in the 18th century."[106]

In 1777, the Continental Congress ordered from Philadelphia's Joseph Belton one hundred rifles that could "discharge sixteen, or twenty [rounds], in sixteen, ten, or five seconds."[107] Belton demonstrated his rifle before leading military officers (including General Horatio Gates and Major General Benedict Arnold) and scientists (including David Rittenhouse), who verified that "[h]e discharged Sixteen Balls loaded at one time."[108] However, the deal fell through when Belton demanded "an extraordinary allowance."[109]

The British similarly recognized the advantage of repeaters, employing the Ferguson Rifle during the Revolutionary War, which "fired six shots in one minute" during a government test on June 1, 1776.[110] The gun was quite expensive to produce, however, and insufficiently sturdy in combat conditions.

When the Second Amendment was ratified, the state-of-the-art repeater was the Girandoni air rifle, which could shoot 21 or 22 rounds in .46 or .49 caliber.[111] The Girandoni was ballistically equal to a powder gun,[112] and powerful enough to take an elk.[113] At the time, "there were many gunsmiths in Europe producing compressed air weapons powerful enough to use for big game hunting or as military weapons."[114] The Girandoni was invented for the Austrian army; 1,500 were issued to sharpshooters and remained in service for 25 years, including in the French Revolution and Napoleonic Wars between 1796 and 1815.[115] Isaiah Lukens of Pennsylvania manufactured such rifles,[116] along with "many makers in Austria, Russia, Switzerland, England, and various German principalities."[117]

Meriwether Lewis seemingly acquired from Lukens the Girandoni rifle he famously carried on the Lewis and Clark Expedition.[118] Lewis mentioned it in his journal 39 times, demonstrating the rifle to impress various Indian tribes encountered on the expedition—often "astonishing" or "surprising" them, and making

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106. *Id.*

107. Joseph Belton, *Letter to the Continental Congress*, Apr. 11, 1777, *in* Papers of the Continental Congress, Compiled 1774-1789, vol. 1 A-B, at 123; 7 Journals of the Continental Congress 1774-1789, at 324 (1907).

108. *Id.* at 139.

109. *Id.* at 361.

110. Roger Lamb, An Original and Authentic Journal of Occurrences During the Late American War 309 (1809).

111. James Garry, Weapons of the Lewis and Clark Expedition 100-01 (2012).

112. John Plaster, The History of Sniping and Sharpshooting 69-70 (2008).

113. Jim Supica, et al., Treasures of the NRA National Firearms Museum 31 (2013).

114. Garry, at 91

115. Gerald Prenderghast, Repeating and Multi-Fire Weapons 100-01 (2018); Garry, at 91-94.

116. Nancy McClure, *Treasures from Our West: Lukens Air Rifle*, Buffalo Bill Center for the American West, Aug. 3, 2014. Located in Cody, Wyoming, the five museums of the Buffalo Bill Center include an outstanding firearms museum.

117. Garry, at 99.

118. Prenderghast.

the point that although the expedition was usually outnumbered, the smaller group could defend itself.[119]

The problem in America, as in England, was that repeating guns require a much closer fitting of the parts than do single-shot guns, so they could only be produced more slowly by very skilled gunsmiths. The same was true for breech-loading guns.[120] The expense made repeaters and breechloaders unaffordable to much of the population. Affordability would change in the nineteenth century with the rise of machine tools. *See* Part C.

4. Edged Weapons

As the American colonies' arms mandates demonstrate, edged weapons were pervasive. Ch. 3.B. Besides the bayonet, there were swords, tomahawks, hatchets, and a wide variety of knives. At close quarters, most firearms would be good for one shot. If a person carried a pair of pistols (a *brace*), then he or she could fire two shots. But there would be no time to reload anything more against an adversary who was within arm's reach. So edged weapons were essential to self-defense.[121]

5. Armor

In Europe in the sixteenth century, the increasing use of firearms had made plate armor obsolete. In the early years of American settlement, when Indians with arrows were the principal opponent, Americans continued to wear armor. For purposes of mobility, leather or quilted jackets became popular; they would not always stop an arrow, but they did mitigate its damage. Once the Indians acquired firearms in large quantities, armor was generally abandoned. By the time of the Revolution, the principal armor was metal headgear. Although it would not necessarily stop a bullet, it offered some protection against edged weapons. Militiamen often had to provide themselves with some form of armor.[122]

6. Production Issues

Today a gunsmith is typically separate from a gun manufacturer. The former repairs or customizes firearms and is usually a small businessperson. In England and America during the seventeenth and eighteenth centuries, the

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119. Meriwether Lewis and William Clark, The Journals of the Lewis & Clark Expedition (Gary Moulton ed., 1983) (13 vols.). *See e.g.*,6 *id.* at 233, Jan. 24, 1806, entry ("My Air-gun also astonishes them very much, they cannot comprehend it's shooting so often and without powder; and think that it is *great medicine* which comprehends every thing that is to them incomprehensible.").

120. Peterson, Arms and Armor, at 217-18.

121. *Id.* at 69-101.

122. *Id.* at 103-51, 307-16; Ch. 3.B.

gunsmiths were also the manufacturers. In England, most gunsmiths belonged to guilds, which imposed price controls on gunsmithing services. There were no such guilds in America.[123] The effect of supplier-based price controls, a form of oligopoly, is usually a reduction in the supply, and an increase in profits to the suppliers.

The United Kingdom's 1750 Iron Act restricted American mines and steel furnaces. Among its provisions were a ban on the use of the tilt hammer, which is necessary to produce the thin iron for knife-making.[124] The Act was poorly enforced, however, because some British officials in America had financial interests in the iron and steel business, and others were simply bribed. Had the American colonists not illegally developed an iron industry, the Revolution would have been impossible for lack of arms.[125] A shortage of quality iron did reduce the quality of American firearms.[126] Thomas Jefferson's 1774 tract *A Summary View of the Rights of British America* listed the Iron Act as among the abuses inflicted on the Americans.

Further reading: David B. Kopel & Joseph G.S. Greenlee, *The Second Amendment Rights of Young Adults*, 43 S. Ill. U.L.J. 495 (2019) (extensive description of American arms and arms terminology from the colonial period through 1800).

C. THE AMERICAN INDUSTRIAL REVOLUTION

1. The Rise of the Machine Tools

The period from the beginning to the middle of the nineteenth century was the greatest in the development of American firearms. By the end of this period, there were mass market firearms basically like those that are common today: repeating, breechloading firearms that use metallic cartridges, which contain the bullet, gunpowder, and primer in a single unit. Repeaters and breechloaders had been produced for centuries. Parts A, B. What put them on the mass market was a revolution in firearms manufacture.

As of 1800, the United States was an importer of manufactured goods, and an exporter of raw materials such as wheat, corn, rice, timber, tobacco, and cotton. By 1900, America had become an industrial powerhouse, exporting its high-quality and low-cost manufactured products globally. The most important cause of the change was the American industrial revolution. That revolution began because of the firearms industry, and the revolution in the firearms industry began because of the federal government.

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123. Brown, at 87, 150.

124. 23 George II ch. 29 (1750).

125. Arthur C. Bining, British Regulation of the Colonial Iron Industry (1933); Brown, at 241.

126. *Id.* at 377. In particular, the steel shortage made American springs for the gunlock inferior to the best European guns, so ignition speed (from the time the trigger is pulled until the gun fires) was slower on American guns. Brown, at 377.

a. The Federal Armories

In 1794, Congress authorized President George Washington to establish federal armories. 1 Stat. 352 (1794). He chose Springfield, Massachusetts, and Harpers Ferry, Virginia. Initially, the armories were collections of craftsmen working under the same roof. Although they had divisions of labor, they did not use machine tools. By using the factory system, the armories before 1815 made guns at a higher rate and for lower cost, and somewhat lower quality than did independent small business craftsmen.[127]

By 1809, the ongoing Napoleonic Wars in Europe had so damaged United States relations with European powers that imported arms were unavailable. The U.S. needed to be self-sufficient in arms manufacture.

Weapons procurement problems during the War of 1812 spurred reorganization. Secretary of War (and future President) James Monroe successfully urged legislation in 1815 to put the federal armories under the direct control of the War Department's Ordnance Department.[128] Thereafter, the Ordnance Department pushed vigorously for firearms with interchangeable parts. The potential military utility was apparent: Suppose that three muskets were damaged in battle. If the parts were interchangeable, then a field armorer might be able to reassemble them into two functioning muskets. Ideally, interchangeable parts would reduce manufacturing costs and increase manufacturing speed. Interchangeability was the Ordnance Department's holy grail. The initial objective was not perfect interchangeability. If a field armorer only needed to do a little filing and fitting, that was good enough.[129]

Before 1815, even firearms from the same artisan did not have interchangeable parts. Interchangeability was impossible without machine tools. Craftsmen could make good parts one at a time, but they could not make them uniform. The heavy capital outlays to buy or build machine tools were made possible by generous federal contracts to private firearms makers. Those contracts awarded much of the payment up front, so that the manufacturers could spend several years setting up and perfecting their factories. The Ordnance Department policy was to subsidize technological innovation.[130] The Democratic-Republicans and the Federalists disagreed on many issues, but they strongly agreed that federal support for advancing the firearms industry was in the national interest, and a proper function of the national government.

The Springfield Armory led the way. Its geographical location was perfect. Far enough inland to be safe from a hostile navy, it was close to the Salisbury iron region. The many tributaries of the Connecticut River provided abundant waterpower for the machine tools, and good transportation. Springfield did not produce everything itself, instead working with a large network of private contractors. Springfield insisted that its contractors work in open, cooperative networks, so that knowledge, personnel, and machinery were freely shared among the Springfield Armory and the private contractors. Soon, the Connecticut River Valley became the

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127. David R. Meyer, Networked Machinists: High-Technology Industries in Antebellum America 82-83 (2006).

128. 8 Stat. 204 (1815).

129. Merritt Roe Smith, Harpers Ferry Armory and the New Technology: The Challenge of Change 107 n.6 (1977).

130. Ross Thomson, Structures of Change in the Mechanical Age: Technological Innovation in the United States 1790-1865, at 54-59 (2009).

center of American firearms manufacture. "Gun Valley" was its nickname.[131] New England remained the leading region for American firearms manufacture until the latter part of the twentieth century. The region accounted for 35 percent of the industry in 1850, 65 percent in 1860, and 60 to 83 percent from 1870 until 1940.[132]

Harpers Ferry had no such stimulating effect. It was too remote from the world of commerce. As in most slave regions, the White population preferred their rural idyll and their craftsmanship to the growing world of industry and mass production. Harpers Ferry was not as productive as Springfield and made no significant contributions to manufacturing knowledge. The great exception was John H. Hall, discussed in Section C.2, who set up his own buildings at Harpers Ferry, and operated as an independent contractor. He and his family were snubbed by the locals. Smith, Harpers Ferry Armory.

In the Springfield area, prosperous farmers, professionals, and businessmen invested their own capital in new manufacturing businesses, which made products to satisfy growing consumer demand. Around Harpers Ferry, as in most of the slave plantation regions, plantation owners produced their own goods. The goods they did purchase for slaves were cheap and imported from elsewhere. In the slavery economy, money invested in new capital was used to buy more slaves—not toward manufacturing equipment, nor toward infrastructure such as roads. In the Gun Valley, and in New England generally, a virtuous cycle of investment, growth, and prosperity led to relentless improvements in firearms manufacture, textiles, and many other products. The stasis of a slave-based economy retarded Harpers Ferry in particular, and Southern firearms manufacturing in general.[133]

While the federal armories and their associated contractors were used to procure weapons for the federal armory, Congress set up a separate system to purchase firearms from private gunsmiths and donate them to state militias. Although the system persisted for decades, the amounts appropriated were not remotely close to sufficient to standardize militia arms. Militia arms were still a hodgepodge of whatever militiamen supplied themselves, notwithstanding the specificity of the Second Militia Act of 1792 (Ch. 5.F.1).

b. The American System of Manufacture

Before the nineteenth century, firearms manufacture was artisanal. Guns were made one at a time by craftsmen. The craftsman, perhaps aided by an apprentice, often made the whole gun himself: "lock, stock, and barrel." The advances in the nineteenth century were made possible by the development of machine tools.

Consider the wooden stock of a long gun. The back of the stock is held against the user's shoulder. The middle of the stock is where the action is attached. For many guns, the forward part of the stock would contain a groove to hold the barrel. Making a stock requires many different cuts of wood, few of them straight. The artisanal gunmaker would cut with hand tools such as saws and chisels.

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131. Felicia Johnson Deyrup, Arms Makers of the Connecticut Valley: A Regional Study of the Economic Development of the Small Arms Industry, 1798-1870 (1948); Meyer, at 73-103, 229-80.

132. Deyrup, at 218, app'x A, tbl. 3; Meyer, at 84.

133. Meyer, at 81.

To make stocks faster and more uniformly, Thomas Blanchard invented 14 different machine tools. Each machine would be set up for one particular cut. As the stock was cut, it would be moved from machine to machine. By mounting the stock to the machine tool with *jigs* and *fixtures*, a manufacturer could ensure that each stock would be placed in precisely the same position in the machine as the previous stock. The mounting was in relation to a *bearing*—a particular place on the stock that was used as a reference point. To check that the various parts of the firearm, and the machine tools themselves, were consistent, many new *gauges* were invented.[134] In a state-of-the-art armory, the number of machinists who maintained the machine tools could be as great as the number of people who operated the machines to make the firearms parts.

What Blanchard accomplished for stocks, John H. Hall accomplished for manufacturing the rest of the gun. Based at Harpers Ferry, Virginia, Hall shipped some of his machine tools to Simeon North, in Connecticut. In 1834, Hall and North made interchangeable firearms. This was the first time that geographically separate factories had made interchangeable parts.[135]

John Hall model 1816 musket. The specimen is a Type II, manufactured 1822-31.

The effect on production volume was tremendous. At the Springfield Armory, the average number of barrels welded annually per man in 1806 was 1,200. By 1860, it had increased to 12,615. That figure would double by 1870.[136]

Mass production by machine tools has many potential benefits: interchangeable parts, faster production, lower cost, or higher quality. The Ordnance Department

134. Deyrup, at 97-98; Thomson, at 56-57.
135. *Id.* at 58; Smith, at 212.
136. Deyrup, at 247, app'x A, tbl. 5.

obtained first what it wanted most: interchangeability. Production speed and volume also gradually improved. The costs, though, were often higher than for craft arms.

Because the federal contractors were producing only for the federal army and navy, which were small, their output was correspondingly small. The next steps to advance the use of machine tools would come from companies that were manufacturing for the consumer market, and who had seen what Hall had accomplished. Because Hall "established the efficacy" of machine tools, he "bolstered the confidence among arms makers that one day they would achieve in a larger, more efficient manner, what he had done on a limited scale. In this sense, Hall's work represented an important extension of the industrial revolution in America, a mechanical synthesis so different in degree as to constitute a difference in kind."[137]

The first to follow Hall was Col. Samuel Colt, who mass-produced revolvers for the consumer and military markets. Colt certainly did not invent the revolver, a design that was already four centuries old.[138] Colt's 1835 revolver patent was preceded by, inter alia, the 1818 patent of Boston's Joseph Collier for a new system of revolver-based handguns and rifles.[139] Colt's initial contribution was twofold. First, he eliminated the long-standing danger of the gunpowder ignition from the firing chamber seeping into other cavities in the cylinder, setting off the powder therein, and causing the gun to explode in the user's hand.[140]

Second, Colt figured out how to use machine tools to make high-quality revolvers in large quantities. Like Henry Ford with the automobile, Colt did not invent the revolver. Like Ford, he "adapted and redesigned an idea into industrial success" so that "what had hitherto been achieved at great expense with only moderately satisfactory results was suddenly rendered highly functional, durable, and," relative to its quality, "remarkably cheap."[141]

To keep workers at their best, Colt limited the working day to ten hours, long before that became a norm, with a mandatory one-hour lunch break. He built a factory town, Coltsville, near Hartford, providing highly paid workers with the finest amenities of the time, sometimes extravagantly so.[142]

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137. Smith, at 249.

138. Held, at 177.

139. Held, at 164.

140. Held at 177.

141. Held, at 177.

142. The families in Coltsville needed furniture. The world's best makers lived in Germany, and Colt convinced some of them to emigrate. He built a replica German town next to the furniture factory in Coltsville. The new town included a beer garden and folk music instruments for the immigrants. Potsdam Village became a major part of Coltsville. Later, furniture-making with machine tools reduced the need for skilled craftsmen such as the German immigrants. Yet Colt continued to employ the immigrants and to maintain their original pay. A grateful workforce made the Colt furniture business so efficient that it could undersell competitors in markets as far away as California and Cuba. *See* Dave Kopel & Michael Brotherton, *Learning from Coltsville: The Case for This National-Park Candidate*, National Rev. Online. Sept. 23, 2002; *see generally* David B. Kopel, "Samuel Colt," *in* Inventors and Inventions 212 (Alvin K. Benson ed., 2009) (Great Lives from History series). Most arms manufacturers did not go to the extremes that Colt did, but they did pay well. A study covering 1850 to 1940 found that average annual wages in the arms industry always exceeded wages in overall U.S. industry, sometimes by large margins. Deyrup, at 217 app'x A, tbl. 1.

In the early 1850s, Christian Sharps hired some of the best machinists from New England to build a state-of-the-art rifle factory in Hartford.[143] In upstate New York, at Ilion, Eliphalet Remington founded the Remington Arms Company. The son of a gunsmith, he turned his family's craft business into a high-volume industrial manufacturer. Remington is America's oldest continuously operating firearms maker. Two other enduring companies—Smith & Wesson, and Winchester Repeating Arms—would enter the market in the 1850s.

At the 1851 Crystal Palace Exhibition in London, visitors marveled at Colt's new American firearms. The British government dispatched experts to visit and study companies such as Colt and their "American system of manufacture."

In Great Britain, artisanal arms makers looked down on the new American system as déclassé. A gunsmith, like a tailor, should make his product precisely to fit the individual buyer. Purchasing a suit or a gun off the track was vulgar.[144] The snobbery was sincere, and a result of the United Kingdom's guild system. British gunmakers, like many other artisans, belonged to guilds, which restrained trade, raised prices, and retarded innovation.

Having begun with firearms, the American system of manufacture spread. Initially, the closest relatives of the arms makers were the textile makers. For example, Hall's firearms gauges were improved for textile use.

Colt's factory incubated machine tool makers who took their expertise into new fields. Among Colt's offspring is the industrial giant Pratt & Whitney.[145] The first application of armory practice to manufacturing other consumer durables was for sewing machines. Later came reapers (machines for harvesting grain), and then bicycles. Bicycle manufacture in turn became the foundation for mass production of automobiles. Remington used its machine tool knowledge to build the first commercial typewriters.[146]

Gun Valley was the Silicon Valley of its era. Its networks of "retained knowledge" and "technical skills and innovations . . . became embedded in communities of practice." The job-hopping, sophisticated, and youthful "machinists in the antebellum East anticipated modern behavior by over one hundred and fifty years." Meyer, at 280.

While manufacturing was concentrated in the Northeast, invention was more dispersed. In 1790-1865, the Mid-Atlantic slightly led New England in American firearms patents. Contributions from the South or the sparsely populated West were much fewer. The combination of the new mass producers catering to consumers, plus the enormous federal government demand for firearms during the Civil War, spurred innovation. In 1856-65, firearms accounted for 64.8 percent of American patents.[147]

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143. Meyer, at 252, 262.

144. Terry S. Reynolds & Stephen H. Cutcliffe, *Technology and the Industrial West*, *in* Technology & the West 259-61 (Terry S. Reynolds & Stephen H. Cutcliffe eds., 1997).

145. Meyer, at 258.

146. David A. Hounshell, From the American System to Mass Production, 1800-1932, at 1-65 (1985); Alexander Rose, American Rifle: A Biography 69-102 (2008), Thomson, at 97, 267-68, Smith, at 325.

147. Thomson, at 69, 93.

The American system eventually caught on almost everywhere. As a Smithsonian Institution book summarized: "Thus it can be said that the firearms industry, especially as it evolved in the United States during the late eighteenth and early nineteenth century, generally exerted a greater economic and technological impact on civilization than any other dynamic human endeavor since the dawn of recorded history."[148]

Artisanal production continues to the present. Yet even artisans took some advantage of machine tools. In the late eighteenth century, firearms artisans had to make their own tools, including saws; this became less necessary over time. From the 1820s onward, more and more artisans owned their own lathe.[149] Rather than producing everything themselves or buying parts from other artisans, artisans increasingly used parts that had been made by machine—for example, rifle barrels in which the bore had already been drilled by machine, to which the artisans would add the rifling themselves.[150]

2. Loading, Ignition, and Ammunition

a. Mass Market Breechloaders

Improvements in machine tools and in gauges made possible the mass production of affordable breechloaders. During the eighteenth century, there had been five English patents for breech-loading firearms. The first American breech-loading patent was awarded in 1811 to John H. Hall, the machine tool inventor discussed in Section C.1. By 1860, there were more than a hundred American breech-loading patents, and by 1871 more than 700—four times the rest of the world combined.[151]

The first consumer mass market breechloader was the Sharps rifle, introduced in 1850. Although it was a single-shot gun, the breech-loading mechanism was so simple that a novice could fire nine shots in a minute. *Sharps' Breech-loading Patent Rifle*, Scientific American, Mar. 9, 1850. The Sharps rifles were particularly popular with pioneer families heading West. A superb long-range gun, the Sharps remained in common use for decades afterward, often retrofitted to use metallic cartridges.[152] Whereas a person using a muzzleloader must stand while reloading, a breechloader can be reloaded from the prone position—a great defensive advantage.[153]

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148. M.L. Brown, Firearms in Colonial America: The Impact of History and Technology, 1492-1792, at 387 (1980).

149. Ned H. Roberts, The Muzzle-Loading Caplock Rifle 329-31 (2d ed. 1944).

150. *Id.* at 384.

151. Norton, at 11, 19.

152. Townsend Whelan, The American Rifle 9 (1923); Section C.4.b (metallic cartridges).

153. Fuller, at 118.

Sharps carbine. This specimen was captured by Indians, who decorated the stock with bone and shell inlays.

b. Ignition

The development of the breechloader was considerably aided by a new method of igniting the gunpowder. Part A describes how the flintlock and its wheellock predecessors were ignited: Pulling the trigger would start a process that would strike a spark in a small pan of gunpowder, the *flash pan*. The flame from the flash pan traveled through a channel to a small opening in the gun, the *touch hole*. Via the touch hole, the flame entered the breech, where the main charge of gunpowder was located, and ignited it.

In 1807, Scottish clergyman Rev. Alexander John Forsyth was granted the first patent for the use of fulminates in ignition. A fulminate (from the Latin word for lightning) is a chemical compound that readily explodes when it is physically struck (*percussed*).

Fulminate-based ignition was simple. The fulminate is next to the touch hole. Pulling the trigger causes a firing pin to strike the fulminate. The fulminate detonation then ignites the gunpowder. The difference between percussion ignition and flintlock ignition is that the primer is hit, not lit.

Percussion ignition was instant, and noticeably faster than the flintlock, increasing accuracy because the shooter is less likely to move the firearm between the time that he or she pulls the trigger and the gun fires.[154] It was about 99 percent less likely to *misfire* (fail to ignite the main powder charge) or to *hang fire* (delayed ignition).[155] Percussion also made reloading faster,

154. In well-made flintlocks of the early nineteenth century, the lapse between trigger pull and ignition was "virtually zero," and in percussion guns, "absolutely zero if the nipple was kept clean." Held, at 174.

155. Fuller, at 113. By Forsyth's time, the best-made flintlocks had become very reliable, albeit not perfectly so. Meanwhile, lower quality flintlocks, such as the Brown Bess, "were not expected to do better than fire seven times out of ten." Held, at 175.

and reduced recoil, thereby improving accuracy.[156] Whereas flintlock ignition started a fire at the bottom of the powder charge, percussion ignition instantly shot a flame through the entire charge, burning it all at once. There being no touch hole from which a little gas could escape, all of the gas contributed to pushing the bullet. Percussion cap guns "shot harder and still faster than the best flintlock ever known."[157]

At first, there were a variety of mechanisms for holding the fulminate. The *tapelock* contained small circles of fulminate in a two-sided strip of tape. Toy cap guns still use the tapelock.

Eventually, the predominant fulminate system became the percussion cap—a small, short cup containing the fulminate. The percussion cap would be placed on a short hollow tube (the *nipple*) near the touch hole. By 1820 the percussion cap had made the flintlock obsolete, and by 1825 only a few gunsmiths catering to hard-core traditionalists were even making flintlocks.[158] Many were retrofitted to use percussion caps, which was an easy conversion.[159] For gunsmiths, "the simplicity of percussion locks required none of the masterful skill of the vanished age, and consequently the manufacture lent itself well to the universally booming new factory system."[160]

This Model 1816 flintlock musket was converted to percussion cap ignition.

156. Lloyd, at 234.
157. Held, at 171.
158. Held, at 174-75.
159. Fuller, at 113; Brown, at 379; Philip B. Sharpe, The Rifle in America 17-20 (1938).
160. Held, at 175.

c. Better Bullets

In a muzzleloader, the bullet must be slightly smaller than the bore diameter and must be of relatively soft lead. In the breechloader, the bullet can be closer to the bore size, so that it fits the rifled grooves more closely. The bullet can also be harder. Hardness helps the bullet retain its shape while traveling through the barrel. Thus, the bullet is more stable aerodynamically, and shooting is more accurate, especially at longer ranges.[161]

For centuries, bullets had been round. In the early nineteenth century, it was recognized that bullets would have more aerodynamic stability if they had a more conical shape. Further, if the back of the bullet were flat, and carefully fitted to match the size of the barrel's bore, the flat surface would prevent forward leakage of expanding gas from the gunpowder's ignition; thus, there would be more gas energy behind the bullet to propel it faster. Speed makes a bullet more resistant to air friction and gravity, which will eventually make a bullet fall to the earth. Although bullets today are conical, one unit of ammunition is still called a *round*, from the days when bullets were spheres.

Additionally, inventors learned how to make bullets that would expand slightly when fired. For rifles, this made it much easier for bullets to engage with the spiral grooves that are cut into a rifle barrel. Such engagement is necessary to make the rifle bullet spin on its axis.[162]

3. The Demand for Accuracy

Percussion-based ignition made the gunpowder burn more efficiently, which meant that the bullet is pushed by more energy, and so will travel a longer distance more accurately.[163] Long-range accuracy was just what Americans wanted as they moved West, where there was more need for longer distance shooting, compared to the thickly wooded regions east of the Appalachian Mountains.

All things being equal, a larger bullet propelled by a larger gunpowder load will travel a longer distance more accurately. More internal gas pressure from gunpowder explosions means that the gun must have a higher tensile strength. Responding to consumer demand, around 1840 the better rifle barrels were made from cast steel, rather than from welded iron. The new barrels had fewer imperfections in the bore, which made them all the more accurate.[164]

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161. Greener, at 640.

162. Held, at 183. Before the expanding bullet, there were two solutions. The German-Swiss solution, as in Jaeger rifles, was to have a bullet as large as the bore, and to force it from muzzle to breech with an iron ramrod. This could take some time. The American solution, as in the Pennsylvania-Kentucky rifle, was to use a bullet slightly smaller than the bore and wrap it in a greased cloth or linen patch. When the gun was fired, the patch would act as a forward gas seal, so that expanding gas did not exit the muzzle before the bullet did (at least not until the patch had been burned in the fire).

163. Roberts, at 51.

164. *Id.* at 11-12.

As more accurate rifles were developed, there was a corresponding increase in demand for telescopic sights—that is, a scope mounted on top of a rifle. While telescopic sights by this time were over two centuries old, the 1840s was the first time that ordinary rifles were accurate enough to take full advantage of them.[165] Sights were among the many consumer goods whose prices dropped as mass production became possible.

4. Repeaters

As described in Parts A and B, repeating firearms had been around for hundreds of years. But they were expensive, out of reach of most consumers. Beginning in the 1830s, cost savings from mass production made repeaters broadly available.

a. Repeating Handguns: Revolvers and Pepperboxes

Front view of the six-barreled pepperbox handgun manufactured by Robbins & Lawrence, 1851-54.

Pepperbox handguns are similar to revolvers but have multiple barrels that fire sequentially. Pepperboxes had been around since the eighteenth century,[166] but it was the combination of the percussion cap and improved manufacturing that brought them to the American mass market in the 1830s. The most common configurations were four to eight shots, but some models had as many as 24.[167] Pepperboxes were good enough for self-defense at close range, but not accurate enough for anything else.[168] The multiple barrels made them unbalanced, being heavy at the muzzle, and so more difficult to aim precisely.

Also in the 1830s, revolvers were first brought to the American market by Samuel Colt. Instead of multiple barrels (as in a pepperbox), his handgun had a single barrel, behind which was a rotating cylinder holding five or six rounds of ammunition.

Unlike the rifles and muskets made in the federal armories, Colt's revolvers were not perfectly interchangeable. Colt and other manufacturers still needed skilled labor hand fitters, who would assemble the parts and file or otherwise adjust them to make the gun work properly. Colt used machine tools for high quality and for high production volume—275 revolvers per day, from 600 employees. Colt revolvers were the most expensive handgun on the mass market.[169] The moving

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165. *Id.* at 51, 66-67.

166. *E.g.*, Held, at 162 (six-barreled flintlock made in London ca. 1760-80).

167. Lewis Winant, Pepperbox Firearms 7 (1952).

168. Jack Dunlap, American British & Continental Pepperbox Firearms (1964); Winant, Pepperbox Firearms.

169. William B. Edwards, The Story of Colt's Revolver (1953); Jack Rohan, Yankee Arms Maker (rev. ed. 1948); Meyer, at 258-59, 278.

parts of a revolver are much more intricate and closely fit than those of a single-shot handgun. Until the rise of machine tools, the mass market revolver was impossible.

Persons who wanted a less expensive, albeit less versatile, repeating handgun bought pepperboxes, which stayed on the market until well after the Civil War. In the Northeast, where most handguns were made, a good pepperbox might cost $10 or $15, and a Colt revolver $25. In California, the Colt might be sold for $200 or more. Many of the Forty-Niners who joined the California gold rush carried pepperboxes.[170] Today, revolvers are still very common in the United States, while the pepperbox has been forgotten.

Colt Dragoon revolver, manufactured 1848-50. It is .44 caliber and uses percussion cap ignition. As the name indicates, it is well-suited for use on horseback, and was popular in the California gold rush for people who could afford one.

b. The Metallic Cartridge

Colt's first revolvers, like pepperboxes, were muzzleloaders. The development of breechloaders and of repeating arms was greatly assisted by the invention of a new type of ammunition in the early 1850s: the metallic *cartridge*, an invention made possible by the expanding bullet.[171] The cartridge contained the bullet, the gunpowder, and the primer (the fulminate) in a single metallic case.

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170. Chapel, at 85.

171. Greener, at 773; Deyrup, at 28; Held, at 183-84. The first self-contained metallic cartridge, the *pinfire cartridge*, had been invented in Paris in 1846. It worked fine when loaded in a gun and fired shortly thereafter, but it was prone to explosions when dropped or when jostled during transport. Held, at 184.

Although cartridges improved in subsequent decades, the basic design remains the same. The metallic cartridge made breech-loading easier; it made the operation of a repeater much easier; and it facilitated much quicker reloading for repeaters and for single-shot firearms.[172]

The first commercially successful American handgun to take advantage of the metallic cartridge was the Smith & Wesson Model 1, of 1857. It was by far the fastest reloading handgun invented up to that time. After the six shots in the cylinder had been fired, loading six fresh cartridges took just a few seconds. The next major step in handgun reloading would take place in the latter nineteenth century, with the detachable box magazine. Part D.

The Smith & Wesson Model 1, the first U.S. firearm to use metallic cartridges. Manufactured 1857-60. The revolver rests atop its original case.

172. The metallic cartridge also solved the last remaining major problem for breech-loaders. Whereas in a muzzleloader the breech is completely sealed, the breech in a breech-loader, which is opened and closed during reloading, could never be perfectly sealed. Thus, some gas from the gunpowder explosion could leak backwards via the breech opening. At the last, the gas leak resulted in a loss of expansive gas that could have propelled the bullet. In metallic cartridges, the brass case expands because of the heat and pressure of the gunpowder explosion. The expansion to the circular base of the case creates a seal that prevents any backwards leakage of gas. Held, at 184.

c. The Repeating Rifle

Inventors were busy on many types of repeating firearms. In 1821, the *New York Evening Post* lauded Isaiah Jennings for inventing a repeater, "importan[t], both for public and private use," whose "number of charges may be extended to fifteen or even twenty . . . and may be fired in the space of two seconds to a charge."[173] The government considered the guns promising. "About 1828 . . . Reuben Ellis . . . made military rifles under contract on the Jennings principle."[174]

There was much innovation in repeating long guns and handguns. The Bennett and Haviland Rifle used the same concept as the pepperbox. It had 12 individual barrels that fired sequentially.[175] The Walch 12-Shot Navy Revolver had six chambers each holding two rounds that fired separately. It was used in the Civil War and made its way to the western frontier.[176] Europeans exported pinfire revolvers, with capacities of up to 21 rounds.[177] In 1855, Joseph Enouy invented a 42-shot Ferris Wheel pistol.[178] Alexander Hall's rifle with a 15-round rotating cylinder was introduced in the 1850s.[179] In 1851, Parry Porter created a rifle with a 38-shot canister magazine. The Porter Rifle could fire 60 shots in 60 seconds.[180] In 1866, the 20-round Josselyn belt-fed chain pistol made its debut. Some later chain pistols had greater capacities.[181]

None of these guns sold well. Some were unwieldy and many had reliability problems. The path to the mass market repeating rifle lay in a different direction. In 1855, an alliance of Daniel Wesson and Oliver Winchester produced a *lever-action* rifle, taking advantage of the new metallic cartridge. The lever action had been invented in the early seventeenth century, but had never become common, due to cost. Section A.4.

With a lever action, loading the next shot is simple. To eject the empty metallic case and then bring a fresh cartridge into the firing chamber, the user pulls down a lever and then pushes it back up. In a typical lever-action rifle, the reserve ammunition is held in a tubular magazine underneath the barrel.

Wesson and Winchester's first model, the 30-shot Volcanic Rifle, had reliability problems. But the Volcanic was improved into the 16-shot Henry Rifle of 1860.[182] Tested at the Washington Navy Yard in 1862, the Henry fired 15 shots in

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173. *Newly Invented Muskets*, N.Y. Evening Post, Apr. 10, 1822, *in* 59 Alexander Tilloch, The Philosophical Magazine and Journal 467-68 (1822).

174. Lewis Winant, Firearms Curiosa 174 (Odysseus 1996) (1955).

175. Norm Flayderman, Flayderman's Guide to Antique American Firearms and Their Values 711 (9th ed. 2007).

176. Chapel, at 188-89.

177. Supica, at 48-49; Winant, Pepperbox Firearms, at 67-70.

178. Winant, Firearms Curiosa, at 208.

179. Flayderman, at 713, 716.

180. *A New Gun Patent*, Athens (Tenn.) Post, Feb. 25, 1853 (reprinted from N.Y. Post); 2 Sawyer, at 147.

181. Winant, Firearms Curiosa, at 204, 206.

182. Fifteen rounds in the tubular magazine, plus one round in the firing chamber.

10.8 seconds.[183] Taking into account reloading time, a Henry could fire about 28 shots per minute. A famous testimonial came from Captain James M. Wilson of the 12th Kentucky Cavalry, who used a Henry Rifle to kill Confederates who broke into his home and ambushed his family. "When attacked alone by seven guerillas I found it to be particularly useful not only in regard to its fatal precision, but also in the number of shots held in reserve for immediate action in case of an overwhelming force."[184] Soon after, Wilson's entire command was armed with Henry rifles.[185]

The 1860 Henry lever action rifle. This specimen was manufactured 1864. The lever is the oval that attaches to the trigger guard. The oval and the guard move as a unit, swung down to eject, then up to reload. The pivot is at the top front of the trigger guard. The rifle is still in production today, with modifications for modern ammunition.

An even bigger success was an improved version of the Henry, the Winchester Model 1866. It had a capacity of "eighteen charges, which can be fired in nine seconds."[186] A favorite in the West, the Model 1866 was the first repeating long gun to become a major consumer product.[187]

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183. H.W.S. Cleveland, Hints to Riflemen 177 (1864).

184. *Id.* at 181.

185. Andrew L. Bresnan, *The Henry Repeating Rifle*, RareWinchesters.com, Aug. 17, 2007.

186. Louis Garavaglia & Charles Worman, Firearms of the American West 1866-1894, at 128 (1985); *see also* Peterson, Treasury, at 234-35 (advertising promised "Two shots a second").

187. Not counting the two-shot double-barreled rifles or shotguns, which had been widespread since the seventeenth century. Part A.4.

More than 170,000 Winchester Model 1866s were produced. For the successor, more than 720,000 Winchester Model 1873s were produced from 1873 until 1919.[188] Magazine capacity for the Model 1873 ranged from 6 to 25.[189] Today, the Henry and the Winchester 1866 and 1873 are manufactured in modern calibers by Uberti, an Italian company specializing in Old West reproductions.[190]

The Winchester Model 1866 lever action rifle, which is still in production today, with modifications for modern ammunition.

5. Conclusion

Mass production in the fullest sense was not perfected until Henry Ford's assembly line for the Model T automobile in the early twentieth century. Even so, the advances that were initially fostered by the Ordnance Department greatly changed

188. Flayderman, at 306-09. As was the American norm since the Jamestown settlement in 1607, almost as soon as a firearm type entered the middle-class market, it ended up in Indian hands. Indians called the Henry and its successors "many-shots guns." *See, e.g.*, James Willard Schultz, Friends of My Life as an Indian 233 (1923) (.44 caliber Henry); Laura Trevalyan, The Winchester: The Gun that Built an American Dynasty 53 (2016) ("William Henry Jackson's portraits of Native Americans show them brandishing what they called 'heap-firing' guns or 'many-shots.'") (citing John E. Parsons, The First Winchester 69 (1955)).

189. Arthur Pirkle, Winchester Lever Action Repeating Firearms: The Models of 1866, 1873 & 1876, at 107 (2010).

190. Among the endorsers of the Winchester 1873 was the famous scout (and later, entertainer) Col. William F. "Buffalo Bill" Cody, who praised the rifle's versatility. Flayderman, at 55.

the firearms used by ordinary Americans. Breechloaders and repeaters were nothing new, but their mass availability and affordability was quite a change from 1791.

With a muzzle-loading musket in 1791, an expert shooter might be able to fire up to five shots per minute—although three was more typical. With a single-shot Sharps rifle, anyone could fire nine shots per minute. With a revolver or a repeating rifle, that rate of fire could be doubled, tripled, or more. And the new guns had much greater range and accuracy than their predecessors.

The trends that had been established in the 1850s were accelerated by the Civil War in 1861-65. "Breechloaders, repeaters, and metal ammunition were exceptional at the beginning of the war but had become the weapon of choice at the war's end." Thomson, at 307. Shortly before the Civil War, federal ordnance spending had been $1.5 million annually. That figure soared to $43 million. During the first year of the war, imports accounted for five-sixths of federal firearms purchases. By 1862, domestic producers supplied the majority of Union arms.[191] The war happened at a time when the domestic industry had developed the ability to scale up massively. That scaled-up industry is essentially the American firearms industry that has continued to the present—of course with various manufacturers rising and falling, and with the early mass producers, such as Colt, Remington, Winchester, and Smith & Wesson going through several changes of ownership.

Even after the Civil War, Americans still had plenty of muzzleloaders, and it took decades before every family could afford to upgrade to a more modern gun. The remainder of the nineteenth century (Part D) would see very important improvements in gunpowder and metallic cartridges; new types of actions (pump, slide, bolt, semi-automatic) to perform the same work as the lever action; and the detachable box magazine (to hold the reserve ammunition in a rectangular box). From 1866 to the present, there would be many improvements in accuracy, reliability, durability, and affordability. While developments in the last century and a half are significant, they pale in comparison to the advances in the first part of the nineteenth century. Invented in the seventeenth century, breech-loading repeaters in the mid-nineteenth century became an ordinary consumer good.[192]

D. THE LATTER NINETEENTH CENTURY: MASS MARKET FIREARMS AS WE KNOW THEM TODAY

During the Civil War, the Union's demand for firearms was enormous, and private companies manufactured between 2.5 and 3 million arms. Alexander Rose, American Rifle: A Biography 137 (2008). This still was not enough to fully supply Union needs, so the Union imported large quantities of firearms from Europe. But the Union's demands for American production did help create a large and robust domestic firearms industry that could produce affordable and reliable firearms.

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191. Thomson, at 301-04.

192. "[C]ivilians and lower-rank military men advanced the effectiveness of firearms further in the forty years between 1830 and 1870 than it had been during the preceding three hundred. . . ." Held, at 183.

1. Ammunition

The single most important advance in arms technology was in ammunition. Part C discussed the invention of the metallic cartridge, which contains the primer, gunpowder, and bullet in a metal case. Most metallic cartridges were originally *rimfire*: The primer (a chemical fulminate) was placed onto the inside of the rim at the base of the cartridge. In 1867, the modern *centerfire* cartridge was invented. It put the fulminate in a short, enclosed cylinder in the middle of the case's base. The rimfire case had to have thin walls, but the centerfire case's wall could be thicker. Stronger walls increased how much gunpowder could be used in a cartridge and resulted in bullets that flew much faster and farther than ever before.[193]

a. Smokeless Powder

The gunpowder that we today call *blackpowder* is as old as firearms. It is made from a mixture of sulfur, charcoal, and saltpeter (Ch. 4.B.7, online Ch. 22.H.1.d). In 1884, modern *smokeless powder* was invented; it is made from insoluble nitrocellulose, soluble nitrocellulose, and paraffin. As the name implies, it creates much less smoke than does traditional blackpowder. One consequence is that when someone is firing the second shot from a repeater, there will be no obscurity from smoke. On a battlefield, where many people are shooting at the same time, the change in visibility is enormous.

Smokeless powder burns cleaner than does blackpowder. In the latter, about 35 percent of the gunpowder is converted into gas, and 65 percent remains as residue. In smokeless powder, 70 becomes gas, and only 30 percent is solid residue. Because smokeless powder is over twice as efficient, the quantity of powder needed is cut in half. Reducing the quantity of gunpowder further reduced the amount of residue, so the new smokeless powder left only about one-quarter as much residue as did blackpowder. The residue reduction thus made cleaning the gun much easier.[194]

Smokeless powder facilitated the improvement of repeating arms. If the first and second shots leave less residue in the barrel, then the third shot does not have to push past so much obstruction (*fouling*). There is less interference with the spin and forward motion of the bullet, so the bullet will exit the muzzle more precisely on its path to the target. *See* W.W. Greener, The Gun and Its Development 560 (9th ed. 1910). Because fouling can clog the small moving parts of a firearm, reduced residue is especially important to the operation of repeaters, which depend on closely fit parts. Powder fouling creates corrosive salts, which promote rust. So the advent of smokeless powders significantly improved firearms durability. M.L. Brown, Firearms in Colonial America: The Impact of History and Technology, 1492-1792, at 11 (1980).

Smokeless powder facilitated the growth of indoor shooting galleries, which proliferated in the following decades. It also made shooting more pleasant, and thus helped the growth of recreational shooting. Blackpowder guns need to be cleaned more often than do smokeless powder guns. At a target match, a blackpowder gun

193. Rose, at 171.

194. Greener, at 560.

might need to be cleaned after every 50 or 100 shots. A.L.A. Himmelwright, Pistol and Revolver Shooting 96 (rev. ed. 1930).

Smokeless powder generates higher gas pressures than does blackpowder. The 1873 invention of decarbonized Bessemer steel was among the advances in metallurgy that made firearms able to tolerate the greater pressures. Rose, at 219.

For technical reasons, smokeless powder was initially easier to use on shotguns. The first commercially successful smokeless powder for rifles came from the Du Pont Company, in 1894.[195] Before the turn of the century, rifles made for smokeless powder could fire 30 rounds a minute.[196]

b. Jacketed Bullets

Another ammunition improvement of the era was the *jacketed* bullet. When a lead bullet travels down a barrel, heat and friction cause some small lead particles to shed from the bullet and remain in the barrel. The shedding degrades accuracy in the short run by altering the bullet shape in uneven ways—and in the long run because lead fouling makes the interior barrel surface (the *bore*) uneven. In 1882, the first copper-jacketed bullet was introduced; the lead bullet was wrapped in a thin layer of copper. Because copper has a higher melting point than lead, and is harder, copper jacketing keeps the bullet intact and the barrel cleaner. As detailed in online Chapters 21.B and G, ammunition today includes the entire spectrum from full-jacketing to no-jacketing, with many intermediate variations, such as jacketing for most of the bullet but not the nose.

Jacketed ammunition, in turn, gave rise to the *hollow-point* bullet. If the point of a bullet is hollow, it is more likely to deform on impact. Thus, all the kinetic energy of the bullet is transferred to the target. If a bullet does not deform, it may pass through the target (*over-penetrate*). For hunting, the hollow point is more humane, because it is more likely to kill the animal quickly, rather than leaving a wound that causes death hours or days later. For self-defense, the hollow-point is superior because it is much less likely to exit the target, and thereby strike someone else. It is also more likely to deliver a fight-stopping hit. Law enforcement agencies in the United States generally require the use of jacketed hollow-points by law enforcement officers while on duty.

2. Repeaters

Section C.4 described the mass market arrival of the lever-action rifle. After firing a cartridge, the user would pull down a lever to eject the empty metallic case. Then, by pushing the lever back up into place, the user would load a fresh cartridge from the magazine into the firing chamber. In the nineteenth century, the lever action was supplemented by the *pump action* (also known as slide action), and the *bolt action*. All of these involved a short back-and-forth (or down-up) movement by the user.

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195. Whelan, at 302.

196. Lloyd, at 275.

As noted in Section A.2, the introduction of the flintlock rifle had reduced from 43 to 26 the number of steps necessary to reload a firearm. With the lever/slide/pump actions, the number of steps for reloading fell to two: move something one way, then move it back. The bolt action has four movements, but they are all very short. Two new types of actions would reduce the number of steps for reloading to zero.

The revolvers discussed in Section C.3, from Colt or Smith & Wesson, had been *single-action*. After firing one round, the user would use his or her thumb to cock back the hammer. Because the hammer was connected to the rotating cylinder, cocking the hammer would rotate the cylinder, and bring a fresh round into the firing position. Then, the user would press the trigger.

In *double-action* revolvers, pressing the trigger also cocks the hammer and rotates the cylinder, so the double-action revolver can be fired as fast as the user presses the trigger.

In 1883, the first *semi-automatic* handgun was invented, by Orbeas Hermanos, of Spain.[197] All semi-automatics use energy from the gunpowder explosion to perform the mechanical work of extracting and ejecting the empty case from the firing chamber, and then loading a fresh round into the chamber. Like the double-action revolver, the semi-automatic has zero steps to reload, and it can fire as fast the user can press the trigger. Also as with the revolver, the semi-automatic user still has to press the trigger to fire a new cartridge. This is what makes semi-automatics different from automatics.[198] In automatics, ammunition will fire continuously as long as the user keeps the trigger pressed. Section D.4. For this reason, automatics fire much faster than semi-automatics. Online Chapter 21 Parts D-G detail how various actions work.

The first functional semi-automatic firearm was the Mannlicher Model 85 rifle, invented in 1885.[199] Mannlicher introduced new models in 1891, 1893, and 1895.[200]

3. The Box Magazine

In repeating rifles or shotguns such as those from Winchester (Section C.4) or Spencer, the reserve ammunition was stored in a line, in a tubular magazine underneath the barrel. In repeating handguns that are revolvers, the ammunition is stored in a rotating cylinder. During the nineteenth century, inventors worked

197. Held, at 185.

198. Orbea's invention was gas-operated. It diverted some of the gas from the gunpowder explosion to do the mechanical work. The alternative method, introduced in 1885, is recoil- (or inertia-) operated. All gunpowder explosions in a firearm create forward energy and an equal amount of backward energy. The forward energy pushes the bullet out of the metal case, and down the barrel toward the muzzle. The backward energy is felt by the user as recoil. A recoil-operated semi-automatic firearm uses some of the recoil energy to eject the empty case, and then move a fresh cartridge from the magazine into the firing chamber. The gas and recoil systems have their advantages. The gas system reduces felt recoil more, but it is more prone to fouling. *See, e.g.*, Phil Bourjaily, *Gas vs. Inertia Shotguns—Which is Better?*, Field & Stream, Jan 25, 2021 ("Gas shotguns are softer-shooting. Inertia guns are ultra-reliable.").

199. U.S. Navy SEAL Sniper Training Program 87 (2011).

200. John Walter, Rifles of the World 568-69 (3rd ed. 2006).

European harmonica pistol, 10 shots in 9 mm caliber.

on box magazines, which hold the ammunition in a stack underneath the firing chamber. The first handgun to use a detachable box magazine was the Jarre harmonica pistol, invented in 1862. Its magazine was horizontal, not vertical, making the gun awkward to carry in a holster.

A more successful design for a semi-automatic pistol with a detachable box magazine came from Hugo Borchardt, whose C-93 pistol, named for the year of its invention, had fairly good sales. But it was soon eclipsed by the 1896 Mauser, which was less bulky.[201] The German Mauser "broomhandle" model C96 came with a ten-round standard magazine, and optional magazines of as few as six or as many as 20 rounds.[202]

Mauser Model 1896 semi-automatic pistol.

Other semi-automatic handguns with detachable magazines were introduced before the turn of the century, including the Bergmann Simplex,[203] Fabrique Nationale M1899, Mannlicher M1896 and M1897, Luger M1898 and M1899,

201. Frank Miniter, The Future of the Gun 25-26 (2014).
202. Kopel, *The History of Firearms Magazines*, at 856-57 (2015); Dougherty, at 84.
203. Dougherty, at 85.

Roth-Theodorovic M1895, M1897, and M1898, and the Schwarzlose M1898.[204] Many of these were issued with magazines greater than ten rounds, including Luger's M1899, which could be purchased with 32-round magazines. Jean-Noel Mouret, Pistols and Revolvers 126–27 (1993); Supica, at 86.

4. Machine Guns and Automatics

From mid-century onward, inventors had been working on machine guns. A major advance was the Gatling Gun, introduced during the Civil War. It had 10 or 12 rotating barrels, which were operated by a hand crank; ammunition was fed from a belt. The Gatling saw mediocre sales. For example, the *New York Times* mounted a Gatling Gun on its roof during the 1863 anti-draft riot in New York City to deter rioters who were angry about the paper's pro-war, pro-draft editorial position. But the Gatling Gun often had reliability problems, and it eventually became a historical curiosity.[205]

True automatic weapons were invented by Hiram Stevens Maxim in 1884. In an automatic, ammunition fires continuously, as long as the user keeps the trigger pressed. This distinguishes automatics from all other types of firearms (revolvers, lever action, semi-automatic action, pump action, etc.). The new automatics were very large and heavy—often mounted on a tripod, and requiring a crew of two or more men to operate or transport. Few individuals bought them, but sales

Gatling Gun, U.S. Navy Model. The blue-gray mount affixed the gun to a ship's deck. Land models of the Gatling Gun were mounted on portable tripods. Note the ten rotating barrels visible at the muzzle, and the hand crank at the rear. Because the Gatling is hand-cranked, it is a machine gun but not an automatic.

204. Leonardo Antaris, *In the Beginning: Semi-Automatic Pistols of the 19th Century*, American Rifleman, Jan. 4, 2018.

205. *See* Julia Keller, Mr. Gatling's Terrible Marvel (2008).

to governments were strong. They were effective weapons for European colonial armies in Africa and Asia. They were also deadly in wars between the colonial powers, as the trench warfare of World War I would demonstrate.

5. Manufacturing

Better machine tools greatly reduced costs and improved quality. Drilling the bore in a rifle barrel had taken hours with the machine tools of the early nineteenth century. Now it took minutes.[206] Many firearms producers did not make all of their own parts, but instead bought them from other companies that sold parts to various manufacturers. The system was a boon for smaller companies; a small business did not have to make a large capital outlay for machines whose full-time use would produce more parts than the company needed.[207]

By the turn of the century, every firearms type that can be found in a twenty-first-century gun store had been invented and was on the commercial market, including the semi-automatic with the box magazine. Like the eighteenth century in England, the twentieth century in the United States would see the refinement and improvement of existing technology, and no dramatic innovations. Better manufacturing during the twentieth century did lead to significant gains in reliability, durability, accuracy, and affordability. Although the firearms technology developments of the twentieth century should not be slighted, they are small compared to what took place in the nineteenth century.

6. Target Shooting

Target shooting became for a while the most popular sport in America, starting in 1873 when the American team beat the world-champion Irish at an NRA-organized match. (The NRA had been founded in 1871 by former Union Army officers.) Shooting events were an Americanized version of the *schützenfeste*, which America's many German immigrants had enjoyed in the old country. Target shooting peaked around 1885, being thereafter displaced by bicycling and automobiling.

During the latter part of the nineteenth century, many colleges and private organizations formed shooting teams, and there was much encouragement of target practice as a patriotic exercise. The theory was that to prevent the need for a large standing army, American civilians should be good shots. If there were a war, citizens would be ready to enlist in the army, which would not have to spend a long time teaching them how to shoot.[208] NRA targets and marksmanship training manuals were adopted by the U.S. Army and Navy.[209] Government and nongovernment

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206. A.C. Gould, Modern American Rifles 7 (1891).

207. *Id.* at 28-30.

208. Rose, at 199-202; Russell S. Gilmore, *"Another Branch of Manly Sport": American Rifle Games 1840-1900, in* Guns in America: A Historical Reader 105 (Jan E. Dizard et al., eds. 1999).

209. James B. Trefethen, Americans and Their Guns 103 (1967).

efforts to promote rifle marksmanship would become even greater in the early twentieth century. *See* Ch. 8.B.2.b.

But target shooting was not just for males who might one day join the military. The NRA "feminized target shooting by opening the door for women to participate in large numbers." By "stressing . . . the patience and temperance needed to succeed, the NRA made it possible for women to be on an equal footing in this arena." Many rifle clubs welcomed women members, and "the overall tone of the sport was not military, but increasingly feminine." Laura Browder, Her Best Shot: Women and Guns in America 66-67 (2006). Firearms advertising of the late nineteenth and early twentieth centuries often featured women using rifles or shotguns for recreation. The ads treated women as typical consumers, without need for advertising copy about why a particular gun or activity might be especially suitable for females. *Id.* at 3-11.

By 1891, rifle accuracy had improved so much that the typical shooting match used targets at 200 yards. Gould, at 195. What was expert-level shooting at the beginning of the nineteenth century was now standard for an ordinary firearms user.

7. Shotgun Shooting

While the NRA and others were promoting rifle marksmanship, a separate development was increasing the popularity of shotgun sports. By the latter nineteenth century, rifles and handguns all fired a single conical projectile—the bullet. In contrast, shotguns fire several or many small spherical projectiles, called *shot*. Descendants of the *fowling pieces* discussed in Section A.2, shotguns are well-suited for bird hunting, and for self-defense at short range. (If the shotgun is loaded with a single large projectile, a *slug*, it can also be used for land-based hunting of mammals, such as deer.) In the latter nineteenth century, sportsmen found a method in which they could use their shotguns more often, without attempting to kill birds on every shot.

Instead of birds, the targets were glass balls, thrown into the air. The glass balls simulated the flight of a bird. Later, glass balls were replaced by brittle flying clay disks, which are sometimes called "clay pigeons." The clay disks gave rise to the sports of skeet shooting and trap shooting. In the latter twentieth century, *sporting clays* would become popular; the basic system of shotguns and clay disks is the same, but sporting clays are thrown in more irregular and challenging patterns than skeet or trap.

E. THE TWENTIETH AND TWENTY-FIRST CENTURIES: REFINEMENTS

As in eighteenth-century Great Britain, the twentieth century and the early twenty-first century in the United States saw improvements in firearms quality, but no great changes in firearms technology.

1. Manufacturing and Affordability

By the first half of the twentieth century, firearms were very affordable. In the early nineteenth century, the finest maker of flintlock shotguns was Old Joe Manton of London. A "strong, plain gun" from Manton cost hundreds of dollars. By 1910, a modern shotgun, "incomparably superior, especially in fit, balance, and artistic appearance" to Manton's cost about ten dollars.[210] A basic rifle suitable for plinking tin cans or bottles could be had for five dollars.[211]

Improved metallurgy was one reason for higher quality and much lower prices. Early in the nineteenth century, gun barrels were usually made from iron. In the late nineteenth century, barrels were made from Damascus steel—iron and steel strips twisted and welded together. Barrels made of fluid steel took over in the early twentieth century. They cost less to make, and were stronger and better able to withstand the higher pressures created by smokeless powder.[212]

Machines now made many parts of the firearm, but not everything. Shotgun barrels were still hand-finished by specialists.[213] Custom gun making—once the only kind of gun making—was now a small part of the market. As of 1910, "ninety-nine guns in the hundred are ordered by mail or bought ready made."[214]

2. Semi-Automatics

a. Handguns

The semi-automatic firearm was invented in 1885, and the first commercially successful semi-automatic handguns appeared in the 1890s. Section D.3. Semi-automatic pistols were superior to revolvers in accuracy, effective range, and ammunition capacity.[215] Revolvers were, and remain, superior in reliability.[216]

In 1911, Colt's Manufacturing brought to market a semi-automatic pistol that many people still consider to be the best defensive handgun ever created. Designed by John Moses Browning, the greatest firearms inventor of all time, the Colt Model 1911 won the War Department's competition to design a new and more powerful military sidearm.[217] Able to fire eight shots without reloading, the Colt 1911 and its .45 caliber round were well-suited for stopping formidable adversaries. More than

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210. Charles Askins, The American Shotgun 21-22 (1910). For more on Manton, see Kings of the Trigger: Biographical Sketches of Four Famous Sportsmen (Tony Reid ed., 1901). Ten dollars in 1913 is approximately equal to $250 in 2021.

211. Sharpe, at 493.

212. Askins, at 25-28.

213. *Id.* at 31.

214. *Id.* at 128.

215. A.L.A. Himmelwright, Pistol and Revolver Shooting 6 (rev. ed. 1930).

216. *Id.* at 8.

217. For more on Browning, *see* Nathan Gorenstein, The Guns of John Moses Browning: The Remarkable Story of the Inventor Whose Firearms Changed the World (2021); John Browning & Curt Gentry, John M. Browning, American Gunmaker: A Illustrated Biography of the Man and His Guns (1964).

Colt 1911 semi-automatic pistol, with seven-round magazine. This specimen was manufactured in 1918, and used by the U.S. Army in World War I and World War II. The openings in the magazine side are "witness holes," so that the user can see how many rounds are in the magazine when loading it.

a century later, the 1911 and its imitators retain a strong place in the market, in a variety of calibers, and often with greater ammunition capacity. The 1911 became the standard handgun used by the U.S. military until it was displaced in 1985 by the Beretta 9 mm pistol.[218]

b. Long Guns

Early in the century, companies such as Remington and Winchester introduced a variety of popular semi-automatic rifles and shotguns.[219] Semi-automatic long guns are superior to long guns that use a manual action (e.g., lever, pump, or bolt) in two important respects. First, they can fire somewhat faster. Second, semi-automatics are more accurate for the second and subsequent shots. To work the bolt on the bolt-action rifle (or a pump or lever on other rifles), the user must take his eyes off the target. Moreover, moving the bolt will move the rifle at least slightly. Training a user to be consistently accurate with a semi-automatic takes less time than training for a bolt action. *Id.* at 1.

Accordingly, in 1900 the Ordnance Department began work on finding a semi-automatic rifle for adoption.[220] The project took 36 years. Given that semi-automatic rifles for the civilian market were abundant, why did the infantry semi-automatic take so long?

Semi-automatics have inherent weaknesses. The complexity of the operating mechanism (the *action*) makes it more vulnerable to malfunction than simpler guns.[221] This is true even under ideal conditions, and all the more so under the hard usage typical of an infantryman's rifle. The Ordnance Department needed a semi-automatic that could function reliably in all environments, including exposure to blowing sand, freezing, and days of rain. Even in the worst conditions, the rifle had to be able to fire many rounds without needing to be cleaned. Basic disassembly for cleaning had to be very simple, so that it could be performed in a

218. Primarily as part of a deal by which the Italian government would accept the controversial placement of intermediate-range nuclear missiles in Italy, in exchange for a very lucrative American military contract for the Italian company Beretta.

219. *See, e.g.*, Julian S. Hatcher, Hatcher's Book of the Garand 14-15 (1948). Major General Julian Hatcher was Technical Editor of the NRA's magazine, *The American Rifleman*. His brother James was one of the three inventors at the Springfield Armory responsible for creating the Garand rifle.

220. Scott Duff, The M1 Garand, World War II, at 2 (2d ed. 1996).

221. Sharpe, at 572.

foxhole. The rifle had to have the fewest possible number of parts, to make field repair straightforward. The rifle could not be too heavy, because soldiers might be carrying it for weeks at a time. And it had to be easily manufactured rapidly and in large quantities.[222] These multiple objectives were at odds with each other. For example, heavier weight (e.g., sturdier stocks, thicker barrels) improved durability but contradicted the weight limit.

Although the civilian semi-automatic rifles of the early twentieth century were perfectly suitable for sports or personal defense, they were not rugged enough for the military, so the Army stuck with the 1903 Springfield bolt-action rifle.[223] The .30-'06 deer rifle is an heirloom in some families.[224] Although a venerable sporting gun, it was based on the standard U.S. infantry weapon.

Close-up of the action of the 1903 Springfield. The bolt is operated by the handle that has a large ball at the end. To eject an empty shell casing, the user moves the handle up and then back. To load a fresh round, the user then moves the handle forward and down. The box magazine, which is not pictured, attaches at the bottom of the rifle, in front of the trigger guard.

During the first third of the twentieth century, citizens purchased semi-automatic rifles, and firearms manufacturers continued to innovate for the civilian market. Progress with semi-automatics on the civilian side fueled technical innovations on the military side. Miniter, at 18-19. To meet federal needs, private experimentation was encouraged. The American Inventors Act authorized sale of

222. Hatcher, at 1-109.

223. *See* Joe Poyer, The Model 1903 Springfield Rifle and its Variations (4th rev. ed. 2013).

224. 30 caliber, cartridge invented in 1906.

Ordnance Department material to private inventors who were working on designs they hoped to submit to the Army.[225] Later, the Educational Orders Act of 1938 gave military contracts to private firms so they could gain experience in mass production of military arms.[226]

John C. Garand had started learning about guns when he was ten years old, working at his brother's shooting gallery. He was employed by machine tools companies, served in the National Guard, and submitted a rifle design to the government. Although his rifle was not adopted, Garand's impressive design led to him being hired in 1919 to work at the Springfield Armory's semi-automatic project.[227] The M1 Garand was officially adopted in 1936. It was fed by an eight-round clip.[228]

During World War II, the Springfield Armory produced 3.5 million M1 Garands, and the Winchester Repeating Arms Company made half a million.[229]

This M1 Garand was manufactured in 1952. The clip has not been inserted.

225. 33 Stat. 276 (1904).

226. Duff, at 43.

227. Hatcher, at 27-31; Duff, at 3.

228. A *magazine* is a closed container for ammunition, usually a box or tube. A *clip* holds several rounds of ammunition by the base, is usually made of stamped metal, and has no moving parts. Firearms invented after 1950 do not use clips. A magazine contains a spring that helps push the next round of ammunition into the firing chamber.

The Garand's biggest weaknesses were the small size of the clip, and that a partially empty clip (e.g., with three rounds left) could not be removed and replaced with a full clip.

229. Duff, at 123. Post-World War II production was 1.4 million, by Springfield Armory, International Harvester Corp., and Harrington & Richardson Arms Co. *Id.* at 124. In 1968, Secretary of Defense Robert McNamara closed the Springfield Armory. The other original federal armory, at Harpers Ferry (Part C.1), had gone out of business after the Confederates captured it in 1861, and took all its machinery to Norfolk.

As soon as the Garand entered combat in 1942, it proved itself under the most difficult conditions—from the steaming jungles of the South Pacific, to the deserts of North Africa, to the bitter cold of the far north.[230] The semi-automatic gave American soldiers a great advantage over their adversaries, who mostly used bolt-action rifles.[231] More American soldiers came home from the war, and more fascist soldiers did not, because of John H. Garand. General George S. Patton called the M1 Garand "the greatest battle implement ever devised."[232]

Some military personnel, such as paratroops, needed a smaller, lighter rifle. For them, the M-1 Carbine was developed by Winchester and adopted by the military in 1941. It uses 15- or 30-round magazines. Notwithstanding the similar name, it is structurally different from the M1 Garand.

M-1 Carbine. This specimen was used in 1944-45 in Pacific Island campaigns against what the Japanese called Dai Nippon Teikoku, the "Empire of Great Japan."

3. Post-World War II

a. Muzzleloaders

Some of the greatest firearms advances of the latter twentieth century were for muzzleloaders. Because of improvement in firearms parts quality, muzzleloaders with in-line ignition became common. For in-line ignition, the nipple that holds the percussion cap is inside the receiver, not outside. Such muzzleloaders had existed since the early eighteenth century, but the necessary close fit for the parts made them far too expensive for ordinary consumers. Newly

230. Joe Poyer & Craig Reisch, The M1 Garand 1936 to 1957, at 7-8 (1995).

231. *Id.*

232. Letter from Lieutenant General George S. Patton, Jr., Commander, 3rd Army, to Major General Levin Campbell, Jr., Chief of Ordnance, War Department (Jan. 26, 1945) *reprinted in* Duff, at 107.

invented blackpowder substitutes, such as Pyrodex, made muzzleloaders much cleaner and easier to use. Although a 2021 revolver or semi-automatic pistol is not all that different from the models of 1899, the 2021 muzzleloader has come a long way.

As for the old-fashioned flintlock, it is more widely available and affordable than ever, thanks to do-it-yourself kits for assembling premade parts, introduced in the 1970s.[233]

b. Manufacturing and Materials

During World War II, manufacturers learned how to use *casting* to create components by pouring steel into molds rather by cutting it. After the war, William Ruger became a leader in applying casting to the citizen firearms market. The Sturm, Ruger Company was also a leader in adopting computer numerical controlled (CNC) machining.[234] These manufacturing innovations facilitated the production of more complex firearms with closer-fitting parts.

Because of new manufacturing techniques, such as semisolid metal casting and metal injection molding, firearms have become more user friendly. Newer guns are much easier to disassemble for cleaning or repair than earlier ones. They are also more easily modified to fit the user. Changing the grips on a handgun to match the user's hand size, or swapping scopes for different applications (e.g., target shooting vs. hunting) is simple on many modern firearms. So is adjusting the weight of the trigger pull to match the user's preference.[235]

Improvements in metallurgy, such as the invention of titanium alloys, have made guns lighter, stronger, more durable, and more accurate. Today, a high-quality firearm (at the upper end of the price range) bought at a store can match the quality of a firearm customized by an expert gunsmith a few decades ago.

Compared to revolvers, semi-automatic pistols have more intricate parts, and there are more ways for malfunctions to occur. Thus, the manufacturing improvements that made parts to tighter tolerances were especially beneficial to semi-automatics. That is one reason why, over the past half-century, semi-automatics have gradually displaced revolvers as the most common handgun.

The first firearm to use plastics was the 1959 Remington Nylon 66, which had a synthetic rather than a wood stock. The company that turned plastics into something entirely normal on a modern firearm was Glock. In 1963, Austrian engineer Gaston Glock created the Glock company at a factory near Vienna, in Deutsch-Wagram. Initially, Glock manufactured plastic and steel products, including curtain rings. After developing expertise in products combining plastic with steel, Glock became an Austrian army supplier of field knives, machine gun belts, practice hand grenades, and entrenching tools.

In the early 1980s, the Austrian army asked many companies to submit bids to manufacture a new duty pistol. Although Glock had never made firearms before, it won the contract for what became the Glock 17 pistol. The Glock was the first handgun to make extensive use of polymers.

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233. Toby Bridges, Muzzleloading 20-59 (2000).
234. Miniter, at 193-94.
235. *Id.* at 200-10.

Most parts of the Glock 17 were still made of metal: the slide, the barrel, the trigger assembly, the magazines, and so on. But the frame was synthetic. The frame is the biggest part of the gun; it is the structure that contains all the other parts. The Glock's polymer frame weighed only 14 percent as much as a steel frame, yet was stronger. The stronger frame helped the gun absorb recoil better, thus improving accuracy and comfort for the user. The much lighter frame also made the Glock more comfortable to carry or wear for extended periods.

Even without the plastic, the Glock would have been a major innovation. Nobody had ever made a modern full-sized pistol with so few parts. The Glock was easy to disassemble and reassemble for cleaning. Compared to other pistols of the time, it was less likely to jam or misfire because of lack of cleaning. The gun was also extremely sturdy, and resistant to cracking or other damage even after firing thousands of rounds of ammunition. The Glock polymers also do not rust, and are generally more durable than metal.

After being adopted by the military and law enforcement in Austria, the Glock 17 found a world-wide market. Norway was the first NATO country to adopt it. In 1985, Glock opened an office in Smyrna, Georgia, the first of many Glock offices around the world.

Glock 17 semi-automatic 9 mm pistol. Named "17" because it was Gaston Glock's 17th patent. Later Glock model numbers also follow the patent sequence. By coincidence, the original Glock 17 held 17 rounds.

The company aimed its initial promotions at the law enforcement market. The light weight and other improvements made the gun naturally attractive to police officers. Glock offered very generous terms to adopting agencies, including buying the agencies' former service handguns. As law enforcement agencies adopted the Glock, other citizens could see that the newfangled guns were reliable and effective for self-defense. American citizens have always looked to law enforcement officers for good examples of appropriate arms for keeping the peace. That was true for the 1873 Colt "peacemaker" revolver and over a century later for the Glocks. Today, many common firearms use polymers.

Further reading: Paul M. Barrett, Glock: The Rise of America's Gun (2013).

c. Magazines and Ammunition

The first semi-automatic handgun to become a major commercial success in the late nineteenth century, the Mauser C96, had an optional 20-round magazine. In the first half of the twentieth century, some manufacturers produced handguns with standard magazines holding more than double the ammunition of a typical revolver—most notably the 14-round Browning Hi-Power of 1935. Greater ammunition capacity

became more common starting in the early 1980s, once the double-stack box magazine was perfected. The double-stack magazine holds the ammunition in two parallel columns, and feeds alternately from each column. As a consequence, many handguns now have standard manufacturer-supplied magazines of 21 rounds or more.

Box magazines in general now have more reliable springs and sturdier lips (where each round of ammunition feeds from the top of the magazine into the chamber of the firearm); because of better magazines, semi-automatics have become less likely to misfeed ammunition.[236]

In appearance and structure, twenty-first century ammunition is similar to ammunition from a century before. Yet quality has improved substantially, as manufacturers have tested ballistics with increasing precision, improved formulas for gunpowder and primers, and refined bullet shapes for better performance.

d. The Right Gun for the Individual

While the word "ergonomics" was coined in 1949, the concept had long been part of firearms technology. For example, mounting a long gun on the shoulder rather than the chest made it easier for the user to aim accurately, and so did the long sight radius of the Kentucky rifle. Ergonomic progress in the latter decades of the twentieth century was strong. Handgun grips became easily replaceable and customizable to better fit the individual user. Some grips could even be molded to exactly match the user's hand. Forward grips on long guns created a better point of contact for stability, compared to the user simply holding the gun's fore-end with her non-trigger hand. Adjustable stocks allowed a user of any height to buy a gun off the rack and have a stock that was just the right length—an advantage that had once belonged only to British aristocrats who could pay for a bespoke long gun.

After World War II, the U.S. domestic shortage of ammunition and new firearms during the war helped create much growth in home gunsmithing and home manufacture of ammunition (*reloading*). Ch. 8.F. The home tools available in 1949 were superior to what was available before the war. The tools have continued to improve, allowing consumers to more easily customize their guns and ammunition, including developing particular ammunition loads tailored for specific purposes such as target competitions or hunting certain game.

In an age where personal preferences reign, it is not surprising that the best-selling firearm in American history is a rifle built on the AR platform. The AR ("ArmaLite Rifle") platform is discussed in Chapters 15.A and 20.D.2.ii. The most famous AR is the Colt's semi-automatic AR-15.[237] But most AR rifles today are not AR-15s. The patents have expired, but Colt still owns the trade name "AR-15," so the typical modern AR usually has a different name despite still being referred to generically as an AR-15. Most twenty-first-century ARs are built for customization, starting with adjustable stocks. All components are easy to swap out and replace with aftermarket substitutes. ARs come with rails that make it easy to mount a scope on top, a laser pointer underneath, and many other options. The ARs are the Mr. and Mrs. Potatohead of firearms.

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236. Kopel, *The History of Firearm Magazines*, at 861-64.

237. That is, ArmaLite's 15th model.

e. Sighting and Computers

In the last two decades, the most important change in firearms has been the adoption of miniaturized lights and electronic optics, such as red dots or holographic sights. As of 1990, many firearms were not even compatible with supposedly "gimmicky" electronics. Today, many guns can be purchased directly from a dealer with electronic optics and light mounts as standard equipment. Battery improvements and miniaturization have made the sighting devices stronger, lighter, and more durable. Firearm-mounted lights enhance defensive safety. Many a confrontation has ended peacefully when the aggressor noticed a red dot on his torso. The lights also help the home defender ensure that the targeted person is really is an intruder. For beginning sport shooters, red dots and holographic optics simplify marksmanship and foster early success.

For traditional glass scopes, manufacturing improvements have led to dramatic increases in affordability and sophistication.

Computing power is now widely available to the general public. For the average firearms user, the result has been better made guns, but the gun itself still operates like a gun from the pre-computing age.

The place today where one is most likely to find guns being used in conjunction with computers is the shooting range. Handheld computers attached to scopes help long-distance rifle shooters adjust their aim precisely to account for wind, elevation differences, and so on. Computer-aided chronographs allow handloaders to determine which combination of ammunition components produces optimal velocity. Handheld chronometers have replaced stopwatches for handgun users timing their speed between shots. Ear muffs with internal computers allow for normal conversation and can even amplify voices, and then block sound in milliseconds when a gun is fired; as a result, instructors and students can hear each other better, while range safety and hearing protection are improved.

Small cameras made to be mounted on firearms are becoming more common. Hunters can record their hunts, and competitive shooters can review videos to improve their technique. At present, however, cameras are a high-end aftermarket accessory. Unlike polymer or titanium alloy frames, they are far from ubiquitous. Chapter 15.D discusses some other computer technologies that might—but have not yet—become very common for firearms.

F. CONCLUSION

The fifteenth century saw the replacement of crude hand cannons with matchlocks. The sixteenth century brought in the wheellock, repeaters, and finally the proto-flintlock (snaphaunce). The successful yet expensive innovations of the seventeenth century, such as the self-loading seven-shot handgun or the 30-shot rifle, were the technological foundation for the most common firearms of the twenty-first century.

The eighteenth century from start to finish was a flintlock century. New flintlocks, such as the Pennsylvania-Kentucky rifle, were made to fit their environments. While the flintlocks of 1800 often looked much like the flintlocks of 1700, the newer models were safer, more reliable, and more accurate.

The manufacturing revolution of the nineteenth century, incubated by the U.S. government, changed everything. By the 1830s, an average person could own a repeating handgun and by the 1860s, a 16- or 18-shot repeating rifle firing metal-cased ammunition. The most typical American firearm of the twenty-first century is a gun that became common in the 1880s and 1890s: the centerfire semi-automatic pistol with a detachable box magazine.

The twentieth century was like the eighteenth—a period of refinement of existing designs. The 1911 Model semi-automatic pistol on a gun store shelf today is mechanically almost the same gun that was first sold over a century ago. Yet today's model may have a polymer frame, a double-stack 13-round magazine, a customized grip, and internal parts that fit better than those of the early twentieth-century version. Like flintlocks during the eighteenth century, modern firearms during the twentieth century were improved by many small changes in components.[238]

Whereas revolvers once outnumbered semi-automatic pistols, the reverse is now true, as semi-automatics have improved in reliability. The use of polymers often makes modern guns appear different and more futuristic compared to their late nineteenth- and early twentieth-century antecedents.

In 1957, British firearms historian Robert Held declared: "Although the *age* of firearms today thrives with ten thousand species in the fullest heat of summer, the *history* of firearms ended between seventy and eighty years ago. There has been nothing new since, and almost certainly nothing will come hereafter."[239] As he put it, any modern bolt-action is "essentially" an updated version of the Mauser bolt-actions of the 1890s or the Mannlicher bolt-actions of the 1880s. "All lever-action rifles are at heart Henrys of the early 1860s," and all semi-automatics "descend from" the models of the 1880s.[240]

No firearms improvements since 1900 have come close in importance to the invention of the flintlock, nor to many inventions of the nineteenth century. Computers might change all that one day, but not yet. In another line of development, *gauss guns* or *coil guns*, are powered by electromagnetism rather than gunpowder. After a century of prototype stages, the first Gauss gun is slated to enter the consumer market in late 2021. It is about as powerful as a strong air gun or a weak .22 caliber firearm. The announced cost is $3,775.[241]

For the time being, the guns you can find today in a gun store are better versions of the guns from the days of your great- and great-great-grandparents.

NOTES & QUESTIONS

1. While acknowledging that the industrial age had made very good firearms very affordable, arms historian Robert Held lamented that the "skill and craftsmanship—one may say the art—of gunmaking has vanished." No longer

238. For example, many but not all modern semi-automatics have eliminated the hammer and replaced it with a small *striker* to hold the firing pin. The triggers on striker-fired guns have lower pull-weights, and so are easier to shoot, especially for beginners.

239. Held, at 186.

240. *Id.* at 185.

241. Brett Tingley, *Preorders for This Electromagnetic Rifle Are Being Taken for $3,775*, The-Drive, Aug. 6, 2021.

did master gunsmiths like Old Joe Manton produce exquisite flintlocks by hand. According to Held, in the Britain of 1956, "there are not two dozen men" who "could make a gun by hand, let alone as well as was demanded of an apprentice" of the old masters. In the United States, "not two dozen . . . could build a rifle out of a maple tree and two bars of pig iron, as was expected of any Pennsylvania riflesmith about the time of Bunker Hill." Held, at 186.

Would it be better if more people today could manufacture a firearm from a maple tree and pig iron? From other home workshop methods? If craft making of modern arms became more common?

2. *Presses and arms.* In the United States Constitution, two technologies are expressly singled out for special protection, "the press" and "arms." While "the freedom of the press" includes more than just the freedom to own printing presses, it surely does include the freedom to own and use presses and their modern equivalents.

Computer word processing, and many other improvements in typesetting and printing, have driven down the time and the cost of production of printed material. Mimeograph machines and then photocopiers made small offices or homes capable of printing sizable quantities of material for public distribution.

The above changes might be roughly comparable to changes in firearms, but nothing in firearms compares to the Internet revolution that began in the late twentieth century and continues today—as an average person in New York City or Nairobi can now instantly access an unimaginably large quantity of "printed" material.

The democratization of presses and arms is celebrated by some persons as fulfilling the ideals of the First and Second Amendments. Information and speech are a form of power, including in their ability to encourage violence. So, too, of course, are arms. The more widely distributed the power, the better, say some. Other people point to the misuse of these forms of power, and observe that in modern times, misuse has become all the more harmful because of technology. Libels that once might have been disseminated only to the readers of a newspaper in one city can now travel round the world in seconds.

The democratization advocates counter that as harmful as such power can be in too many hands, concentrating such power in the hands of the government or an elite can be even more harmful.

Taking into account what you have read in the preceding chapters of this textbook about the past and present of the United States and the world, and considering your own moral views and other knowledge, has the democratization of communication power and physical power been overall harmful or beneficial? How can harms be reduced and benefits increased?

3. *George Orwell.* Two months after the United States used the atomic bomb to force unconditional surrender by fascist Imperial Japan, George Orwell wrote about the democratizing and anti-democratizing effects of different types of arms:

> It is a commonplace that the history of civilisation is largely the history of weapons. In particular, the connection between the discovery of gunpowder and the overthrow of feudalism by the bourgeoisie has been pointed out over and over again. And though I have no doubt exceptions can be brought forward, I think the following rule would be found generally true: that ages in which the dominant weapon is expensive or difficult to make will tend to be ages of despotism, whereas when the dominant weapon is

> cheap and simple, the common people have a chance. Thus, for example, tanks, battleships and bombing planes are inherently tyrannical weapons, while rifles, muskets, long-bows and hand-grenades are inherently democratic weapons. A complex weapon makes the strong stronger, while a simple weapon—so long as there is no answer to it—gives claws to the weak.
>
> The great age of democracy and of national self-determination was the age of the musket and the rifle. After the invention of the flintlock, and before the invention of the percussion cap, the musket was a fairly efficient weapon, and at the same time so simple that it could be produced almost anywhere. Its combination of qualities made possible the success of the American and French revolutions, and made a popular insurrection a more serious business than it could be in our own day. After the musket came the breech-loading rifle. This was a comparatively complex thing, but it could still be produced in scores of countries, and it was cheap, easily smuggled, and economical of ammunition. Even the most backward nation could always get hold of rifles from one source or another, so that Boers, Bulgars, Abyssinians, Moroccans—even Tibetans—could put up a fight for their independence, sometimes with success. But thereafter every development in military technique has favoured the State as against the individual, and the industrialised country as against the backward one. There are fewer and fewer foci of power. Already, in 1939, there were only five states capable of waging war on the grand scale, and now there are only three—ultimately, perhaps, only two. This trend has been obvious for years, and was pointed out by a few observers even before 1914. The one thing that might reverse it is the discovery of a weapon—or, to put it more broadly, of a method of fighting—not dependent on huge concentrations of industrial plant.

George Orwell, *You and the Atomic Bomb*, Tribune (London), Oct. 19, 1945. Do you agree with Orwell's assessment of the effects of different weapons up to 1945? Does Orwell's analysis mesh with the history of resistance movements after 1945? What, if any, changes in firearms, firearms manufacture, or other technologies since 1945 have increased or reduced the ability of common people to resist a powerful industrial state?